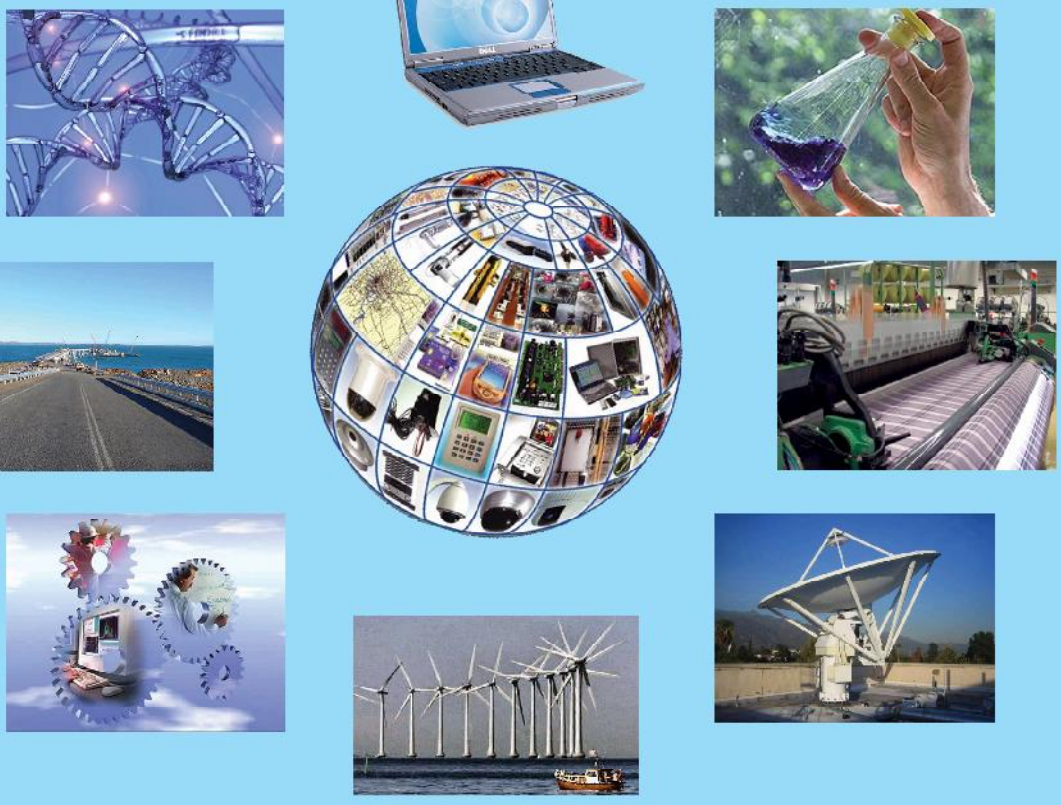
IJEST

ISSN: 0973-6255
Vol. 3 No. 2
July - December 2009

Indian Journal of Engineering, Science, and Technology

A Refereed Research Journal



BANNARI AMMAN INSTITUTE OF TECHNOLOGY
Stay Ahead

BANNARI AMMAN INSTITUTE OF TECHNOLOGY
(Autonomous Institution Affiliated to Anna University - Coimbatore
Approved by AICTE - Accredited by NBA and NAAC with "A" Grade)
Sathyamangalam - 638 401 Erode District Tamil Nadu India

Indian Journal of Engineering, Science, and Technology

IJEST is a refereed research journal published half-yearly by Bannari Amman Institute of Technology. Responsibility for the contents rests upon the authors and not upon the IJEST. For copying or reprint permission, write to Copyright Department, IJEST, Bannari Amman Institute of Technology, Sathyamanagalam, Erode District - 638 401, Tamil Nadu, India.

Indian Journal of Engineering, Science, and Technology

ISSN: 0973-6255

Volume 3 Number 2 **July - December 2009**

CONTENTS

Nature of Reversed Hazard Rate: An Investigation

D. Desai, V. Mariappan, A.D. Telang and M.J. Sakhardande
Mechanical Engineering, Government Engineering College, Farmagudi, Ponda, Goa - 403 401,
E-mail:dbd@gec.ac.in, anand587@rediffmail.com, mari@gec.ac.in, arundtelang @yahoo.co.in
(Received on 01 August 2007 and accepted on 18 June 2009)

Abstract

Reversed hazard rate is a useful tool in the area of maintenance management, particularly for condition monitoring. Its typical behaviour makes it suitable for the assessment of waiting time and hidden failures. Nature of reversed hazard rate is therefore, analytically and numerically investigated, for the standard distributions and presented in this paper. It is shown that it is a decreasing function for important statistical distributions, which rather makes it viable to be used in the field of maintenance engineering. Required data was simulated in MATLAB version 7.0 and the nature of RHR is investigated analytically.

Keywords: *Bathtub profile, Hazard rate, RHR, Reliability measures, Statistical distribution*

1. INTRODUCTION

Stiff global competition has made maintenance as an important activity in a business environment. The objective of maintenance is to restore and maintain the reliability of various production facilities. Reliability and the availability are to be continuously monitored for effective maintenance.

Hazard rate, one of the reliability measures plays a crucial role in reliability and survival analysis. A typical curve, between hazard rate h(t) and failure time T, is called bathtub profile, in the reliability engineering, due to its shape. In case of hidden failures, hazard rate looses its relevance. Therefore, there is a need to have another characteristic known as reversed hazard rate (RHR), r(t) [1]. It is defined as the conditional probability of a failure of an object per unit time in (t-Ät, t) given that the failure occurred in (0,t). Recently, the properties of RHR have attracted the attention of researchers. Anderson *et al* (1993) used it in the estimation of the survival function in presence of life-censored data [2]. Block *et al* (1998) characterized some useful properties for k out of n systems in terms of RHR [3]. Chandra and Roy [4] studied some properties of waiting time; the time elapsed since the failure of an object till the time of observation, with respect to RHR. In this paper the nature of RHR is investigated analytically, for various distributions, widely used in reliability engineering.

2. RELATIONSHIP WITH HAZARD RATE

As per the definition r(t) can be expressed as

$$\mathrm{r(t)} = \frac{f(t)}{1-R(t)} \; or \; \frac{f(t)}{F(t)} \qquad - \quad (1)$$

Hazard rate is expressed as given in Equation (3)

$$h(t) = \frac{f(t)}{R(t)} \qquad - \quad (2)$$

Substituting h(t) RHR can be expressed as

$$r(t) = \frac{h(t)}{R^{-1}(t) - 1} \qquad - \quad (3)$$

$$= \frac{h(t)}{e^{0}^{\int_{t}^{} h(\tau) d\tau} - 1} \qquad - \quad (4)$$

3. BEHAVIOUR OF REVERSED HAZARD RATE

Differentiating Equation (4) with respect to t,

$$r'(t) = \frac{[e^{0}^{\int_{t}^{} h(\tau) d\tau} - 1] h'(t) - h(t) \frac{d}{dt} \{e^{0}^{\int_{t}^{} h(\tau) d\tau} - 1\}}{[e^{0}^{\int_{t}^{} h(\tau) d\tau} - 1]^{2}} \qquad - (5)$$

Applying Leibnitz's rule,

$$r'(t) = \frac{[e^{\int_0^t h(\tau)d\tau} - 1]h'(t) - h^2(t)e^{\int_0^t h(\tau)d\tau}}{[e^{\int_0^t h(\tau)d\tau} - 1]^2} \quad - (6)$$

It can be seen from Equation (6) that if h(t) is a monotonically decreasing function of 't', r'(t) becomes negative. It implies that r(t) is monotonically decreasing function for a decreasing hazard rate. When hazard rate is constant, it results into r'(t) negative. This reveals that RHR decreases even for a constant hazard rate. But for monotonically increasing nature of hazard rate, investigation is to be carried out in a different way, for which the well-known results of Weibull analysis are applied. It is known that the shape parameter of Weibull distribution assumes value greater than unity to represent an increasing hazard rate. Density function, reliability function and Hazard rate, of Weibull distribution are given in Equations (7), (8) and (9).

$$f(t) = \beta \frac{t^{\beta-1}}{\theta^\beta} e^{-\left(\frac{t}{\theta}\right)^\beta} \quad - (7)$$

$$R(t) = e^{-\left(\frac{t}{\theta}\right)^\beta} \quad - (8)$$

$$h(t) = \beta \frac{t^{\beta-1}}{\theta^\beta} \quad - (9)$$

Where, â and θ are shape and scale parameters. The reversed hazard rate for Weibull is

$$r(t) = \frac{\beta}{\theta^\beta}\left[\frac{t^{\beta-1}}{e^{(\frac{t}{\theta})^\beta} - 1}\right] \quad - (10)$$

Differentiating the above equation w.r.t. t,

$$r'(t) = \frac{\beta t^{\beta-2} e^{(\frac{t}{\theta})^\beta}}{\theta^\beta \{e^{(\frac{t}{\theta})^\beta} - 1\}^2}\left[(\beta-1)\{1 - e^{-(\frac{t}{\theta})^\beta}\} - \beta\frac{t^\beta}{\theta^\beta}\right] \quad - (11)$$

The first factor of Equation (11) is positive. The second factor is to be investigated, for which three different cases are identified.

Case i: r'(t) > 0

Let the factor be φ(t)

$$\varphi(t) = (\beta-1)\{1 - e^{-(\frac{t}{\theta})^\beta}\} - \beta\frac{t^\beta}{\theta^\beta} > 0 \quad - (12)$$

Applying power series,

$$(\beta-1)\left[1 - \{1 - (\frac{t}{\theta})^\beta + \frac{(\frac{t}{\theta})^{2\beta}}{2!} - ...\}\right] - \beta\frac{t^\beta}{\theta^\beta} > 0 \quad - (13)$$

As $R(t) = e^{-(\frac{t}{\theta})^\beta} < 1$, which implies that t/θ <1 and â>1

$$(\beta-1)(\frac{t}{\theta})^\beta - \beta(\frac{t}{\theta})^\beta > 0$$

(â-1) > â - (14)

Equation (14) is absurd and therefore r'(t) can not be positive which in turn reveals that r(t) can not be an increasing monotone.

Case ii: r'(t)=0

$$\varphi(t) = (\beta-1)\{1 - e^{-(\frac{t}{\theta})^\beta}\} - \beta\frac{t^\beta}{\theta^\beta} = 0 \quad - (15)$$

Using power series, Equation (15) becomes

$$(\beta-1)\left[1 - \{1 - (\frac{t}{\theta})^\beta + \frac{(\frac{t}{\theta})^{2\beta}}{2!} - ...\}\right] - \beta\frac{t^\beta}{\theta^\beta} = 0 \quad - (16)$$

As $R(t) = e^{-(\frac{t}{\theta})^\beta} < 1$, which implies that t/θ <1 and â>1

$$(\beta-1)(\frac{t}{\theta})^\beta - \beta(\frac{t}{\theta})^\beta = 0 \quad - (17)$$

(â-1) = â - (18)

Equation (18) is absurd and therefore r'(t) can not be zero i.e., r(t) can not be a constant.

Case iii: r'(t)<0

$$\varphi(t) = (\beta - 1)\{1 - e^{-(\frac{t}{\theta})^{\beta}}\} - \beta\frac{t^{\beta}}{\theta^{\beta}} < 0 \qquad \text{- (19)}$$

Applying power series,

$$(\beta - 1)\left[1 - \{1 - (\frac{t}{\theta})^{\beta} + \frac{(\frac{t}{\theta})^{2\beta}}{2!} - ...\}\right] - \beta\frac{t^{\beta}}{\theta^{\beta}} < 0 \text{ -(20)}$$

As $R(t) = e^{-(\frac{t}{\theta})^{\beta}} < 1$, which implies that t/θ <1 and â>1

$$(\beta - 1)(\frac{t}{\theta})^{\beta} - \beta(\frac{t}{\theta})^{\beta} < 0$$

$$(\hat{a}\text{-}1) < \hat{a} \qquad \text{- (21)}$$

Equation (21) is not absurd which implies that r'(t) is negative and therefore r(t) is a decreasing function for even monotonically increasing hazard rate. From this, it is clear that reversed hazard rate is a decreasing monotone irrespective of nature of hazard rate. That is, it does not result any bathtub profile unlike the conventional hazard rate. This fact of course in general about reversed hazard rate. However, in the field of reliability engineering, the practitioners normally experience only few standard statistical distributions.

4. REVERSED HAZARD RATE FOR STANDARD DISTRIBUTIONS

In this section, attempts are made to obtain expression for RHR for various distributions. Here standard distributions, which normally the time to failure random variable assume in reliability and maintenance engineering, are considered.

4.1 Exponential Distribution

Using Equation (2), the r(t) for the exponential distribution is,

$$r(t) = \frac{\lambda e^{-\lambda t}}{1 - e^{-\lambda t}} \qquad \text{- 22)}$$

When t = 0, r(0) = ∞ and when t = ∞, r(∞) = 0. Taking first derivative to check for decreasing monotone,

$$r'(t) = \frac{-\lambda^2 e^{-\lambda t}}{[1 - e^{-\lambda t}]^2} \qquad \text{- (23)}$$

From Equation (23), it is clear that reversed hazard rate, r(t) is a monotonically decreasing function.

4.2 Normal Distribution

r(t) = f(t)/F(t) takes an indeterminate form for t = -∞. Applying L'Hospital rule,

$$\lim_{t \to -\infty} r(t) = \lim_{t \to -\infty} \frac{-f(t)\{\frac{t-\mu}{\sigma^2}\}}{f(t)} = \infty \qquad \text{- (24)}$$

When t = ∞, r(t) = 0. Investigating whether the function decreases monotonically,

$$r'(t) = \frac{-f(t)}{F^2(t)}\left[(\frac{t-\mu}{\sigma^2})F(t) + f(t)\right] \qquad \text{- (25)}$$

It is quite evident from Equation (25) that t in the interval [μ, ∞], r(t) is a decreasing function as r'(t) becomes negative.

Investigation on [-∞, μ)

Let

$$\phi(t) = (\frac{t-\mu}{\sigma^2})F(t) + f(t) \qquad \text{- (26)}$$

when t = -∞, ϕ(t) takes an indeterminate form, evaluating which using order of zero, ϕ(-∞) = 0 and ϕ(μ) = f_{max} substituting t = μ in Equation (26). Checking for monotone,

$$\phi'(t) = \frac{1}{\sigma^2}F(t) > 0 \qquad \text{- (27)}$$

From Equation (27), it is clear that ϕ(t) is a monotonically increasing function in [-∞, μ). This in turn reveals that ϕ(t) assumes positive value in this range. Thus r'(t) is negative revealing r(t) is a decreasing function in this range. Therefore, r(t) is a decreasing function for normal distribution for the entire range of t.

4.3 Lognormal Distribution

$$r(0) = \frac{f(0)}{F(0)} = \frac{0}{0}$$

Evaluating the above indeterminate form,

$$\lim_{t \to 0} r(t) = \lim_{t \to 0} -\frac{1}{t}\left[\frac{\ln t - \mu_x}{\sigma^2_x} + 1\right] = \infty \qquad \text{- (28)}$$

When t = ∞, r(∞) = 0. Thus it is found to be that r(t) decreases from ∞ to 0. However, it is a must to ascertain whether it decreases monotonically or not. h(t) of lognormal distribution increases initially and after reaching mode it declines [5]. It is already shown that for increasing h(t), r(t) decreases and also it has been shown that for a constant and decreasing h(t), r(t) decreases. Therefore it can be inferred that for lognormal distribution r(t) is a decreasing monotone.

4.4 Weibull Distribution

Virtually Weibull distribution takes care of important distributions involved in data analysis. That is the reason, the reliability assessment is known as Weibull analysis. For two parameter Weibull distribution, the reversed hazard rate can be expressed as

$$r'(t) = \frac{\beta t^{\beta-2} e^{(\frac{t}{\theta})^{\beta}}}{\theta^{\beta}\{e^{(\frac{t}{\theta})^{\beta}} - 1\}^2}\left[(\beta-1)\{1-e^{-(\frac{t}{\theta})^{\beta}}\} - \beta\frac{t^{\beta}}{\theta^{\beta}}\right] \quad \text{- (29)}$$

When â = 1, r'(t) is negative and hence r(t) is a decreasing function. â < 1 also evidently reveals r'(t) is negative, which in turn reveals r(t) is a decreasing function. For â > 1, r(t) is a decreasing which has been already discussed in §3. Thus for all the Weibull family reversed hazard rate is a decreasing function.

5. RESULTS AND DISCUSSION

The uniqueness of Weibull distribution is that it can be used to model and identify various failure modes. Reversed hazard rate is a monotonically decreasing function for all the range of shape parameters of Weibull distribution. In case of distribution like lognormal, which do not follow bathtub curve of hazard rate function, there is likelihood of misleading investigation of failure phenomenon. Whereas reversed hazard rate does not impose such restrictions.

Therefore, to confirm the nature of reversed hazard rate, data for various distributions of interest, were simulated in MATLAB, Version 7.0. The results clearly show that RHR is a monotonically decreasing function, as shown in Figures 1, 2, 3 and 4.

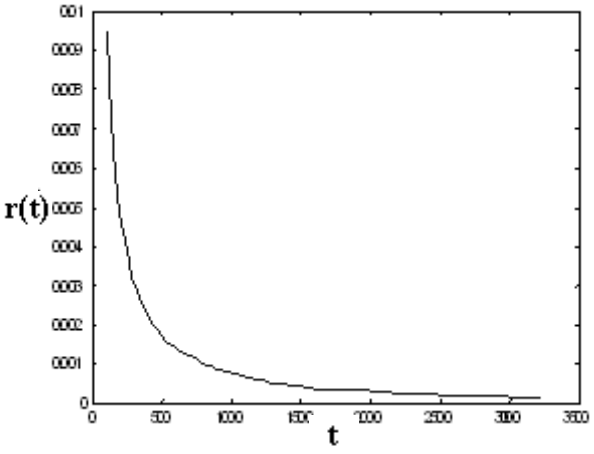


Fig.1Plot of RHR for exponential distribution with l = 0.0005

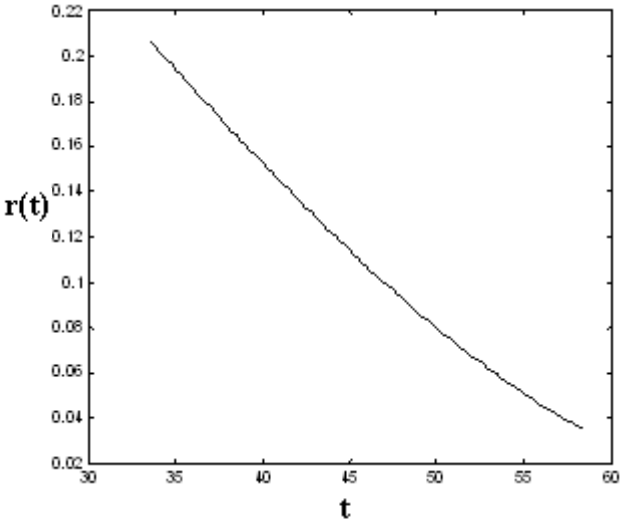


Fig.2 Plot of RHR for normal distribution with μ = 50 & σ =10

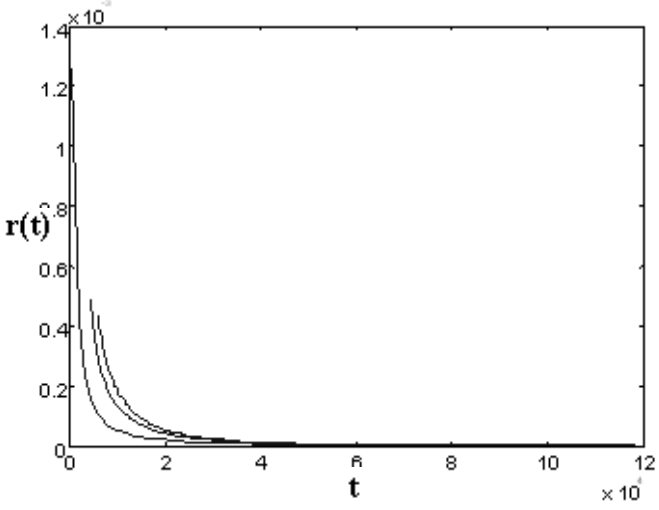


Fig.3 Plot of RHR for lognormal distribution with μx =10 & σx = 0.8, 1 & 2

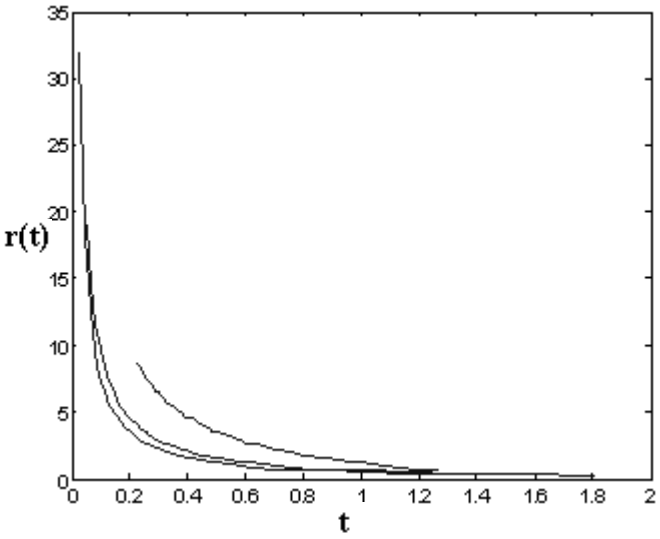


Fig.4 Plot of RHR for weibull distribution with $\beta = 0.8, 1$ & 2

6. CONCLUSION

It was felt that reversed hazard rate could prove to be a better tool as compared to hazard rate for the investigation of failure modes. To confirm this analytically and numerically, investigations were carried out.

It has been shown that RHR has monotonically decreasing pattern for all the statistical distributions of engineering importance. RHR has already been used for modeling waiting times, with this investigation its scope is further widened; to include, application in the area condition based maintenance.

REFERENCES

[1] M.S.Finkelstein, "On Reversed Hazard Rate", Reliability Engineering & System Safety, 2002, pp.71-75.

[2] P.K.Andersen, O.Borgan and R.D.Gill, "Statistical Methods Based on Counting Processes" Springer, New York, 1993.

[3] H.Block, T.H.Savits and H.Singh, "The Reversed Hazard Rate Function", Probability in the Engineering and Informational Sciences, Vol.12, 1998, pp.69-90.

[4] N.K.Chandra and D.Roy, "Some Results on Reversed Hazard Rate", Probability in the Engineering and Informational Sciences, Vol.15, 2001, pp.95-102.

[5] V.Mariappan, S.Ranjan, B.Usgaonkar and A.D. Telang, "Typical Hazard Rate Behaviour of Lognormal Distribution", Proceedings of 22nd International conference on CARs & FOF, VIT, Vellore, Tamilnadu, 2006, pp.1027-1034.

An Experimental Investigation into Ultrasonic Machining of Pure Titanium

Jatinder Kumar[1], J.S. Khamba[2] and S.K. Mohapatra[3]
[1]Department of Mechanical Engineering, SUSCET, Mohalli - 140 306, Punjab
[2]Department of Mechanical Engineering, University College of Engineering, Punjabi University, Patiala-147 004, Punjab
[3]Department of Mechanical Engineering, Thapar University, Patiala-147 004, Punjab
E-mail: jatin_thaparian@yahoo.co.in
(Received on 01 August 2007 and accepted on 20 June 2009)

Abstract

Ultrasonic Machining (USM) is one of the most widely used non-traditional machining processes for the machining of non-conductive, brittle materials such as engineering ceramics, glass, quartz, precision stones and diamond etc. Although the process can also be applied to the machining of tough materials, this issue has not been explored to a great extent so far and hence needs further investigation.This paper initially reviews the research on machining of titanium with conventional methods and ultrasonic machining process. Experimental research is subsequently presented on ultrasonic drilling of titanium (ASTM Grade-I) under established experimental conditions using two different tool materials-high carbon steel and titanium alloy; three different abrasive materials-alumina, silicon carbide and boron carbide with three different grit sizes-220,320 and 500. The results obtained for machining rate and tool wear rate were presented as main effects plots. It was concluded that tool material properties such as hardness, fracture toughness affect the machining performance of USM very significantly. Machining efficiency is also found to improve with increase in the hardness and coarseness of the abrasive media used for preparation of the slurry.

Keywords: *Grit size, Machining rate, Titanium, Tool wear rate, Ultrasonic machining*

1. INTRODUCTION

Ultrasonic Machining (USM) is a non-conventional mechanical material removal process used for machining both electrically conductive and non-metallic materials; preferably those with low ductility [1-2] and a hardness above 40 HRC [3-4] e.g. inorganic glasses, ceramics and nickel alloys.

In USM, high frequency electrical energy is converted into mechanical vibrations via a transducer/booster combination which are then transmitted to an energy focusing as well as amplifying device: horn/tool assembly. This causes the tool to vibrate along its longitudinal axis at high frequency (usually >20 kHz) with amplitude of 12-50 μm [5-6]. The power ratings range from 50-3000W and a controlled static load is applied to the tool. Abrasive slurry, which is a mixture of abrasive material; e.g. silicon carbide, boron carbide or aluminium oxide suspended in water or some suitable carrier medium is continuously pumped across the gap between the tool and work (25-60 μm). The vibration of the tool causes the abrasive particles held in the slurry to impact the work surface leading to material removal by microchipping [7]. A typical USM set up uses a megnetostrictive/piezoelectric transducer (Figure 1).

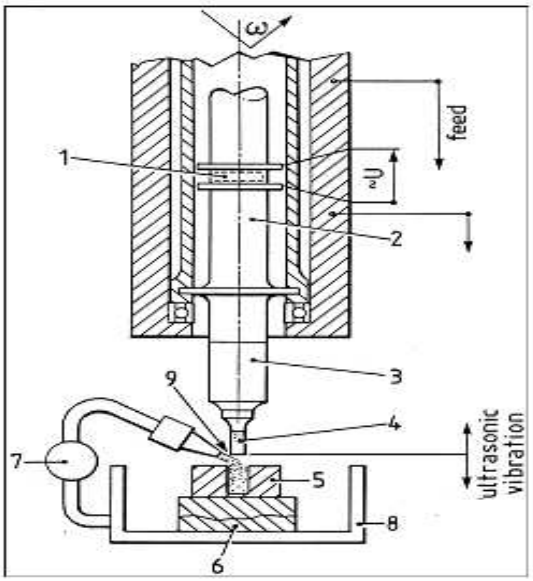


Fig.1 USM Set up
1- Transducer element, 2-body, 3-tool holder (horn), 4- Tool, 5-work sample, 6-fixture, 7-slurry pump

2. LITERATURE REVIEW ON ULTRASONIC DRILLING OF TITANIUM

Titanium and its alloys are used extensively in Aerospace because of their excellent combination of high specific strength, which is maintained at elevated temperature, their fracture resistant characteristics and their exceptional resistance to corrosion. They are being used increasingly in other industrial and commercial applications such as petroleum refinery, nuclear reactors, surgical implants and marine applications [8].

The machinability of Titanium and its alloys is generally considered to be poor owing to several inherent properties of the material. Titanium is very chemically reactive and therefore, has a tendency to weld to the cutting tool during machining thus leading to premature tool failure [9]. Its low thermal conductivity increases the temperature at the tool-work interface thus affecting the tool life adversely. Additionally, its high strength maintained at elevated temperature and its low modulus of elasticity further impairs the machinability. Owing to all these problems, it is very difficult to machine Titanium and its alloys by conventional machining processes.

Non-Traditional machining methods such as electric discharge machining (EDM) and laser beam machining (LBM) has been applied to the machining of Titanium and its alloys during recent times but even these established processes have their limitations; particularly in machining of small and deep holes in Titanium and its alloys.

Sharman *et al.,*[10] have discussed the application of ultrasonic assisted turning to titanium aluminide. As compared to conventional turning, the cutting forces are reported to be of very small magnitude (approx. 12%) in this process thereby improving the tool life and surface finish both. Aspinwall *et al.,*[11] have reported the use of USM for production of 3 mm holes in γ-titanium aluminide. When machined with USM, satisfactory results have been achieved with polycrastalline diamond tooling. Grit Size has been identified as the greatest factor affecting Material Removal Rate (MRR) followed by static load, tool type: solid/hollow and power level. In contrast to brittle materials, the combination of fine grit size, low power level and solid tool type gives maximum tool wear rate. The surface finish obtained is superior to ceramics.

Thoe *et al.,* [12] have investigated the effect of ultrasonic vibration introduction in EDM process to machine micro holes in ceramic coated nickel alloy; concluding an increase in MRR as well as the process stability along with reduction in arcing phenomenon. When applied to machining of titanium alloy, the combined EDM-USM process has been found to demonstrate better performance in term of improved MRR, discharging efficiency and reduced thickness of the recast layer. Wansheng *et al.,* [13] have also shown a similar result; the introduction of ultrasonic vibration into deep hole EDM of titanium alloy can improve the machining quality and efficiency distinctly. Singh and Khamba [14] have investigated the machining characteristics of titanium alloy (ASTM Grade-V) using ultrasonic drilling. The effect of important parameters such as slurry temperature, abrasive type, power rating of the machine etc was studied by means of established experimental conditions. Titanium alloy was found to be fairly machinable with ultrasonic drilling process. Also, the machined surface quality was superior to other conventional processes.

3. EXPERIMENTATION

The experimental study was conducted with AP-500 Sonic Mill ultrasonic drilling machine. Commercially pure titanium (ASTM Grade-I) was chosen as work material for this study. The important structural and mechanical properties of titanium are shown in Table 1.

Table 1 Structural and Mechanical Properties of Commercial Titanium

Chemical composition (by weight %) of Titanium (ASTM Grade I)						
O	N	C	H	Fe	residual	Ti
0.18	0.03	0.08	0.01	0.2	0.4	99.1
Yield Strength 220 MPa					Density 4.51 g/cm^3	
Ultimate strength 340 MPa					Mod. of elasticity 103 GPa	
Hardness 115 HV						

Tools were prepared from two different materials-High carbon steel and titanium alloy. The tools were prepared as solid, single piece unit on a centre lathe machine. All the tools were of same geometry, straight cylindrical with a diameter of 8 mm. Three different abrasive materials (Alumina, Silicon carbide and Boron carbide) were used to prepare slurry (concentration 25%) with three different grit sizes-220,320 and 500. All other factors such as vibration frequency, amplitude, static force etc. were kept constant during the experimentation.

Table 2 Design Matrix for Experimentation

Abrasive Material	Tool Material					
	High Carbon Steel			Titanium alloy		
	Grit Size			Grit Size		
	220	320	500	220	320	500
Alumina	(14)	(1)	(5)	(4)	(13)	(18)
Silicon Carbide	(10)	(6)	(2)	(8)	(17)	(15)
Boron Carbide	(3)	(11)	(7)	(9)	(16)	(12)

(Number in brackets indicates the Trial / Experiment number)

The power input to the machine was maintained at 400 W. According to the scheme of the experimentation outlined in Table 2, holes were drilled in the work samples which were prepared in the form of circular discs with thickness of 10 mm and diameter of 34 mm. Each trial was replicated twice. Hence, three holes were drilled for each of the eighteen trial runs and moreover, all the fifty four trial runs in all were executed in completely randomized fashion to reduce the effect of experimental noise to the maximum possible extent. The flow rate of the abrasive slurry was maintained constant at a value of 36.4 x 10^3 mm^3/min. To avoid any possibility of dullness of the edges of the abrasive grains, a large volume of slurry was prepared.

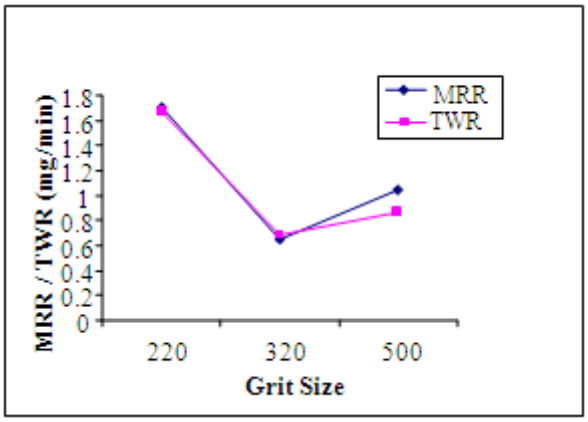


Fig.3 MRR & TWR Vs GRIT size using Al2O3 slurry (W/P Titaium & tool titan alloy)

4. RESULTS AND DISCUSSION

The experimental results have been presented as main effects plots (in Figures 2-7). The machining rate was calculated as the ratio of loss of the work material (in milligrams) to the time of machining (min). Tool wear rate was computed in the same manner.

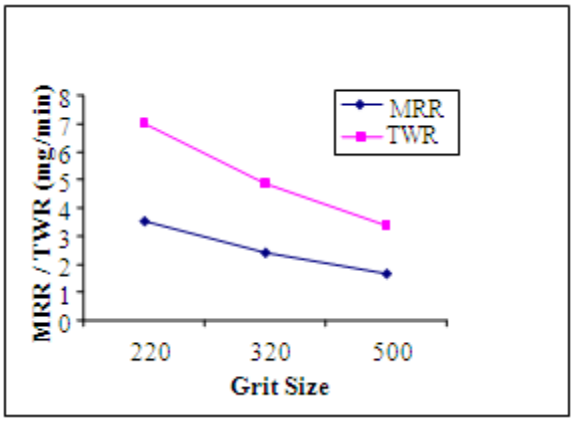


Fig. 2 MRR & TWR Vs GRIT size using Al2O3 slurry (W/P Titaium & tool HCS)

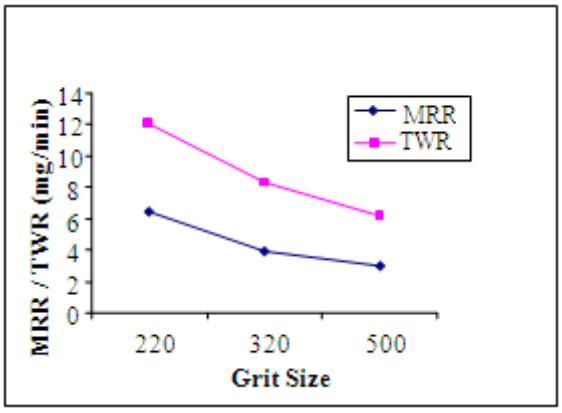


Fig.4 MRR & TWR Vs GRIT size using SiC slurry

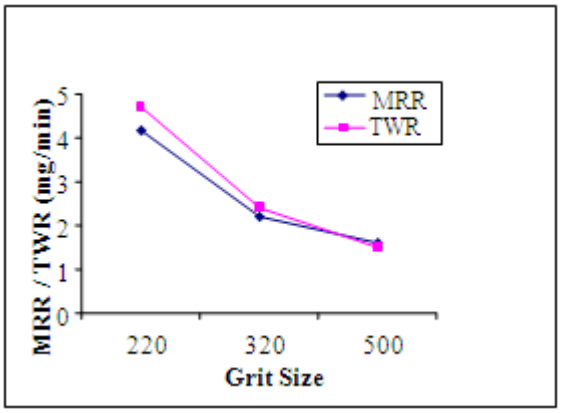


Fig.5 MRR & TWR Vs GRIT size using SiC slurry (W/P Titaium & tool titan alloy)

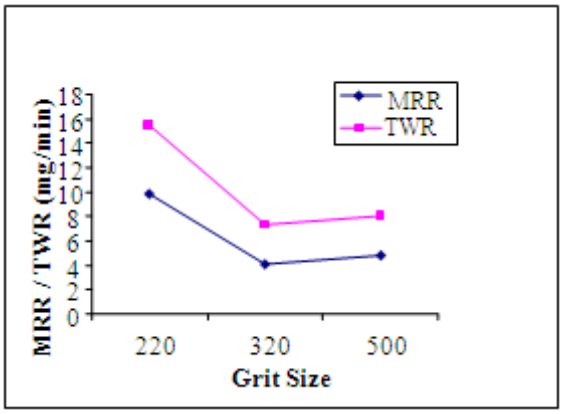


Fig. 6 MRR & TWR Vs GRIT size using B4C slurry (W/P Titanium & tools HCS)

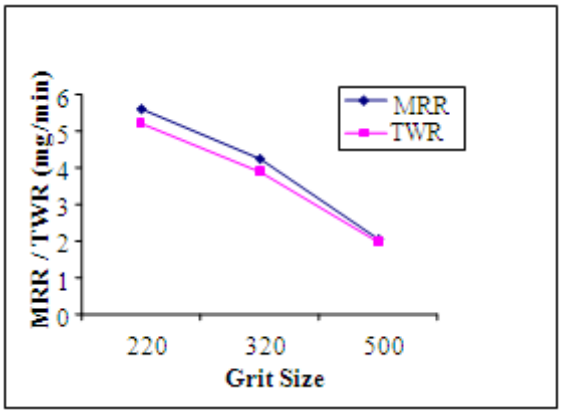


Fig. 7 MRR & TWR Vs GRIT size using B4C slurry (W/P Titaium & tool titan alloy)

From repetitive number of experiments conducted under six different setups, the comparative results have been plotted. From Figures 2-7, the following points can be concluded:

i. The Material removal rate with HCS tool is more than Titanium alloy tool for a given abrasive-grit size combination. This can be attributed to the higher hardness of HCS tool (56 HRC) as compared to titanium alloy tool (42 HRC). In USM process, use of a comparatively harder tool increases the machining rate of the work material as more of the fracturing takes place at work surface as compared to tool surface.

ii. Tool wear rate is more in case of HCS tool as compared to titanium tool under all conditions. This again can be explained on the basis of strain hardenability of the titanium tool which reduces its wear rate. On the other hand, HCS being relatively harder and more brittle is worn out by rapid erosive action of the slurry.

iii. Tool wear rate in case of HCS tool is 2-3 times the MRR of titanium work piece. This can be attributed to relative hardness and fracture toughness of the two materials. Also, TWR for titanium alloy tool is approximate of the same order as that of MRR of the titanium work piece for the same reason.

iv. The Machining rate has been found to increase with an increase in the coarseness of the abrasive material, regardless of the other conditions. However, for boron carbide abrasive, machining rate drops when the grit size is changed from 500 to 320. This can be explained on the basis of the fact that coarser abrasive particles carry more momentum and hence kinetic energy, and therefore can dislodge larger chunks of material from the work surface thereby causing the formation of larger micro cavities at the work surface which improves the MRR.

v. The performance of the different abrasives can be ranked in terms of increasing MRR as: Alumina, Silicon carbide, Boron carbide. This fact is associated with the knoop hardness of the abrasive grains for each abrasive material. Boron carbide is the hardest among the three abrasives; hence its use results in rapid brittle fracturing of the work surface, hence increasing the MRR. However, the tool wear rate also increases

vi. The Tool Wear Rate (TWR) has been found to be maximum at the conditions of maximum Machining rate (MRR). Hence, it can be concluded that the

process settings that result in more MRR also involve more TWR. This is an inherent characteristic of USM process when applied to the machining of other materials. This fact has now been verified with titanium as a work material as well.

5. CONCLUSIONS

The experimental work undertaken in this investigation is targeted at identification of the significant parameters that can contribute the variation in the machining performance of USM process when applied to the machining of pure titanium (ASTM Grade-I). The following conclusions can be drawn from this study:

i. Titanium is well machinable with ultrasonic drilling process.
ii. The machining rate depends upon all the three factors investigated in this study to a significant extent. Use of harder tool material and abrasive material tend to improve the MRR. Also, MRR has been found to increase while the grain size of the abrasive material is increased.
iii. The tool wear rate is found to increase with an increase in machining rate under all conditions.
iv. Higher machining rate and lesser tool wear rate can be achieved by selecting a specific tool with appropriate abrasive material with appropriate grit size under controlled experimental conditions.

REFERENCES

[1] R. Gilmore, "Ultrasonic Machining and Orbital Abrasion Techniques", SME Technical Paper (series) AIR, NM89-419, 1989, pp. 1-20.
[2] M.A. Moreland, "Versatile Performance of Ultrasonic Machining", Ceramics Bulletin, Vol. 67, No.6, 1988, pp.1045-1047.
[3] R. Gilmore, "Ultrasonic Machining of Ceramics", SME Paper, MS90-346, 1990, pp.1012.
[4] M. Haslehurst, "Manufacturing Technology", 1981, pp. 270-271.
[5] D.C. Kennedy and R.J. Grieve, "Ultrasonic Machining - A Review", The Production Engineer, Vol. 54, No.9, 1975, pp.481-486.
[6] D. Kremer, "New Developments on Ultrasonic Machining", SME Paper, MR91-522, 1991, pp.13.
[7] M.A. Moreland, "Ultrasonic Impact Grinding: What it is: What it will Do", Proceedings of 22nd Abrasive Engineering Conference: Abrasives and Hi-Technology, 1984, pp.11-117.
[8] E.O. Ezugwu and Z.M. Wang, "Titanium Alloys and Their Machinability - A Review", Journal of Materials Processing Technology, Vol. 68, 1997, pp. 262-274.
[9] Z. Wansheng, *et al.,* "Ultrasonic and Electric Discharge Machining to Deep and Small Hole on Titanium Alloy", Journal of Materials Processing Technology, Vol. 120, 2002, pp.101-104.
[10] Sharman, *et al.,* "Ultrasonic Assisted Turning of Gamma Titanium Aluminide", Proceedings of 13th International Symposium for Electromachining, Spain, 9-11 May 2001, pp.939-951.
[11] D.K. Aspinwall and V. Kasuga, "The Use of Ultrasonic Machining for the Production of Holes in Y-TIAL", Proceedings of the 13th International Symposium for Electro Machining ISEM XIII, Vol. 2, 2001, pp. 925-937.
[12] T.B. Thoe and D.K. Aspinwall, "Combined Ultrasonic and Electrical Discharge Machining of Ceramic Coated Nickel Alloy", Journal of Materials Processing Tech, Vol.92-93, 1999, pp. 323-328
[13] Y.C. Lin and B.H. Yan, "Machining Characteristics of Titanium Alloy Using a Combination Process of EDM with USM", Journal of Materials Processing Technology, Vol.104, 2000, pp. 171-177.
[14] J.S. Khamba and Rupinder Singh, "Effect of Alumina (White fused) Slurry in Ultrasonic Assisted Drilling of Titanium Alloys (TITAN 15)", Proceedings of National Conference on Materials and Related Technologies NCMRT, 2003, pp.75-79.

New-Fangled Fingerprint Engendered Key for a Secured VoIP

P.Arul[1] and A.Shanmugam[2]

[1]Department of Computer Science, CMS College of Science and Commerce, Coimbatore - 641 006, Tamil Nadu

[2]Bannari Amman Institute of Technology, Sathyamangalam - 638 401, Erode District, Tamil Nadu

E.mail : phdarul2004@yahoo.co.in, principal@bitsathy.ac.in

(Received on 12 December 2007 and accepted on 11 March 2009)

Abstract

In the recent internet technology, the transmission of voice communications over IP networks, commonly known as Voice-over- IP (VoIP) telephony, is rapidly gaining wide acceptance. With private phone conversations being conducted on insecure public networks, security of VoIP communications is increasingly important. VoIP has a very different architecture than traditional circuit based telephony, and these differences result in significant security issues. Encryption is one of the essential security technologies for computer data, and it will go a long way towards securing VoIP. In this paper we proposed a Biometric-Crypto system which generates a cryptographic key from the fingerprints for Encrypting and decrypting the voice data packets for VoIP Security [4].

Keywords*: AES, Biometrics, Cryptography, Fingerprint, Minutiae,VoIP, VoIP security*

1. INTRODUCTION

Internet telephony systems are becoming popular as businesses begin to see value in converging voice with other data applications such as presence, conferencing and e-mail. A Voice over Internet Protocol [1] (VoIP) is a protocol optimized for transmission of voice through the internet or other packet switched networks. VoIP is often used abstractly to refer to the actual transmission of voice (rather than the protocol implementing it). VoIP is also known as IP Telephony, Internet telephony, Broadband telephony, Broadband Phone and Voice over Broadband. For the right situations, it's a truly wonderful solution. Lower phone bills, virtual offices, centralized management and rapid deployment are just a few of the benefits. Voice over IP protocols carry telephony signals as digital audio, typically reduced in data rate using speech data compression techniques, encapsulated in a data packet stream over IP.

Unfortunately, new technologies bring new security concerns [2]. In VoIP, we have the burden of protecting two infrastructures - voice and data. Information about a call is almost as valuable as the voice content. For instance, a compromised signaling server used to setup and manage calls, might yield the following: a list of incoming and outgoing calls, their durations and parameters. Using just this information, an attacker could map all of the calls on your network, creating complex conversation records and user tracking [2].

The conversation itself is also at risk and the most obvious target of a VoIP network [2]. By breaching a key part of the infrastructure, such as a VoIP gateway, an attacker could capture and reassemble packets in order to eavesdrop on the conversation. Or even more nefariously, record everything, and replay all conversations occurring on the network. On the PSTN, this would be an impressive feat, since few are skilled enough on or have access to the huge switches managing calls. That's obviously not the case on a data network, as legions of script kiddies prove every day. And if your VoIP packets traverse the internet to reach a destination, a number of attackers have a shot at your voice data. The calls are also vulnerable to hijacking or a man in the middle attack [2]. In such a scenario, an attacker would intercept a connection and modify call parameters. This is an especially scary attack, since the participants likely wouldn't notice a change. The ramifications include spoofing or identity theft and call redirection, making data integrity a major risk.

One way to help protect your privacy is to encrypt these conversations so that they aren't simply floating around out there for potential hackers to latch onto. In our approach we have proposed a system which will encrypt the VoIP data packets using Advanced Encryption Standard (AES) [5],[6] with the novel method of Biometrics [7] based Key Generation technique.

The rest of the paper is organized as follows. Section 2 provides a brief introduction to VoIP and its security vulnerabilities. Section 3 provides a brief introduction to AES and Biometric-Crypto Systems. Section 4 describes the process of key generation from biometrics. Section 5 presents the conclusion.

2. VoIP SECURITY VULNERABILITIES

Voice over IP technology is opening up a wide range of new services and access options for users; however, it also exposes a host of new security vulnerabilities to be exploited by criminal hackers [3] . Traditional network security counter-measures are hampered by the complexity of VoIP protocols and the stringent service requirements demanded by voice communications. VoIP is based on IP, it is vulnerable to all of the attacks that can plague traditional IP networks .Unauthorized access, packet snooping and spoofing and especially denial of service attacks can all be problems for VoIP as well.

Threats to the VoIP service fall into two broad categories; threats to the network and threats to the end users [4]. Threats to the network include theft of services and fraudulent use of service as well as denial of service and attacks against network elements such as switches, routers and servers. VoIP traffic flows across the internet in unencrypted packets, which means anyone that has access to the network between sender and recipient can intercept these packets essentially allowing them to create a recording of your conversation.

3. ADVANCED ENCRYPTION STANDARD

Encryption is one of the essential security technologies for computer data, and it will go a long way towards securing VoIP. Encryption is the process of transforming information (referred to as plaintext) using an algorithm (called cipher) to make it unreadable to anyone except those possessing special knowledge, usually referred to as a key. An encryption algorithm along with a key is used in the encryption and decryption of data.

Advanced Encryption Standard (AES) [6] , is one of the most popular algorithms used in symmetric key cryptography. AES is a symmetric block cipher that can encrypt (encipher) and decrypt (decipher) information .

It has been analyzed extensively and is now used widely worldwide enough to protect classified information up to the TOP SECRET level, which is the highest security level and defined as information which would cause "exceptionally grave damage" to national security if disclosed to the public. AES supports key sizes of 128 bits, 192 bits and 256 bits and will serve as a replacement for the Data Encryption Standard which has a key size of 56 bits.

In addition to the increased security that comes with larger key sizes, AES can encrypt data much faster than Triple-DES, a DES enhancement that which essentially encrypts a message or document three times. According to NIST's "The AES algorithm is a symmetric block cipher that can encrypt (encipher) and decrypt (decipher) information" [5].

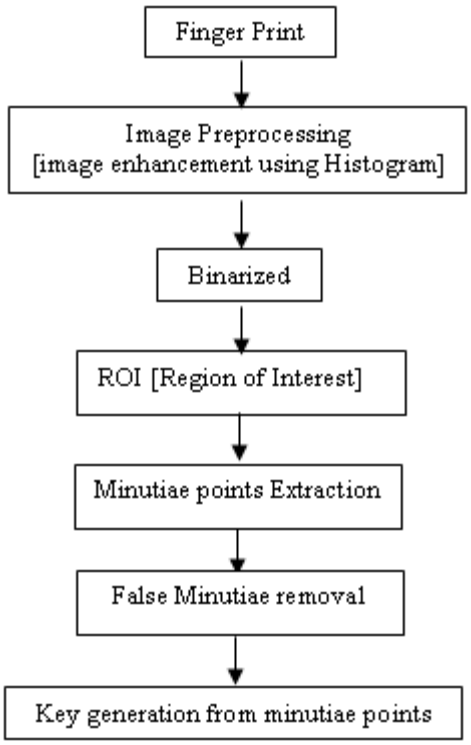
3.1 Biometric Crypto Systems

Cryptography provides the secure manner of information transmission over the insecure channel. It authenticates messages based on the key but not on the user. It requires a lengthy key to encrypt and decrypt the sending and receiving the messages respectively [8]. But these keys can be guessed or cracked. Moreover, maintaining and sharing lengthy, random keys in enciphering and deciphering process is the critical problem in the cryptography system. The above mentioned problem is solved by a Biometric cryptosystems.

Biometric cryptosystems combine cryptography and biometrics to benefit from the strengths of both fields [9]. In such systems, while cryptography provides high and adjustable security levels, biometrics brings in non-repudiation and eliminates the need to remember passwords or to carry tokens etc. In biometric cryptosystems, a cryptographic key is generated from the biometric template of a user stored in the database in such a way that the key cannot be revealed without a successful biometric authentication.

4. CRYPTOGRAPHIC KEY GENERATION FROM BIOMETRICS

Numerous biometrics have been proposed for user authentication and conceivably many are candidates for generating cryptographic keys using recently proposed techniques. In our approach we have selected fingerprint as the biometrics feature for generating cryptographic key. We have extracted minutiae points from the fingerprint and used that point set for generating cryptographic key.



4.1 Extracting Minutiae Points from Fingerprint

For extracting minutiae points from fingerprint, a three-stage approach is widely used by researchers. They are preprocessing, minutia extraction and postprocessing stage.

For the fingerprint image preprocessing, Histogram Equalization and Gabor Filters are used to do image enhancement [12]. And then the fingerprint image is binarized using the locally adaptive threshold method [10].Then the Region of Interest [ROI] is extracted by Morphological operations. For minutia extraction stage, three thinning algorithms [10 & 11] are tested and the Morphological thinning operation is finally bid out with high efficiency and pretty good thinning quality.

4.1.1 Histogram Equalization

Histogram equalization is to expand the pixel value distribution of an image so as to increase the perceptional information. The original histogram of a fingerprint image has the bimodal type, the histogram after the histogram equalization occupies all the range from 0 to 255 and the visualization effect is enhanced.

(a)
Captured Fingerprint

(b)
After Histogram Equalization

4.1.2 Gabor Filter

A Gabor filter is a linear filter whose impulse response is defined by a harmonic function multiplied by a Gaussian function. Because of the multiplication-convolution property (Convolution theorem), the Fourier transform of a Gabor filter's impulse response is the convolution of the Fourier transform of the harmonic function and the Fourier transform of the Gaussian function.

$$g(x, y; \lambda, \theta, \psi, \sigma, \gamma) = \exp(-\frac{x'^2 + \gamma^2 y'^2}{2\sigma^2}) \cos(2\pi \frac{x'}{\lambda} + \psi)$$

Where
$x' = x \cos\theta + y \sin\theta$ and $y' = -x \sin\theta + y \cos\theta$

In this equation, λ represents the wavelength of the cosine factor, θ represents the orientation of the normal to the parallel stripes of a Gabor function, ψ is the phase offset, and γ is the spatial aspect ratio, and specifies the ellipticity of the support of the Gabor function

4.1.3 Binarization

Fingerprint Image Binarization is to transform the 8-bit Gray fingerprint image to a 1-bit image with 0-value for ridges and 1-value for furrows. After the operation, ridges in the fingerprint are highlighted with black color while furrows are white.

A locally adaptive binarization method is performed to binarize the fingerprint image. Such a named method comes from the mechanism of transforming a pixel value to 1 if the value is larger than the mean intensity value of the current block (16x16) to which the pixel belongs.

(c) After binarization

4.1.4 Roi Extraction By Morphological Operations

Two Morphological operations called 'OPEN' and 'CLOSE' are adopted. The 'OPEN' operation can expand images and remove peaks introduced by background noise. The 'CLOSE' operation can shrink images and eliminate small cavities.

The bound is the subtraction of the closed area from the opened area. Then the algorithm throws away those leftmost, rightmost, uppermost and bottommost blocks out of the bound so as to get the tightly bounded region just containing the bound and inner area.

4.1.5 Minutiae Points Extraction

Ridge Thinning is to eliminate the redundant pixels of ridges till the ridges are just one pixel wide[10] uses an iterative, parallel thinning algorithm. In each scan of the full fingerprint image, the algorithm marks down redundant pixels in each small image window (3x3). And finally removes all those marked pixels after several scans. After the fingerprint ridge thinning, marking minutia points is relatively easy.

For each 3x3 window, if the central pixel is 1 and has exactly 3 one-value neighbors, then the central pixel is a ridge branch. If the central pixel is 1 and has only 1 one-value neighbor, then the central pixel is a ridge ending. Suppose both the uppermost pixel with value 1 and the rightmost pixel with value 1 have another neighbor outside the 3x3 window, so the two pixels will be marked as branches too. But actually only one branch is located in the small region. So a check routine requiring that none of the neighbors of a branch are branches is added.

4.1.6 False Minutia Removal

The preprocessing stage does not totally heal the fingerprint image. For example, false ridge breaks due to insufficient amount of ink and ridge cross-connections due to over inking are not totally eliminated. Actually all the earlier stages themselves occasionally introduce some artifacts which later lead to spurious minutia. These false minutia will significantly affect the accuracy of matching if they are simply regarded as genuine minutia. So some mechanisms of removing false minutia are essential to keep the fingerprint verification system effective.

4.1.7 Key Genration from Minutiae Points

In this section we explain the Key Generation Algorithm.

Assumptions

Kl - length of the AES key
Mp - Minutiae point set
Ki - Key length
Np - Size of Minutiae point set
S - Seed value
Sl - Seed limit.
m - (x,y) – coordinate of a minutiae point
Kv - Key Vector

The Extracted minutiae points are represented as

$$Mp = \{ mi \} i=1,\ldots, Np$$

The initial key vector is defined as follows,

$$Kv = \{ xi : p(xi) \}\ i=1, \ldots.., Kl$$

Where

$$p(x) = Mp[I \% Np] + Mp[(i+1) \% Np] + S\ i=1,\ldots . , Kl$$

Initial value of S is equal to total Number of Minutiae points. The value of S will be dynamically changed as follows:

$$S = Kv (i) \% Sl , -1 < i < Klz$$

Then the initial key vector (Kv) is converted in to a matrix Km of size Kl / 2 * Kl / 2

$$Km = (aij)\ Kl / 2 * Kl / 2$$

Then a intermediate key vector is generated as follows:

$$KIV = \{ Ki : (m(ki) \} \; i=1,\ldots. Kl$$

Where

$m(k) = |Aij|$, $Aij = Km\, i,j : i+size,j+size$, $-1 < i < Kl/2$

Aij is a submatrix formed from the key matrix. Then the final key vector is formed is

$Sv = \{ 1, \text{if } KlV[i] > \text{mean}(KlV)\ 0 , \text{otherwise} \}$

5. CONCLUSION

This paper proposed a method of securing VoIP communication using Encryption and a novel approach for fingerprint based cryptography system. The crypto keys have been generated using fingerprint patterns, which is stable throughout person's lifetime. Since it creates more complexity to crack or guess the crypto keys. This approach has reduced the complicated sequence of the operation to generate crypto keys as in the traditional cryptography system. It can generate more complex keys with minimum amount of time complexity, which is aptly suited for any real time cryptography.

REFERENCES

[1] J. Davidson, "Voice over IP Fundamentals", Cisco Press, Indianapolis, IN, 2000.

[2] S. Kent and R. Atkinson, "Security Architecture for the Internet Protocol", RFC 2401 (Proposed Standard), November 1998.

[3] Klaus Steinklauber, "VoIP Security in Small Businesses", SANS Institute GIAC M Repository, November 2004.

[4] Pawel Lawecki, "VoIP Security in Public Networks", Master Thesis, February 2007.

[5] L. Hong, Y. Wan and A. Jain, "Fingerprint Image Enhancement: Algorithm and Performance Evaluation", IEEE Trans. Pattern Analysis and Machine Intelligence, Vol.20, No.8, 1998, pp.777-789.

[6] Joan Daemen and Vincent Rijmen, "The Design of Rijndael, AES - The Advanced Encryption Standard-Information Security and Cryptology", Springer, 2001.

[7] S.Nanavati, M.Thieme and R.Nanavati, " Biometrics: Identity Verification in a Networked World" , John Wiley & Sons, 2002.

[8] Umut Uludag, Sharath Pankanti, Salil Prabhakar and Anil K.Jain, "Biometric Cryptosystems Issues and Challenges", Proceedings of the IEEE 2004.

[9] Kholmatov and B.Yanikoglu, "Biometric Cryptosystem Using Online Signatures," in Computer and Information Sciences – ISCIS 2006, pp. 981-990.

[10] J.S. Kwon, J.W. Gi and E.K. Kang, "An Enhanced Thinning Algorithm Using Parallel Processing", in Proceedings of the International Conference on Image Processing, 2001, pp.752-755.

[11] X. Luo, J.Tian and Y. Wu, "A Minutia Matching Algorithm in Fingerprint Verification", IEEE Proceedings of the International Conference on Pattern Recognition (ICPR'2000), 2000, pp. 833-836.

[12] D.Maio and D. Maltoni, "Direct Gray-Scale Minutiae Detection in Fingerprints", IEEE Transaction on Pattern Analysis and Machine Intelligence, Vol.19, No.1, 1997, pp.27-40.

A Model for an Adaptive NIDS using Fuzzy Association Rule Mining

A. Marimuthu[1] and A. Shanmugam[2]
[1]Department of Computer Science, Government Arts College (Autonomous), Coimbatore - 641 018, Tamil Nadu
[2]Bannari Amman Institute of Technology, Sathyamangalam - 638 401, Erode District, Tamil Nadu
E-mail: mmuthu2005@yahoo.com
(Received on 15 December 2007 and accepted on 18 March 2009)

Abstract

Several data security techniques are available today to protect information systems from unauthorized use, duplication, alteration, destruction and virus attacks. An Intrusion Detection System (IDS) is a program that analyzes what happens or has happened during an execution and tries to find indications that the computer has been misused. The main objective of a Network-based Intrusion Detection System (NIDS) is to identify patterns of known intrusions (misuse detection) or to differentiate anomalous network activity from normal network traffic (anomaly detection). Data mining methods have been used to build automatic intrusion detection systems based on anomaly detection. The goal is to characterize the normal system activities with a profile by applying mining algorithms to audit data so that abnormal intrusive activities can be detected by comparing the current activities with the profile. A major difficulty of any anomaly-based intrusion detection system is that patterns of normal behavior change over time and the system must be retrained. An IDS must be able to adapt to these changes, and be able to distinguish these changes in normal behavior from intrusive behavior. The goal of this paper is to provide a general model for an adaptive anomaly detection module that utilizes fuzzy association rule mining.

Keywords: *Adaptive anomaly detection module, NIDS*

1. INTRODUCTION

Security of network systems is becoming increasingly important as more and more sensitive information is being stored and manipulated online. Intrusion Detection Systems (IDSs) have thus become a critical technology to help protect these systems.

Most IDSs are based on hand-crafted signatures that are developed by manual encoding of expert knowledge. These systems match activity on the system being monitored to known signatures of attacks. The major problem with this approach is that these IDSs fail to generalize to detect new attacks or attacks without known signatures. Recently, there has been an increased interest in data mining-based approaches to building detection models for IDSs. These models generalize from both known attacks and normal behavior in order to detect unknown attacks. They can also be generated in a quicker and more automated method than manually encoded models that require difficult analysis of audit data by domain experts. Several effective data mining techniques for detecting intrusions have been developed [1], many of which perform close to or better than systems engineered by domain experts.

Intrusion detection is defined as identifying unauthorized use, misuse, and abuse of computer systems by both inside and outside intruders [2]. There are many categories of network intrusions [3]. Examples include SMTP (SendMail) attacks, password guessing, IP spoofing, buffer overflow attacks, multiscan attacks, denial of service (DoS) such as ping-of-death, SYN flood, etc. Intrusion detection techniques can broadly be divided into two categories: Misuse detection and Anomaly detection [4]. Misuse detection is based on knowledge of system vulnerabilities and known attack patterns, while anomaly detection assumes that an intrusion will always reflect some deviation from normal patterns. Many AI techniques have been applied to both misuse detection and anomaly detection. Pattern matching systems like rule-based expert systems, state transition analysis, and genetic algorithms are direct and efficient ways to implement misuse detection. On the other hand, inductive

sequential patterns, artificial neural networks, statistical analysis and data mining methods have been used in anomaly detection.

The goal of mining association rules is to derive multi-feature (attribute) correlations from a database table [5]. It has been observed that program executions and user activities exhibit frequent correlations among system features. Audit data can be formatted into a database table where each row is an audit record and each column is a field (system feature) of the audit records.

The rules mined from audit data are merged and added into an aggregate rule set to form the user's normal profile. To analyze a user login session, frequent patterns are mined from the sequence of commands during the session and this new pattern set is compared with the established profile pattern set. Similarity functions are used to evaluate deviations to generate alarms in case of intrusive behaviors.

A major problem for such an IDS is that it can give false alarms in cases where there are modifications in the normal system behavior. The IDS must be capable of adapting to these changes and the user profile must be updated at regular intervals. One straight forward approach can be to generate a new user profile with each set of new audit data. This approach is not computationally feasible and can cause the system to incorporate patterns of intrusive behavior as normal. The paper discusses some of the issues encountered in developing an adaptive NIDS using data mining techniques and outlines a general model of an adaptive NIDS.

2. RELATED WORK

2.1 Association Rule Mining

The goal of mining association rules is to derive correlations between the features of a database table. An association rule is an implication of the form $X \rightarrow Y$ [c,s], where X and Y are disjoint itemsets, s is the support of $X \cup Y$ (indicating the percentage of total records that contain both X and Y), c is the confidence of the rule and is defined as $S_x \cup Y_Y / S_X$ [6].

It has been observed that program executions and user activities exhibit frequent correlations among system features. A typical example of an association rule obtained from audit data can be ftp $\rightarrow$ get $_{[4,.1]}$, which implies 40% of the time when the user uses the ftp command, get command is also invoked and doing so constitutes 10% of the commands issued by the user. Audit data can be formatted into a database table where each row is an audit record and each column is a field (system feature) of the audit records.

Audit data contains quantitative features. During mining, the quantitative data are partitioned into intervals. But a sharp boundary problem results from this partition that may create problems in intrusion detection. For example, let us assume [a1..a_p] and [a_p+1..an] are two intervals for a quantitative attribute A, a_p has a support of 15%, a_p+1 has a support of 5%, and the support threshold is 10%. Even if a_p+1 lies near a high support value, it may not gain enough support. Now, if the interval [a1..a_p] is mined as normal pattern, the interval [a_p+1..an] will be considered as abnormal. Similarly, an intrusive pattern with a small variance may fall inside [a_p+1..an] and remain undetected. To overcome this boundary problem, an intrusion detection system that integrates fuzzy logic with data mining algorithms (association rules and frequent episodes) was developed. They categorize quantitative features into categories having fuzzy membership values. For example the feature datasize can be divided into three categories low, med, and high. If the feature is not fuzzy, then a particular value of datasize would fall into exactly one category and would have a membership of 1 for that category and 0 for all other categories. But if it is a fuzzy feature, then a particular value of datasize can fall into more than one category with some fuzzy membership values. The authors used a normalized measure to compute the fuzzy membership values. For example, a particular value of datasize can be "low" with 0.9 and "med" with 0.1.

Though the system works well generally, the selection of fuzzy membership function parameters is done by experience that may lead to some false alarms. Genetic algorithms are used to automatically optimize the fuzzy-membership function parameters. In his approach, he defined a chromosome to consist of a sequence of the fuzzy function parameters. The process starts with a random initial population of chromosomes where each chromosome is a possible set of parameters. A fitness function is used that gives preferences to high similarity between rules mined from reference and non-intrusive data and to low similarity between rules mined from reference and intrusive data. The process evolves a

population of chromosomes to come up with an optimized set of parameters.

3. PROBLEM DESCRIPTION AND RELATED ISSUES

A major shortcoming of current IDSs that employ data mining methods is that they can give a series of false alarms in cases of a noticeable systems environment modification. There can be two types of false alarms in classifying system activities in case of any deviation from normal patterns: false positives and false negatives. False positive alarms are issued when normal behaviors are incorrectly identified as abnormal and false negative alarms are issued when abnormal behaviors are incorrectly identified as normal. Though it's important to keep both types of false alarm rates as low as possible, the false negative alarms should be the minimum to ensure the security of the system.

To overcome this limitation, an IDS must be capable of adapting to the changing conditions typical of an intrusiuon detection environment. For example, in an academic environment, the behavior patterns at the beginning of a semester may be different than the behavior patterns at the middle/end of the semester. If the system builds its profile based on the audit data gathered during the early days of the semester, then the system may give a series of false alarms at the later stages of the semester.

System security administrators can tune the IDS by adjusting the profile, but it may require frequent human intervention. Since normal system activities may change because of modifications to work practices, it is important that an IDS should have automatic adaptability to new conditions. Otherwise, an IDS may start to lose its edge. Such adaptability can be achieved by employing incremental mining techniques. Such an adaptive system should use real time data (log of audit records) to constantly update the profile.

One straight forward approach can be to regenerate the user profile with the new audit data. But this would not be a computationally feasible approach. When the current usage profile is compared with the initial profile, there can be different types of deviation as mentioned in section 2. Each of these deviations can represent an intrusion or a change in behavior. In case of a change in system behaviors, the base profile must be updated with the corresponding change so that it does not give any false positives alarms in future. This means that the system needs a mechanism for deciding whether to make a change or reject it. If the system tries to make a change to the base profile every time it sees a deviation, there is a potential danger of incorporating intrusive activities into the profile. The IDS must be able to adapt to these changes while still recognizing abnormal activities. If both intrusive behavior a change in normal behavior occur during a particular time interval, the problem becomes more complicated. Again, determining which rules to add and which to remove is critical. There are also additional issues that need to be addressed in case of updating.

The system should adapt to rapid changes as well as gradual changes in system behavior. Selecting the time interval at which the update should take place is also an important issue. If the interval is too long, the system may miss some rapid changes or short-term attacks. If the interval is too small, the system may miss some long-term changes.

So, we consider two problems as the major issues in developing an adaptive intrusion detection system. One is to select the time when the update should be made. The other is to select a mechanism to update the profile. To tackle the first issue, we can continuously measure the similarity between each day's activity and the profile and utilize this similarity trace. If the similarity stays above a threshold level, then the profile is taken to be a correct reflection of the current activities. If the similarity goes down below the threshold level, then there can be two possibilities: either the behavioral patterns are changing or the system is under attack. To take care of these two possibilities, we need to measure the rate of change in the similarity. If an abrupt change is encountered, it is interpreted as an intrusion, and that time window will not be used to update the profile. If a gradual negative change is encountered, then that time window will be used to update the profile. We can assume that behavioral change occurs gradually, not abruptly. This is illustrated in Figure 1. The activities before point A are considered to be normal and the profile does not need any update. Between points A and B, the patterns represent some behavioral change and the profile needs to be updated. Between points C and D, the patterns represent intrusive behavior and no update is made.

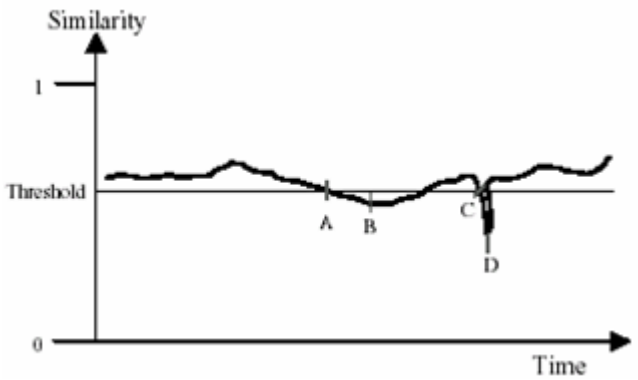


Fig.1 Change of similarity with time

The last issue is which technique to apply to update the profile rule set that would minimize the amount of recomputation. The problem of maintaining discovered association rules was first studied in Cheung *et al.* [7]. They described the Fast Update Algorithm (FUP) for incrementally maintaining association rules from large databases. The incremental database is scanned for large itemsets of the original database to update their support counts in the modified database and only the itemsets passing the support threshold test with respect to the new modified database are retained. At the same time, all new large itemsets in the incremental database are created and the original database is scanned to retain ones passing the support threshold test with respect to the new modified database. The problem with FUP is that it can handle the maintenance problem only in case of insertions. Cheung, Lee, and Kao [7] described a more general incremental updating technique FUP^2 for maintaining the association rules that can handler insertions, deletions, and modifications of transactions in the database.

4. A MODEL FOR AN ADAPTIVE INTRUSION DETECTION SYSTEM

In this section a rough model for the adaptive maintenance of the profile rule set that can overcome the need for recomputation of the rules without sacrificing the detection capabilities is proposed. The profile rule set can be updated by adding new rules, deleting old rules, or by modifying existing rules. Existing rules can be modified by changing their support and confidence. The flexible framework will exploit the rule generated during the earlier stages. We will store some rules that do not have sufficient support and confidence to be considered as strong at that time in addition to the strong rules. We will employ an overlapping sliding window approach that generates rules from recent data avoiding the use of old data. The profile will be maintained by periodic updates where strong rules and negative borders are added and other rules are discarded. The central idea behind the sliding window approach is the concept of a time window, an interval of time outside of which audit records are considered too old to reflect current system activities. The time window therefore acts to filter out outdated audit data and tries to build a profile based on only recent data that reflects the recent system activities. Based on the newly updated data, new model will be generated to detect new intrusions.

Figure 2 presents an architecture for our framework. The process begins with an initial set of audit data. Genetic algorithms [6] would be used to tune the fuzzy membership function parameters. Then fuzzy association rule mining will be applied to mine rules into a normal profile. During each time window, the audit data in the incremental part will be mined and compared with the profile rule set. There can be three possibilities. If the similarity stays above threshold, no update is needed and the system continues with the current profile. If similarity goes below threshold with a sharp negative change, intrusion will be signaled and the profile will not be updated. If similarity goes below threshold with gradual change, the profile will be updated with the audit data in the current time window. If there is any updation in the profile, a new adaptive model will be generated based on the new audit data to detect the most recent intrusions.

5. CONCLUSION AND FURTHER WORK

Data mining methods provide automatic intrusion detection capabilities. They mine knowledge from audit data to characterize normal and abnormal user behavior. One of the major limitations of the systems is that they lack adaptability to changing behavior patterns. In this paper, a model for an adaptive intrusion detections system using fuzzy data mining is addressed. This work may be extended a direction about how to tackle the a time window that contains both intrusive and non-intrusive data representing the a changing behaviour.

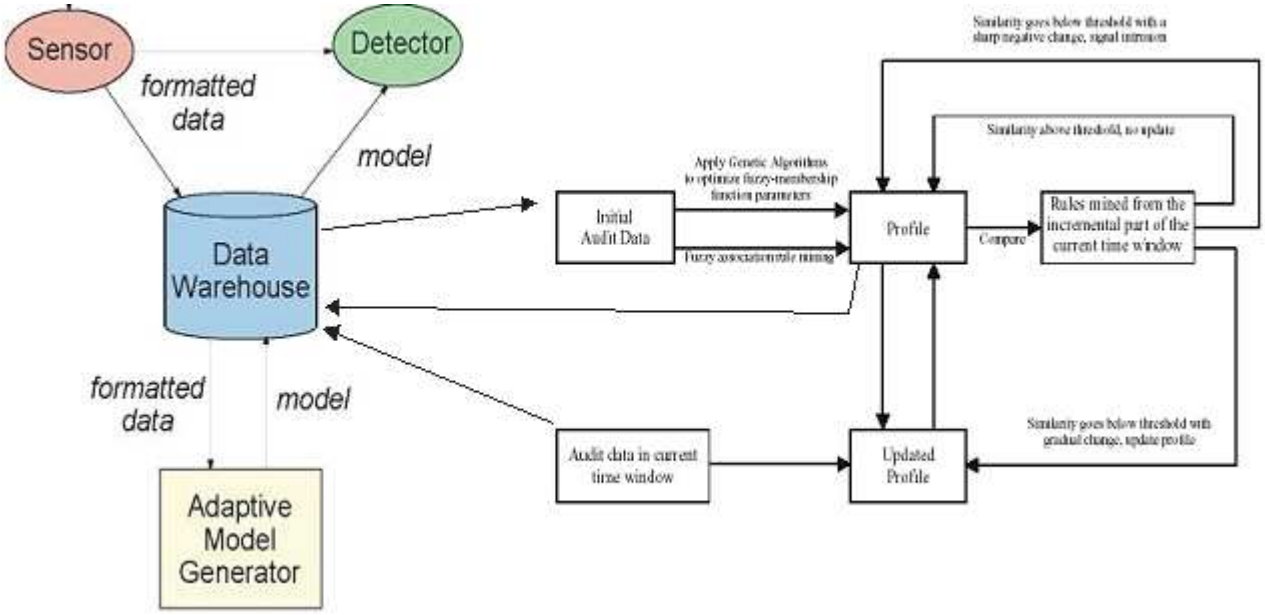


Fig.2 The model adaptive intrusion detection system

REFERENCES

[1] B. Mukherjee, L. Heberlein and K. Levitt, "Network Intrusion Detection", IEEE Network, Vol.8, No.3, 1994, pp.26-41.

[2] R. Graham, "FAQ: Network Intrusion Detection Systems, 1999.

[3] A. Sundaram, " An Introduction to Intrusion Detection Crossroads", The ACM Student Magazine, Vol. 2, No.4, 1996.

[4] R. Agrawal, T. Imielinski and A. Swami, "Mining Association Rules between Sets of Items in Large Databases", In Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data", Washington, D.C., 26-28 May 1993, pp.207-216.

[5] W. Lee and S. Stolfo, "Data Mining Approaches for Intrusion Detection", In Proceedings of the 7th USENIX Security Symposium (SECURITY '98), San Antonio, TX, 26-29 January 1998, pp.79-94.

[6] Fajun Shi, "Genetic Algorithms for Feature Selection in an Intrusion Detection Application", Masters Thesis Report, Mississippi State University, 2000.

[7] D. Cheung, S. Lee and B. Kao, "A General Incremental Technique for Pdating Discovered Association Rules", In Proceedings of the 5th International Conference on Database Systems for Advanced Applications (DASFAA'97) Melbourne, Australia, 1- 4 April 1997, pp.185-194.

Elevated Concentrations of Nitrate in Groundwater and Associated Health Risks

B.S.Shankar
Department of Civil Engineering, East Point College of Engineering, Bangalore - 560 049, Karnataka
E-mail: shankar_bs1@yahoo.co.uk
(Received on 26 December 2008 and accepted on 12 March 2009)

Abstract

Contamination of drinking water by nitrate is an evolving public health concern since nitrate can undergo endogenous reduction to nitrite, and nitrosation of nitrites can form N-nitroso compounds, which are potent carcinogens. Nitrates are also responsible for a number of health disorders, both in human beings and animals. In the present study, nitrate contents have been quantitatively estimated in the groundwaters of Bellandur area during the pre-monsoon and post-monsoon periods of 2007 by collecting 30 samples in each season. The hydrochemical data indicates a large variation of nitrate from 4 mg/l to 394 mg/l in the pre-monsoon and 6 mg/l to 418 mg/l in the post-monsoon seasons. 54% of the samples have shown high nitrate contents (>45 mg/l), which is more than the permissible limits of drinking water as per the Bureau of Indian Standards, BIS 10,500. The study shows that the nitrate levels of the groundwater are more during the post-monsoon season. An attempt has been made to identify the possible sources of the high nitrate level in groundwater and some mitigative measures for the same have been suggested.

Keywords: *Groundwater, Health, Nitrate, Pollution, Toxicity*

1. INTRODUCTION

The presence of high nitrate concentration (>45mg/l) in groundwater would normally indicate pollution of groundwater. Since presence of excess nitrate ions in groundwater is harmful to health, their occurrence in high concentrations in groundwater is a matter of great concern. The leaching of nitrates from agriculture land has been a major research focus in past two decades. Inorganic nitrogen fertilizers, septic tanks, poor dug wells and defective sewerage systems are the suspected major sources of nitrate in groundwater [1-3]. Nitrate is often considered an agricultural pollutant because high concentrations above 10 mg-N/L have found in aquifers located beneath agricultural fields where fertilizer and manure use is common. Soil bacteria may also increase nitrate levels in groundwater by oxidizing ammonia into nitrite and then to nitrate ion in oxygen-rich water [4]. In addition to agricultural practices, there are other potential sources that can contribute to the increase of nitrate concentrations in groundwater. Most of these sources are related to urbanization and thus the types of sources are directly related to urban development. For example, the rapid growth of urban population in developing countries leads to unplanned settlements where the access to sewerage is limited and pit latrines or septic tanks are the only options available for sewage disposal. Urban sources of nitrate-N may have a high impact on groundwater quality because of the high concentration of potential sources in a smaller area than agricultural land [5]. Nitrate sources can be group in diffuse sources (parks and gardens, atmospheric deposition), intense point sources (industrial chemical spills or landfill leachate) and multi-point sources such as leaking sewers and septic tanks [6]. The main sources of nitrate and other pollutants of urban groundwater is sewage, nitrate can reach the aquifer by sewer leakage and on-site disposal systems such as septic tanks. Septic tanks are common practice in some cities of developing countries. For example in Sana'a, Yemen, it is estimated that 80% of the urban recharge is wastewater from cesspits [7]. Leakage from sewerage and water supply networks provides the highest percentage of water recharge to aquifers underlying many cities through out the world. Water mains and sewers leak because of improper installation or deterioration through age, subsidence or earthquakes. Sewage leakage occurs when sewers are situated above the water table.

However, when a substantial proportion of the sewer network is lower than the water table, a net infiltration

occurs. Mains leakage can be also a nitrate contributor due to the high volume of water loss. The major sources of nitrate in aquifers throughout the world are mostly related to wastewater disposal (on-site systems and leaky sewers) and solid waste disposal (landfills and waste tips).

2. HEALTH EFFECTS OF NITRATES ON HUMAN BEINGS

Groundwater is the major source for drinking purposes. Nitrates and nitrites in food may cause methaemoglobinemia in babies [8], where due to the oxidation of ferrous iron in haemoglobin to ferric state, the oxygen-carrying capacity of the red blood corpuscles is lost and the affected baby dies. Other health problems associated with nitrate toxicity include oral cancer [9], cancer of the colon, rectum or other gastrointestinal cancers [10-13], alzeimer's disease, vascular dementia of biswanger type or multiple small infarct type [14], absorptive and secretive functional disorders of the intestinal mucosa and changes in maturation, differentiation and apoptosis in intestinal crypts [15], reduced casein digestion [16], multiple sclerosis[17 & 18], neural tube defects [19], cytogenetic effect in children [20], non- hodkins's lymphoma [21 & 22] and hypertrophy of thyroid [23]. Craig *et.al* have shown that nitrate consumption leads to a decrease in the ascorbate/nitrite ratio in gastric juice, which regulates the synthesis of potentially carcinogenic N-nitroso compounds and decrease in the ratio leads to increased risk of gastric cancer[24]. Graham *et.al* while reviewing the measurements and association of nitrite and nitrate ions with various clinical conditions such as hypertension, infection, renal and cardiac disease, inflammatory diseases, and diseases of the central nervous systems expressed that such associations between disease incidence and drinking water nitrate content are controversial except for methaemoglobenemia [25]. However, nitrates are useful for such conditions as cardiovascular diseases, where they reduce platelet aggregation and prevent anginal attacks of both symptomatic and silent types [26].

3. TOXICITY OF NITRATE TO ANIMALS

Nitrites and nitrates act as exogenous sources of nitric oxide which is an extreme physiologically active agent in animals and man [27]. This process manifests itself in the formation of nitrosyl hemoglobin and dinitrosyl iron complexes (DNIC) with thiol groups of proteins. The latter compounds are stable enough to function as a depot of nitric oxide. DNIC degradation is assumed to be associated with the formation of S-nitrothiols, another depot of nitric oxide in the organism. The S-nitrosothiols as well as DNIC can affect various metabolic processes through the release of nitric oxide as well as nitrosonium ion, a powerful nitrosylating agent. Nitrate toxicity varies according to species and, in general, ruminant animals develop methaemoglobinemia while monogastric animals exhibit severe gastritis [28]. Unlike nitrate, nitrite is capable of inducing methaemoglobinemia in a wide range of species, viz. cattle, sheep, swine, dogs, guinea pigs, rats, chickens and turkeys. The various effects of nitrate on different animals such as intestinal disorders in pigs [29], pregnancy-related disorders in rats [30], depression, muscle tremors and in coordination in goats [31], loss of body weight and reduced water consumption in broiler chicken [32], sexual disorders in sheep [33], hyperthyroid in foals [34], etc. have been reported.

An ecologic study was conducted to determine whether nitrate levels in drinking water were correlated with non-hodgkin lymphoma and cancers of the digestive and urinary tracts in Trnava district of the Slovak Republic. Routinely collected nitrate data (1975-1995) for villages using public water supplies were computerized, and each village was categorized into low (0-10 mg/l), medium (10.1-20 mg/l), or high (20.1-50 mg/l) levels of total nitrate in drinking water. Observed cases of cancer in each of these villages were ascertained through the district cancer registry for the time period 1986-1995. These ecologic data supported the hypothesis that there was a positive association between nitrate in drinking water and non-hodgkin lymphoma and colorectal cancer [35].

In Bangalore, close to the study area, when a eight-year-old girl's finger nails turned blue, a doctor's diagnosis revealed that she suffered from methaemoglobinemia, a condition he associated with nitrate poisoning. Having ruled out other sources of poisoning, the doctor recommended that her family get the borewell water tested. The test revealed high levels of nitrate contamination in the water.

Nitrate levels in several areas of the city are as high as 300 mg/l mainly because of sewage contamination of groundwater. At St. Johns National Academy of Health

Sciences, one of the very few facilities in the city for a methaemoglobin test, 31 such cases were reported in 2006-07. At Shampura, for instance, not only are the nitrate levels nearly 20 times the permissible limit, the Ambedkar Medical College receives 500 cases of nitrate related diseases every year from the surrounding slums. According the reports of Department of Mines and Geology, nitrate levels here revealed an alarmingly high value of 747 mg/l.

Emphasizing on the need for a re-look at environmental health, the doctors opine that the civic authorities need to inform the public, including medical practitioners, about possible geographical clusters that might pose hazards to health and it is the Government's social responsibility to give this information to the appropriate authorities, doctors and citizens so they can take action as without a holistic understanding of a disease, doctors may treat the patients symptomatically and send them back into an environment from where they contracted the problem [36].

Thus, the present study aims to assess the extent of nitrate contamination in the study area and suggest mitigative measures for the same.

4. DETAILS OF THE STUDY AREA

Bellandur is the area to the south of Bangalore city, India, covering 23 sq.km and the catchment area comprises of Bellandur, Challaghatta, Yamalur, Agara, Madiwala, Puttenahalli and Yelachenahalli. The area lies between latitude $12^{0}53^{1}30^{11}$ to $12^{0}56^{1}50^{11}$ East and Longitude $77^{0}34^{1}$ to $77^{0}41^{1}40^{11}$ North. It is covered under Survey of India Toposheet number 57H/9.

The study area forms a gently undulating terrain with only a few Nallas running from SW to NE. No ridges or hillocks are present in the area. The highest contour is 900 m and lowest is 800 m, thus a drop of 100 m is observed in the area. The drainage pattern is dentric type and is characterized by gneiss and gneiss granite rocks. Three main streams join the tank, which form the entire watershed. Further, before the confluence with Bellandur tank, all the streams come across two to three tanks. On the northwestern side of Bellandur tank, the Koramangala and Challaghatta valley sewage treatment plant is situated. The total wastewater generated in the catchment is about 3,00,000 m^3/day. The designed capacity of the plant is 1,63,000 m^3/day of wastewater. But currently it is treating only 1, 00,000 m^3/day. The incapability of the network of pipes to transport the generated wastewater is one of the main reasons for less flow in to the sewage treatment plant (STP). The remaining 2,00,000 m^3/day of wastewater requires complete treatment. At present, this wastewater is directly entering various tanks in the catchment, and polluting them.

The area comprising of Madiwala, Agara, Koramangala, Challaghatta and Bellandur come under the existing sewerage zone that is sewage from Koramangala, Madiwala and Agara all drain into Bellandur tank and treated waste water from Challaghatta treatment plant also drains into Bellandur tank. At present there is no catchment for these tanks as the Nallas on the upstream side are converted into settlements. Since the tank is dry, they have become a store house for the sewage coming from different parts of the city. The BWSSB is also conveniently directing the raw sewage through storm water drains into Bellandur tank.

Bellandur tank is a rainfed tank. The central stream joins the tank from the northwestern part. Before the confluence of the central stream, it joins with the western stream and finally flows as one and joins the tank. Though the actual area of the tank is about 328.87 hectares, the growth of weeds, siltation and slush formation have reduced it to 154.34 hectares. For the last few decades, treated, partially treated and untreated wastewater has been discharged to this tank. The Minor Irrigation Department is using the water of this tank for irrigating agricultural lands, coconut trees, etc. Many episodes of diseases in coconut trees have been reported due to this contaminated water.

The study area is encompassed by about 156 industries. Based on the distribution of the industries, three clusters have been identified. Each cluster has been classified into several categories considering the type of production. All the three clusters are located at the periphery of the city. The urban encroachment has affected these industrial clusters, giving rise to mixed land use pattern. The details of the existing industries in the three clusters are presented in Table 1.

Table 1 Details of Industries in Clusters I, II and III

Sl. No.	Type of Industries	Total Number of Industries	Type of Industries	Total Number of Industries	Type of Industries	Total Number of Industries
	Cluster I		Cluster II		Cluster III	
1	Engineering	13	Engineering	13	Engineering	11
2	Rubber	1	Rubber/ Plastic	1	Rubber	6
3	Textile	1	Textile	6	Textile	3
4	Bricks/Granites	2	Electronic/Electrical	5	Bricks/Granites	1
5	Dyeing	1	Bricks/Granites	4	Dyeing	1
6	Miscellaneous	24	Chemical	2	Miscellaneous	20
7	-	-	Miscellaneous	41	-	-
	Total	42	Total	72	Total	42

5. CLIMATE

The study area has a climate which is pleasant, salubrious, and devoid of extremes, neither very humid nor very dry. The temperature in the study area varies between 28^0C and 37^0C during the hottest months (April/ May) and from 16^0C to 25^0C during winter months (December/January). Annual average rainfall in the catchment is about 860 mm.

6. MATERIALS AND METHODS OF ANALYSIS

Thirty water samples each were collected from both the borewells and open wells in the area during April (pre-monsoon) and November (post-monsoon) seasons of 2007 in one litre PVC containers, sealed and were analyzed for nitrates, using a UV-visible spectrophotometer, in accordance with the Standard Methods for the Examination of Water and Wastewater as per American Public and Health Association, APHA [37]. The location map of the area with the sampling stations is presented in Figure 1.

7. RESULTS AND DISCUSSION

The results of nitrate analysis of groundwater samples are presented in Table 2. The analysis has shown that the nitrate concentration in 53.33% of the groundwater samples is well above the permissible limit of 45 mg/l prescribed by the Bureau of Indian Standards, BIS [38]. The maximum, minimum and mean concentrations of nitrate are found to be 394, 4 and 90.9 mg/l respectively during pre-monsoon and 418, 6 and 101.7 mg/l respectively during post-monsoon season. The Sample percentage based on different ranges of nitrate concentration is shown in Figure 2. The nitrate contours during pre-monsoon is presented in Figure 3. The nitrate concentration is slightly on the higher side during post-monsoon season. This may be attributed to the lack of drainage conditions, longer contact of groundwater with the aquifer material and anthropogenic activities [39]. Nitrates also have high solubility and immediately dissolve in rain water and percolate to the ground water. Further, the nitrate concentrations are quite high in open wells, when compared to hand pumps and borewells as shown in Table 3. This is mainly because of the poor structure and improper maintenance.

In general the possible sources of nitrate that lead to nitrite in groundwater are nitrogen rich sediments, interaction of groundwater with nitrogen rich industrial waste, inputs of organic nitrogen into soil, biological denitrogen fixation by microorganisms, inputs of human and animal waste, water in unused dug wells, stagnate water and nitrogenous inorganic fertilizers etc [40-43].

The fertile soil of the study area is very much favorable for the cultivation of paddy. The inorganic nitrogenous fertilizers are used to increase the growth rate of this agricultural production. The nitrogen content in these fertilizers is quite high. Mostly these fertilizers are soluble in water and easily release nitrogenous mass. In chemical process, fertilizer reacts with water/moisture and decomposes into amino acid. These amino acids are degraded to ammonium sulphates and ammonium amines, which in turn oxidise to nitrites. In atmospheric condition

nitrites are very unstable and soon converted into nitrates. In view of the nitrates solubility in water, they rapidly increase the nitrate pollution level in the groundwater [44]. Further, the indiscriminate discharge of wastes from industrial, municipal and domestic activities in the neighbourhood, coupled with leaking drains and inadequate sewage treatment in the study area has led to the elevated levels of nitrates.

Table 2 Nitrate Concentrations in Groundwater During Pre and Post-monsoon Seasons of 2007

Sample No.	NO_3 Concentration, mg/l (Pre-monsoon)	NO_3 Concentration, mg/l (Pre-monsoon)
1	66	82
2	210	224
3	54	52
4	18	27
5	24	33
6	102	104
7	290	335
8	126	155
9	32	40
10	10	10
11	22	28
12	6	8
13	84	97
14	58	68
15	50	54
16	280	284
17	6	6
18	394	418
19	32	40
20	78	92
21	32	40
22	52	66
23	266	292
24	230	252
25	20	20
26	28	35
27	55	62
28	40	48
29	36	41
30	28	38

8. RECOMMENDATIONS

Protecting the drinking water supply from nitrate contamination is important for health and to protect property values and minimize potential liability. Some measures that can be taken in this regard are summarized below:

i. High nitrate levels often are associated with poorly constructed or improperly located wells. New wells may be located uphill and at least 100 feet away from feedlots, septic systems, barnyards and chemical storage facilities. Abandoned wells must be properly sealed or capped.
ii. Non-point sources of water pollution (fields, lawns) must be managed to limit the loss of excess water and plant nutrients. Fertilizer and irrigation applications must be matched to precise crop uptake needs in order to minimize nitrate contamination of groundwater.
iii. High nitrate content of poor dug wells can be reduced by proper maintenance of its structure.
iv. Leaching of nitrate from the inorganic fertilizers can be minimized by controlled use of nitrogenous fertilizers.
v. While it may be technically possible to treat nitrate contaminated groundwater, it can be difficult, expensive and not totally effective. For this reason, prevention is the best way to ensure clean water.

Water treatments include distillation, reverse osmosis, ion exchange or blending.

i. Distillation boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Nitrates and other minerals remain behind in the boiling tank.
ii. Reverse osmosis forces water under pressure through a membrane that filters out minerals and nitrate. One-half to two-thirds of the water remains behind the membrane as rejected water.
iii. Ion-exchange takes another substance, such as chloride, and trades places with nitrate. An ion exchange unit is filled with special resin beads that are charged with chloride. As water passes over the beads, the resin takes up nitrate in exchange for chloride. As more water passes over the resin, all the chloride is exchanged for nitrate. The resin is recharged by backwashing with sodium chloride

solution. The backwash solution, which is high in nitrate, must be properly disposed of.

iv. Blending is another method to reduce nitrates in drinking water. Contaminated water may be mixed with clean water from another source to lower overall nitrate concentration. Blended water is not safe for infants but is acceptable for livestock and healthy adults.

Table 3 Range of Nitrate Concentrations and their Mean Values in Groundwater Samples

Sl. No.	Source	No. of Samples	Range of Nitrate Concentration, mg/l		Mean Concentration of Nitrate (mg/l)	
			Pre-monsoon	Post-monsoon	Pre-monsoon	Post-monsoon
1	Open Well	04	210- 394	224- 418	281.0	307.3
2	Hand Pump	09	06- 266	06- 292	85.33	96.77
3	Bore Well	17	04- 280	08- 284	49.24	55.94

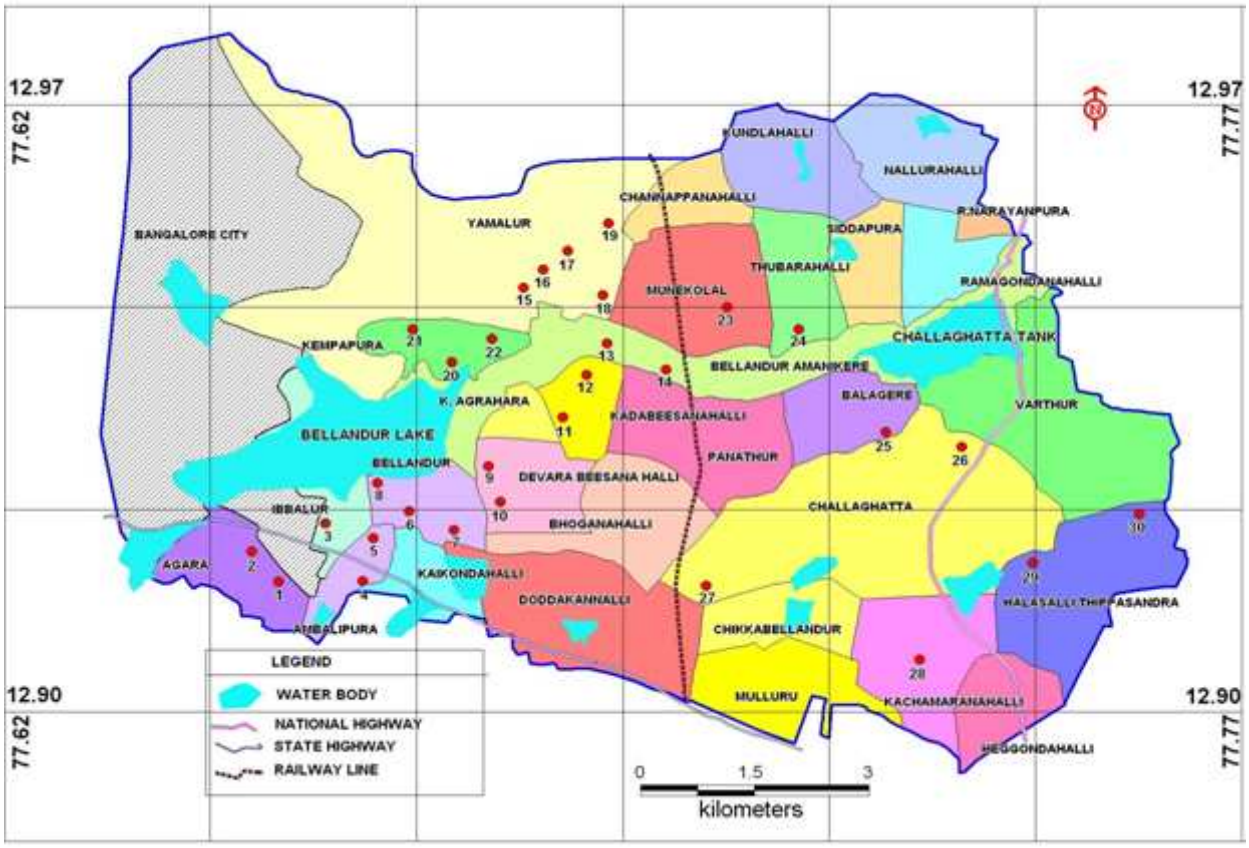


Fig.1Location map of Bellandur area showing the sampling stations

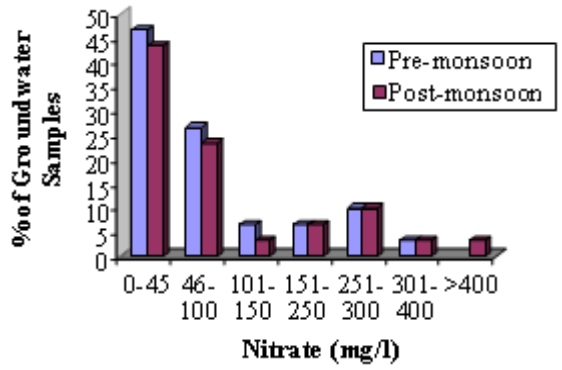


Fig. 2 Sample percentage based on different ranges of nitrate concentration

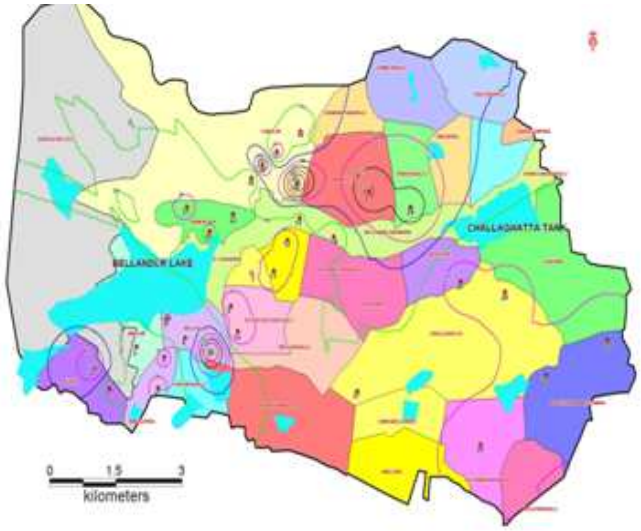


Fig.3 Nitrate contours for the groundwaters of Bellandur industrial area during post-monsoon

REFERENCES

[1] R. Piskin, "Evaluation of Nitrate Content of Groundwater Hall County, Nebraska", Groundwater, Vol.11, No.6,1973, pp. 4-13.

[2] L.W.Canter, "Nitrate in Groundwater", Lewis Publishers, 1997, pp.263.

[3] W. L. Lindsay, "Chemical Equilibrium in Soils", John Willey, New York, 1979, pp.149.

[4] M.M..Dorsch, R.K.R. Scragg, A.J.McMichael, P.A.Baghurst and F.Dyer, "Congenital Malformations and Maternal Drinking Water Supply in Rural South Australia", Journal of Epidemiol, Vol.119, 1984, pp. 473-485.

[5] F.T.Wakida and D.N. Lerner, "Non-agricultural Sources of Groundwater Nitrate: A Review and Case Study", Water Res, Vol.39, No.1, 2005, pp.3- 16.

[6] D.N.Lerner, "Estimating Urban Loads of Nitrogen to Groundwater", Journal of the Chartered Institution of Water and Environmental Management, Vol.17, No.4, 2003, pp.239-244.

[7] A.M. Alderwish and J. Dottridge, " Urban Recharge and its Influence on Groundwater Quality in Sana'a, Yemen", in J. Chilton, (Ed.), Groundwater in the Urban Environment, Selected City Profile, Balkema, Rotterdam, 1999, pp.85-90.

[8] E.V.S.Prakasa Rao and K. Puttanna, "Nitrates, Agriculture and Environment", Current Science, Vol. 79, No.9, 2000, pp. 1163-1168.

[9] A.F.Badawi, H.Gehen, E.H.Mohamed and H.M. Mostafa, Dis. Markers, Vol. 14, 1998, pp. 91-97.

[10] K.Paul, J.Ritva, D. Jan and H. Timo, International Journal of Cancer, Vol.80, 1999, pp. 852-856.

[11] W.J.Peter, "The Iowa Women's Health", University of Iowa, USA, 1998, pp. 255.

[12] C.D.Leaf and R.T. Steven, "The Role of Nitrate and Nitrite in Human Cancer", R. E. Watson and S. I. Mufti, (Eds.), CRC Press, Florida, 1996, pp. 317-324.

[13] R.Derache and P. Derache, Carence Nutrition Diet, Vol.32, 1997, pp. 283-293.

[14] H.Tohgi, T.Abe, K.Yamazaki, T. Murata, C. J. Isobe, Journal of Neural Transactions, Vol.105, 1998, pp. 1283-1291.

[15] G.P.Ireneusz, Roez Panstw, Zakl. Hig, 1998, 49, 321-30, CA130: 263274c. CHK

[16] W.Jan and Pokorska Lis Grazina, "Bromatol", Chem. Toxicol, Vol. 31, 1998, pp. 229-231.

[17] G. Govannoni, S.J.R.Heales, N.C.Silver, R.F. Miller, J.M.Land, J.B. Clark and E.J. Thompson, Journal of Neurol Science, Vol. 145, 1997, pp. 77-81.

[18] D.G.Irvine, K.Robertson, W.J. Hader and R.West, Appl.Geochem. Supl. 2 ,1993, pp.235-240.

[19] G.Li, J.Tian, X.Hu and F. Liu, "Zonghua Yufang Yixue Zazhi", CA125: 31412q, Vol. 30,1996, pp.17-19.

[20] T. Aspasia, S. Kitsou-Izeli, A. Galla, D. Gourgiotis, J. Papagiorgiou, S. Mitron, P.A.Molybdas and C. Sinaniotis, Arch. Environ. Health, Vol.51, 1996, pp. 458-461.

[21] M.W. Helen, "Non-hodkin's Lymphoma and Drinking Water Nitrate: A Case Study", Johns Hopkins University, USA, 1994, pp. 289.

[22] F.D.Michal, "A Population Based Case Control Study on the Association Between Nitrate in Drinking Water and Non-hodkin's Lymphoma", Johns Hopkins University, USA, 1998, pp. 285

[23] M.Van, M.S.Johannes, D.Van, K.A.Mulder, M.H. De Baets, C.A.M. Paul, H.D.M.Vander, L.J.M.Paul and C.K. Jos, "Toxicol. Lett", Vol.72, 1994, pp. 365-374.

[24] M.Craig, M, C. Andrew, W. Angela, Kenneth Mc Coll,"Gastroenterology", Vol.116, 1999,pp. 813-822.

[25] E.Graham, A.Ian, Y.Mehrdad and K.M.Sinnikka, Clinical Biochemistry, Vol.31, 1998, pp. 195-200.

[26] D.J.Harald, Cardiovasc. Pharmacol. (Supl. 2), Vol.34, 1999, pp. 515-520.

[27] A.F.Vanin, "Free Radicals in Biology and Environment", Kluwer, Dordrecht, 1997, pp. 351-363.

[28] S.B.Colleen and B.K. John, Vet. Hum. Toxicol, Vol.35, 1993, pp. 237-253.

[29] V.Egorova, N.Timofeeva, G. Shcherbacov, V.Paskin, S. Starkenkov, EAAP Publ, Vol.88, 1997, pp. 335-338.

[30] V.V.Egorova, N.N. Iezuitova, N, N.M. Timofeeva, and N. M. Fiziol, Sechenova, Vol.79, 1993, pp.93-101.

[31] D.B.Mondal and N.N. Pondey, Indian Journal of Animal Science, Vol.69, 1999, pp.157-159.

[32] G.Judith, A.Tammy, B. Melissa, and S. Arnold, J. Appl. Poult. Res, Vol.5, 1996, pp. 330-336.

[33] N.Julia, T. Ivan, N. Ivan and I. Nedka, Zhivotnovud Nauki, CA128: 304993r, Vol.34, 1997, pp. 149-151.

[34] A.L.Allen, H.G.G. Townsnd, C.E. Doyle and P.B. Frzet, Proceedings of the 5th International Symposium on Poisonous Plants, 1997, pp. 334-338.

[35] G.Gulis, M.Czompolyova and J.R. Crehan, "An Ecologic Study of Nitrate in Municipal Drinking Water and Cancer Incidence in Trnava District, Slovakia", Environ Res, Vol.88, No.3, 2002, pp. 182-187.

[36] Doctors in the Dark about Environmental Health in the City- Article, The Hindu Newspaper (24th February 2007), Bangalore, India.

[37] APHA, "Standard Methods for the Examination of Water and Wastewater", 20th edition, American Public and Health Association, Washington D.C, New York, USA, 2002.

[38] BIS, Bureau of Indian Standards, IS: 10500, Manak Bhavan, New Delhi, India. 1991.

[39] N. Subba Rao, "Seasonal Variation of Groundwater Quality in a Part of Guntur District, Andhra Pradesh, India", Environmental Geology, Vol.49, 2006, pp.413-429.

[40] R.J.Burden, "Elevated Levels of Nitrate in Groundwater Beneath Grazed Pasture Land in Newzealand and Impact of Agriculture Activity on Groundwater", Int. contri. to Hydrogeology, Vol.5, 1986, pp. 263-269.

[41] M.J.Hammer, "Water and Waste Water Technology", John Willey, New York, 1986, pp.550.

[42] C.J.Dudley, "Nitrates the Threat to Food and Water", Green Print, London, 1990, pp.71-76.

[43] C.J.Barnes and G.D. Smith, "The Origin of High Nitrate Groundwater in the Australian arid Zones", Journal of Hydrology, Vol.137, 1992, pp.181-197.

[44] N.C. Saxena, Mondal and V.S.Singh, "Occurrence of Elevated Nitrate in Groundwaters of Krishna Delta, India" Proceedings of International Groundwater Conference, Coimbatore, India, 2007, pp.21-28.

"Tex" Textile Revolution for the Indian Textile Industry

Seshadri S. Ramkumar
Nonwovens & Advanced Materials Laboratory, The Institute of Environmental & Human Health,
Texas Tech University, Box 41163, Lubbock, Texas 79409-1163, USA
Presented in 6th edition of Advances in Textiles, Machinery, Nonwovens and Technical Textiles-
ATNT 09, Sathyamangalam, Erode District, Tamil Nadu, India, 7 December 2009
E-mail: s.ramkumar@ttu.edu

ATNT collaborative conference between Bannari Amman Institute of Technology and Texas Tech University, USA will address current crisis situation in the textile industry and will provide pathways for the long term viability of the textile industry.

1. OUTCOMES

i Chart out plans to enhance the value of the Indian textile industry.

ii Build the technical textiles industry in India by seeking collaborations with world's leading technical textiles associations such as the USA based: a) Association of the Nonwoven Fabrics Industry (INDA) and b) Industrial Fabrics Association International.

iii Collaboration between Texas Tech University and Bannari Amman Institute of Technology for "student exchanges," joint research projects and faculty development in Technical Textiles, Nonwovens and Cotton Research. A formal Memorandum of Understanding will be initiated soon after this conference.

This conference comes at an important time when the relationship between India and the United States of America is at all times high. Only just a few days back, Honorable Prime Minister of India, Shri Manmohan Singh received the honor as the First State Guest of the new Obama administration. Apart from strengthening bilateral relationship between India and USA, one of the aims of the recent state visit was to increase United State-India business and educational tie-ups. ATNT conference serves as an immediate follow-up on the recent bilateral efforts.

This conference is going to propose the way forward for the Indian textile industry. International textile trade is at crossroads now and the effect of the economic meltdown is visible in export related trades such as the IT and the Indian Textile Industry (IT). This conference, which is a collaborative event between United States of America, which one of world's largest importer of commodity goods such as textiles and India, which is one of the leading exporter of commodity goods. In other words, this conference is directly linking the leading importer and a leading exporter. In addition, the conference serves as an international platform where delegates from USA, Italy, Czech Republic, Turkey, Iran, China, Egypt and India will have opportunity to deliberate on the latest issues facing the textile industry. Some 250 delegates from all parts of India and seven other countries will discuss subjects from fiber to fashion, nano and nonwovens, defense and medical textiles, etc.

Indian textile industry is one of the two largest bread baskets in India and a major export income earner. Just for example, the total textile exports in 2007-08 has been around 22 billion US dollars. However, it is expected to drop by a over a billion dollar in the 2008-09 period. More importantly, the exports to USA is expected to dip by around 8% in 2008-09. In addition, the Indian textile industry is currently facing problems in three fronts:1) Raw materials; 2) Skilled labour force; 3) Technology. More importantly, the issues surrounding the availability of cotton, which is the backbone of the Indian textile industry, have put enormous stress on the Indian textile industry.

This ATNT 09 conference will address these aforementioned issues by providing an international platform where, industrial and academic experts from many leading institutions around the globe are convening in Sathyamngalam, India for three days to discuss the advancements in textile processes and products. The conference will feature timely topics such as advancements in natural and synthetic fibres, machinery and instrumentation, developments in spinning and other processes. Special emphasis has been given to nonwovens, technical textiles and cotton sectors as these are very critical on the growth of the Indian textile industry.

The special session on cotton will bring leading associations representing cotton on one platform. In fact,

ATNT 09 is the first international platform where associations in India such as The Southern Indian Mills Association (SIMA), the Southern Indian Cotton Association (SICA), Central Institute for Research Cotton Technology, Mumbai (CIRCOT) and the USA based Plains Cotton Growers of Texas will have a seat on the table to talk about cotton and its impact on the global textile trade. Representatives from the world's largest consumer of cotton, India will have opportunities to meet representation from Texas, USA, which is the largest cotton producing state in the USA.

It is estimated that the United States will produce 12.1 million bales of cotton (480 pounds each). Texas is estimated to produce 4.9 million bales of cotton, this cotton season. Based on the latest report, length and micronorie of the current Texas crop is good. Apart from building-up the cotton textile industry in India, it is time to beef-up the nonwovens and technical textiles sector. Nonwovens and technical textiles industry is directly related to the growth of economy of nations, rise in income levels and the improvement in life-style of the masses. These are the three factors which have aided the growth of the global nonwovens and technical textiles sectors. As the GDP grows, technical textiles industry will grow. According to a recent prediction by Mr. Robert Zoellick, President of the World Bank, India's growth will be in 8 to 9% range during the next two years. More importantly, his emphasis on enhancing the infrastructure in India which involves projects related to roads, bridges, seaports, etc. will boost the growth of technical textiles sector. As a thumb rule, 20% of the total project will be dedicated to technical textiles.

2. TEXTILE "TEX" REVOLUTION IN INDIA

In a recent splendid editorial page article in The Hindu, India's father of Green Revolution, Dr. M. S. Swaminathan has articulated the factors that have enabled tremendous crop yields in India four decades ago. According to Dr. Swaminathan, important factors that contributed to the green revolution were: 1) Technology; 2) Communication/Services; 3) Supporting Government Policy and 4) Enthusiasm by the end-user community. The Indian textile industry is at cross-roads now and the aforementioned factors with regard to green revolution as given above fit exactly with the current requirements of the of the Indian textile industry. The industry needs latest technology, favorable government polices and more importantly knowledge transfer. The knowledge transfer should not only involve technology but it should also focus on market know-how and trade information. In other words, Indian textile industry should adopt a revolution called "Tex- Revolution". The need of the hour is the greater adaptation of technology and know-how transfer for the Indian textiles industry. This is what "Tex-Revolution" or Textile Revolution is!

3. WHAT SHOULD THE INDIAN TEXTILE INDUSTRY DO?

Indian textile industry is predominantly cotton based and is export dependent. The industry mix on an average is 60 % cotton and 40 % synthetics. So for, the Indian textile industry has targeted traditional textile markets such as USA and Western Europe. Recession in these developed economics since December-2007 has had tremendous negative impact on the global economy and more importantly the exports from India. This situation has given a serious beating to India's exports and in particular to the Indian textile Industry. As textile products are not life saving essentials, with the disposable incomes shrinking in advanced nations such as USA, European Union, it is necessary for the Indian textile Industry to take a "Moon Shot" and chart out new plans for growth and development. The Tex-Revolution should involve adaptation of new technology to develop new products or significantly enhance the value of products and target untapped new markets.

In addition to taking these little steps in bringing about Tex-Revolution, collaboration and cooperation have to be aggressively sought after to bring in raw materials and technologies to fulfill the requirements of the Indian textile industry. More importantly, these factors are very critical now due to the raw material shortfalls such as cotton. All major industry based associations such as The Southern India Mills' Association, Tirupur Exporters Association, Confederation of the Indian Textile Industry, etc., all are making coordinated efforts to alleviate the current cotton crisis faced by the industry. As the Indian textile industry is predominantly cotton based, the unavailability of the basic raw material can lead to negative economic effects. And as the cotton end-products are targeted towards exports, the impact will be very drastic. These current situations such as lack of cotton, lack of weaving and other technical textile machines, the export dependency are all serious concerns faced by the Indian textile Industry.

4. SOME REMEDIAL MEASURES

Rightly, the Government of India has undertaken dedicated efforts to formulate a National Fiber Policy. This Fiber Policy should encompass all fibers including natural and synthetics. It is estimated that in the 2009-10 cotton session India's production of cotton will be around 300 lack bales. Out of this amount, 100 lack bales will be of below average quality. Even though tremendous improvements have been made to enhance the cotton sector, there are still challenges with regard to cotton quality and its consistency. Given the nature of agricultural practices in India, with many farmers owning less than one hector plots, it will be an onerous task to expect good quality and consistent quality characteristics. Quality variation will have adverse effect on the final product and the export earnings. The Technical Mission on Cotton should be further enhanced to focus on both yield and quality of cotton produced in India. Both BT cotton and hybrid varieties have played their own magic in enhancing the yield. However, greater emphasis has to be placed in improving the quality and reducing the variability in cotton characteristics.

The National Fiber Policy should place emphasis on creating a synthetic fiber base in India which can cater to the requirements of technical textiles sector. There is a need for high tenacity polyester fibers and yarns. These can find application in geotextiles and composite sectors. India should gear-up its technical textiles sector.

Indian Government has done fairly good job in creating awareness and establishing four Centers of Excellence related to technical textiles sector. These centres should be the conduits for creating value-added textiles industry in India. It is not possible to have many million dollar investments such as the one by Ahlstrom in Gujarat. It is important to boost the technical textiles sector by developing converting clusters. Such converting clusters will lead to many SMEs in the technical textiles sector in India.

5. NEXT STEPS FOR THE INDIAN TEXTILE INDUSTRY?

i. Boost domestic consumption and build the domestic market. The consumption of technical textiles products in day-to-day activities and industrial sectors should be boosted. More importantly, with the growing middle class population in India, life-style improving textile products, such as hygiene and health care textiles will be in greater need. It will be in the interest of all stakeholders to create an industry which can produce these life-style enhancing textile products.
ii. As of today, there is no concerted effort among all stakeholders to develop these products and route them through marketing channels to reach consumers. There needs to be an interactive platform between the technical textiles industry and the consumer base.
iii. Greater awareness on how to market technical textiles and value-added textile products should be infused to potential investors.
iv. As Dr. Swaminathan rightly pointed out, enthusiasm is a key factor in the growth of any industry. So, efforts have to be made to boost the confidence among entrepreneurs to start investing in value-added textiles sector.
v. It will be good for the Indian textile industry to invest in knowledge enrichment of its human resource. This aspect is more important for the technical textile sector which is at its infancy.
vi. Conventional textile industry, academic and R&D base should actively participate in international forums which will not only provide new knowledge, but also will give opportunity for networking.

6. OPPORTUNITY FOR THE INDIAN TEXTILE INDUSTRY

The USA based Texas Tech University and Bannari Amman Institute of Technology, Sathyamangalam, India, is organizing the 6th edition of, "International Conference on Advances in Textiles, Machinery, Nonwovens and Technical Textiles-ATNT 2009," during 7-9 December 2009.

For the past five years, USA based Texas Tech University has been providing an international platform in the Coimbatore area, India for exchanging cutting-edge topics and ideas on emerging textile fields such as nonwovens, specialty fabrics and technical textiles. Value-addition and diversification are very critical at the present times due to the global economic slow down.

The ATNT-2009 international conference, which is held at the Bannari Amman Institute of Technology campus in Sathyamangalam, India from 7-9 December 2009, is focusing on finding solutions to some of the difficulties faced by the Indian and global textile industries and providing information on new market opportunities

for global players. The conference is bringing industrial and academic experts from many parts of the world to deliberate on latest topics in the field of value-added textiles spanning the entire spectrum of the textile industry. These will be of immediate use to the Indian and global textile industry. The major thrust of the conference is to bring industry, academia, research and government agencies on a single platform. More Importantly, India now offers 100 percent foreign direct investment opportunity in the textiles sector and therefore it is of immense value for the global textile industry to participate in the international event, ATNT-2009.

Some Important features of this year's conference are: 1) tips to diversify with the existing infrastructure and enhance textile sectors' core competency and 2) discussions related to international tie-up opportunities in both technology and marketing, which will be of timely use for the textile industry.

In summary, in order for the Indian textile industry to come out of the current recession and plan for its successful future, revolutionary measures are necessary. In other words, textile industry should go for "Tex-Revolution" which should involve technology infusion, knowledge transfer, government support and more importantly a receptive audience.

The Level of Customers' Satisfaction of Canara Bank in Erode District, Tamil Nadu - A Factor Analytic Study

R.Shunmughan
Department of Commerce, Gobi Arts and Science College, Gobichettipalayam - 638 453,
Erode District, Tamil Nadu
E-mail: shanmuganarul@gmail.com
(Received on 02 May 2009 and accepted on 02 July 2009)

Abstact

Customer satisfaction represents a modern approach for quality in enterprises and organisations and serves the development of a truly customer-focused management and culture. Measuring customer satisfaction offers an immediate, meaningful and objective feedback about clients' preferences and expectations. This study measures the satisfaction level of customers and to give suggestions to improve the customers' satisfactions of Canara Bank in Erode District, Tamil Nadu. The study found that the satisfaction level of customers regarding people factor ranks the highest on the list, which signifies that the prompt attention of customers by the bank were quite good and other factors were found moderately satisfactory by the customers.

Keywords: *Canara bank,Customer satisfaction, Marketing strategies*

1. INTRODUCTION

Marketing assumes a wider dimension in the case of a service industry like banking where the services are rendered and intangibles are dealt with. Banking and financial products on an ongoing basis presupposes the establishment of a firm relationship with the customers. It involves 'ensuring a high degree of consultancy and quality in terms of both product creation and delivery. On the part of the bank, a competitive edge is to be maintained. Thus, the quality and commitment of people responsible for creation of banking services as well as simplicity and operational ease of the procedures relating to the delivery of the banking services also come within the ambit of bank marketing.

2. NEED FOR THE STUDY

This study has been taken on considering the follwing points:

i. Are the depositors satisfied with the existing services and facilities provided by Canara Bank?
ii. Are the borrowers satisfied with the existing services and facilities provided by Canara Bank?
iii. What is the state of satisfaction among customers about individual components of marketing mix of Canara Bank?
iv. How could customer satisfaction be improved?

3. OBJECTIVES OF THE STUDY

The objectives of the study are as follows:

i. To measure the satisfaction level of customers as to the marketing strategies followed by Canara Bank.
ii. To analyse the role of individual components of marketing mix on satisfaction of customers.
iii. To offer suggestions to improve customers satisfaction.

4. REVIEW OF PREVIOUS STUDIES

The following earlier studies have been conducted by various researchers in the area of marketing strategies, customer service and customer satisfaction in public sector banks. A review of these studies enabled the researcher to formulate the present study.

According to Berry [1] (1980), the service components of any bank product have a number of unique characteristics, which distinguish them from the tangible aspects of the product.

Richard L. Oliver [2] (1980) had pointed out that service quality and satisfaction have a strong influence on purchase intention. The service quality and service value has a significant impact on satisfaction and behavioral intention.

Archana Mathur [3] (1986) in her article "Customer Service in Public Sector Banks-A Comparative Study" revealed that customers face the problems of delayed service, lack of proper guidance and discrimination by bank staff. She suggested automation to reduce delay in the performance of services.

Nageswar Rao [4] (1987) in his article "Customer Service in Banks must improve" has highlighted the customer services being offered by the nationalized banks. He has pointed out shortcomings in this regard and made some concrete suggestions for streamlining and improving services. His suggestions include education of bank customers, analysis of customer behavior, matching of marketing efforts with customer service and powers of top management to impose discipline among the bank staff.

In this study, "Marketing Strategies in Canara Bank", David Soundarajan [5] (1989) has analyzed the marketing strategies followed by the bank and concluded that service strategy assumes greater importance in expanding banks' market share.

In another landmark research on the dimensions of the customer service aspects V.A. Zenithaml, A. Parasuraman and L.L. Berry [6] (1990) identified ten criteria for judging service quality. These dimensions are directly dependent on the service provider (bank employee) and they arise out of the organizational policies of the bank. The ten factors are Tangibility, Reliability, Responsiveness, Competence, Country, Credibility, Security, Access, Communication and Understanding the customer.

Stan Comber [7] (1990) in his article 'Banks Designed by Customers' observed that cash dispensers and automated deposit facilities can take care of the normal business of a bank while the staff are to talk to customers about any financial need they may have. He stressed the need for bank staff to be trained to fully understand the products and to relate them to individual customers needs.

'Spotlight on Personal Services' an article by John Berry [8] (1990), identified the main areas where services in banks are required to be improved. He suggested that each branch should have customer service managers with overall responsibility for customers' welfare and satisfaction.

A. Dilshath [9] (1992) conducted a study on 'Customer Satisfaction in Nationalized Banks' – with special reference to Madras city. Some of the important findings are:

i. Customers are not satisfied at the counters due to long time taken for drawing money.
ii. Customers are also dissatisfied because certain services like investment advice and tax advice are not given to them.
iii. Borrowers are dissatisfied because of the cumbersome procedural formalities in getting loans sanctioned.

Laurence Shurman [10] (1993), in his report of the Indian Banks Association concluded that there are dissatisfied customers and stressed the role of Bank ombudsman to resolve fairly the problems of customer.

M.M. Sathe [11] (1994) in his article, "Measurement of Customer Satisfaction" has analyzed the new package on customer service brought out by the Ministry of Finance and identified factors for poor customer service including inefficient managerial attention to service issues, archaic procedures, bureaucratic and monopolistic mindset, restrictive practices poor motivation, overstaffing and inadequate technology. He developed Service Quality Index shortly called as 'Servequal' with the help of five variables such as Tangibility, Reliability, Responsiveness, Assurance and Empathy. The index denotes the differences between the expectation score and perception score.

R.M. Chidambaram [12] (1994) in his study, "Thrust Areas of Customer Service" has identified eight thrust areas such as: Customer recognition, Courteous service, Customer friendliness, Group effort, Awareness building among bank personnel, Time consciousness, Prospective customer segment identification, and Unions' approach towards customer's expectations. If the above qualities are developed among the bank personnel, the banks can develop and win the competition from other financial intermediaries.

S. Benjamin Christopher and P. Maruthu Pandian [13] (1994) in their paper on "Customer Satisfaction in Public Sector Banks" assessed the level of customer satisfaction of the customers of select Public Sector Banks by

constructing satisfaction index. They concluded that customers are dissatisfied with various services and suggested the need for refinement in customer service.

S. Subramanian [14] (1995) in his study, "Introducing a New Service-Automatic Teller Machines: Applying Lovelock Services Classification Model" has attempted to develop marketing insights for introducing ATMS by applying Lovelock's model. The nature of services offered, type of relationship of the service organization with its customers, customization, nature of demand for the service and delivery of the same has been examined. He has identified six matrices of Lovelock's model in the service industry and the rationale, marketing insights, implications and use of each matrix for ATM service" The present study aims to identify the extent of satisfaction of bank customers with different banking transactions in Canara Bank.

5. SAMPLING SCHEME

Gobichettipalayam Taluk in Erode District of Tamilnadu consists of three blocks namely Gobichettipalayam, Nambiyur and T.N.Palayam. Canara Bank has seven branches in Gobichettipalayam taluk and one leading branch from respective block was selected for this study. Accordingly, Gobichettipalayam branch from Gobichettipalayam Block, Kolappalur branch from Nambiyur Block and Kasipalayam branch from T.N. Palayam Block were selected.

5.1 Selection of Sample Customers and Collection of Data

Purposive sampling method was adopted for the selection of customers from the three selected Canara Bank branches in Gobichettipalayam taluk. The customers who visited the Gobichettipalayam branch during the month of November 2007, customers who visited the Kolappalur branch during the month of May 2008 and customers visited Kasipalayam branch during the month of June 2008 were considered as targeted population of sample customers.

A well-structured questionnaire was prepared and distributed to 1000 bank customers of the three selected branches in the ratio of 4:3:3. Help was sought from the Managers of the bank for distributing the questionnaire to the customers during working hours of the bank. The residential address of sample customers with phone number were collected at the time of distributing the questionnaire.

There was no time limit given to the respondents to complete and return the questionnaire but the subject was instructed not to linger on for long while giving responses. On an average one hour was required by an individual to complete the questionnaire. However, within one month from the issue of questionnaire, more than 75% of them were collected from the customers.

Table 1 shows the clear picture about the number of questionnaires issued and number of questionnaires received from the customers of the three branches of Canara Bank in Gobichettipalayam taluk.

Table 1 Response Rate of the Questionnaire

Branches	Number of Questionnaires		
	Distributed	Returned	Used
Gobichettipalayam	400	341	325
Kolappalur	300	226	200
Kasipalayam	300	232	200
Total	1000	799	725

Out of 1000 questionnaires distributed to the customers, 799 completed questionnaires were received. Owing to illegible handwriting, incomplete entries and inconsistency in the questionnaires from the respondents, 725 sample customers were considered for final analysis.

6. CUSTOMER SATISFACTION - FACTOR ANALYSIS

A sample of 725 customers were taken for the study. The data collected for the study were classified, tabulated and processed for factor analysis, which was the most appropriate multivariate technique to identify the groups of determinants. Factor analysis identifies common dimensions of factors from the observed variables that link together the seemingly unrelated variables and provides insight into the underlying structure of the data. In this study, Principal Component Analysis has been used since the objective was to summarise most of the original information in a minimum number of factors for prediction purpose.

Marketing strategy is the set of controllable variables and their levels that the bank uses to influence the target market. It means any variable under the control of the bank that can influence the level of customer response is a marketing mix variable. A five-factor classification has been given to support this concept namely Product, Price, Promotion and Place (Four Ps). The study takes into account one more 'P' namely People besides the traditional 4 'Ps', as this is a vital component in the marketing mix of banks. On the backdrop of the above concept, this chapter attempts to review the marketing strategies adopted by the Canara Bank based on five 'Ps' is explained below.

A Principal Component Analysis was a factor model in which the factors were based on the total variance. Another concept in factor analysis was the rotation of factors. Varimax rotations are one of the most popular methods used in the study to simplify the factor structure by maximising the variance of a column of pattern matrix. Another technique called latent root criteria was used. An Eigen value was the column sum of squares for a factor. It represents the amount of variance in data. After determination of the common factors, factor scores were estimated for each factor. The common factors themselves were expressed as linear combinations of the observed variables.

Factor Model: $F_i = W_{i1}X_1+W_{i2}+\ldots\ldots\ldots W_{ik}X_k$

Where

F_i = Estimate of the i^{th} factor

W_1 = Weight or factor score coefficient

K = Number of variables

A customer considers various factors while deciding about investing in a bank. These ranges of factors begin with customer's perception, the promised return and the attractiveness of the offer. Based on informal discussions with customers, all the relevant variables were included in the study. Fifty statements were generated for measuring the satisfaction of the customers on a five-point scale. Factor matrix and their corresponding factor loading after the Varimax rotation were presented in Table2.

The grouping of variables with a factor coefficient > 0.5 was shown in Table 2. Factor I has an Eigen value of 22.375 and explain 44.75% of the total variance. The Eigen value of the second, third, fourth, fifth and sixth factors are 2.863, 2.497, 2.286, 1.916 and 1.384 respectively. Naming the factors has been done based on the size of factor loading of the variables.

Table 2 depicts the variables under each of the six derived factors. The first factor comprises variables viz. attention of cashier at counter, answering queries over telephone, knowledge of bankers about products, customers profile knowledge, courteous service at the counters, mutual ownership, uninterrupted service, helpfulness of manager and readiness of manager. These were grouped under factor F1 and termed as core factor which indicates the common expectations of any customer while making use of the banks.

Table 2 Statement Loadings of Satisfaction Level for the Varimax Rotated - Principle Components

Factors	Loadings	Eigen Value	% of Variance
Factor 1			
Attention of Casher at Counter	0.645	22.375	44.750
Answering Queries Over Telephone	0.752		
Knowledge of Bankers about Products	0.736		
Customers Profile Knowledge	0.746		
Courteous Service at the Counters	0.748		
Mutual Ownership	0.740		
Uninterrupted Service	0.721		
Helpfulness of Manager	0.736		
Readiness of Manager	0.645		

Factor 2			
No. of Staff Working in the Branch	0.697	2.863	5.726
Existing Branch Network	0.717		
Branch Location and Hi-Tech Service	0.743		
Infrastructure and Environment	0.723		
Availability of Stationeries / Forms	0.704		
Facilities for Illiterate / Old Aged	0.724		
ATM Location	0.763		
Counter for Collection and Payment	0.728		
Automated Environment	0.660		
Factor 3			
Advt. TV / News Paper	0.603	2.497	4.994
Personal Canvassing	0.678		
Customers Meet	0.694		
Deposit Mobilization Week	0.731		
Loan Mela	0.723		
Information about Maturity of Deposit	0.721		
Customer Relationship Programme	0.696		
Public Relation	0.686		
Customer Education	0.649		
Introduction of New Product	0.583		
Factor 4			
Interest on Deposit	0.542	2.286	4.571
Interest on Loan	0.671		
Service Charge	0.677		
Help of Manager	0.709		
Accepting Small Denomination Notes	0.706		
Exchange of Soiled / Mutilated Notes	0.735		
Knowledge about Customers' Right	0.650		
Knowledge about Customers' Need	0.665		
Community Development Programme	0.602		
Dissemination of Information	0.575		
Factor 5			
Opening Bank Account-Procedure	0.666	1.916	3.832
Depositing / Drawing- Procedure	0.731		
Time Taken for Depositing/Drawing	0.764		
Minimum Balance to be Maintained	0.783		
No. of Withdrawal Allowed	0.731		
Procedure in Getting Loan	0.720		
Securities Required for Getting Loan	0.759		
No. of Visits Required for Getting Loan	0.656		
Factor 6			
Time for Outstation Cheque Collection	0.805	1.384	2.767
Procedure for Facilities	0.703		

(N = 725)

7. SUMMARY AND CONCLUSION

Principal Component Analysis was used since the objective is to summarize most of the original information in a minimum number of factors for prediction purpose. Varimax rotations were used in the study to simplify the factor structure by maximizing the variance of a column of pattern matrix. An Eigen value was the column sum of squares for a factor represents the amount of variance in data. After determination of the common factors, factor scores were estimated for each factor. The common factors themselves were expressed as linear combinations of the observed variables.

The second factor was Place factor, which includes attributes such as number of staff working in the branch, existing branch network, branch location and hi-tech service, infrastructure and environment, availability of stationeries, facilities for illiterate and aged, ATM location and counter for collection and payment. This factor suggests that the service and delivery should be prompt and on time. It is a very important duty of the banker to provide services on a continuous basis so that the customers stay loyal and happy.

The third factor was Promotion factor, which includes attributes such as advertising in T.V and Newspaper, personal canvassing, customers meet, deposit mobilization week, loan mela, information about maturity of deposit, customer relationship programme, public relation, customer education and introduction of new product. This factor suggests that the banks should have close touch with customers and steps should be taken to minimise the gap between the customer and the banker. Communication gap is one of the root causes of all the banking ills. Regular and frequent meetings between the bankers and customers would help the banks in receiving proper feedback as to what the customers want on one hand and it would motivate the customers to be loyal and cooperative with the bank on the other hand.

The fourth factor was Price factor which includes attributes such as interest on deposit, interest on loan, service charge, help of manager, accepting small denomination notes, exchange of soiled/mutilated notes, knowledge about customers' right, knowledge about customers' need, community development programme and dissemination of information. It generates slight satisfaction because the Canara Bank customers feel that they were not getting enough for the price they were paying to avail bank services.

The fifth factor was Product factor which includes attributes such as interest on deposit, interest on loan, service charge, help of manager, accepting small denomination notes, exchange of soiled/mutilated notes, knowledge about customers' right, knowledge about customers' need, community development programme and dissemination of information. It generates slight satisfaction because the Canara Bank customers feel that they were not getting enough for the price they were paying to avail bank services.

The sixth factor includes time taken for collection of outstation cheques/demand draft procedure in getting locker facility, credit card facility, debit card facility and ATM card facility. This factor indicates the combination of two attributes – technology innovation in the bank and bank's innovation towards introducing new services. These facilities are the need of the hour for banks to achieve/garner the confidence of the customers.

The satisfaction level of customers regarding people factor ranks the highest on the list, first factor, which signifies that the prompt attention of customers by the bank were quite good and other factors were found moderately satisfactory by the customers. Procedure in getting locker facility, Credit card, Debit card and ATM card is very low which signifies that the customers were dissatisfied. Therefore, bank should gear up to promote their activities to attract and retain their customers by providing quality services.

The first factor identified the variables viz., attention of cashier at counter, answering queries over telephone, knowledge of bankers about products, customers profile knowledge, courteous service at the counters, mutual ownership, uninterrupted service, helpfulness of manager and readiness of manager and grouped under factor F1 (People factor) and termed as core factor which indicates the common expectations of any customer while making use of the banks.

It was found that the satisfaction level of customers regarding people factor ranks the highest on the list, which signifies that the prompt attention of customers by the bank were quite good and other factors were found moderately satisfactory by the customers.

REFERENCES

[1] L.L. Berry, "Service Marketing is Different", Business, May-June, 1980, pp.24

[2] L. Oliver Richard, "A Cognitive Model of the Antecedents and Consequences of the Satisfaction Decisions", Journal of Marketing Research, Vol.17, November 1980, pp. 446-469.

[3] Archana Mathur, "Customer Service in Public Sector Banks – A Comparative Study", of SBBJ and SBI. Indian Journal of Marketing, Vol.18, April - June 1986, pp.3-10.

[4] Nageswar Rao, "Customer Service in Banks Must Improve", Yojana, July 1987, pp.20-22.

[5] David Soundarajan, "Marketing Strategies Canara Bank" Unpublished M. Phil Dissertation, Annamalai University, 1989.

[6] V.A. Zenithal, A. Parsuraman and L.L. Berry, "Delivering Quality Service", the Free Press, 1990, pp.9-10.

[7] Stan Comber, "Banks Designed by Customers", Banking World, December 1990, pp.25.

[8] John Berry "Spotlight on Personal Services", Banking World, December 1990, pp.28-29.

[9] A. Dilshath, "Customer Satisfaction in Nationalized Banks-with Special Reference to Madras City", Unpublished M. Phil dissertation, Madras University, 1992.

[10] Laurence Shurman, "Ombudsman Not a Champion but an in Dependent Arbitrator", Text of Address at the 45th Annual General Meeting of the Indian Banks Association, July 1993.

[11] M.M.Sathye, "Measurement of Customer Satisfaction", Financial Express, 24 July 1994, pp.7.

[12] R.M. Chidambaram, "Thrust Areas of Customer Service", Financial Express, 24 July 1994, pp.7.

[13] S. Benjamin Christopher and Maruthu Pandian, "Customer Satisfaction in Public Sector Banks", Paper Presented in the National Seminar on Indian Banking by 2000 AD Organized by the Department of Commerce, Madras University P.G. Extension Centre, Salem, October 1994.

[14] S. Subramanian, "Introducing a New Service-Automatic Teller Machines: Applying Lovelock Services Classification Model", The Banker, February 1995, pp.28-30.

Prototyping of a Novel, Externally Coiled Magneto-Rheological Damper

Allen Anilkumar, Anoop C. Vijayan, V. Arun Vijay, P. Ayyappadas and N.R. Jaget Babu
Department of Mechanical Engineering, College of Engineering Trivandrum, Trivandrum - 695 016, Kerala
Email: allentvm@gmail.com
(Received on 05 August 2009 and accepted on 30 November 2009)

Abstract

Magneto-rheological fluid (MR fluid), the apparent viscosity of which can be controlled by suitable variation in the magnetic field in its region, is widely used in dampers. A new externally coiled MR damper has been designed. Damping action of the prototyped damper is due to viscosity of the fluid. By controlling the magnetic field in the vicinity, its viscosity and hence damping action can be controlled. Novelty of the design lies in the fact that the electromagnet coil windings were made external to the cylinder assembly. A closed loop was developed to control the magnetic field instantaneously with application of force on the piston. Fabrication was done in three stages- making the damper assembly, MR fluid and the closed loop circuit. Prior to preparation of MR fluid, various commonly available oils were tested and coconut oil was found to be the best carrier for mild steel particles. The damper was tested and damping action was successfully achieved for a range of forces. The damper has potential applications in automatic door closers, human prosthetics, bridge stay cables, automobile shock-absorbers and seismic dampers by suitable accessories.

Keywords: *Coconut oil, External magnetic coil, Magneto-rheology, Vibration damper*

1. INTRODUCTION

Magneto-rheological fluids (MR fluids) are non-colloidal suspensions of magnetisable particles that are on the order of 20-50 microns in diameter. The fluid was originally developed by Jacob Rabinow at the US national Bureau of Standards in the late 1940's and has since been used in a variety of Magneto-rheological devices (MR devices) [1]. Although similar in operation to electro-rheological fluids and ferrofluids, MR devices were capable of much higher yield strengths when activated. The major difference between ferrofluids and MR fluids was the size of the polarisable particles. In ferrofluids, these particles' magnitudes are smaller than those of MR fluids; i.e. they are 1-2 microns, in contrast to 20 –50 microns for MR fluids. For the first few years after invention, there was a flurry of interest in MR fluids but this interest quickly waned. In the early 1990's there was resurgence in MR fluid research that was primarily due to Lord Corporation's research and development [1 & 2]. MR fluid was composed of an oil, usually mineral or silicone based, and varying percentages of ferrous particles that were coated with an anti-coagulant material. When inactivated, MR fluids display Newtonian-like behaviour. When exposed to a magnetic field, the ferrous particles that are dispersed throughout the fluid form magnetic dipoles [1 & 2].

Among MR devices, MR dampers have been most widely studied and developed for commercial applications. The most commercially successful MR device to date is the Rheonetic RD-1005-3 MR damper that is manufactured by Lord Corporation [3]. The damper has a mono tube construction with an extended and compressed length of 8.2 and 6.1 inches, respectively when measured from eye to eye. When compressed, the damper is 6.1 inches long also measured from eye to eye. The RD-1005-3 MR damper achieved a minimum of 500 lbs of damping force at velocities larger than 2 in/sec with 1 Amp of current. When no current is supplied to the damper (i.e. the off-state), the damper had a force of less than 150 lbs at 8 in/sec. The Rheonetic RD-1005-3 MR damper was used in a seat suspension system called the "Motion Master", which was intended as a retrofit to existing hydraulic truck seat dampers, and used by the original equipment manufacturer and was very well received by a variety of industries. For example, variations of this damper are being used for the Lord Motion Master™ truck seat damper [4 & 5] as well as for a prosthetic leg that is being developed by Biedermann Motech Gmbh [6].

The commercialized success of MR dampers reaches beyond the Motion Master System by Lord Corporation,

described earlier. It also includes automotive applications such as the recent announcement by Delphi Corporation to manufacture MR dampers for certain Cadillac models. Other proposed applications for MR dampers include building control systems, use in earthquake mitigation, and gun recoil dampers, for managing the impact dynamics of the gun [7]. In most currently used MR-devices, the magnetic coils are installed internally within the device causing bulky installations within them. The possibilities of fabricating MR devices using externally coiled systems have been explored in the prototyped design of an externally coiled MR damper.

2. MATERIALS AND METHODS

The prototyped damper comprised of the damper frame, closed loop circuit board and damper oil.

2.1 The Damper Frame

Damper frame included the cylinder, cylinder cap, o-ring, oil seal, piston, piston rod, load cell, electromagnet and associated fasteners. The disassembled and assembled views of the damper frame are shown in Figure 1 (note: the figure excludes the electromagnet). The cylinder and cylinder cap were made out of stainless steel 304-A. The cylinder cap housed an O-ring and an oil seal. The cylinder was made 18 cm long, with an internal diameter of 5.5 cm and an external diameter of 6.0 cm. Two 4 mm diameter, internally threaded holes were made on the bottom surface of the cylinder to attach itself to the free end of the load cell. The O-ring prevented MR fluid from coming out through the joint between the cylinder and its cap whereas the oil seal prevented the MR fluids from seeping out whilst sticking on to the piston rod. The cylinder cap had a linear guide way to guide the piston rod's movement. The piston was made out of nylon. It was made 5 cm in diameter and 2 cm in height. The piston rod was made of stainless steel 304-A. The fasteners included two stainless steel washers and a bolt. These were used to attach the piston rod on the piston. A cantilever type load cell was used to measure the vertical force on the cylinder. One end of the load cell was mechanically fixed to the base plate (through some packing pieces) so that it was at rest relative to the frame of reference, while the other end was screwed directly beneath the cylinder. So whatever force was transmitted through the cylinder was experienced in the load cell too. The load cell used in the fabrication of the MR damper was originally fabricated by the California based company, Sentran. On loading, it produced a linear output proportional to the load. The maximum output of the load cell is 2mV/V. The electromagnet was made by making 1600 windings of super enamelled copper wire on a wrought iron core. The ends of the core were shaped to direct the field lines perpendicular to the movement of the piston. The loading pan was prepared from nylon, to reduce the piston load. Base plate was made from cast iron.

2.2 Fabrication of the Closed Loop Circuit Board

For the damper to be self acting, a closed loop circuit was to be introduced. Two alternate power sources were made available, a 12 V DC battery or a 230 V AC power supply (Figure 2). The force experienced on the piston, was transmitted to the cylinder through the MR fluid. Although, the entire magnitude of piston force was not experienced by the cylinder (a small part of the force is used up to accelerate the piston and an even smaller part is wasted by fluid friction in the MR fluid), it was harmless to consider the losses negligible. The cylinder was made to rest on the free end of the cantilever load cell so that the entire piston force was experienced on the load cell. The output obtained from the load cell was of the order of millivolts. It could not directly produce an appreciable magnetic flux density. An amplifier circuit board was used to increase the strength of the voltage output from load cell before feeding it to the electromagnet.

2.3 Selection of the Oil

MR fluid needed three ingredients- mild steel particles, the carrier oil and white lithium grease. Mild steel powder was collected from a variety of sources, mainly from cylindrical grinding and surface grinding machines. A powdery mixture of the abrasive and mild steel was produced as a by-product of grinding. This was collected and sieved to make the particle sizes more or less the same. The mild steel particles were then separated from the abrasive by the use of a magnet. Five commonly available oils were tested prior to selection of the carrier oil. 250 ml, of each oil was added separately with 50 ml of powdered mild steel to produce various samples of MR fluids. The samples were mixed thoroughly till homogeneous fluids were obtained. A viscometer was constructed to study the variation in fluid viscosity with magnetic field. The viscometer could be used to measure

the time for discharge of fluid through a 4mm diameter circular orifice under various magnetic fields. The fluid to be tested was taken in the discharge chamber (Figure3). By lifting the stopper, discharge of the fluid could be made possible. Once 250 ml was collected in the measuring jar, the stopper was put back in its seat. The magnetic fields were controlled by varying the field currents. The five oils selected for the test were, gear oil, 2T oil, 20w40, 20w50 and coconut oil. Each fluid was tested and time taken for 250 ml discharge was noted with 0, 0.5 and 1 Ampere field currents.

2.4 Preparation of MR Fluid

Five grams of grease was added to 45 grams of coconut oil in a container. The grease-oil mixture was made homogeneous by vigorously shaking the container for one minute. The container was opened and 150 grams mild steel powder was added to the mixture. Finally the container was vigorously shaken for one more minute.

2.5 Testing of the Damper

Various weights were placed on the loading pan. Time taken for the piston to slide through a distance of 9 cm was noted for every load, both with and without the magnetic field. Currents generated by the closed loop circuit, which was further passed through the field windings were also noted.

3. RESULTS AND DISCUSSION

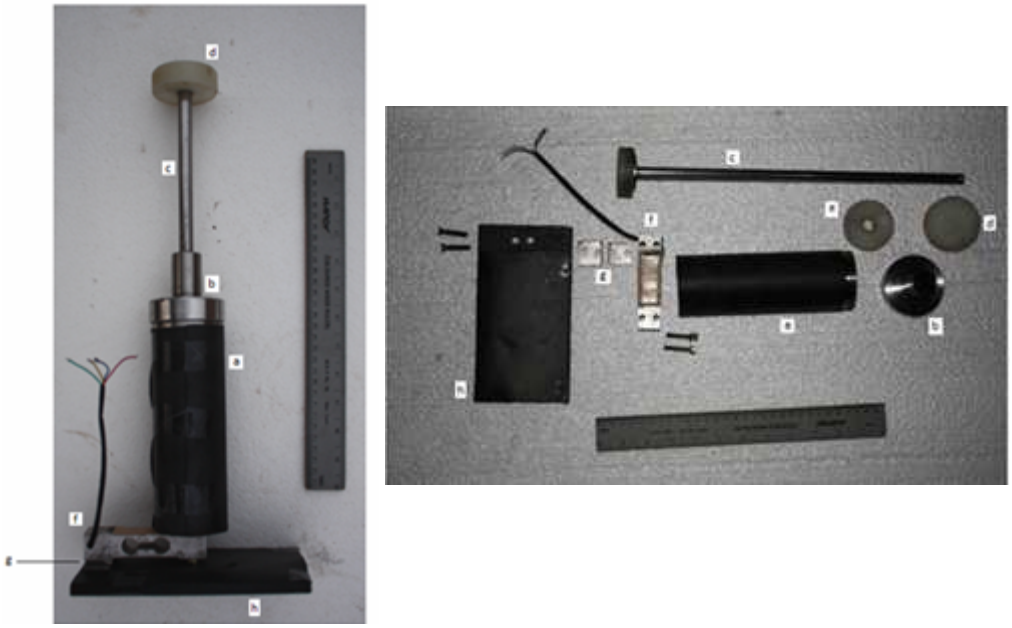
The novel design of externally coiled MR device addressed several problems of conventional internal coiled MR devices. The inherent difficulty in manufacturing a mono tube, twin tube or double ended MR damper are their complex deigns. Moreover, the coil windings are conventionally installed on the piston. The piston being smaller in dimension compared to the damper unit, poses a limitation to the maximum number of windings. The smaller number of coils further affected the maximum magnetic field that could be applied. Hence the damper action was restricted to a small range of forces. Another disadvantage of keeping the windings on the piston is that it increases its total mass. This increases the momentum of the piston, which in turn makes the feedback circuit, still more complex. In order to address these disadvantages, the magnetic coil was shifted to an extra-cylindrical position. Also, the complex accumulator was avoided by adopting the principle of a double ended MR damper. The complete assembly of the damper unit is shown in Figure 4.

To find the best carrier for use in MR fluids, five commonly available oils- Gear oil, 2T oil, 20w-40, 20w-50 and coconut oil were tested in a viscometer. Among these, the gear oil did not form a homogeneous mixture and therefore could not be tested. Observations made from the test are presented in Table 1. Coconut oil was found to be the best carrier oil for powdered mild steel. Coconut oil based MR fluid has a low viscosity in the absence of a magnetic field as evident from the data presented in the Table 1 (please see column 2) but its viscosity shot up at a field current flow of 1A (please see column 4).

Since MR fluid with coconut oil as carrier showed the widest variation of viscosity, with magnetic field, it was selected for further study. An added advantage of coconut oil was that it is cost efficient compared to MR fluids currently available in the market. However, coconut oil has never before used for preparing MR fluid. Optimization of the fluid was therefore achieved by trial and error method. To prepare 200 grams of MR fluid, it was found that 45 grams coconut oil, 150 grams powdered mild steel and 5 grams white lithium grease were to be mixed into a homogeneous consistency. This damper fluid was found satisfactory for further experiments.

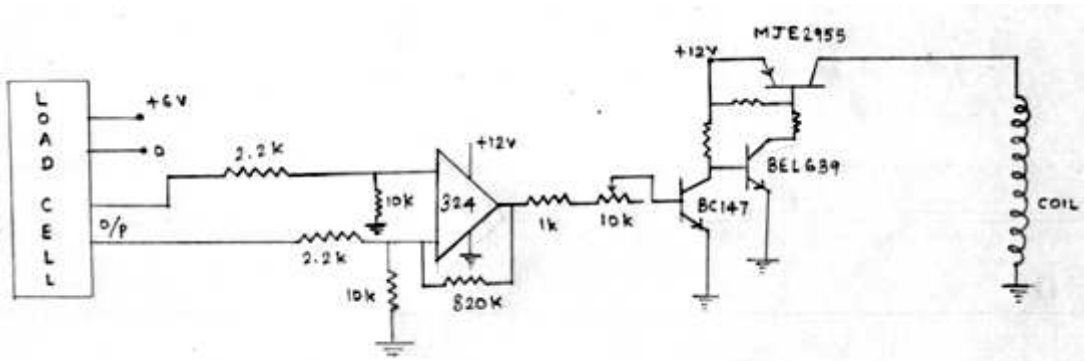
The MR damper was tested by placing various weights on the loading pan. Loads ranging from 0.98 to 9.8 Newton were applied. A considerable increase was noted, in the time taken for the piston to traverse 9 cm on application of the magnetic field (Table 2).

The MR damper operation was as predicted, in the 2.94 and 6.86 Newton range. Within this range, regardless of the load applied on it, the piston traversed the 9 cm distance in around 25 seconds. Loads smaller than 2.94 Newton were found too small for successful damping. For every load above 6.86 Newton, the closed loop circuit remained saturated, giving out a constant current of 0.9 Amperes. However, the damper could be implemented to damp a wider range of forces, by suitably modifying it.

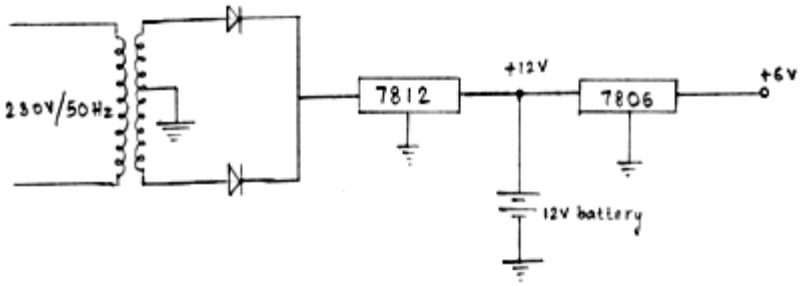


a-Cylinder
b-Cylinder cap
c-Piston rod
d-Loading pan
e- o ring
f- loadcell
g- Packing pieces
h-Base plate

Fig.1 Damper assembly (assembled and disassembled views)



A (amplifier circuit)



B (power supplying circuit)

Fig.2 Circuit diagrams of closed loop circuit

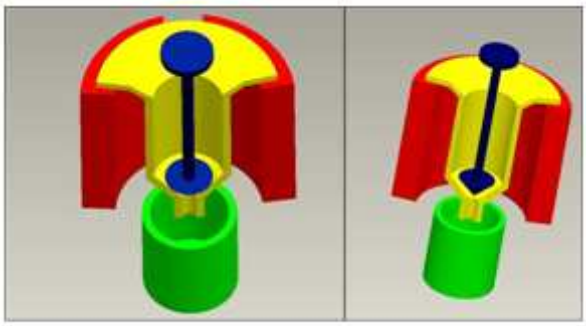


Fig. 3 Viscometer used by the project group- computer generated cross sectional view

Fig. 4 The complete damper unit

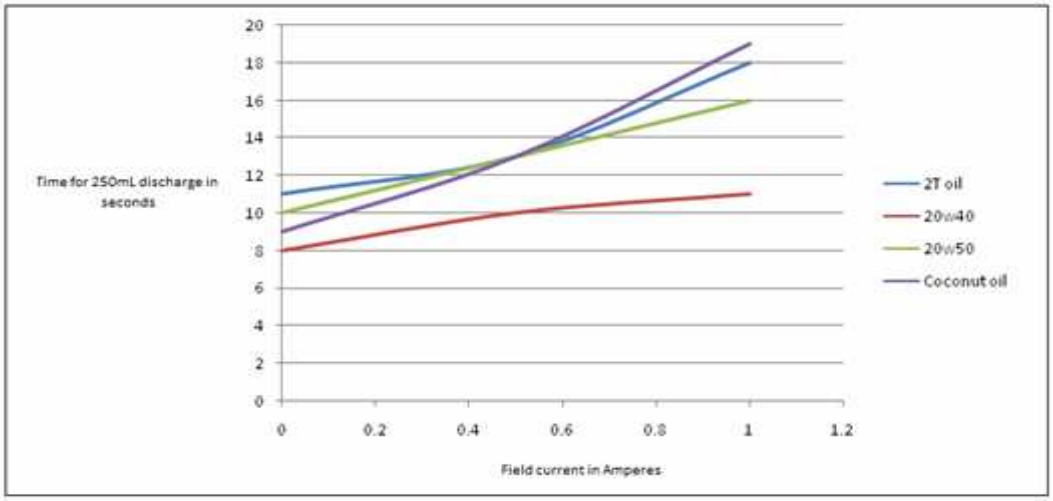


Fig.5 Plot of time for 250mL discharge in seconds vs. field current in amperes for four different oils

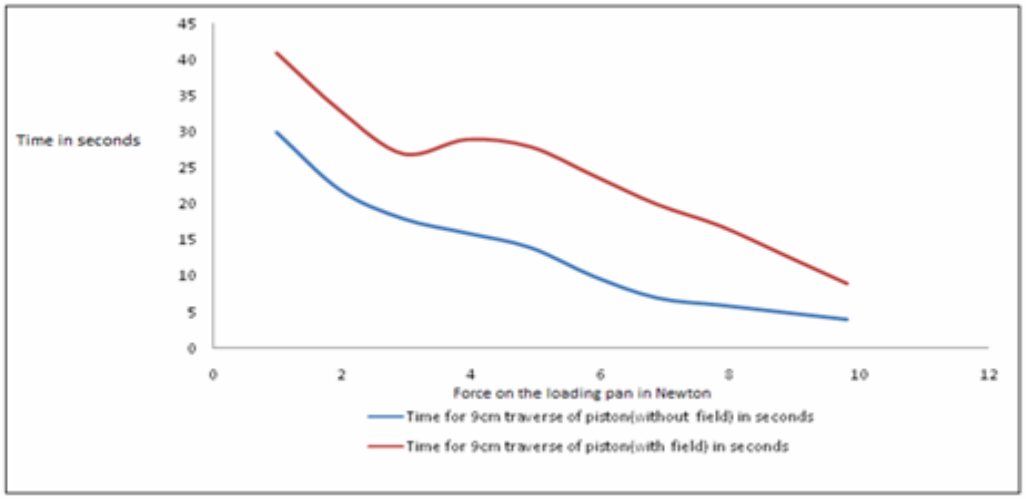


Fig. 6 Plot of force on loading pan vs. time for 9cm traverse of piston tables

Table 1MR Fluid Testing, Observations, Coconut Oil had the Widest Range of Discharge Times

Carrier Oil	Time for 250mL Discharge with no Field Current (Seconds)	Time for 250mL Discharge with Half Ampere Field Current (Seconds)	Time for 250mL Discharge with One Ampere Field Current (Seconds)
Gear Oil	Did not Form a Homogeneous Mixture		
2T Oil	11	13	18
20w-40	8	10	11
20w-50	10	13	16
Coconut Oil	9	13	19

Table 2 MR Damper Testing, Observations, Set of Readings, 3 to 7 Show Almost the Same Time for 9cm Traverse

Sl. No.	Mass on the Loading Pan	Force on the Loading Pan	Time for 9cm Transverse of Piston (without field)	Time for 9cm Transverse of Piston (with field)	Current through Magnetic Field Windings
	kilograms	Newton	Seconds	Seconds	Amperes
1	0.1	0.98	30	41	0.1
2	0.2	1.96	22	33	0.2
3	0.3	2.94	18	27	0.3
4	0.4	3.92	16	29	0.5
5	0.5	4.90	14	28	0.7
6	0.6	5.88	10	24	0.8
7	0.7	6.86	7	20	0.9
8	0.8	7.84	6	17	0.9
9	0.9	8.82	5	13	0.9
10	1	9.8	4	9	0.9

4. CONCLUSION

An externally coiled damper assembly has been proposed to address several disadvantages of magneto-rheological dampers. The advantages are simplicity in design, light piston, independent magnetic coils and cheap damping fluid. Moreover, the use of coconut oil as a damper-fluid was evaluated and a recipe for a fluid combination has been suggested by mixing powdered mild steel and white lithium grease in coconut oil. The novel coconut oil based MR fluid showed a wide variation in viscosity and achieved very good damping effects. The fabrication cost of the prototype indicated economical and commercial viability.

REFERENCES

[1] J.C. Poynor, "Innovative Designs for Magneto-Rheological Dampers", Master of Science Thesis, Virginia Polytechnic Institute and State University, Department of Mechanical Engineering, August 2001.

[2] M.R. Jolly, J.W. Bender and J.D. Carlson, "Properties and Applications of Commercial Magnetorheological Fluids", SPIE 5th Annual Symposium on Smart Structures and Materials; San Diego, CA; March 1998.

[3] Rheonetic RD-1005-3 MR Damper, Lord Corporation Product Bulletin, Cary, NC, 2001.

[4] "Vibration and Seat Design", Lord Corporation White paper, Thomas Lord Research Center, Cary, NC, 2001.

[5] Designing with MR Fluids, Lord Corporation Engineering Note, Thomas Lord Research Center, Cary, NC, December 1999.

[6] J.D. Carlson, D.M. Catanzarite and K.A. St. Clair, "Commercial Magnetorheological Fluid Devices", International Journal of Modern Physics B, Vol.10, No. 23-24, pp. 2857-2865.

[7] O. Ashour, C.A. Rogers and W. Kordonsky, "Magnetorheological Fluids: Materials, Characterization, and Devices", Journal of Intelligent Material Systems and Structures, Vol. 7, March 1996, pp.123-130.

Performance Analysis of Zigbee in Coexistence Heterogeneous Wireless Packet Network with Bellman Ford, AODV and DSR Protocols - A Comparative Approach

G.M.Tamilselvan, A. Shanmugam and T.V.P. Sundararajan
Department of Electronics and Communication Engineering, Bannari Amman Institute of Technology,
Sathyamangalam - 638 401, Erode District, Tamil Nadu
E-mail: tamiltamil@rediffmail.com, dras@yahoo.co.in, tvpszen@yahoo.co.in
(Received on 22 July 2009 and accepted on 12 November 2009)

Abstract

Coexistent heterogeneous wireless networks may interfere with each other and result in significant performance degradation when devices are collocated in the same environment. Understanding the impacts of interference among different wireless networks is one of the critical issues for designing and implementing network system with multiple wireless technologies. This paper reviews characteristics of each different classes of routing protocols. Moreover, most of current routing protocols assume homogeneous networking conditions where all nodes have the same capabilities and resources. Although homogenous networks are easy to model and analysis, they exhibits poor scalability compared with heterogeneous networks that consist of different nodes with different resources. This paper presents extensive studies simulations for AODV, DSR and Bellman Ford in homogenous and heterogeneous networks. The results showed that these which all protocols perform reasonably well in homogenous networking conditions, their performance suffer significantly over heterogonous networks. Further this paper presents the mobility model for the heterogeneous network for different interference size.

Keywords: *AODV, Bellman ford, Coexistence, DSR, Heterogeneous, Wifi, Zigbee*

1. INTRODUCTION

Because of the mobility and ubiquitous deployment of wireless systems, there are many scenarios where different systems operate in the same place at the same time. Hand-held PDA can use a Bluetooth device to connect to a laptop with 802.11b WLAN.

Many routing protocols have been proposed to mange the communication on this kind of networking. Moreover, there are many issues that must be considered in constructing any routing protocol such as power consumption, reliable data delivery, and overheads and delays. Recent work on MANET routing protocols have focused on achieving stability and reliability to reduce packet loss, communication overheads, and to increase data delivery ratio. Different approaches have been proposed to achieve those goals. Some of those focused on improving physical layer to provide reliable transmission, like diversity techniques, coding and Single Path Parallel Relays (SPPR) strategies [1-3]. Cooperation between link layer and network layer was another approach [3], where the state and the availability of the link on link layer were analyzed before calculating the routes [3]. Others expanded the existing protocols like AODV, LAR, and DSR by implementing the multipath strategy [4, 5].

However, mobility of the nodes has not been the main focus of those papers. We anticipate that several problems in MANETs arise due to the mobility such as high data delay and low packet delivery ratio. Hence, node mobility has to be considered in order to achieve high stability and reliability. Different strategies have been implemented in [6-8] to satisfy different degrees of mobility. On the other hand, most existing routing protocols have not been able to satisfy both scalability and mobility.

Most of current routing protocols assume homogeneous network conditions where all nodes have the same capabilities and resources. Although homogenous network are easy to model and analysis, they exhibits poor scalability compared with heterogeneous networks that consist of different nodes with different resources. Heterogeneous MANET comprise of mobile devices as Figure1 that have different communications capability such as radio range, battery life, data transmission rate, etc. Moreover, in real world, some of MANET networks

are obviously heterogeneous like military battlefield networks and rescue operations system. For instance, in a rescue operations system, there are limited mobile devices that are provided to individual rescuers, ambulances and police vehicles, and helicobacter. Limited mobile devices have lowest communication capabilities, while helicobacter is the most powerful communication device which forms backbone of the rescue team. Therefore, heterogeneity of nodes is another issue that needs to be considered in constructing and developing routing protocols for MANETs.

Recently, a few publications have introduced some strategies to develop routing protocols to accommodate heterogeneous MANETs. In this paper extensive studies simulations of AODV, DSR and Bellman Ford in homogenous and heterogeneous networks is studied.

Fig.1 Heterogeneous network system

The comparison of different classes of protocols is analyzed in section two. Section three describes our simulations of different protocols in homogenous and heterogeneous network. Section four discusses our results. Last section concludes this paper.

2. COMPARISON OF DIFFERENT CLASSES OF ROUTING PROTOCOLS FOR MANETS

In this section, comparison of proactive, reactive and hybrid protocols is outlined by combining their published theoretical performance [10]. That comparison is further verified through the published simulation results [6, 9, 13, and 14]. Based on that comparison, a suitable class of routing protocols is suggested to perform well in a particular network conditions.

2.1 Theoretical and Model Based Analysis

As the node moves, there is a flooding of packets containing the topology changes causing high overheads. Hence, in general, proactive protocols produce more overheads resulting in a lower throughput in case of high mobility as illustrated in theoretical and model based analysis below. In order to compare the protocols, the following set of parameters is usually defined:

N = number of nodes.
L = average path length (in hops).
R = average number of active routes per node.
ì = average number of link breakage per second (reflect mobility degree).
á = route activity, which gives how the frequently the node is changing its destination.
ñ = route concentration factor that monitors the traffic hotspots in MANET.

Proactive, reactive and hybrid protocols have been evaluated theoretically in [13]. It has been found that asymptotic overhead for proactive is O (N1.5) due to the process of maintaining and forwarding tables to keep periodic updates. In reactive protocols, route requests and reply messages create overhead of cost O (N2), while in hybrid protocols this is O (N1.66). The number of packets that are produced by proactive protocols per second is ì*L*N2 while for reactive protocols is (á+ñ*R*ì)*L*N2. Reactive is found to be better than proactive if ì*L*N2 > (á+ñ*R*ì)*L*N2. It has been concluded proactive protocols can be used mostly in static or quasistatic networks, reactive protocols are preferred in more dynamic networking, while hybrid protocols are more efficient in adapting to changes in network conditions.

Analytical model that compared control overhead with mobility and data traffic for proactive and reactive protocols for MANETs has been also presented in [10]. It has been found that number of packets produced by optimized reactive protocols in MANET is orìaLN2 and opìANpN2 for optimized proactive protocols, where

or = route request optimization factor.
ANp = active next hops ratio.
a = number of active routes per node (activity).
op = broadcast optimization factor.

Hierarchal routing protocols, geographic position information assisted routing protocols, and hybrid routing

protocols are more adaptable to various node destination than flat protocols [11 & 12]. In [11], hierarchal routing protocols have been found to be more scalable than flat protocols because they limit the propagation area by structuring the network nodes. However, overheads are increasing with those routing schemes due to location management. Therefore, hierarchal protocols are suitable in scenario like high density but low mobility. Geographic routing protocols also perform well in high density because of the simplicity of location management localized route discovery.

2.2 Simulation Observations

Several simulations have been carried out to compare different protocols from different classes in different scenarios of nodes mobility and density [6, 9, 13, and 14].

The results of these simulations indicated that proactive protocols have higher overhead than reactive and hybrid protocols in terms of mobility and density while they have smaller delay than reactive ones. On the other hand, reactive protocols have lower delay than hybrid protocols. Although it is noticed that as the density increases and the mobility decreases, the delivery ratio increases. Proactive protocols have better delivery ratio but hybrid protocols have the best delivery ratio. Hence, they perform better in high density networks.

In [14], several simulations of four protocols have been carried out using GloMoSim simulator. These protocols were distance vector (DV), DSR and AODV as reactive protocols, and WRP as proactive protocol. The simulations have been run under different network conditions like different mobility degrees and different nodes density. It has been found that DSR has highest delay, while WRP has the lowest overhead as mobility increases.

To conclude what we have outlined theoretically and from existing simulations, proactive protocols class perform well in network with low mobility nodes. However, this class can adapt different node density, because they include hierarchal and geographical routing protocols. Moreover, hierarchal, geographic and hybrid routing protocols, have been more flexible with high density networks. Therefore, they can operate with medium and high density. In medium density and mobility, reactive protocols can work well.

3. SIMULATION MODEL

In this section we present simulations that have been carried out to compare the performances of different protocols from different classes in heterogeneous and homogenous MANET. In homogenous MANETs, all nodes have same capabilities and resources while with heterogeneous MANET different nodes have different resources like transmission range and power saving. We preformed the simulations using the Qualnet simulator.
Figure 2 illustrates a scenario of the coexistence of 802.15.4 and 802.11b, where 802.15.4 nodes form a multi-hop network and a part of the network is being interfered by 802.11b system. Since the nodes are connected in multi-hop mesh network, packets are routed by visiting the nodes on the routing path. Random way point was used as mobility model with ten different values of speed that were 2, 4,6,8,10,12,14,16,18 and 20 meter/sec. Constant Bit Rate (CBR) was used to generate data traffic. Each packet was 127 bytes for IEEE 802.15.4 nodes, 512 bytes for IEEE 802.11b nodes and transmitted at 1 s interval.

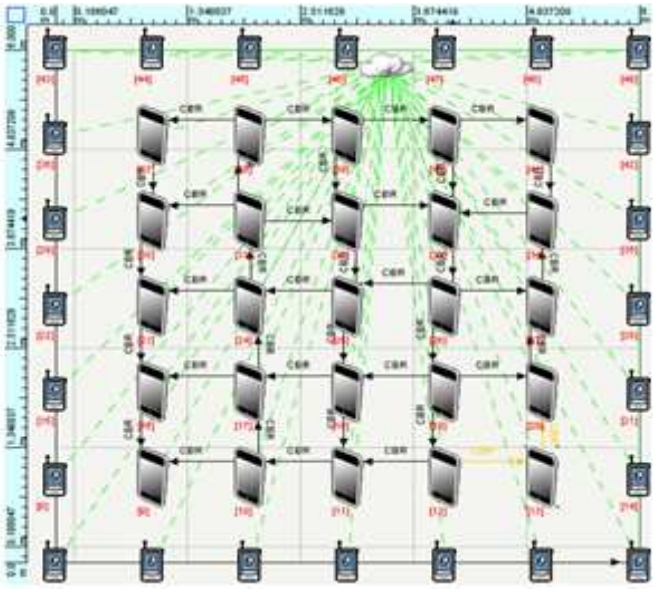


Fig.2 Heterogeneous network with Interference

IEEE 802.11b was used as MAC protocol with constant transmission bandwidth of 2Mbps. The transmission power was 15dbm for all IEEE 802.11b nodes and 3dbm for all IEEE 802.15.4 nodes. The simulations run five different protocols that were AODV, DSR, and Bellman ford. Bit error, Throughput, Average End-to-End Delay and Average jitter were used as performance metrics of each protocol.

4. RESULTS

This section gives a detailed analysis of BER of IEEE 802.15.4 under the interference of IEEE 892.11b. Here different interference models have been analyzed under different routing protocols like bellman ford, AODV, and DSR, where both the static and mobile conditions are taken into account. In addition to this, interference size is varied as 0%, 10%, 20%, 30%, 40% and 50%. Table 1 shows the simulation and configuration parameters of IEEE 802.15.4.

Table 1 Simulation and Configuration Parameters of IEEE 802.15.4 and IEEE 802.11b

Parameter	IEEE 802.15.4	IEEE 802.11b
Centre Frequency	2.4 GHz	2.4 GHz
Transmission power	3 dBm	15 dBm
Payload size	105 bytes	1500 bytes

Figure 3 (a-d) shows the simulation results of heterogeneous network for different routing protocols for different interference size with out assuming the mobility model.

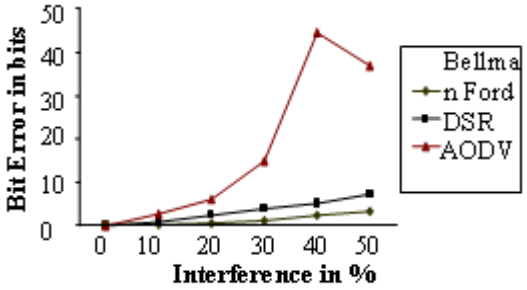


Fig.3 (a) Bit error analysis of IEEE 802.15.4 without mobility

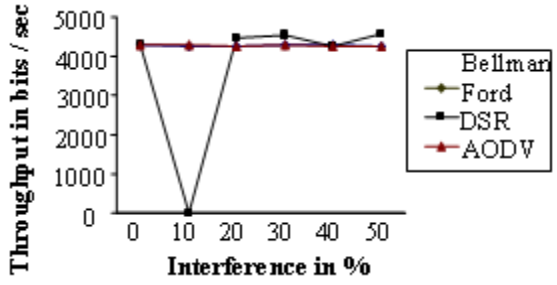


Fig.3 (b) Throughput analysis of IEEE 802.15.4 without mobility

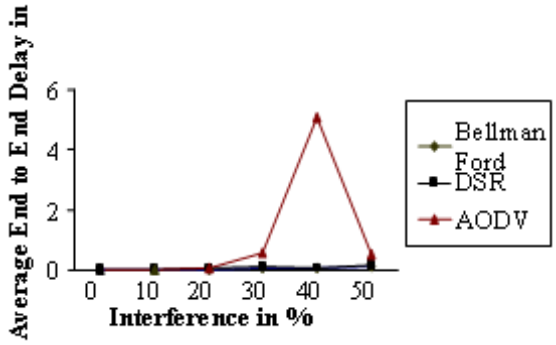


Fig.3 (c) Average end-end delay analysis of IEEE 802.15.4 without mobility

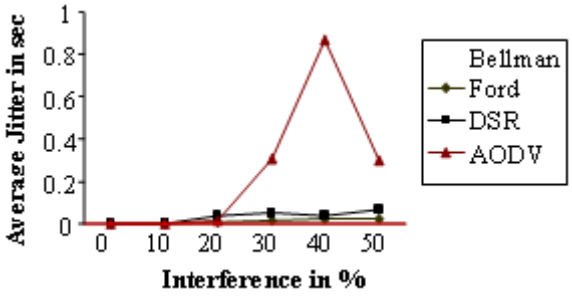


Fig.3 (d) Average jitter analysis of IEEE 802.15.4 without Mobility

The following figure (4-7) shows the performance metrics of IEEE 802.15.4 such as bit error, throughput, average end-end delay and average jitter respectively for the interference sizes 10%,20%,30%,40% and 50%.

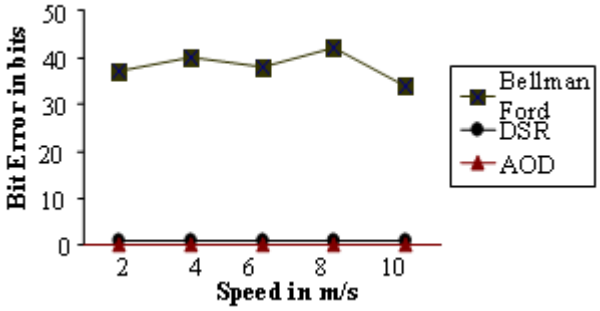


Fig.4 (a) Bit error analysis of IEEE 802.15.4 without interference (Homogeneous)

The mobility model Random way point is assumed for the performance analysis of heterogeneous networks with the speed of 2, 4,6,8 and 10 meter/sec.

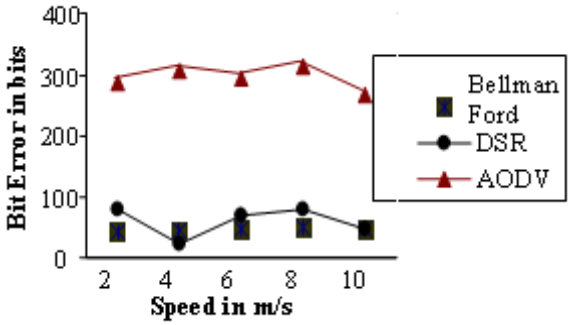


Fig.4 (b) Bite error analysis of IEEE 802.15.4 with 10% interference

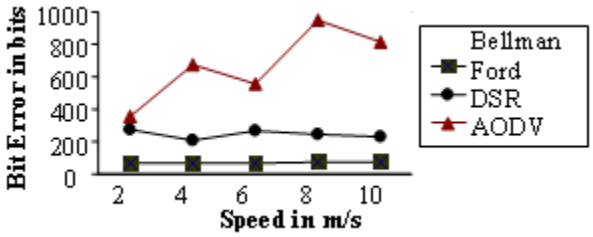


Fig. 4 (c) Bit error analysis of IEEE 802.15.4 with 20% interference

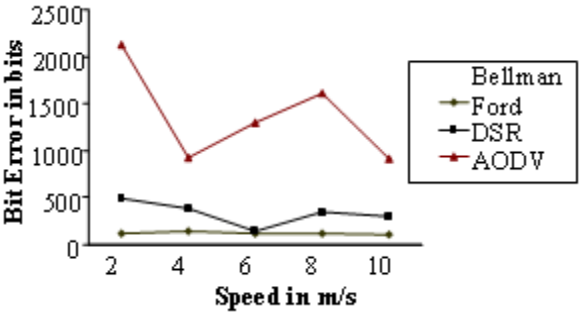


Fig.4 (d) Bit error analysis of IEEE 802.15.4 with 30% interference

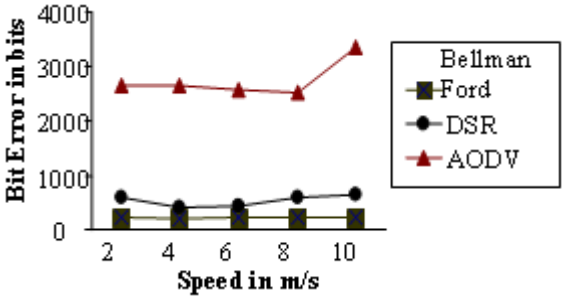


Fig. 4 (e) Bit error analysis of IEEE 802.15.4 with 40% interference

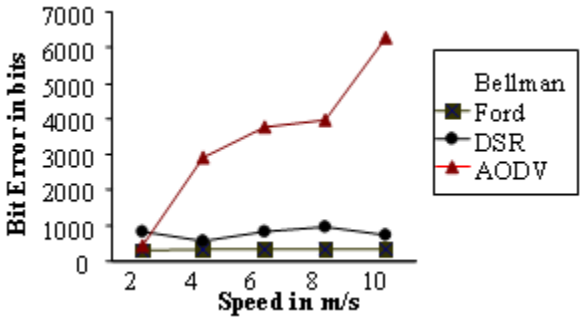


Fig.4 (f) Bit error analysis of IEEE 802.15.4 with 50% interference

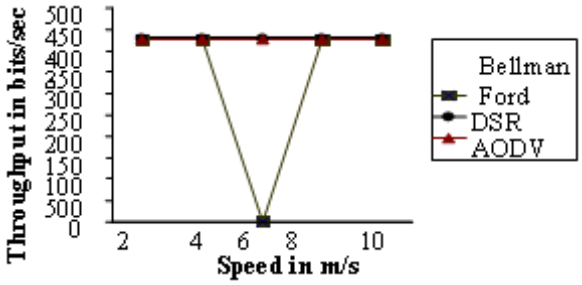


Fig. 5 (a) Throughput analysis of IEEE 802.15.4 with out interference (Homogeneous)

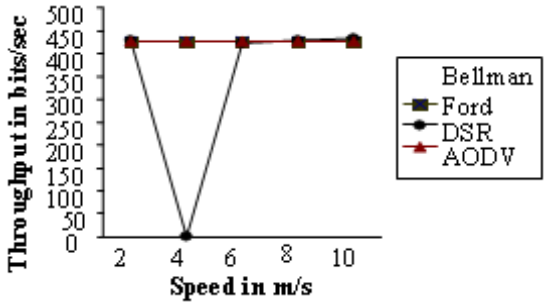


Fig.5 (b) Throughput analysis of IEEE 802.15.4 with 10% interference

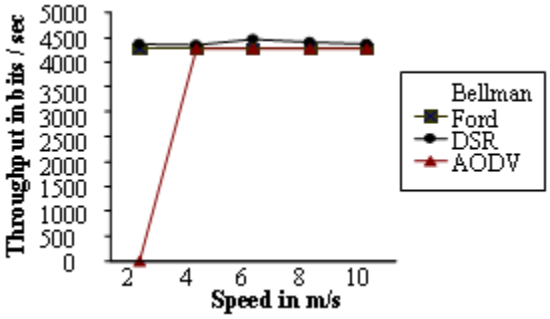


Fig.5 (c) Throughput analysis of IEEE 802.15.4 with 20% interference

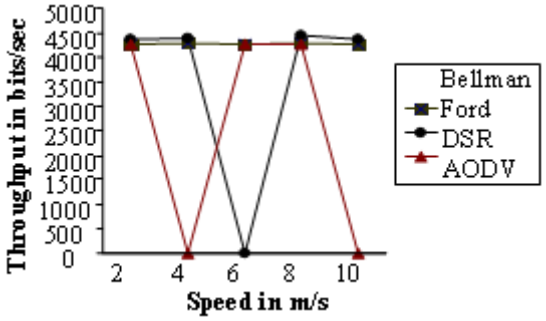


Fig. 5 (d) Throughput analysis of IEEE 802.15.4 with 30% interference

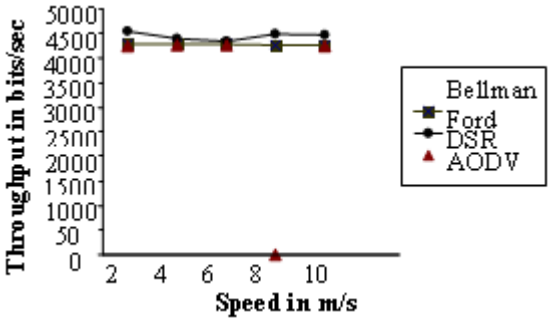


Fig. 5 (e) Throughput analysis of IEEE 802.15.4 with 40% interference

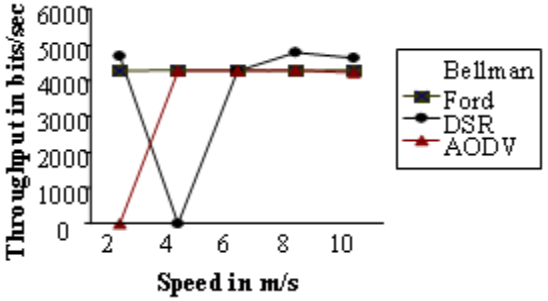


Fig.5 (f) Throughput analysis of IEEE 802.15.4 with 50% interference

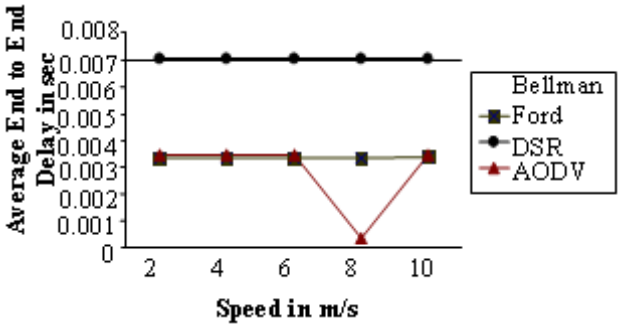


Fig. 6 (a) Average end-end delay analysis of IEEE 802.15.4 with out interference (Homogeneous)

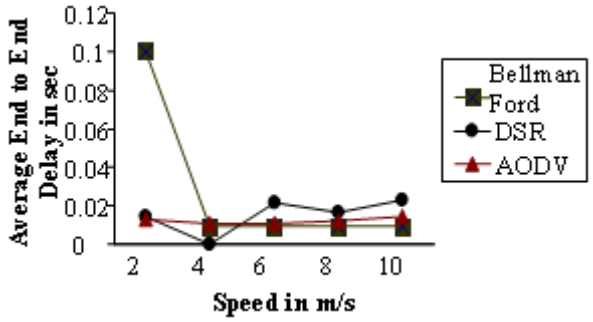


Fig. 6 (b) Average end-end delay analysis of IEEE 802.15.4 with 10% interference

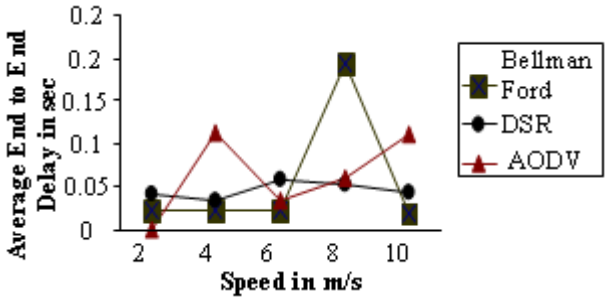


Fig. 6 (c) Average end-end delay analysis of IEEE 802.15.4 with 20% interference

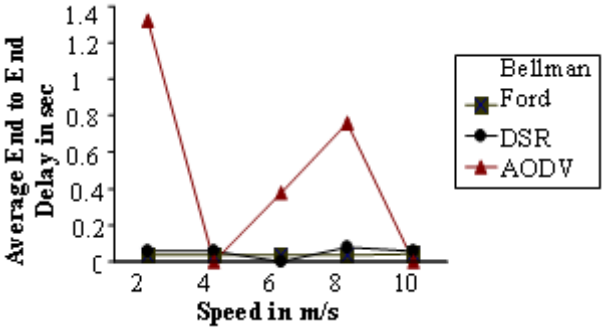


Fig. 6 (d) Average end-end delay analysis of IEEE 802.15.4 with 30% interference

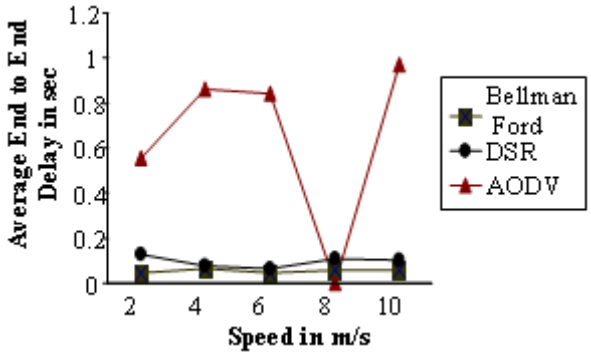


Fig. 6 (e) Average end-end delay analysis of IEEE 802.15.4 with 40% interference

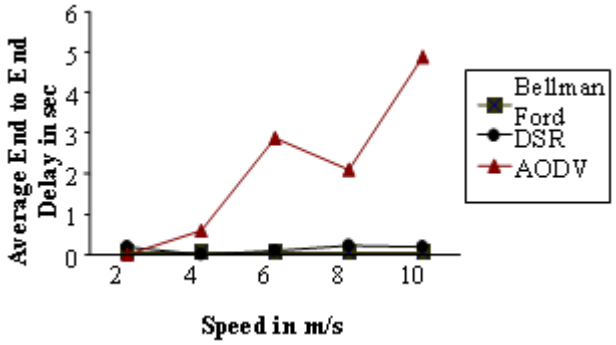


Fig. 6 (f) Average end-end delay analysis of IEEE 802.15.4 with 50% interference

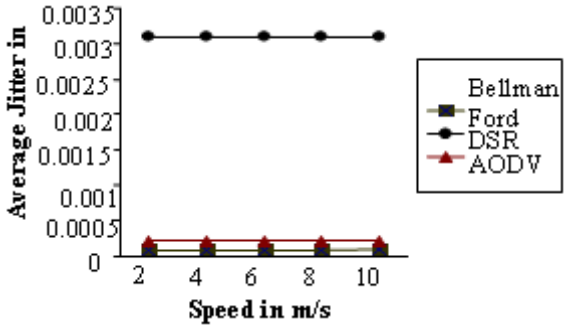


Fig. 7 (a) Average jitter analysis of IEEE 802.15.4 with out interference (Homogeneous)

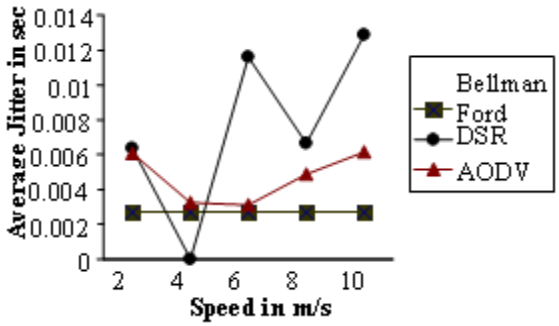


Fig. 7 (b) Average jitter analysis of IEEE 802.15.4 with 10% interference

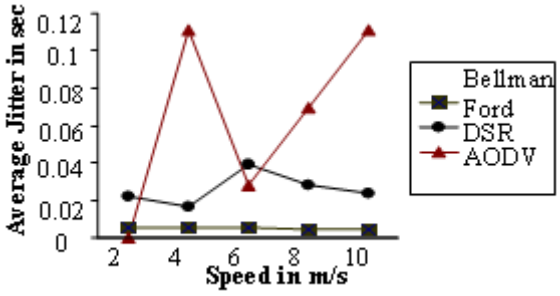


Fig. 7 (c) Average jitter analysis of IEEE 802.15.4 with 20% interference

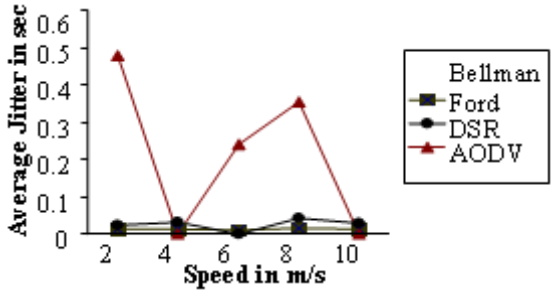


Fig.7(d) Average jitter analysis of IEEE 802.15.4 with 30% interference

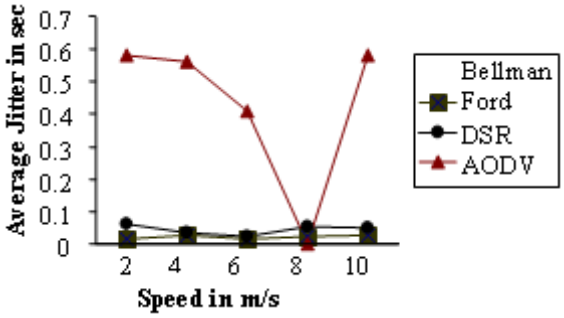


Fig. 7 (e) Average jitter analysis of IEEE 802.15.4 with 40% interference

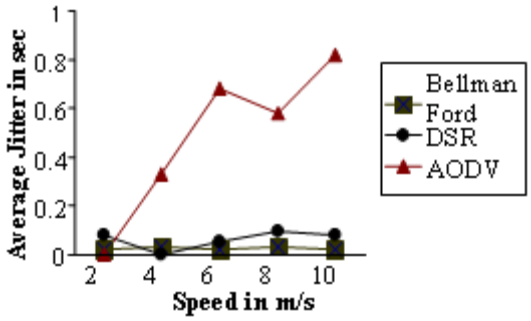


Fig.7 (f) Average jitter analysis of IEEE 802.15.4 with 50% interference

Generally, most protocols behave inefficiently and unexpectedly in heterogeneous networks. AODV assumes all links between two nodes are bidirectional which gives incorrect routing information. Therefore, this incorrect information creates large delay and packet loss in heterogeneous networking.

However, in heterogeneous networking, there are nodes which have high transmission range to connect to large number of nodes. Therefore, the number of neighbor nodes increases. Hence, as network size increases, powerful nodes will consume more memory

and bandwidth in storing neighbor tables and updating routing information. Therefore, proactive protocols might experience higher percentage of packet losing and lower success rate.

5. CONCLUSION

When the network is homogeneous there is no interference, and when IEEE 802.15.4 and IEEE 802.11b are operated at the safe distance i.e. 2 to 4 meters there is no interference. But when an IEEE 802.11b network coexists with multiple IEEE 802.11b interference occurs. For this condition i.e. for heterogeneous network; among the three protocols compared, Bellman Ford suits the best. But for a homogeneous network Bellman Ford does not perform well and AODV's performance is the best among the three protocols.

Mobility has a significant effect. Bit Error is low at high mobility speed while Bit Error is high at low mobility speed. Practically the nodes (or users) usually move at a very low speed. This implies that mobility do not affect the performance much. Hence the users are almost free to move within the coverage range.

Further, the analysis can be extended by varying the frequency offset and also by varying the spacing between the nodes. Interference mitigation can be done by developing an adaptive algorithm which combines the properties of both AODV and DSR

REFERENCES

[1] Y. Zhenzhen and H. Yingbo, "Networking by Parallel Relays: Diversity, Lifetime and Routing Overhead", 2004.

[2] Y. Zhenzhen and H. Yingbo, "Stability of Wireless Relays in Mobile AdHoc Networks", 2005.

[3] W. Erik, *et al., "*Improving Routing Performance in Wireless Ad Hoc Networks using Cross-layer Interactions", Ad Hoc Networks, Vol.5, No.5, 2007, pp.579-599.

[4] A.Y. Khan, S. Rashid, and A. Iqbal, "Mobility Versus Predictive MPR Selection for Mobile Ad Hoc Networks using OLSR", 2005.

[5] A. Valera, W.K.G. Seah, and S.V. Rao, "Cooperative Packet Caching and Shortest Multipath Routing in Mobile Ad Hoc Networks", 2003.

[6] B. Athanasios, *et al.*, "A Mobility Sensitive Approach for Efficient Routing in Ad Hoc Mobile Networks", in Proceedings of the 9th ACM International Symposium on Modeling Analysis and Simulation of Wireless and Mobile Systems, 2006, ACM Press: Terromolinos, Spain.

[7] S. Mueller and D. Ghosal, " Analysis of a Distributed Algorithm to Determine Multiple Routes with Path Diversity in Ad Hoc Networks", 2005.

[8] D. Xiaojiang and W. Dapeng, "Adaptive Cell Relay Routing Protocol for Mobile Ad Hoc Networks", IEEE Transactions on Vehicular Technology, 2006, Vo.55, No.1, pp. 278-285.

[9] J. Per, *et al.*, "Scenario-Based Performance Analysis of Routing Protocols for Mobile Ad-Hoc Networks", in Proceedings of the 5th Annual ACM/ IEEE International Conference on Mobile Computing and Networking, 1999, ACM Press: Seattle, Washington, United States.

[10] V. Laurent, J. Philippe and C. Thomas Heide, "Analyzing Control Traffic Overhead Versus Mobility and Data Traffic Activity in Mobile Ad-Hoc Network Protocols", Wirel. Netw., Vol.10, No.4, 2004, pp. 447-455.

[11] M. Abolhasan, T. Wysocki and E. Dutkiewciz, "A Review of Routing Protocols for Mobile Ad Hoc Networks", Elsevier Journal of Ad Hoc Networks, Vol.l2, No.1, 2004, pp. 1-22.

[12] H. Xiaoyan, X. Kaixin, and M. Gerla, "Scalable Routing Protocols for Mobile Ad Hoc Networks", IEEE Networks, 2002, Vol.16, No.4, pp. 11-21.

[13] P. Sholander, *et al., "*Experimental Comparison of Hybrid and Proactive MANET Routing Protocols", 2002.

[14] K.P. Ashwini and F. Hiroshi, "Study of MANET Routing Protocols by GloMoSim Simulator", International Journal of Network Management, Vol.15, No.6, 2005, pp. 393-410.

Treatment of Textile Plant Effluent by Ultrafiltration and Reverse Osmosis for Waste Water Reuse

M. Ramesh Kumar[1] and K. Saravanan[2]

[1]Department of Textile Technology, SSM College of Engineering, Komarapalayam - 638 183, Namakkal District, Tamil Nadu.

[2]Department of Chemical Engineering, Kongu Engineering College, Perundurai - 638 052, Erode District, Tamil Nadu.

E-mail: rk_textile@yahoo.co.in

(Received on 08 November 2009 and accepted on 05 December 2009)

Abstract

Textile wet processing unit involves a variety of chemicals comprising a various class of dyes along with huge amount of waster resulting from wet processing operation. Many wet processing industries about 80% needed to feed the fabric in the garment industries. So large amount of effluent will be produced from dyeing industries. For this reasons, effluent treatment planning is a burning question for a wet processing unit. The waste water from textile dyeing industries can be used for the recycling purpose, so that the shortage in water can be greatly reduced. In addition the problem of disposal of waste water from these industries can be solved if the water is reused for recycling same industries.

This paper deals with the different wastages of textile wet processing industries along with biological approach in the treatment of effluent. Waste water is treated using a sequence of physicochemical and biological unit process, the waste water is passed into Ultrafiltration (UF), two stages Reverse Osmosis (RO) membrane system where the permeate is reused for processes. This rejects about 10 -12% of the inlet volume is then subjected to reverse osmosis and sent to evaporators. Dye bath water after treating, the permeate is used in proess for dye bath preparation and this reject about 20 -25% is sent to multi effect evaporator / Solar Evaporation Pond (SEP). The final rejects from reverse osmosis system is directed to multi effect evaporator system where condensed waters are recovered. The removal of Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD) and Chloride (Cl^-) are in the range of 82 – 96%, 90 – 97% and 78 – 95% respectively. This study was carried out at Perundurai Common Effluent Treatment Plant (PCETP), SIPCOT, Perundurai, Erode District, Tamil Nadu.

Keywords: *COD, pH, Reverse osmosis, Textile effluent, Ultrafiltration, Waste water recycling.*

NOMENCLATURE

pH - Percentage of hydrogen
PCETP - Perundurai Common Effluent Treatment Plant
AVGF - Automatic valve gravity filter
ACF - Automatic carbon filter
TDS - Total Dissolved Solids
TSS - Total Suspended Solids
COD - Chemical Oxygen Demand
BOD - Biological Oxygen Demand
Ca(OH) - Lime
NaCl - Sodium Chloride
$FeSO_4$ - Iron sulphate
Cl^- - Chlorides
Free Cl_2 - Free Chlorine
TH - Total Hardness
SO_4 - Sulphate
SO_3 - Sulphide
Si - Silica
Fe - Iron
PPM - Parts Per Million
NTU - Nepelometric Turbidity Unit
PCB - Pollution Control Board
UF - Ultrafiltration
RO - Reverse Osmosis
DAP - Di-ammonium phosphate
TNPCB - Tamil Nadu Pollution Control Board
APHA - American Public Health Association
AWWA - American Water Work Association
WEF - Water Environment Federation

1. INTRODUCTION

Waste water discharged from a textile wet processing plant contains various types of impurities depending on the type of raw materials, dyes, chemicals, auxiliaries and process used. Some of these impurities are considered toxic while some are not. The toxicity or harmfulness also depends on the amount present in a certain amount of processed or waste water. Different types of water application also require different level of acceptable toxicity. For example water is used for drinking purposes, irrigation in the fields, in various types of textiles, chemicals, food processing, and leather processing, pharmaceutical industries and also to maintain the aquatic life in the canals and rivers. In all these cases different level of purity in terms of toxicity and harmfulness are required. About 50% of the textile mills are using approximately 200 – 250 liters of water per kg of fabric produced while about 20% of the mills are using below 200 liters of water per kg of fabric depending on the process sequence and water utilization practices adopted in the mill. Water pollution by the textile mills in mainly attributable to various waste liquor coming out of the unit operations in wet processing such as desizing, scouring, bleaching, mercerizing, dyeing, printing and finishing.

Water is essential to all forms of life in Erode and Tirupur in Tamilnadu are well known textile centers in India particularly for textile processing. The main water resources for these industries are Noyyal, Bhavani and Cauvery rivers. Most of the textile industries situated in these regions are small and medium, which are unorganized in nature in view of effluent treatment facilities. Most of the color effluents are discharged into the river particularly into river Noyyal, without any proper treatment. So it is necessary to find low cost and affordable treatment for the colors textile wastewater [1].

The reagents used in textile industry are very diverse in chemical composition. Over 7,00,000 tons of approximately 10,000 types of dyes and pigments are produced to be discharged as industrial effluent during the textile dyeing processes. Conventional biotreatment methods are not effective for the most of the synthetic dyestuffs due to the complex polyaromatic structure and recalcitrant nature of the dyes [2].

The textile dyeing industry is regarded as water intensive sector as it used water as the principal medium for applying dyes and chemicals and removing of impurities [3]. The main environmental concern is therefore about the amount of water discharged and the chemical, load it carries. To illustrate, for each ton of produced fabric 20 – 350m³ of water are consumed, the rather wide range reflecting the variety of involved processes and process sequences [4]. In order to reduce environmental impact, discharge limits imposed on textile mills are becoming even more stringent. Stricter regulations are forcing plant managers to upgrade existing waste treatment systems or install new systems where none were needed in the part. Moreover, in future reuse of purified effluents will be of increasing relevance due to raising water prices as well as to preserve natural water resources. The textile processing industry is therefore a prime candidate for the development of advanced water treatment strategies [5]. The quality of textile wastewater depends very much on the employed coloring matters, dyestuffs and accompanying chemicals as well as the process itself. Depending on the season and the fashion, the compositions of textile wastewater were of the same process changes often. About 8000 different coloring matters and 6900 additives are known and lead to an organic as well as inorganic pollution of the wastewater [6].

Organic matter represents the main emission load for textile waste water suggesting treatment based on biological processes. However, the introduction of effective and sustainable water recycling techniques in this branch of production is often prevented by recalcitrant organic compounds and remaining colour. Because of poor biodegradability and sometimes even toxicity of the textile wastewater components, an advanced treatment technology is necessary. Especially if reuse of treated wastewater is the objective, extensive removal of organic contents as well as almost complete decolourization is required [5].

The textile industry uses valuable dyes, which are clearly visible if discharged into public water ways. Thus, these disposals create both an aesthetic and environmental wastewater problems. At the same time, the textile industry continually seeks to conserve water and would economically benefit from dye recovered and reused. Second, water way pollution is avoided, and third, reusable water is produced [7].

2. LITERATURE REVIEW

2.1 pH

pH is the negative log base of hydrogen ion concentration and is unit-less. The hydrogen-ion concentration is an important quality parameter. The concentration range for existence of most biological life is quite narrow and critical [8]. The hydrogen-ion concentration in water is closely connected with the extent to which water molecules dissociate [9]. The solubility of heavy metals is dependent on the pH, due to this a lot of process units are heavily dependent on pH such as chemical treatment.

2.2 Total Dissolved Solids

Total Dissolved Solids, TDS, describes the amount of dissolved compounds in the water and is similar to conductivity. Water is a good solvent and picks up impurities easily. Dissolved solids refer to any minerals, salts, metals, cations or anions, which are dissolved in water. TDS consists of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulphates). It also consists of some small amounts of organic matter that are dissolved in water. TDS concentration is the sum of the cations (positively charged ion) and the anions (negatively charged ions) in the water. TDS tells the quantity of dissolved ions but not the nature of them [10]. TDS is an indicator to determine the general quality of the water. High TDS concentration is not a health hazard but more an aesthetic matter. However, if higher TDS is found it can indicate that some metal levels, such as lead or aluminium, are very high. Chemical Oxygen Demand, COD, is the amount of oxygen needed to chemically oxidize the organics in the water. A strong oxidizing agent, commonly used is potassium dichromate, which is used to oxidize the organic matter instead of microorganisms used in BOD. COD measures the same thing as BOD, but has the advantage of only taking two hours to produce the result. The temperature needs to be elevated and some inorganic compounds will interface with the test, so these have to be removed before hand. The COD is in general higher than the BOD because more compounds can be chemically oxidized than biologically oxidized. Different types of water have different translations between BOD and COD.

2.3 Chemical Oxygen Demand

Chemical Oxygen Demand, COD, is the amount of oxygen needed to chemically oxidize the organics in the water. A strong oxidizing agent, commonly used is potassium dichromate, which is used to oxidize the organic matter instead of microorganisms used in BOD. COD measures the same thing as BOD, but has the advantage of only taking two hours to produce the result. The temperature needs to be elevated and some inorganic compounds will interface with the test, so these have to be removed before hand. The COD is in general higher than the BOD because more compounds can be chemically oxidized than biologically oxidized. Different types of water have different translations between BOD and COD.

2.4 Biological Oxygen Demand

Biological Oxygen Demand, BOD, measures the readily biodegradable organic carbon. There are a number of different tests developed to determine the organic content of wastewater. BOD measures the dissolved oxygen used by microorganisms when they are oxidizing organic matter. BOD_5 is the amount of dissolved oxygen used from the water sample by microorganisms as they break down the organic matter at 20°C, over a five days period. Clean waters have a BOD_5 value of less then 1 mg/l and wastewater has between 150-1000 mg/l [9]. BOD_5 is widely used around the world for measuring organic compounds in the wastewater but it has limitations. Firstly a high concentration of active bacteria is required. Secondly only the biodegradable organics are measured. Thirdly a particularly long period of time is necessary to obtain the results. Fourthly BOD does not have stoichiometric validity after the soluble organic present in the solution has been used.

2.5 Total Suspended Solids

Total Suspended Solids, TSS, includes all particles in a known volume of liquid not passing through a filter of 1.2 micrometer pore size. TSS is measured in mg/l. The filter-solid fraction consists of colloidal and dissolved solids of particles of both inorganic, organic molecules and ions. The particles have a size of 10^{-3}-10^{-6} m [8]. TSS is commonly used to measure the amount of particles removed during the treatment process.

3. MATERIALS AND METHODS

3.1 Materials

The textile processing sector may be classified into four categories namely woven fabric dyeing, Knitted fabric dyeing, yarn dyeing and printing. The present work focus on the process and treatment methodology adopted in various sector listed above.

One of the leading knitted fabric dyeing unit, SIPCOT, Perundurai, Erode, visited and collected information on manufacturing process and waste water quantity were collected. Six number of soft flow reactors (batch process), and three numbers of Winch dyeing machines are used for knitted fabric dyeing with different capacities of machines are used for dyeing. The process is described in Figure 1.

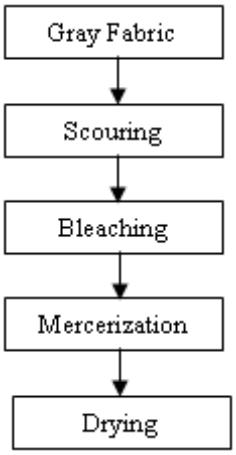


Fig.1 Sequence process of knitted fabric

The total quality of fabric processed in the unit is 1500 – 2000 kgs/day and the volume of effluent generated is of the order of 100-200 m³/day. Effluents are segregated into dye bath wastewater and wash water treatment is effected accordingly.

The effluent samples were collected after the dyeing process is over. The samples were collected as per APHA, AWWA and WEF standards. For this purpose eleven locations have been identified which is as follows:

- Wash water untreated effluent
- Dye bath plant feed parameters
- Wash water treated effluent (Biological – inlet Parameters)
- Biological treatment – secondary clarifier
- Tertiary clarifier – DMF (Dual Media Filter) output
- Ultrafiltration feed parameters
- Ultrafiltration Permeate parameters
- Ultrafiltration reject parameters
- Feed parameters of Reverse Osmosis
- Permeate parameters of Reverse Osmosis
- Reject parameters of Reverse Osmosis

3.2 Treatment Method

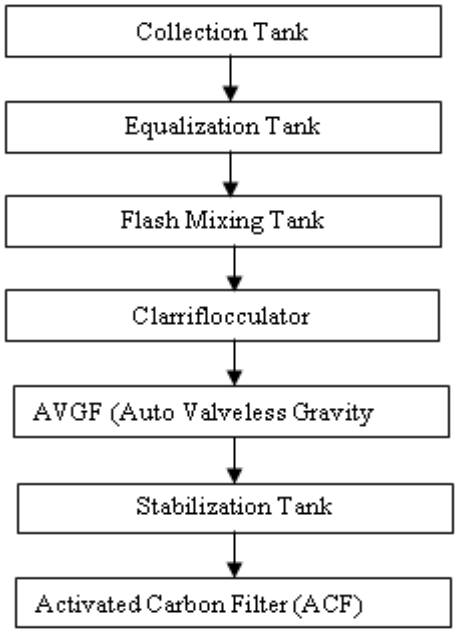


Fig. 2 Sequence process for wash water plant (Pre treatment – I)

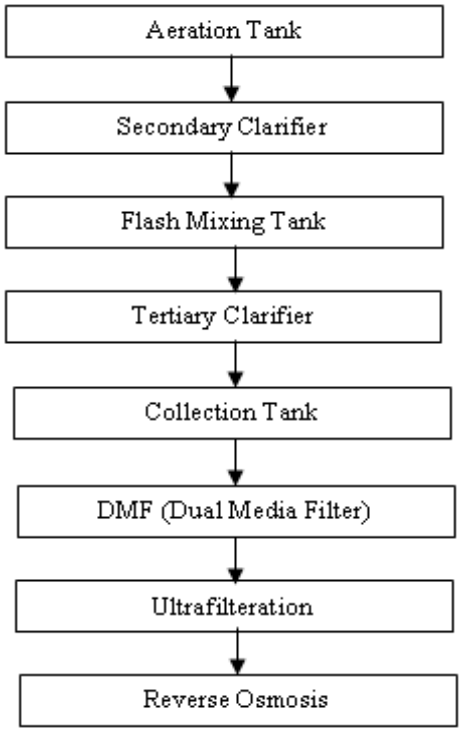


Fig. 3 Sequence process for biological and tertiary treatment (Pre treatment II)

4. RESULTS AND DISCUSSION

Table 1 Wash Water Untreated Effluent

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Alkalinity ppm	Total Hardness ppm
1	8.90	2200	850	705	320	830	1110	75
2	8.60	2140	840	680	316	815	1140	82
3	8.58	1830	550	670	310	695	1200	98
4	8.80	1540	300	700	340	460	1100	80
5	8.88	1610	320	680	310	700	1250	66
6	8.84	1560	300	650	330	582	1370	52
7	8.09	1910	620	690	340	860	1270	54
8	8.64	1940	750	645	310	800	1050	72
9	8.70	1680	520	700	324	680	1000	84
10	8.62	1720	390	710	320	696	1170	68
11	8.70	1590	360	690	330	510	1200	90
12	8.18	1890	530	650	340	610	1260	58
13	8.60	1690	555	680	320	640	1240	70
14	8.72	1760	410	600	310	620	1300	58
15	8.66	1740	520	600	330	660	1040	82

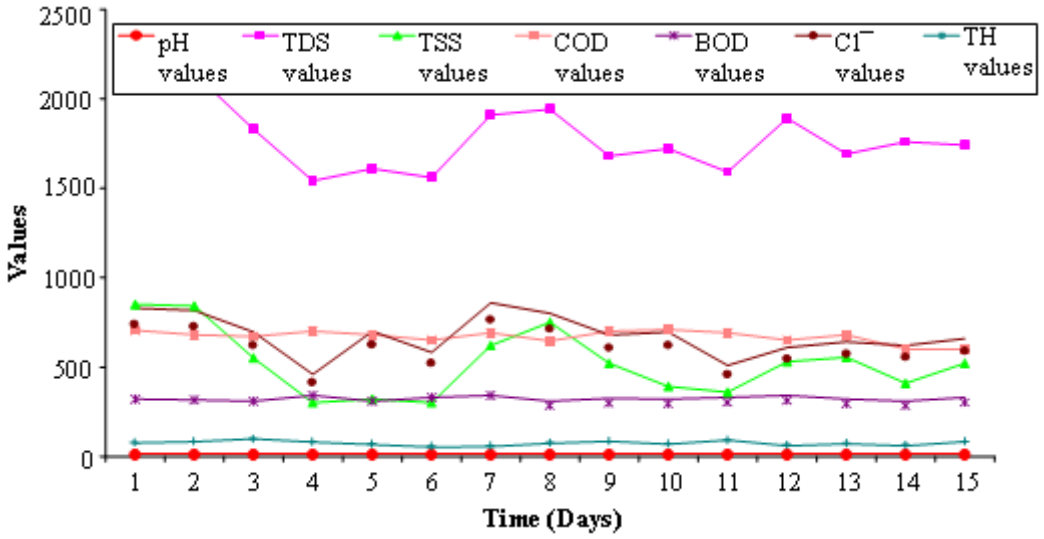


Fig. 4 Wash water untreated effluent combined values

Table 1 and Figure 4 show that the characteristics of wash water untreated effluent in the frequency of fifteen days.

Table 2 Dye Bath Plant Feed Parameters

Day	pH	TDS ppm	TSS ppm
1	8.81	46100	6760
2	8.74	35200	10005
3	8.91	52300	9760
4	8.67	46050	5920
5	8.81	34400	8300
6	8.68	45900	9320
7	9.00	29800	4930
8	8.82	22920	3340
9	8.88	52610	8730
10	8.86	38800	7690
11	8.86	68010	4260
12	8.82	37330	5010
13	8.93	27300	4350
14	8.82	17700	3900
15	8.62	34620	4080

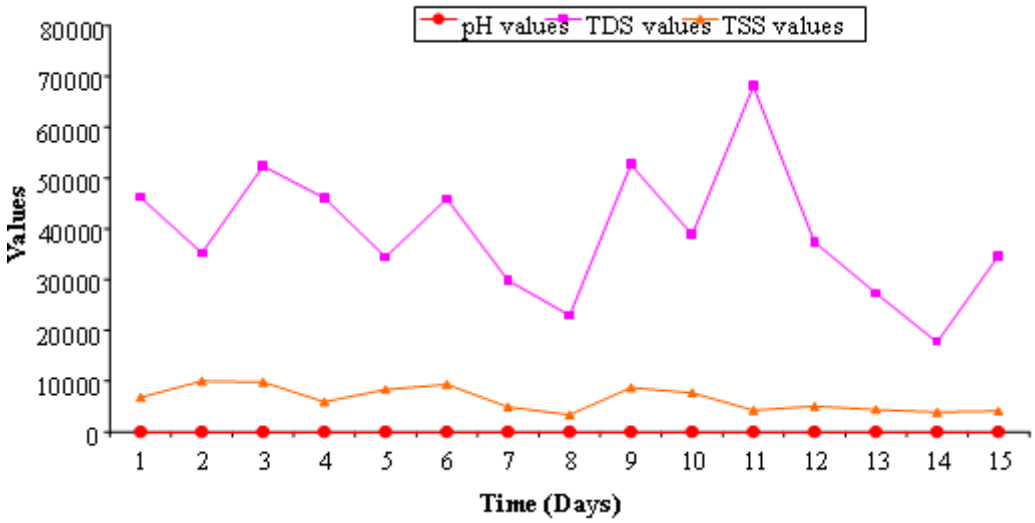


Fig. 5 Dye bath plant feed parameters combined values

Table 2 and Figure 5 represent the characteristics of untreated dye bath plant feed parameters in the frequency of fifteen days.

Table 3 Wash Water Treated Effluent (Biological Inlet Parameters)

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Alkalinity ppm	Total Hardness ppm	Turbidity ppm
1	7.15	2280	550	384	155	956	140	55	12.6
2	7.87	2270	570	392	150	908	170	58	14.1
3	8.04	2080	500	408	190	850	130	50	15.0
4	7.43	2010	280	412	162	890	140	62	13.7
5	7.29	2310	250	394	180	840	170	64	14.1
6	8.35	2030	310	402	160	880	190	52	13.6
7	7.88	2160	300	392	225	766	150	58	12.9
8	8.01	2220	500	400	200	851	140	101	17.8
9	7.90	1980	510	600	180	910	130	76	14.9
10	8.45	2360	330	620	170	770	130	36	16.0
11	7.95	2150	340	440	180	830	170	82	14.7
12	7.80	2200	340	610	190	840	160	84	13.4
13	7.90	2130	420	600	215	890	160	90	14.6
14	7.92	2173	400	590	180	770	220	78	17.0
15	8.66	2340	490	430	190	880	130	62	13.9

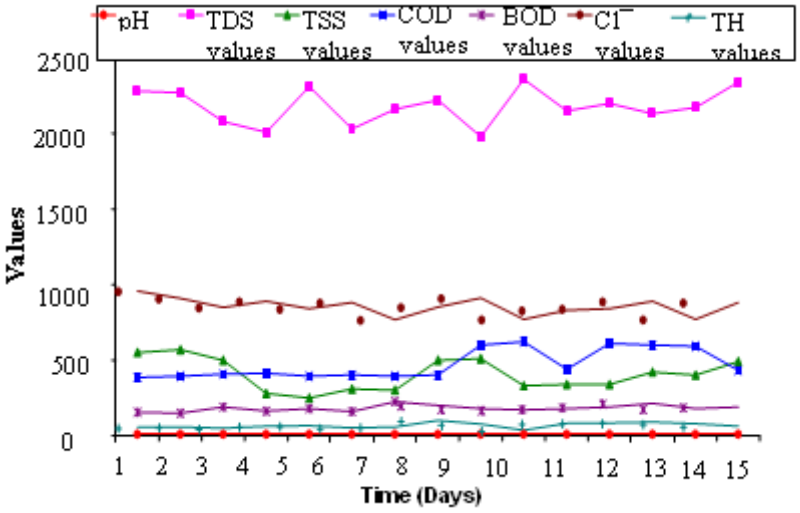


Fig. 6 Wash water treated effluent (Biological inlet parameters) combined

Table 3 and Figure 6 show that the characteristics of wash water treated effluent (Biological inlet parameters). The following results show the comparison between untreated and treated of wash water effluent.

pH reduced by – 19.66%, TDS reduced by – 11.11%, TSS reduced by – 70.59%, COD reduced by – 45.92%, BOD reduced by – 55.88%, Total Alkalinity reduced by – 90.00% and Total Hardness reduced by 48.98%.

Table 4 Biological Treatment (Secondary Clarifier)

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Hardness ppm
1	7.41	2050	130	104	30	1170	90
2	7.52	2105	120	94	28	1070	94
3	7.50	1960	100	72	26	970	80
4	7.51	2040	80	64	32	890	90
5	7.30	2110	90	68	30	1110	94
6	7.37	1980	110	88	34	1050	80
7	7.31	2010	120	90	30	856	98
8	7.41	2020	140	96	34	865	80
9	7.42	2130	90	82	32	964	81
10	7.39	1920	80	74	30	921	92
11	7.27	2190	110	86	36	88	64
12	7.22	2030	90	74	33	872	64
13	7.34	2040	120	80	36	957	56
14	7.53	2010	100	84	32	836	62
15	7.41	2140	110	86	30	842	68S

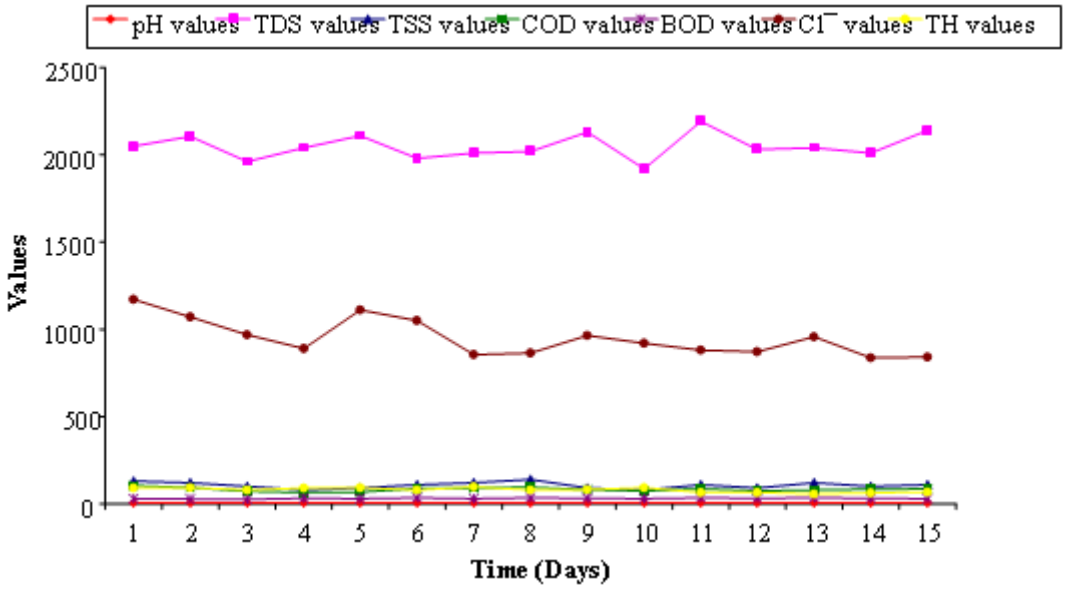


Fig. 7 Biological treatment (secondary clarifier) combined values

Table 4 and Figure 7 show that the characteristics of Biological treatment (Secondary Clarifier) parameters of pH, TDS, COD, BOD, Cl^- and Total Hardness.

Table 5 Tertiary Classifier DMF (Dual Media Filter) Output

Day	pH	TDS ppm	TSS ppm	COD ppm	BOD ppm	Cl^- ppm	Total Hardness ppm	Total Alkalinity ppm	Turbidity ppm
1	6.92	2300	36	64	24	957	102	140	2.1
2	7.02	2360	30	56	22	979	126	160	1.8
3	7.11	2270	28	48	20	920	100	130	2.2
4	6.90	2210	33	72	26	985	120	140	1.7
5	6.92	2150	29	58	24	940	132	130	2.2
6	6.83	2110	30	48	25	856	82	120	2.0
7	6.74	2120	28	64	23	886	98	150	1.6
8	6.82	2010	27	40	22	936	86	150	1.0
9	6.80	2210	30	60	28	930	88	130	1.2
10	6.88	2230	23	56	24	1014	96	110	1.5
11	6.74	2150	29	64	27	837	68	150	1.3
12	6.63	2220	38	56	28	907	110	140	1.2
13	6.90	2260	40	52	22	957	70	130	1.7
14	7.10	2210	28	53	26	990	78	150	1.4
15	6.96	2170	30	50	28	980	82	160	1.0

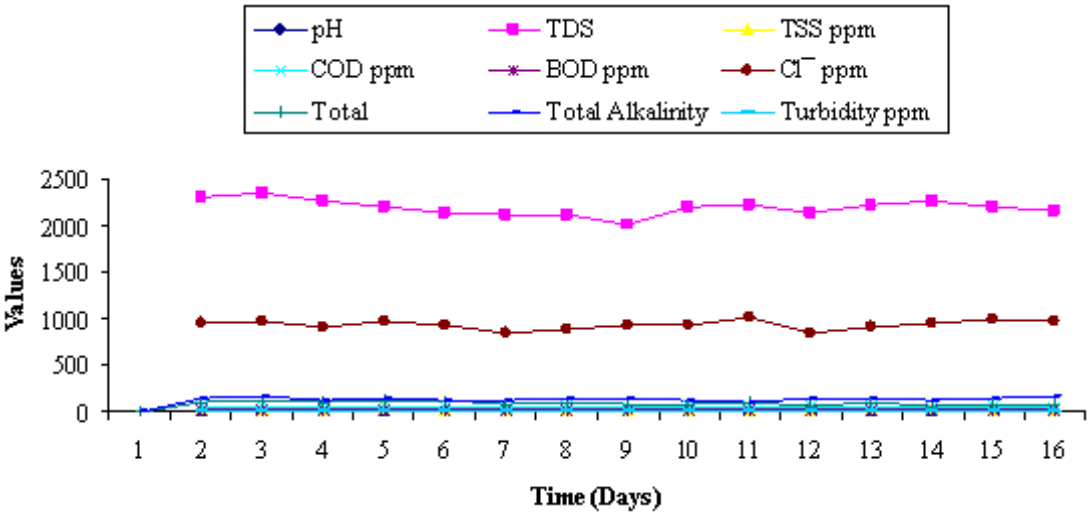


Fig. 8 Tertiary clarifier DMF (Dual media filter) output combined values

Table 5 and Figure 8 show that the characteristics of Tertiary Clarifier DMF (Dual Media Filter) out put parameters of pH, TDS, COD, BOD, Cl^-, Total Alkalinity and Turbidity.

Table 6 Ultrafiltration Feed Parameters

Day	pH	TDS ppm	Cl^- ppm	Total Hardness ppm	Total Alkalinity ppm	Turbidity ppm	Free Cl_2 ppm
1	7.38	2380	1200	230	140	0.2	0.180
2	6.40	2330	1210	190	135	0.3	0.220
3	6.80	2300	1220	170	145	0.4	0.200
4	6.92	2260	1260	166	150	0.4	0.140
5	6.71	2240	1280	130	135	0.3	0.220
6	6.72	2250	1210	150	165	1.5	0.120
7	7.00	2290	1180	140	145	1.3	0.102
8	7.05	2100	1190	130	155	0.2	0.220
9	7.30	2180	1220	150	160	0.1	0.320
10	7.35	2010	1190	140	145	0.2	0.310
11	6.93	2160	1230	130	165	0.6	0.420
12	7.00	2030	1240	120	145	0.5	0.310
13	6.90	2150	1260	160	150	0.6	0.320
14	7.10	2170	1180	130	155	0.7	0.380
15	6.95	2290	1260	140	165	0.6	0.340

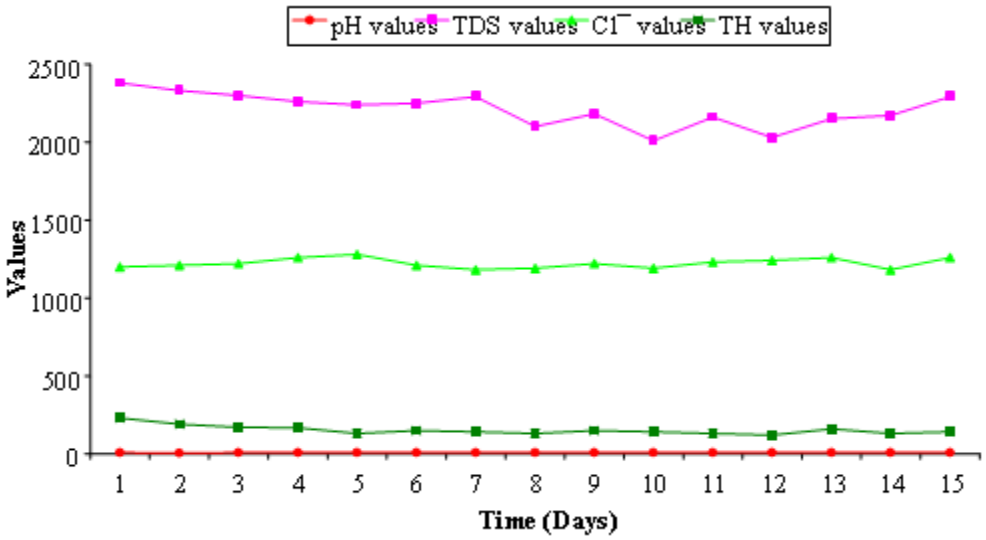


Fig. 9 Ultra filteration feed parameters combined values

Table 6 and Figure 9 show that the Ultrafiltration feed parameters.

Table 7 Ultra filtration Permeate Parameters

Day	pH	TDS ppm	Cl^- ppm	Total Hardness ppm
1	6.85	2220	1140	125
2	7.15	2300	1100	150
3	7.60	2200	1090	130
4	7.20	2210	1000	150
5	6.10	2260	1100	135
6	7.25	2220	1100	135
7	7.10	2190	1110	140
8	7.20	2160	1120	128
9	7.40	2150	1100	130
10	7.20	2400	1120	140
11	7.30	2300	1110	110
12	7.36	2360	1060	100
13	7.30	2420	1090	120
14	7.20	2460	1120	130
15	7.26	2390	1140	125

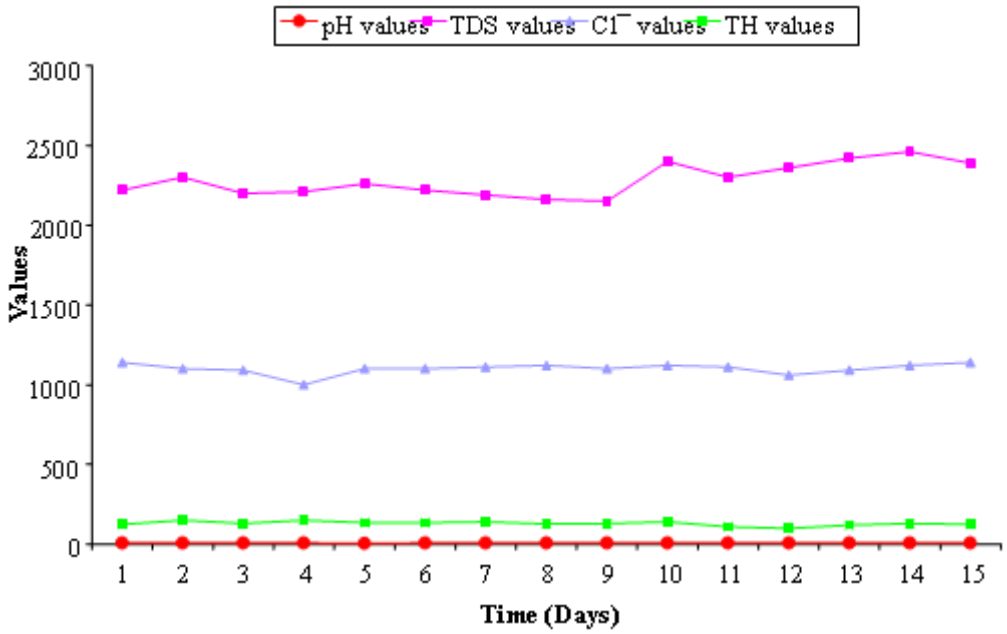


Fig. 10 Ultra filteration permeate parameters combined values

Table 7 and Figure 10 show that the Ultrafiltration Permeate parameters, which is the comparison between feed and permeate parameters of Ultrafiltration given below.

TDS reduced by - 9.70%
Cl^- reduced by - 21.90%
Total Hardness reduced by - 56.52%

Table 8 Ultrafiltration Reject Parameters

Days	pH	TDS ppm
1	7.40	2240
2	7.32	2280
3	6.80	2160
4	7.30	2150
5	7.50	2200
6	6.88	2210
7	7.35	2200
8	7.10	2100
9	7.20	2140
10	7.03	2300
11	7.40	2340
12	7.35	2390
13	7.40	2410
14	7.20	2450
15	7.30	2390

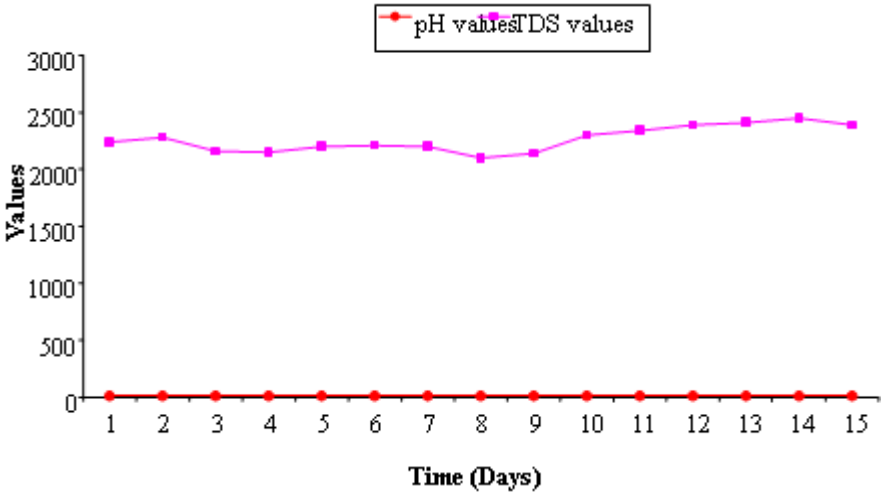


Fig. 11 Ultra filteration reject parameters combined values

Table 8 and Figure 11 show that the Ultrafiltration reject parameters, which is the comparison between feed and reject parameters of ultrafiltration reduction percentage given below.

pH reduced by - 14.67%
TDS reduced by - 17.96%

Table 9 Reverse Osmosis Feed Parameters

Day	pH	TDS ppm	COD ppm	Cl^- ppm	Total Hadness ppm	Total Alkalinity ppm	SO_4 ppm	SO_3 ppm	Free Cl_2 ppm	Si ppm	Fe ppm
1	7.38	2380	60	820	180	120	230	2.4	0.105	1.56	0.07
2	6.10	2300	64	1010	170	120	240	3.2	0.070	1.77	0.05
3	7.26	2250	56	1100	160	130	248	6.2	0.109	0.52	0.26
4	6.82	2260	54	1020	152	120	220	3.1	0.054	2.62	0.09
5	6.47	2210	62	1100	132	100	230	2.6	0.060	2.20	0.11
6	6.20	2240	40	1070	142	140	310	1.6	0.084	1.94	0.10
7	6.77	2220	32	1130	134	100	280	2.2	0.084	2.20	0.37
8	6.63	2100	20	1080	142	130	230	1.3	0.037	1.68	0.13
9	6.95	2120	32	1130	138	140	230	1.8	0.065	1.74	0.07
10	6.75	2270	34	1100	136	110	260	1.6	0.080	1.60	0.13
11	6.50	2240	36	1000	132	120	240	1.9	0.071	1.69	0.18
12	6.43	2210	40	1030	130	90	300	2.4	0.080	2.20	0.13
13	7.01	2200	32	1060	128	120	240	5.8	0.072	10.70	0.10
14	7.10	2140	44	1120	120	130	260	2.2	0.056	10.55	0.05
15	6.89	2120	42	1110	114	120	290	2.7	0.062	8.25	0.06

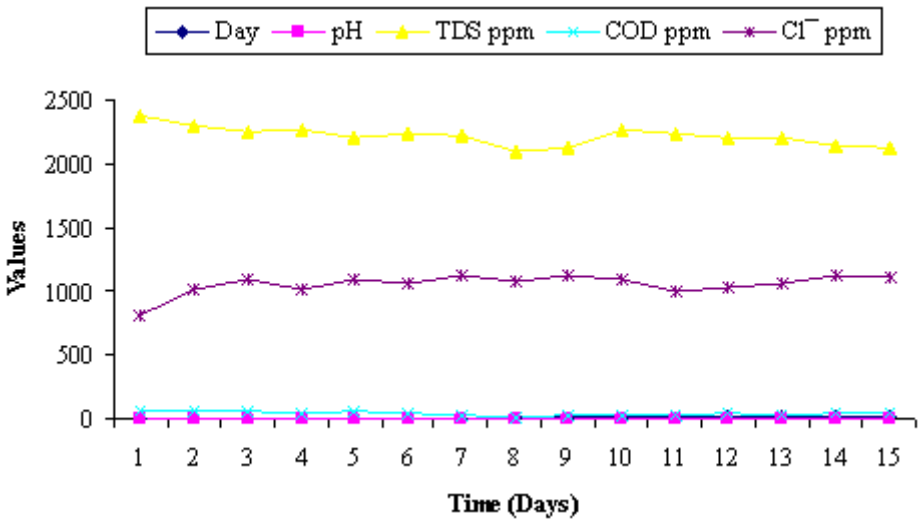


Fig. 12 Reverse osmosis plant feed parameters combine values

Table 9 and Figure 12 show that the Reverse Osmosis feed parameters of pH, TDS, Cl^-, Total Hardness, Total Alkalinity, SO4 , SO3, Free Cl2 , Si and Fe in the frequency of fifteen days.

Table 10 Reverse Osmosis Permeate Parameters

Day	pH	TDS ppm	Cl^- ppm	TH ppm
1	6.7	88	72	5.0
2	6.6	82	60	6.0
3	6.8	90	74	6.0
4	6.9	92	80	6.0
5	6.3	70	52	2.0
6	6.4	80	62	6.0
7	6.5	90	68	6.0
8	6.3	86	61	5.0
9	6.5	82	58	2.0
10	6.2	94	70	6.0
11	6.0	98	52	1.5
12	6.2	90	55	2.0
13	6.1	100	61	1.5
14	6.2	140	82	2.0
15	6.2	130	80	2.5

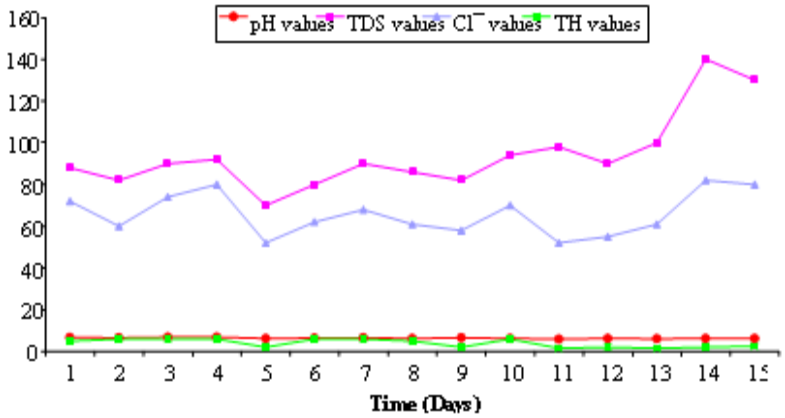


Fig. 13 Reverse osmosis permeate parameters combined values

Table 10 and Figure 13 show that the Reverse osmosis parmeate parameters, from the results a comparison was made between Reverse osmosis feed and permeate, the reduction percentage can be given below.

pH reduced by - 18.70%
TDS reduced by - 96.55%
Cl^- reduced by - 95.40%
Total Hardness reduced by - 99.17%

Table 11 Reverse Osmosis Reject Parameters

Day	pH	TDS ppm	Cl^- ppm	TH ppm
1	6.40	15300	8200	1300
2	6.50	16800	9300	1240
3	6.30	14400	8400	1350
4	7.01	18250	9200	1370
5	6.65	17400	8150	1140
6	6.00	1800	7800	1200
7	7.00	21000	8200	1250
8	6.90	18300	9300	1290
9	7.20	20240	8300	1250
10	6.90	17300	8600	1210
11	6.20	16400	8200	1130
12	6.00	12200	5637	690
13	6.50	17000	10280	1210
14	7.00	16100	11400	1140
15	7.10	18200	9040	1050

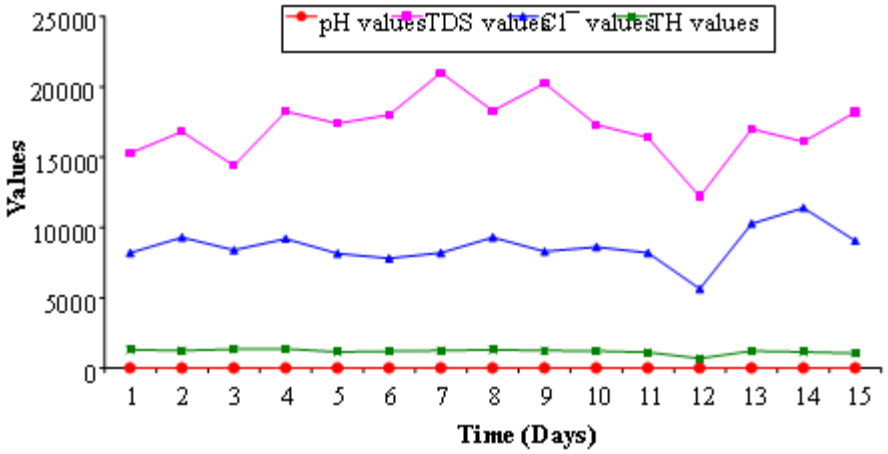


Fig. 14 Reverse osmosis reject parameters combined values

Table 11 and Figure 14 show that the Reverse osmosis reject parameters of pH, TDS, Cl^- and Total Hardness. The comparison between reverse osmosis feed and reject reduction percentage was given below.

pH reduced by - 15.28%
TDS reduced by - 90.00%
Cl^- reduced by - 92.81%
Total Hardness reduced by - 91.23%.

5. CONCLUSION

From the study, the following conclusions can be derived:

- At present wet processing industries in India are under pressure to install CETP. For financial and space constraints, it is difficult to meet the deadline of installation. So, joint efforts are needed by water technologists and textile industries experts to reduce the consumption in industry while the used industry should optimize water consumption.
- RO was successfully used for the treatment of a knitted textile effluent.
- The textile plant effluent was treated by a biological treatment process.
- The recycling of treated waste water and zero waste water discharge concept are found technically flexible

and economically visible in the textile dyeing industries. The average percent removals of BOD, COD, TDS and Chlorides in the advance treatment technology are in the range of 88-98%, 91-97% and 75-97% respectively.

- Wastewater treatment plant installation and commissioning cost is in
  i. The range of 40 – 100 lacs for small scale (below 300 m^3/d).
  ii The range of 100 – 200 lacs for medium scale (300 - 600 m^3/d).
  iii The range of 200 – 300 lacs for large scale (above 600 m^3/d) textile dyeing industries.
- In this biological treatment of effluent, though the installation cost and running cost are less.
- Less amount of chemicals only used in this process and hence recovery is easy than other methods.
- These qualities suggest that use of biological method for treating effluent may give good results.
- Waste water can be treated new techniques to produce fresh water quality for non-portable uses at reasonable cost.
- To introduce a new and cost effective waste water treatment technique to reduce the environment and pollution problem due to textile industry
- To provide a solution to the preventing environment problems due to waste water from textile industry
- Reverse osmosis permeate water 90% used for recycling.
- Reverse osmosis permeate gives better results of TDS - 96%, Cl^- - 95% and Total Hardness – 99% reduced.
- These industries have a telling need for technologically feasible and economically justifiable means for

  i. Product, process ad quality improvement.
  ii. Sustainable technology for processing.
  iii. Effluent utilization of process water.
  iv. Clean and green technology aiming at zero discharge eventually.

REFERENCES

[1] R. Malathy, "Treatment of Textile Effluent using Fly Ash Adsorbent - A Case Study", for Tirupur Region, Nature Environmental and Pollution Technology, India, 2007, pp.649 -654.

[2] N. Azbar, T.Yonar and K.Kestioglu, "Comparision of Various Advanced Oxidation Process and Chemical Treatment Method for COD and Colour Removal from Polyester and Acetate Fibre Dyeing Effluent", Chemosphere 55, 2004, pp.35-43.

[3] D.G. European Commission, JRC, "Integrated Pollution Prevention and Control (IPPC), Reference Document on best Available Techniques for the Textile Industry", http:// europa.eu.int/comm./ environment/ippc/brefs/text_bref_0703.pdf.2002.

[4] M. Jekel, "Wastewater Treatment in the Textile Industry", in: Treatment of Wastewater from Textile Processing, TU-Berlin Schriftenreihe Biologische Abwasserreinigung, Berlin, 1997, Vol.9.

[5] U.Ratt and R.Minks, "Overview of Wastewater Treatment and Recycling in the Textile Processing Industry Water", Sci Technology, Vol.40, No.1, 1999, pp.137-144.

[6] V. Wagner and Uber, "Die oxidative Behandlung Van fabigen Abwassern and Losungen ans der Textilveredlungsindustric mit kombinationen von O_3, H_2O_2, UV-Strahlung", Ph.D Thesis, Technische Universitat Munchen, Germany, 1995.

[7] A.Akbari, S. Desclaux, J.C Remigy and A.Aptel., "Treatment of Textile Dye Effluents using a New Photogrfted Nonofiltration Membrane", Desalination Vol.149, 2002, pp.101-107.

[8] G. Tchobanoglous, "Wastewater Engineering: Treatment and Resue, 3rd edition, McGraw Hill,Boston, 1991.

[9] G. Kiely, "Environmental Engineering", McGraw Hill, London, 1997.

[10] WU CEQ, Wilkes University Center for Environmental Quality GeoEnvironmental Science and Engineering Department, Total Dissolved Solids, 2004 <http://wilkes 1,wilkes.edu/-eqc/tds.htm>.

A Study of the Process of Tube Making in Hard-to-Work Materials

Sukhwinder Singh Jolly[1] and D.S. Bedi[2]

[1]Sri Sukhmani Institute of Engineering and Technology, Dera Bassi - 140 507, Punjab.

[2]Institute of Engineering and Technology, Bhaddal - 140 108, Punjab.

E-mail: ssjolly2004@yahoo.co.in

(Received on 25 March 2009 and accepted on 10 July 2009)

Abstract

The trend in moving the metal is for the process where the forming forces localize the deformation zone to a small volume of the work piece. Thus working range is limited between the yield point and the instability point of the respective stress strain curve. Method has been suggested to increase the ductility of hard-to-work material in this paper. Average yield stress of the material has been calculated and Bridgeman Law of Volume constancy has been satisfied. Power and forces required for making tube when diameter of roller is not affected as well as when roller flattens has been discussed. Comparison has been made with the work carried out by other researchers while dealing with soft as well as hard-to-work materials.

Keywords: *Tupe making, Hard-to-work materials*

NOMENCLATURE

D_R	Diameter of the roller
d	Diameter of the mandrel
ε	Strain rate
$\varepsilon_{xy,}\ \varepsilon_{y,}\ \varepsilon_z$	Strain rates in three coordinate directions
t_o	Thickness of the blank/work piece/ tube hollow
t	Thickness of the finished tube
K	Constant used in equation for volume constancy
m	Friction factor
σ_y	Average yield stress of the material
ω	Angular speed of the roller
U_i	Energy of plastic deformation under roller
U_a	Energy due to velocity discontinuity at the entrance
U_r	Energy due to velocity discontinuity at the exit
U_f	Frictional energy consumed on the contact surface between the roller and the work piece
U_e	Total energy consumed in the deformation
P_r	Radial force i.e. force in y-direction
P_z	Axial force i.e. force in the direction of pull i.e. force in z-axis
S_f	Contact area on the x-z plane
R	Reduction in wall thickness (%)
V_0	Velocity of the deforming material in the tangential direction to the tube at the contact point between roller and deforming tube
V_x	Vzelocity in the circumferential direction parallel to V_0 of the element is situated at angle È with the vertical
V_z	Velocity of pull of tube parallel with mandrel along its perpendicular axis.
Y_f	Volume of metal flow over the contact area in direction of y axis
α	Half cone angle of the mandrel / angle of the roller
θ	Inclination of an element in the deformation zone situated at angle with the vertical
θ_1	Maximum inclination of an element in the deformation zone situated at an angle with the vertical

1. INTRODUCTION

Philosophy of moving the metal rather than removing it encouraged the researchers and technologists to go in for processes where the forming forces localize the deformation zone to a small volume of the work piece, thus saving in the materials and energy for getting the final shape.

Therefore in metal forming, the working range is limited between the yield point and the instability point of respective stress strain curve of the material.

Based on extensive experimentation on different types of materials including brittle materials, Bridgeman has enunciated a law (which is known after his name) which states that when a material is deformed whatever volume change has to occur it takes place upto the elastic limit point even though material may be deformed plastically upto instability point. Mathematically for the plastic range this law can be expressed by the following equation.

$$V = \text{Constt.}$$
$$\text{or } dV = 0$$

In other words, this equation is synonymous with well known fluid flow equation of continuity [1].

In the so called ductile or soft materials the working range is usually very large and in the so called hard-to-work materials, this range is relatively very small. Thus, these so called hard-to-work materials like titanium and its alloys viz Incoloy, Inconel and Stainless Steel are difficult to work due to following factors:

i. Higher stress level for a given strain.
ii. Small range of strain between yield point and instability point.

Bridgeman has confirmed experimentally that in many materials the ductility improves with increased hydrostatic pressure [4].

M. Hayama and H.Kudo (1979) have studied the diametral growth and working forces in tube spinning [2]. M. Hayama and H. Kudo (1979) have also studied the mechanism of deformation in tube spinning on the basis of the observation of metal flow experimentally [3]. R.P. Singhal, S.R. Das and Rajnish Prakash (1987) have studied the shear spinning of long tubes which are also axially pulled side by side[9]. This paper presents the results of experiments conducted on commercially pure titanium, Incoloy 825, Inconel 600 and Stainless Steel AISI-304, R.P. Singhal, P.K. Saxena and R. Prakash (1990) have presented a generalised expression for the estimation of power required in the spinning of long tubes, in which the material is assumed to be perfectly plastic and to obey the von mises criterion of yielding, and the tools are assumed to be rigid [10]. R.P. Singhal and Rajnish Prakash (1990) have carried out an experimental study of shear spinning of tubes of hard-to-work materials [8]. Shear spinning technology for manufacture of long thin wall tubes of small bore has been discussed by Rajnish Prakash and R.P. Singhal (1995) [6].

However in the attempt made by Singhal (1990), following points are found lacking without which his analysis is not only incomplete but totally wrong.

i. Singhal has neither brought out the special characteristics of 'hard-to-work' materials nor given their constitutive equation for the plastic region so that mathematical model for the forming process could be developed.
ii. In addition strangely Singhal has not even developed the theoretical analysis for the 'hard-to-work' materials by using constitutive equation of the material.
iii. He has done the analysis for the materials without taking into account the constitutive equation. One can easily argue as to what type of material he has analysed in his work whether it is for soft materials or hard-to-work materials.
iv. There are three rollers which are mounted on trunions which in turn rotate along with chuck. The speed of the roller is different from the rotational speed of chuck as it is an epicyclic train. But he has taken them same for the analysis.
v. Singhal states that average value of yield stress has to be evaluated on the basis of the average height of area under the stress-strain limit, but he has not given the data or the coordinates of stress-strain curves for materials he has experimented on.

For using upper bound theorem, the basic requirement of the 'kinematically admissibility of velocity field' has not been met since the velocity boundary conditions have not been satisfied in the analysis by Singhal (1990).

In the light of above comments, the authors had made correct analysis of the process of tube making in hard-to-work materials.

2. YIELD UNDER PLANE-STRAIN CONDITIONS

Plane strain is defined as a condition in which (a) the flow is everywhere parallel to a given plane, say the (x,y)

plane, and (b) the motion is independent of z. Thus one principal strain-increment, say $d\in_2$, is zero. It follows that if there is no volume change $d\in_1 = -d\in_3$, assuming no elastic deformation, that is assuming an incompressible rigid-plastic material. The deformation is thus pure shear-strain. It is assumed that pure shear strain is produced by pure shear stress [7].

When we apply Von Mises yield criterion and upper bound technique then, it is convenient to suppose that the diameter of the tube remains constant, and that the wall thickness alone is changed during tube making. There is then no hoop strain, and plane-strain conditions can be assumed. Let $d\varepsilon_1$, $d\varepsilon_2$ and $d\varepsilon_3$ be the principal components of an increment of strain. Then

$$\overline{d\varepsilon} = \sqrt{\frac{2}{3}(d\varepsilon_1^2 + d\varepsilon_2^2 + d\varepsilon_3^2)}$$

In uniaxial test

$$d\varepsilon_2 = -\frac{1}{2}d\varepsilon_3 = d\varepsilon_1$$

$$\overline{d\varepsilon} = \sqrt{\frac{2}{3}\left[\left(-\frac{1}{2}d\varepsilon_3\right)^2 + \left(-\frac{1}{2}d\varepsilon_3\right)^2 + (d\varepsilon_3)^2\right]}$$

$$= \sqrt{\frac{2}{3}\left[\frac{d\varepsilon_3^2}{4} + \frac{d\varepsilon_3^2}{4} + d\varepsilon_3^2\right]}$$

$$= \sqrt{\frac{2}{3}\left[\frac{6\,d\varepsilon_3^2}{4}\right]}$$

$$= \sqrt{\frac{2}{3}\left[\frac{3}{2}\,d\varepsilon_3^2\right]} = d\varepsilon_3$$

Thus $\frac{\overline{d\varepsilon}}{d\varepsilon_3} = 1$

In plane strain conditions

$d\varepsilon_2 = 0$, $d\varepsilon_1 = -d\varepsilon_3$

Thus $\overline{d\varepsilon} = \sqrt{\frac{2}{3}\left[(-d\varepsilon_3)^2 + (o)^2 + (d\varepsilon_3)^2\right]}$

$$= \sqrt{\frac{2}{3}(d\varepsilon_3^2 + d\varepsilon_3^2)}$$

$$\sqrt{\frac{2}{3}x2d\varepsilon_3^2} = \frac{2}{\sqrt{3}}d\varepsilon_3$$

$$\overline{d\varepsilon} = 1.155\,d\varepsilon_3$$

$$\frac{\overline{d\varepsilon}}{d\varepsilon_3} = 1.155$$

Thus percentage increase in ductility

$$\frac{1.155-1}{1}x100 \qquad = 15.5\%$$

Thus ductility of the hard-to-work material increases by approximately 15%.

3. AVERAGE YIELD STRESS

Stress-strain curve for Titanium (one of the hard-to-work materials) has been taken from Metals handbook [5]. Curve fitting has been carried out with the help of Excel. From this we have obtained constitute equation for the stress-strain coordinates. Then average yield stress calculations has been made on the basis of selecting strain hardening portion Rowe (2000). This is the portion between the elastic limit point and the instability point as shown in Figure 1.

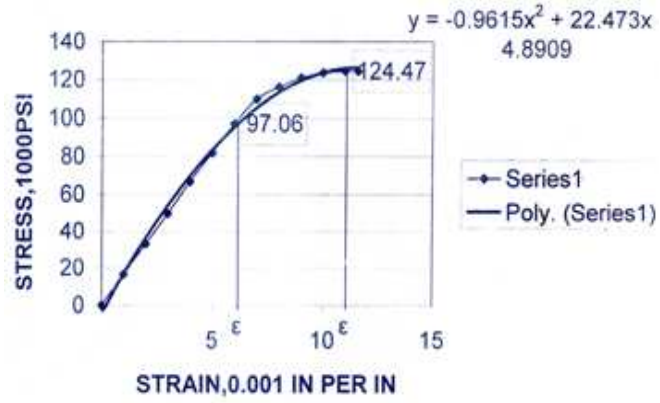


Fig.1 Average yield stress

Average Yield Stress Calculation

The equation for stress is given by:

$\sigma y = -0.9615\,\varepsilon^2 + 22.473\,\varepsilon - 4.8909$

The average stress is given by equation

$$\sigma y = 1/(\varepsilon_a - \varepsilon_b) \int_{\in_b}^{\in_a} \sigma_y\, d\varepsilon$$

$$= 1/(11-6) \times 10^3$$

$$\int_6^{11} (-0.9615\ \varepsilon^2 + 22.473\ \varepsilon - 4.8909\ )\, d\varepsilon$$

$= 1/5 \ x\ 10^3 \left| -0.9615 \ \varepsilon^3/3 + 22.473\ \varepsilon^2/2 - 4.8909\ \varepsilon \right|_6^{11}$

$= 1/5 \times 10^3 [\{-0.9615 (11^3/3) + 22.473 (11^2/2)$
$-4.8909 (11)\} - \{-0.9615 (6^3/3) + 22.473$
$(6^2)/2 - 4.8909 (6)\}]$
$= 1/5 \times 10^3 [-.426.58 + 1359.6 - 53.80] -$
$[- 69.23 + 404.51-29.34]$
$= 1/5 \times 10^3 [879.22 - 305.94]$
$= 1/5 \times 10^3 [573.28]$

$\sigma_y = 114.66 \times 10^3$ psi
$\sigma_y = 114.66 \times 10^3 \times 6.895 \times 10^3$ N/m^2
(1 psi = 6.895×10^3 N/m^2)
$\sigma_y = 790.581 \times 10^6$ N/m^2
$\sigma_y = 790.581$ N/mm^2 ~ 791 N/mm^2 = 791MPa

4. ROTATIONAL SPEED OF ROLLERS

In this system, there are three rollers which are mounted on trunion which in turn rotate along with chuck. As the three rollers not only revolve along with chuck about the axis of tube but also rotate about their own trunion as well. The analysis of the system is made by considering it to be an epicyclic train. The rotational speed of rollers is different from the rotational speed of chuck. There is no slipping in the rollers and tube material.

To find the rotational speed of roller, the epicyclic trainshown in Figure 2 is analysed as given below:

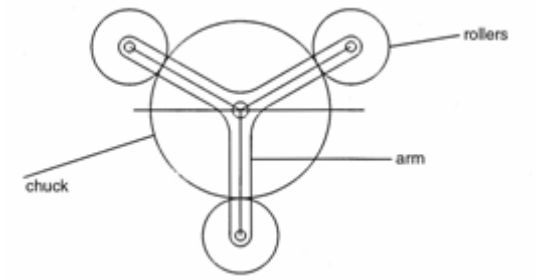


Fig.2 Rotational speed of roller

Condition of Motion	Rotation of Arm/Trunion	Rotation of Pipe	Roller Speed
Arm Fixed, Pipe is given Anti-Clock wise (positive) Rotation	0	+1	-Np (Dp/Dr)
Arm Fixed, Pipe is given +x Rotation	0	+x	-x (Dp/Dr)
y Rotations Added to System	y	x+y	y-x (Dp/Dr)

Since Pipe is fixed
$x + y = 0$
$x = -y$
If chuck speed (y) = 500 r.p.m.
x = -500 r.p.m.
Roller speed, $N_R = y\text{-}x\ (Dp/Dr)$

$$= 500 + 500 \left(\frac{25}{80}\right)$$

$$= 500\ 1+ \frac{25}{80}\Big)$$

$$= 500 \left(\frac{105}{80}\right)$$

$N_R = 656.25$ rpm
Angular speed of Roller,
$\omega = 2\pi Nr/60$
$= (2 \times 3.14 \times 656.25)/60$
$\omega = 68.68$ rad/sec
~ 69 rad/sec

5. CRITERION

It is assumed that there is no build up of the material ahead of the roller. The deformation is localised in a small volume of the work piece and there is work hardening of the material. But for the purpose of analysis the same is not taken into account and the material is assumed to be perfectly plastic obeying Von Mises yield criterion. This assumption permits the use of upper bound analysis for the purpose of estimating forces for designing the equipment. In the first instance rollers are assumed to be perfectly rigid bodies, however later flattening of rollers has been taken into account. The size of the roller is large enough in comparison with the diameter and thickness of the tube. It is convenient to suppose that the diameter of the tube remains constant, and the wall thickness alone is changed during process. Thus plane-strain conditions can be assumed.

In the process each element at a given radius is reduced in thickness with a simultaneous elongation in the axial direction. The elongation in length of tube is proportional to the reduction in wall thickness, therefore, the volume constancy condition is applied in the analysis. Figure 3 shows how the thickness is being reduced by pulling the tube inside the rollers. The x-axis coincides with the direction of the movement of the contact surface of the rollers and z-axis is parallel to the axis of the tube.

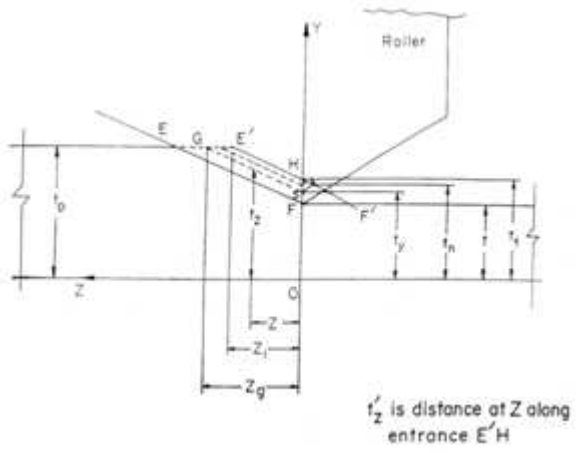


Fig.3 Reducing of thickness

The rollers are making epicyclic train with the tube and angular speed ù of the roller is calculated from there and from this V_o which is the velocity of the deforming material in the tangential direction to the tube at the contact point between roller and deforming tube is calculated.

The percentage reduction 'R' in terms of wall thickness is given by

$$R = \frac{t_o - t}{t_o} \times 100\%$$

Where t_0 is the initial wall thickness and 't' is the thickness after reduction.

The equation for flow rate

$$\text{Flow rate} = \int_0^{\theta_1} 2\pi\left(v_0^2\cos^2\theta + v_z^2\right)^{1/2}\left[\frac{D_R}{2} + t\right]\frac{D_R}{2}\sin\theta\, d\theta$$

$$- \int_0^{\theta_1} 2\pi\left(v_0^2\cos^2\theta + v_z^2\right)^{1/2}\frac{D_R}{2}\cos\theta\frac{D_R}{2}\sin\theta\, d\theta$$

$$= I_1 - I_2$$

Also flow rate = Area of cross-section x v_z

$$I_1 - I_2 = 2\delta\,(t_0 - t)\,KV_0$$

$$F = I_1 - I_2 - 2\delta\,(t_0 - t)\,KV_0$$

The computer programme was run to find the value of K. This value of K satisfies the condition of volume constancy.

6. STRAIN RATES

Strain rate in x-direction

$$\varepsilon_x = \frac{4xV_0}{D_R^2\left[1 - \frac{4x^2}{D_R^2}\right]^{1/2}} \quad \ldots (1)$$

Strain rate in z-direction

$$\varepsilon_z = -K\omega\tan\alpha \quad \ldots (2)$$

Strain rate in y-direction

$$\varepsilon_y = -K\omega\tan\alpha - \frac{4xV_0}{D_R^2\left[1 - \frac{4x^2}{D_R^2}\right]^{1/2}} \quad \ldots (3)$$

The equivalent plastic strain in given by

$$\varepsilon = \sqrt{4\left[\frac{16x^2V_0^2}{D_R^2\left[1 - \frac{4x^2}{D_R^2}\right]} + K^2\omega^2\tan^2\alpha - \frac{4xV_0K\omega\tan\alpha}{D_R^2\left[1 - \frac{4x^2}{D_R^2}\right]^{1/2}}\right]} \quad \ldots (4)$$

7. ESTIMATION OF THE TOTAL ENERGY

(a) Estimation of plastic deformation under roller

$$U_i = \frac{2}{\sqrt{3}}\sigma_y\int_0^{\theta_1}\varepsilon \quad \ldots (5)$$

(b) Energy due to Velocity Discontinuity at the entrance

$$U_a = \frac{1}{\sqrt{3}}\sigma_y\int_0^{z_1}\int_0^{t'_z}\sqrt{\left\{-\left[\frac{4xV_0}{D_R^2\left[1 - \frac{4x^2}{D_R^2}\right]^{1/2}}.y - kwy\tan\alpha + \right]^2 + (KV_0)^2\right\}}\,dydz \quad \ldots (6)$$

(c) Frictional energy consumed on the contact surface between the roller and the work piece

$$U_f = \frac{\sigma_y}{\sqrt{3}}m\int_0^{\theta_1}\int_0^{z_g}|KV_0|\frac{D_R}{2}\cos\theta\, d\theta\, dz \quad \ldots (7)$$

(d) Energy due to Velocity discontinuity at the exist of the metal from the roller

$$U_r = \frac{1}{\sqrt{3}}\sigma_y(v_z - \omega\frac{D_R}{2})\frac{D_R}{2}\,x\,\theta_1 x(t_0 - t)\cos\alpha \quad \ldots (8)$$

(e) Total Energy U_e consumed in the deformation

$$U_e = (U_i + U_a + U_f + U_r) \quad \ldots (9)$$

8. WORKING FORCES

When we integrate the velocity of displacement V_y in the direction of y-axis over the contact area we get say Y_f.

$$= \int_0^{x_a}\int_0^{z_g} \varepsilon_y . y . dz\, dx$$

$$= \int_0^{x_a}\int_0^{z_g} \varepsilon_y . \frac{v_0}{v_z} dz\, dx$$

$$y = \frac{v_0}{v_z}$$

$$x = \frac{D_R}{2}\sin\theta$$

$$dx = \frac{D_R}{2}\cos\theta\, d\theta$$

$$Y_f = \frac{v_0}{v_z}\int_0^{z_1}\int_0^{\theta_1} (\varepsilon_y \frac{D_R}{2}\cos\theta\, d\theta)\, dz$$

Contact area on the x-z plane is obtained by

$$S_f = \int_0^{\theta_1} z_1 dx = \int_0^{\theta_1} z_1 \frac{D_R}{2}.\cos\theta\, d\theta$$

Radial Force P_r, is given by

$$P_r = \frac{U_e}{Y_f}.S_f \qquad \text{.... (10)}$$

Pulling force/Axial Force P_z, is given by

$$P_z = P_r . \tan\alpha \qquad \text{.... (11)}$$

Working Data

Diameter of the Roller 'D_R' = 80 mm.
Diameter of the mandrel 'd'= 18 mm.
Thickness of the tube 't_o' = 3.5 mm
Reduction in thickness 'R' = 10, 15, 20, 25, 30,35,40%
Angle of Roller 'α' = 20degrees
Friction factor 'm' = 0.05 nominal

Average yield stress of the material 'σ_y' = 791 N/mm^2 (791 MPa)

Angular speed of roller 'ω' = 69 rad/sec

Constant used in equation

for volume constancy 'K' = 1.95
Maximum inclination of an element in the deformation zone situated at an angle with the vertical '$\grave{e}_1$' = 14°

9. RESULTS AND DISCUSSION

Thus, the power consumed, the radial force and the axial force or pulling force can be calculated numerically from equations. Equations 5-9 give the variation of the power consumption and equations 10 and 11 given the variation of forces with various process variables. The effect of variation in the different process variables is shown in graph of Figures 4-15.

9.1 Reduction vs. Total Energy

This graph shows the variation in the total power consumption in deformation with respect to the percentage reduction. It can be noted that the power consumption increases with the increase in the percentage reduction. It is quite obvious that as the thickness of the work piece increases i.e. volume of the material deformed increases more power is required for deformation and also to push the material over the mandrel.

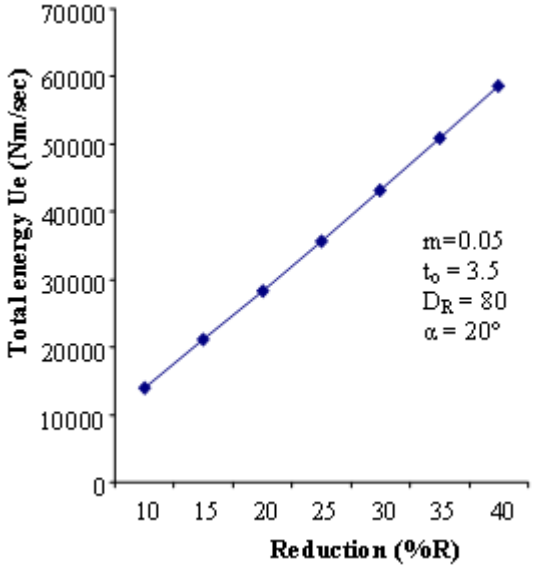


Fig. 4 Relationship between U_e and R

9.2 Reduction vs. Radial Force (Pr) and Axial Force (Pz)

These graphs shows the variation in axial force and radial force with respect to the percentage reduction in the thickness of the tube. It can be seen that with the increase in percentage reduction in wall thickness the radial and axial force also increases. It is obvious as the volume of the deformed materials increases necessitating more force to push the deformed material.

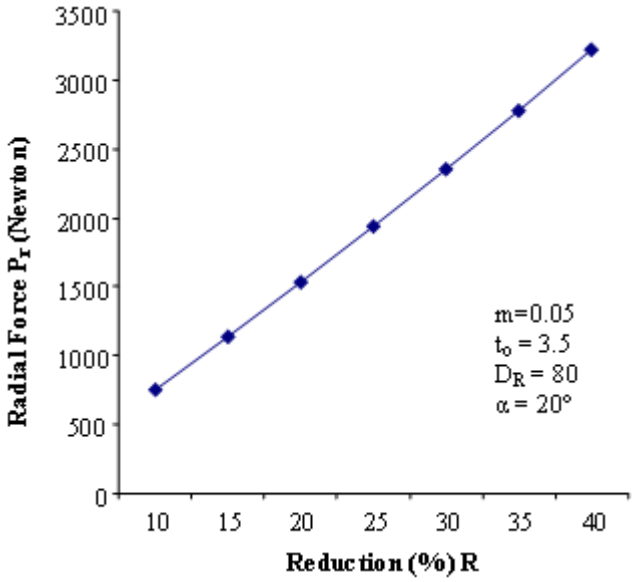


Fig. 5 Relationship between P_r and R

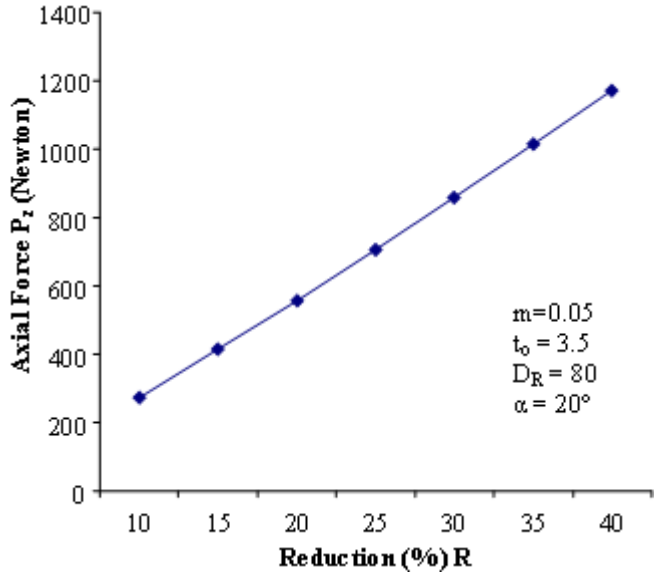


Fig. 6 Relationship between P_Z and R

9.3 When the Roller Flattens and Roller is not Assumed to be Rigid

In the previous analysis, the roller is assumed to be rigid. However, the rolls will deform elastically to an appreciable extent, and allowance must be made for this. A sufficiently accurate correction is obtained by supposing that the rolls, flatten to some greater diameter D_R'. The changed diameter may be approximated as per $D_{R'} = 1.1 D_R$.

$D_{R'}=1.1\ D_R=1.1x80=88$ mm $\therefore D_R = 80$ mm

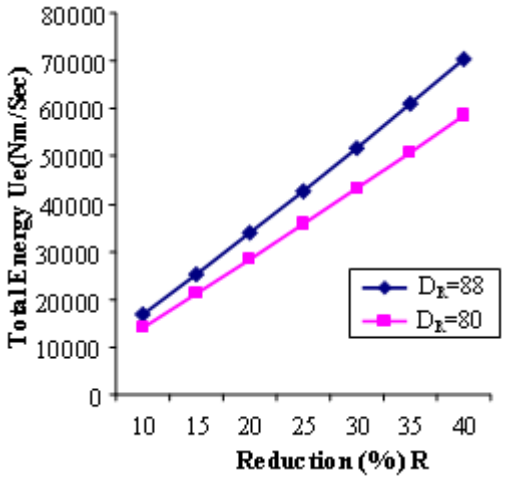


Fig. 7 Total energy vs. %age reduction at different roller diameter

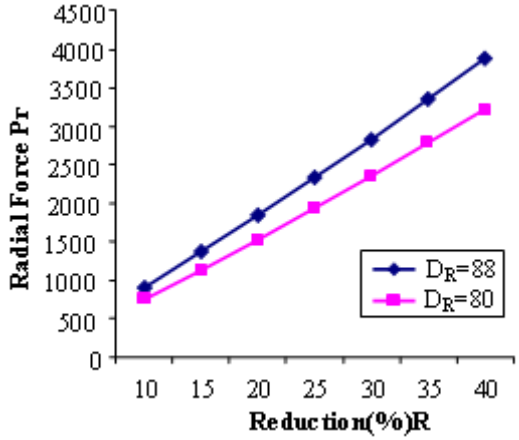


Fig. 8 P_r vs. reduction % at different roller diameter

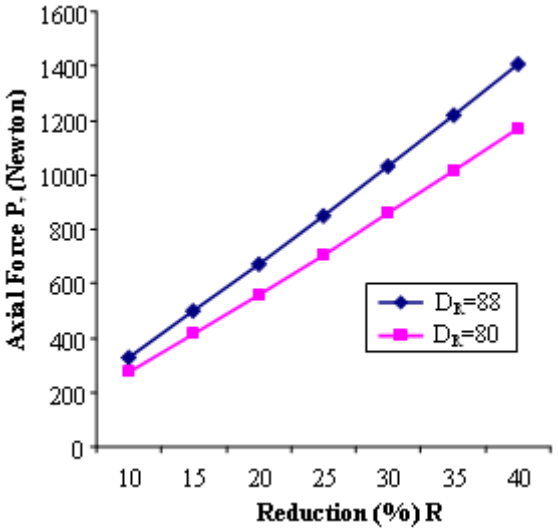


Fig. 9 P_z vs. of reduction % at different roller diameter

In the graphs plotted between Total energy, radial force and axial force vs. reduction % can be seen that power consumption, axial force and radial force increases as the diameter of the rollers increases due to flattening. This may be because of the fact, as the diameter of the roller increases due to flattening, the area of contact between the roller and the work piece increases which necessitates more power and larger forces to cause the plastic flow in the material.

9.4 Comparison with Singhal (1990) and Hayama and Kudo (1979)

In these graphs comparison has been made with the work carried out Singhal (1990) and Hayama and Kudo (1979). In his work on hard-to-work materials Singhal has taken value of Average yield stress as 43.8 kg/mm^2 (430 MPa) but he has no where mentioned how it has been calculated. Hayama and Kudo has worked experimentally on soft materials with average yield stress 23 kg/mm^2 (226 MPa).

In the case of present author the average yield stress for Titanium (one of the hard-to-work materials) has been calculated as 791 MPa. These figures show comparison of total energy, axial force and radial force verses reduction. The trend of the graphs is similar i.e. total energy, axial force and radial force increases with increase in percentage reduction. But the value are higher in the case of ó = 791 MPa followed by ó = 430 MPa and ó = 226 MPa. It shows that more energy forces are required in the case of working on hard materials.

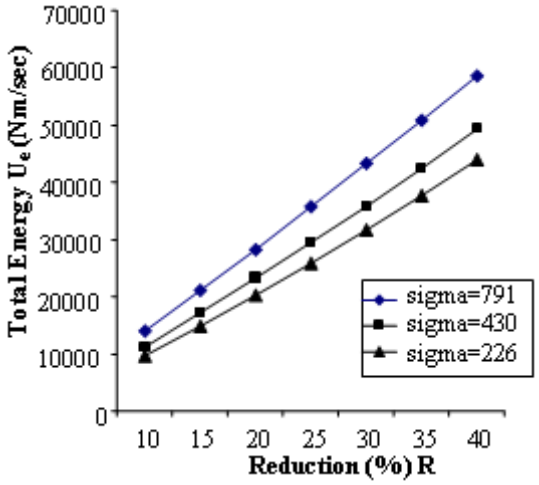


Fig. 10 Comparison of relationship between U_e and reduction % for same value of m

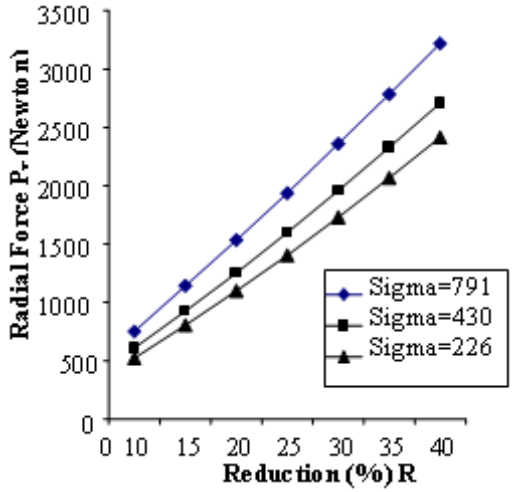


Fig. 11 Comparison of relationship between P_r and reduction % for same value of m

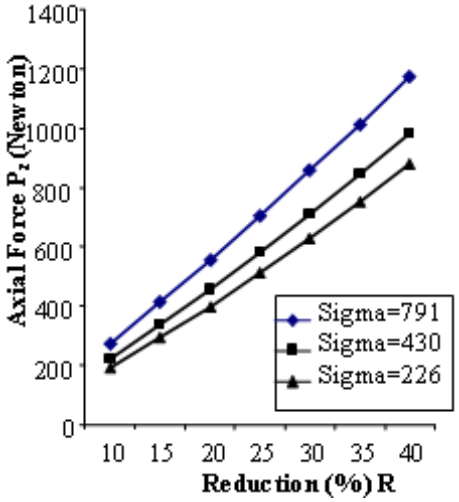


Fig. 12 Comparison of relationship between P_z and reduction % for same value of m

With the Figures 13, 14 and 15, comparison has been made with σ = 430 Ma and m=0.5 in the case of Singhál (1990) and σ = 226 Ma and m=1 in the case of Hayama and Kudo (1979 I, II). Present author has taken σ = 791 MPa and m=0.05. Singhal has taken static friction with m=0.5, Hayama and Kudo has taken m=1 arbitrary whereas present author has taken m=0.05 as in the case of rolling friction. The trend of the graphs is similar i.e. total energy, axial force and radial force increases with increase in percentage reduction. But the values are higher in the case of Singhal followed by Hayama and Kudo and present author. Thus it can be seen that average yield stress and friction factor both plays significant role. However the correct choice of friction factor can help in reducing the values of energy and forces which happens in the case of present author. In this case the value of average yield stress is more than others but due to rolling friction (m=0.05) the values of energy and forces are less.

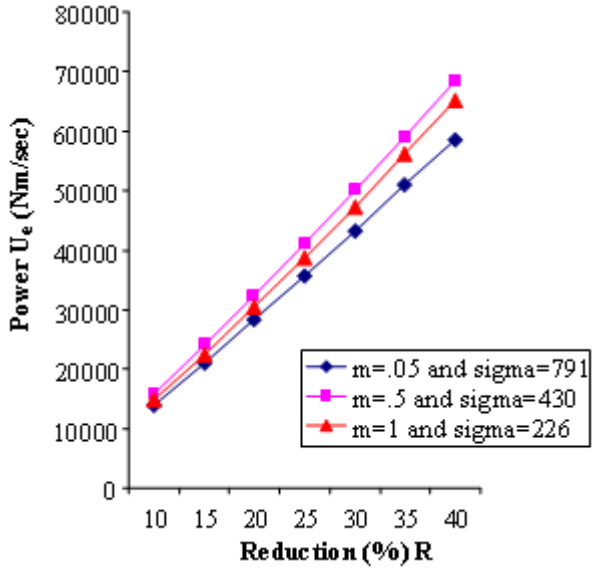


Fig. 13 Comparison of relationship between U_e and reduction % for different value of m

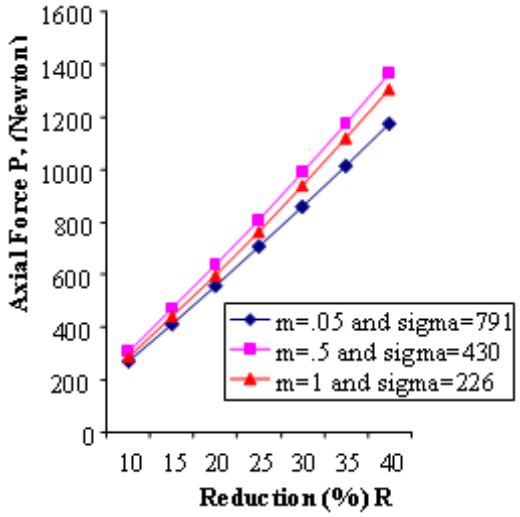


Fig. 14 Comparison of relationship between P_z and reduction % for different value of m

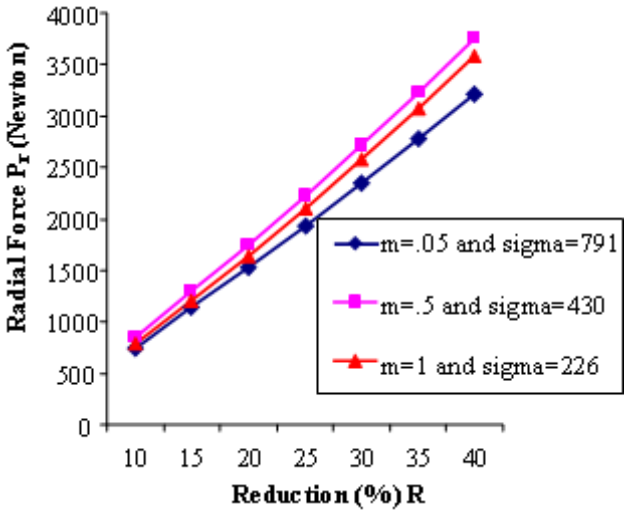


Fig. 15 Comparison of relationship between P_r and reduction % for different value of m

10. CONCLUSIONS

i. The working range in case of hard-to-work materials is less. Improvement in the ductility of the titanium one of the hard-to-work materials has been calculated under plane strain condition and it has improved by about 15% because of the presence of hydrostatic stress in conformity to the Birdgeman Law.

ii. Equation of continuity which stands for volume constancy has been satisfied. The value of K has been calculated which is applied in the analysis of velocity equations.

iii. Constitutive equation for Titanium, one of the hard-to-work material has been developed and value of average yield stress of the material has been calculated to be 791 MPa.

iv. The three rollers which are mounted on the chuck make an epicyclic train. The angular speed of rollers has been calculated as 69 rad/sec.

v. From Figures 4, 5 and 6, it is clear that with increase in %age reduction there is increase in power consumption, radial force and axial force.

vi. From Figures 7, 8 and 9 it is clear as the roller flattens, then diameter of the roller increases and consequently there is increase in power consumption, axial force and the radial force. This may be due to the fact that as the diameter of the roller increases, more volume of the material comes into contact due to which more power and forces are required.

vii. Singhal (1990) has taken the value of yield stress 430 MPa which is near to the average value of yield stress for soft materials taken by Hayama and Kudo (1979) as 226 MPa. Whereas the present author has calculated this value of average yield stress for hard-to-work material as 791 MPa. The comparison has been made for these values of average yield stress vs. % age reduction in Figures 10, 11 and 12. The trend of the graphs is similar but the value for total energy, axial force and radial force are higher in the case of average yield stress 791 Mpa. Thus it becomes obvious that in the case of hard materials more energy, axial force and radial force is required as compared to soft materials.

viii. Singhal (1990) has taken value of friction factor 'm' as 0.5 which is the case of sticking friction. Hayama and Kudo (1979) has taken friction factor 'm' as 1 which is again a case of sticking friction. However, the present author has taken this problem under rolling friction for which the value of friction factor 'm' is 0.05. The comparison is shown in Figures 13, 14 and 15, which shows that trend of the graphs is similar i.e. total energy, axial force and radial force increases with increase in percentage reduction. But the values are higher in case of m=0.5 followed by m=1 and m=0.05. Thus however the value of average yield stress is more in the case of present author but due to rolling friction less energy and forces are required for same percentage reduction.

REFERENCES

[1] B. Avitzur, "Metal Forming Process and Analysis", Tata McGraw Hill Publishing Company Limited, New Delhi, 1977.

[2] M. Hayama and H. Kudo, "Experimental Study of Tube Spinning", JSME, Vol. 22, No.167, 1979 I, pp. 769-775.

[3] M. Hayama and H. Kudo, "Analysis of Diametral Growth and Working Forces", Bull. JSME, Vol.22, No.167, 1979 II, pp.776-784.

[4] W. Johnson and P.B. Mellor, "Plasticity for Mechanical Engineers", D. Van Nostrand Company Ltd., London, 1962.

[5] "American Society for Metals", Metals Park, Ohio-44073, USA, Metals Hand Book, 8th Edn.,Vol.1, 1975.

[6] Prakash, Rajnish and R.P. Singhal, "Shear Spinning Technology for Manufacture of Long Thin Wall Tubes of Small Bore", Journal of Materials Processing Technology, Vol.54, 1995, pp.186-192.

[7] G.W. Rowe, "Principles of Industrial Metalworking Process", CBS Publishers and Distributors, New Delhi, 2000.

[8] R.P. Singhal and Rajnish Prakash, "An Experimental Study of Shear Spinning of Tube of Hard-to-work Materials", Advanced Technology of Plasticity, Vol. 2, 1990, pp. 853-857.

[9] R.P. Singhal, S.R. Das and Rajnish Prakash, "Some Experimental Observations in the Shear Spinning of Long Tubes", Journal of Mechanical Working Technology, Vol.14, 1987, pp.149-157.

[10] R.P. Singhal, P. K. Saxena and Rajnish Prakash, " Estimation of Power in the Shear Spinning of Long Tubes in Hard-to-work Materials", Journal of Material Processing Technology, Elsevier, Vol.23, 1990, pp. 29-40.

Indian Journal of Engineering, Science, and Technology (IJEST)

(ISSN: 0973-6255)
(A half-yearly refereed research journal)

Information for Authors

1. All papers should be addressed to The Editor-in-Chief, Indian Journal of Engineering, Science, and Technology (IJEST), Bannari Amman Institute of Technology, Sathyamangalam - 638 401, Erode District, Tamil Nadu, India.
2. Two copies of manuscript along with soft copy are to be sent.
3. A CD-ROM containing the text, figures and tables should separately be sent along with the hard copies.
4. Submission of a manuscript implies that : (i) The work described has not been published before; (ii) It is not under consideration for publication elsewhere.
5. Manuscript will be reviewed by experts in the corresponding research area, and their recommendations will be communicated to the authors.

Guidelines for submission

Manuscript Formats

The manuscript should be about 8 pages in length, typed in double space with Times New Roman font, size 12, Double column on A4 size paper with one inch margin on all sides and should include 75-200 words abstract, 5-10 relevant key words, and a short (50-100 words) biography statement. The pages should be consecutively numbered, starting with the title page and through the text, references, tables, figure and legends. The title should be brief, specific and amenable to indexing. The article should include an abstract, introduction, body of paper containing headings, sub-headings, illustrations and conclusions.

References

A numbered list of references must be provided at the end of the paper. The list should be arranged in the order of citation in text, not in alphabetical order. List only one reference per reference number. Each reference number should be enclosed by square brackets.

In text, citations of references may be given simply as "[1]". Similarly, it is not necessary to mention the authors of a reference unless the mention is relevant to the text.

Example

[1] M.Demic, "Optimization of Characteristics of the Elasto-Damping Elements of Cars from the Aspect of Comfort and Handling", International Journal of Vehicle Design, Vol.13, No.1, 1992, pp. 29-46.

[2] S.A.Austin, "The Vibration Damping Effect of an Electro-Rheological Fluid", ASME Journal of Vibration and Acoustics, Vol.115, No.1, 1993, pp. 136-140.

SUBSCRIPTION

The annual subscription for IJEST is Rs.600/- which includes postal charges. To subscribe for IJEST a Demand Draft may be sent in favour of IJEST, payable at Sathyamangalam and addressed to IJEST. Subscription order form can be downloaded from the following link http:// www.bitsathy.ac.in./ ijest.html.

For subscription / further details please contact:

IJEST
Bannari Amman Institute of Technology
Sathyamangalam - 638 401, Erode District, Tamil Nadu Ph: 04295 - 221289
Fax: 04295 - 223775 E-mail: ijest@bitsathy.ac.in Web:www.bitsathy.ac.in/ijest.html

Indian Journal of Engineering, Science, and Technology

Volume 3, Number 2, July - December 2009

CONTENTS

Published by

BANNARI AMMAN INSTITUTE OF TECHNOLOGY

(Autonomous Institution Affiliated to Anna University - Coimbatore
Approved by AICTE - Accredited by NBA and NAAC with "A" Grade)
Sathyamangalam - 638 401 Erode District Tamil Nadu India
Ph: 04295-221289 Fax: 04295-223775

BANNARI AMMAN INSTITUTE OF TECHNOLOGY
Stay Ahead

TUV NORD ISO 9001