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Extraction of Natural Dye Collected from Outer Skin of Onion and it's Application on Silk Fabric

By Nurunnesa, Md. Alamgir Hossain & Md. Mahbubur Rahman

Northern University

Abstract- Due to eco-friendliness of natural dyes and the awareness among people regarding the environmental and health hazards associated with the use of synthetic dyes, the craze for the clothing dyed with natural dye is increasing day by day. The aim of the work is to produce a variety of shades on the silk fabric by using Onion (*Allium cepa*) outer skin with different types of mordants such as Alum, Copper Sulfate, and Potassium Dichromate. Three different techniques of mordanting (Pre-mordanting, Meta-mordanting, and Postmordanting) have applied. The color fastness properties of dyed materials have also analyzed. After assessment of color fastness, it was found satisfactory in some cases and improved in many cases. As Onion is available and cheap, it will be convenient to produce unique shades of silk fabric, and to produce trendy and fashionable garments.

Keywords: *natural dye, allium cepa, extraction, mordanting, silk, color fastness.*

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Extraction of Natural Dye Collected from Outer Skin of Onion and it's Application on Silk Fabric

Nurunnesa^α, Md. Alamgir Hossain^σ & Md. Mahbubur Rahman^ρ

Abstract- Due to eco-friendliness of natural dyes and the awareness among people regarding the environmental and health hazards associated with the use of synthetic dyes, the craze for the clothing dyed with natural dye is increasing day by day. The aim of the work is to produce a variety of shades on the silk fabric by using Onion (*Allium cepa*) outer skin with different types of mordants such as Alum, Copper Sulfate, and Potassium Dichromate. Three different techniques of mordanting (Pre-mordanting, Meta-mordanting, and Post-mordanting) have applied. The color fastness properties of dyed materials have also analyzed. After assessment of color fastness, it was found satisfactory in some cases and improved in many cases. As Onion is available and cheap, it will be convenient to produce unique shades of silk fabric, and to produce trendy and fashionable garments.

Keywords: natural dye, *allium cepa*, extraction, mordanting, silk, color fastness.

I. INTRODUCTION

Nowadays, the Environment pollution is emerging as an alarming issue all over the world. The textile industry regards as the most polluting, as water pollution caused by effluents. These effluents contain toxic chemicals like carcinogenic amines and mutagens in Azo dyes, heavy metals, formaldehyde, etc. [1]

Environmentalists are always concerned about the unbridled use of synthetic dyes in the textile industry as they cause water pollution and different problems related to waste disposal. [2]

In recent times, due to lower price and a wide range of bright shades with improved color fastness properties, synthetic dyes have been widely used as compared to natural dyes [3-4].

Natural dyes are experiencing a new beginning in the field textile coloration. They are more compatible with the environment compared to synthetic dyes because they are eco-friendly, non-toxic, non-allergenic and biodegradable. [5]

Natural dyes are colorants obtained from different natural sources without any synthesizing. It includes all the dyes derived from different natural sources such as plants, animals, and minerals. There are different types of natural dyes like henna, onion, turmeric, marigold, betel nut, etc. The roots, stems,

barks, leaves, berries, and flowers of various dye plants are continuously using for dyeing carpets, rugs, and clothing. Due to no substantivity of most of the natural dyes, it has to apply to the substrate with the help of different mordants. [6]

Even though Synthetic dyes have many benefits, it has one negative side which deluges all the benefits, and the negative side is that it is not compatible with our environment. It is the high time to reconsider the use of natural dyes. [7]

In this regards, many commercial dyers already have started using natural dyes as a convenient replacement of synthetic dyes to overcome the environmental damage caused by synthetic dyes. Also, synthetic dyes such as azo dyes are found to be carcinogenic. [8]

Natural dyes are capable of producing unique, uncommon, alleviating and soft shades as compared to synthetic dyes as well Onion (*Allium cepa*) is a vegetable used in our daily life for cooking food and widely cultivated around the world. Most onions cultivated contain about 89% water, 4% sugar, 1% protein, 2% fiber. Onion also contains different types of Vitamins like Vitamin B1, Vitamin B2, Vitamin B3, and Vitamin C; it also contains compounds such as phenolics and flavonoids as well as elements like iron, calcium, magnesium, manganese, and zinc. [9]

The skin of onion is not edible and considered as wastage. However, it contains a coloring pigment called "Pelargonidin" (3, 5, 7, 4 tetrahydroxyantocyanidol). The amount of this coloring pigment is found to be 2.25%, and the structural formula of it has shown in Figure-1. [10]

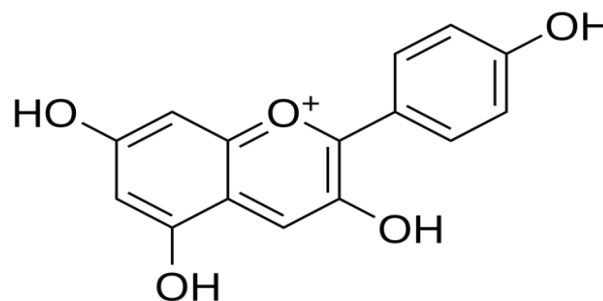


Figure 1: Structural Formula of Pelargonidin" (3, 5, 7, 4 tetrahydroxyantocyanidol)

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Onion is cultivated all over the country but extensively cultivated in Faridpur, Dhaka, Rajshahi, Comilla, Jessore, Dinajpur, Mymensingh, Rangpur, and Pabna in Bangladesh. Onion has become an integral part of the people's daily diet, and its use is very typical in almost all food preparations in Bangladesh. Onion mainly uses as a spice in Bangladesh. The only edible portion of onion is the bulb whereas Onion skin is inedible. [11]

II. MATERIALS AND METHOD

a) Colorant and Substrate

Waste outer skin of Onion (*Allium cepa*) was brought from the local market and washed with water and then dried at room temperature. After that, the skin had meshed and extracted the color by heating with water at 60 degree Celsius temperature for one hour. Degummed silk fabric had used as a substrate for dyeing.

b) Chemicals and Machine

As chemicals Alum, Potassium dichromate, and Copper sulfate of different concentrations, and as the

machine the conventional sample (lab) dyeing machine had used for dyeing in this research.

c) Fastness properties

According to the ISO 105 C03 test method washing fastness of the dyed sample was done. The assessment of color fastness to rubbing was done by following ISO 105:12 test method.

d) Extraction Process of Onion

Extraction is usually used to recover a component either from a solid or liquid. The outer skin of onion can be extracted with water by heating. The collected outer skin of onion mixed with water, and heated for 60 minutes at 65 °C (degree Celsius) temperature. Finally, the liquid dye from the skin was separated by filtration. The process was repeated for the same solid material to extract the dye portion as much as possible. The extraction process curve of onion has shown in Figure-2.

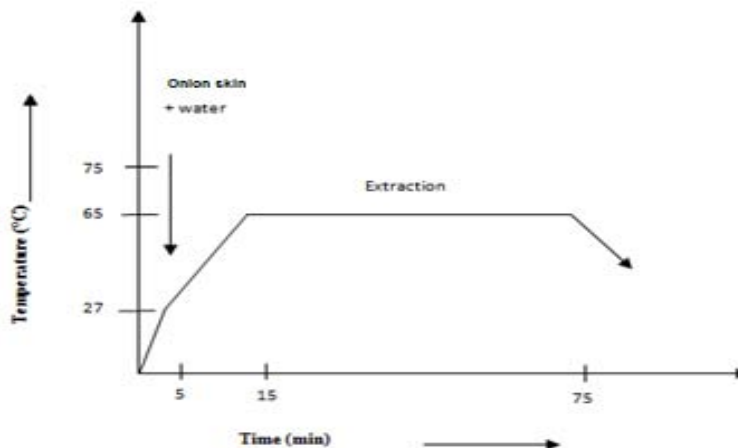


Figure 2: Extraction Process Curve of Onion

e) Mordanting process

A mordant is a dye fixative and able to use for dyeing fabrics with natural dyes. The natural dyes have no substantivity to the substrate. Three types of mordanting techniques named pre-mordanting, meta-mordanting, and post-mordanting commonly used for the coloration of textile substrate with natural dyes. In pre-mordanting the substrate is treated with the mordant, and then dyed, in meta-mordanting, the mordant is added to the dye bath itself, and in post-mordanting, the dyed material is treated with the mordant.

In this experiment three types of mordants used with the different concentration of mordants and pre, meta, and post-mordanting techniques had applied. In

this experiment, 1% to 3% mordant used in all pre, meta and post-mordanting techniques.

f) Degumming of Silk Fabric

Silk fiber contains natural impurities called gum or sericin. This sericin is near about 20% of weight compared to the whole weight of Silk fiber. Besides this Silk fiber comprises some wax and natural colors. In this work, degumming had used to remove these materials by treating the substrate with soda ash.

Raw Silk fabric was degummed in according to the following recipe which is shown in Table-1, and the degummed fabric was washed with 2 g/l detergent at 65°C for 10 minutes. Also, the process curve for degumming of silk fabric has been shown in figure-3.

Table 1: Recipe for Degumming of Silk Fabric

Detergent	5 g/l
Soda ash	3 g/l
Sequestering agent	1 g/l
Wetting agent	1 g/l
M:L	1:20
Temperature	90°C
Time	60 minutes
pH	9

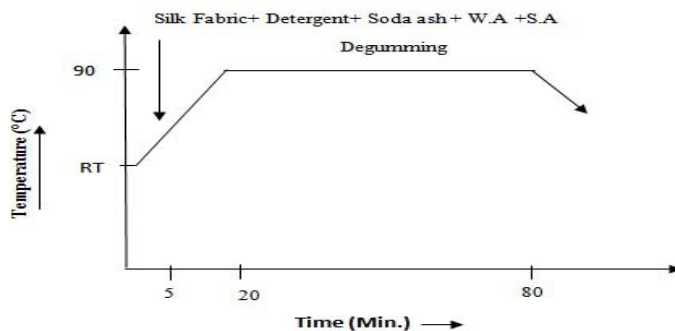


Figure 3: Process Curve for Degumming of Silk Fabric

g) Dyeing process

In the pre-mordanting technique, the pre-mordanted sample immersed in liquid extracted from the outer skin of Onion at a liquor ratio of 1:50. Then dyeing had done by the sample (lab) dyeing machine. It carried out for 60 minutes at 70 °C temperature, and the pH was around 6.0 in the dye bath. Then the dyed material was washed with cold water and dried at room temperature. Finally a dyed sample found.

For meta and post-mordanting the dyeing process was the same, but the mordant used in dye bath during dyeing for meta-mordanting, and after dyeing for post-mordanting. The recipe for dyeing of silk fabric with onion skin has shown in table-2. Also, the process curve for dyeing of silk fabric with onion skin has represented in figure-4.

Table 2: Recipe for Dyeing of Silk Fabric with Onion Skin

Silk fabric	1 g
Liquid dye	50 ml
Mordant	(1-3)%
M:L	1:50
Temperature	70°C
Time	60 minutes
pH	6

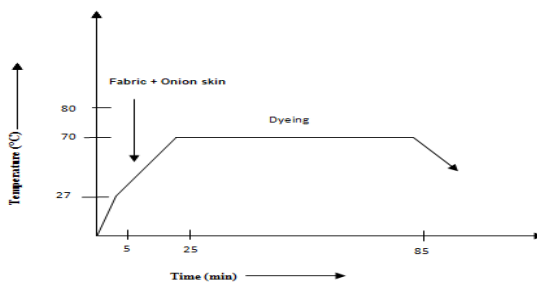







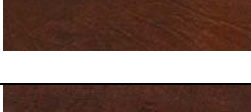
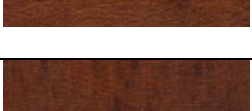
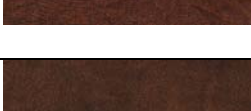
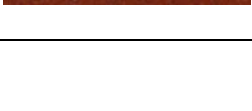
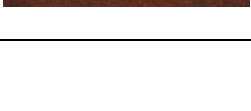
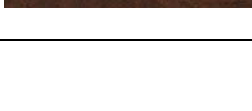


Figure 4: Process Curve for Dyeing of Silk Fabric with Onion Skin

III. RESULT AND DISCUSSION

a) Visual comparison

Table 3: Dyed Samples

Mordants	Conc. (%)	Pre-mordanted	Meta-mordanted	Post-mordanted
Alum	1			
Alum	2			
Alum	3			
K ₂ Cr ₂ O ₇	1			
K ₂ Cr ₂ O ₇	2			
K ₂ Cr ₂ O ₇	3			
CuSO ₄	1			
CuSO ₄	2			
CuSO ₄	3			

b) Color fastness to wash

Table 4: Assessment Result for Color Change

Sl. No.	Mordants	Pre-mordant	Meta-mordant	Post-mordant
1	Alum 1%	2	1	2
2	Alum 2%	3	2	2
3	Alum 3 %	4	3	3
4	CuSO ₄ 1%	2	1	2
5	CuSO ₄ 2%	3	2	3
6	CuSO ₄ 3%	4	3	3
7	K ₂ Cr ₂ O ₇ 1%	3	3	3
8	K ₂ Cr ₂ O ₇ 2%	3	4	4
9	K ₂ Cr ₂ O ₇ 3%	2	4	4

Table 5: Assessment Result for Color Staining

Sl. No.	Mordants	Pre-mordant	Meta-mordant	Post-mordant
1	Alum 1%	4-5	4-5	4-5
2	Alum 2%	4-5	4-5	4-5
3	Alum 3 %	4-5	4-5	4-5
4	CuSO ₄ 1%	4-5	4-5	4-5
5	CuSO ₄ 2%	4-5	4-5	4-5
6	CuSO ₄ 3%	4-5	4-5	4-5
7	K ₂ Cr ₂ O ₇ 1%	4-5	4-5	4-5
8	K ₂ Cr ₂ O ₇ 2%	4-5	4-5	4-5
9	K ₂ Cr ₂ O ₇ 3%	4-5	4-5	4-5

c) Color fastness to rubbing

Table 6: Assessment Result for Color Fastness to Rubbing

Sl. No.	Mordants	Dry/Wet	Pre-mordant	Meta-mordant	Post-mordant
1	Alum 1%	Dry	4-5	4-5	4-5
		Wet	4	4	4
2	Alum 2%	Dry	4-5	4-5	4-5
		Wet	4	4	4
3	Alum 3 %	Dry	4-5	4-5	4-5
		Wet	4	4	4
4	CuSO ₄ 1%	Dry	4-5	4-5	4-5
		Wet	4	4	4
5	CuSO ₄ 2%	Dry	4-5	4-5	4-5
		Wet	4	4	4
6	CuSO ₄ 3%	Dry	4-5	4-5	4-5
		Wet	4	4	4
7	K ₂ Cr ₂ O ₇ 1%	Dry	4-5	4-5	4-5
		Wet	4	4	4
8	K ₂ Cr ₂ O ₇ 2%	Dry	4-5	4-5	4-5
		Wet	4	4	4
9	K ₂ Cr ₂ O ₇ 3%	Dry	4-5	4-5	4-5
		Wet	4	4	4

In this research, a variety shades of silk fabric produced by using the outer onion skin, shown in Table-3. Besides, it also found that for getting excellent shade, it must need to use different types of mordants. In this experiment, it has been tried to show that how different techniques of mordanting change the shades despite using the same mordant with the same concentration. Table- 6 shows color fastness to rubbing was very good for all the samples but color fastness to washing was not good for all that has shown in Table- 4. It also found that assessment result for color change was very good in case of the pre-mordanting technique for 3% Alum and 3% Copper sulfate, in meta-mordanting technique for both 2% and 3% Potassium dichromate and post-mordanting technique for 2% and 3% Potassium dichromate. The result was found to be good for color change in pre-mordanting technique for 2% Alum, 2% Copper sulphate, 1% and 2% Potassium dichromate, in meta-mordanting technique for 3% Alum, 3% Copper sulphate and 1% Potassium dichromate and in post-mordanting technique for 3% Alum, 2% and 3% Copper sulphate and 1% Potassium dichromate. Besides, it also found that assessment result for color staining was very good for all the samples which are very convenient for dyeing of silk fabric with Onion skin.

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Performance Analysis of Mild Steel (ASTM A36) under Varying Drilling Conditions using Taguchi and ANOVA

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Abstract- This study is conducted to analyze the performance of Mild Steel (ASTM A36) using a drill bit (8.25mm & 10.25mm high-speed steel) at two different speeds (270 & 630 RPM) under the three conditions (Dry, MQL, and Wet). The Taguchi has been introduced to find out the most influential factors and most of the cases it was drilling conditions. This performance study has been accelerated by using minitab18 software for ANOVA analysis. Thus it gives the clear indication about the effects of RPM, drilling conditions and drill bit size on drilling a particular materials MS (ASTM A36). The conditions and factors have been shown whether it is statistically significant and how much. One conspicuous thing that the interaction between conditions and factors also have the significant effect.

Keywords: MQL, drilling conditions, MS (ASTM A36), drill bit size, RPM, taguchi, anova.

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Performance Analysis of Mild Steel (ASTMA36) under Varying Drilling Conditions using Taguchi and ANOVA

Md. Al Amin^α, Usama Abdullah Rifat^σ, Md. Habibur Rahman^ρ & Md. Golam Kibria^ω

Abstract- This study is conducted to analyze the performance of Mild Steel (ASTM A36) using a drill bit (8.25mm & 10.25mm high-speed steel) at two different speeds (270 & 630 RPM) under the three conditions (Dry, MQL, and Wet). The Taguchi has been introduced to find out the most influential factors and most of the cases it was drilling conditions. This performance study has been accelerated by using minitab18 software for ANOVA analysis. Thus it gives the clear indication about the effects of RPM, drilling conditions and drill bit size on drilling a particular materials MS (ASTM A36). The conditions and factors have been shown whether it is statistically significant and how much. One conspicuous thing that the interaction between conditions and factors also have the significant effect. The wet cooling condition has shown the better performance on surface roughness for all conditions and drill bit size. The drilling under wet cooling and MQL conditions have almost the same results but it varies in the case of the dry condition. Low RPM is found to be statistically significant than it is for high RPM. The regression line equation can bring the remarkable significance of further drilling Mild Steel at any drilling conditions.

Keywords: MQL, drilling conditions, MS (ASTM A36), drill bit size, RPM, taguchi, anova.

1. INTRODUCTION & LITERATURE REVIEW

Drilling is the operation of cutting a hole of circular cross-section in solid materials using a drill bit. The drill bit is usually a rotary cutting tool, often multipoint. The drill bit is pressed against the workpiece and rotated at rates from hundreds to thousands of revolutions per minute. A drilling machine comes in many shapes and sizes, from small hand-held power drills to bench mounted and finally floor-mounted models. They can perform operations other than drilling, such as countersinking, counterboring, ream, and tap large or small holes (Eskicioglu & Davies, 1983; Kibbe, White, Meyer, Curran, & Stenerson, 2014; Lemelson, 1967).

Anderson & Whitcomb (2016) defined Minimum Quantity Lubrication (MQL) as the use of cutting fluids of only a minute amount-typically of a flow rate of 50-500 ml/hour-which is about three to four orders of magnitude lower than the amount commonly used in flood cooling. The concept of Minimum Quantity Lubrication (MQL),

sometimes referred to as near dry lubrication 'or micro lubrication (Asad, Girardin, Mabrouki & Rigal, 2008).

A large amount of heat is generated in dry machining because of rubbing between the cutting tool and workpiece. The application of cutting fluid during machining operation reduces cutting zone temperature and increase tool life yet it causes skin and lung disease to the operators and air pollution (Ezugwu & Lai, 1995; Beaubien & Cattaneo, 1964).

Ahsan, Kibria, Ahmed, Islam & Hossain (2010) found that MQL generally uses vegetable oil or ester oil as the cutting fluid. These high- performing oils have excellent lubrication and natural dissolving properties. This result avoids pollution of the environment and related problems of health and safety, and drastically reduces lubricant costs (Khan, Mithu & Dhar, 2009), although it may cause problems of corrosion (Kirkaldy & Young, 1987). Furthermore, they are environmentally friendly (Khan, Mithu & Dhar, 2009). In our study, Diod sol-M is used as a lubricant. According to a survey conducted by the European Automobile Industry, the cost incurred on lubricants comprises nearly 20% of the total manufacturing cost. The cost of the cutting tool is only 7.5% of the total cost (Brockhoff & Walter, 1998).

Braga, Diniz, Miranda, & Coppini (2002) compared the performances of the uncoated and diamond coated carbide drills, using minimal lubrication (10 ml/h of oil in a flow of compressed air) and abundant soluble oil as a refrigerant/lubricant in the drilling of aluminum-silicon alloys (A356).

In the experiments cutting speeds of 10–50 m/min and feed of 0.1–0.2 mm were used. The lubrication was applied either with an external nozzle or internally through the drill. It was concluded that the measured temperature with the application of MQL internally through the tool was 50% smaller than those obtained with MQL applied with an external nozzle. When MQL was applied with an external nozzle the greatest temperature was measured in a piece drilled with an uncoated drill. For different coatings, there was no significant variation in temperature (Zeilmann & Weingaertner, 2006). A study was conducted at Georgia Institute of Technology to compare the mechanical performance of minimum quantity lubrication over completely dry lubrication for the turning of hardened

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bearing-grade steel materials with low content CBN cutters (Liang & Ronan, 2003).

A series of MQL drilling tests were conducted to determine if a high penetration rate could be achieved under oil delivery rate was 50 ml/hr, Air pressure for all tests was 4.96 bars, and air consumption was approx. 31 l/min. It was concluded that MQL process costs were approximately 10% lower than the traditional machining process. Dry chips were produced and could have been sold to a recycling facility without additional processing. Air quality for MQL was better than conventional machining, with a significant reduction in aerosol particle concentration (Filipovic & Stephenson, 2006). Taguchi method analyzes the influence of parameter variation on response characteristics. Thereby, and an optimal result can be obtained from the sensitivity analysis respect to parameter variation. However, Taguchi method has shown some defects in dealing with the problems of multiple performance characteristics (Bement, 1989; Roy, 2001; Berginc, Kampus & Sustarsic, 2006; Kopač, Bahor & Sokovč, 2002; Li & Hong, 2005; Ming-der & Yih-fong, 2004; Grzesik, Rech, & Wanat, 2006). Further, design optimization for quality was carried out and signal-to-noise (S/N) ratio and analysis of variance (ANOVA) were employed using experimental results to confirm the effectiveness of this approach (Yang & Tarn 1998; Islam et al., 2015). The main objective of this paper is to analyze the performance of mild steel (ASTM A36) under varying drilling conditions. The rest of

the paper is organized as follows: section 2 Experimental setup with working principle section 3 Data Analysis and Interpretation section 4 ANOVA Analysis section 5 Graphical Analysis section 6 Findings and section 7 Conclusion.

II. EXPERIMENTAL SETUP WITH WORKING PRINCIPLE

In this study lubricant and the air is mixed by MQL setup which is based on spray gun concept. The two separate hollow pipes carry lubricant and air which mixed in mixing chamber just before the tip of the nozzle. The lubricant flow is controlled by the knob. In order to have contentious mist, constant pressure is assured by the pressure gauge reading because the change in pressure may vary the quantity of the lubricant coming out of the nozzle. The developed MQL system consists of four major parts (a) compressor (b) lubricating Oil reservoir (c) Mixing chamber (d) Nozzle. The lubricating agent needs to be supplied at high pressure and impinged at high speed through the nozzle at the cutting zone under MQL condition. Considering the requirements for the present work and uninterrupted supply of MQL at constant pressure, an MQL delivery system has been designed and fabricated. The thin but high-velocity stream of MQL was projected in such a direction so that the coolant could reach as close to the chip-tool and the work-tool interfaces as possible.



(a) MQL set up (b) Operation performing on MQL

Figure 1: Photographic view of MQL set up and an operation performing on MQL.

III. DATA ANALYSIS AND INTERPRETATION

The data obtained from the experimental investigation are analyzed with two statistical tools Taguchi and ANOVA. All collected data were recorded

using Microsoft Excel and transferred to Minitab 17 statistical software for the ANOVA analysis. Before ANOVA analysis the normality test has been performed to check whether the data is normal & fit for the ANOVA analysis.

Taguchi design under varying conditions are shown in table 3.1 below:

Table 3.1: Taguchi Design

Drilling conditions	RPM	Drill bit: 8.25mm			Drill bit: 10.25mm		
		Feed (mm/rev)	Roughness (Ra), mm	S/N Ratio	Feed (mm/rev)	Roughness (Ra), mm	S/N Ratio
Dry	270	0.158	3.835	-11.67	0.123	3.341	-10.477
	270	0.158	3.496	-10.87	0.123	3.209	-10.127
	270	0.158	3.380	-10.57	0.123	3.422	-10.685
	270	0.080	3.896	-11.81	0.060	3.545	-10.992
	270	0.080	3.873	-11.76	0.060	3.007	-9.562
	270	0.080	3.962	-11.95	0.060	3.812	-11.623
	630	0.158	3.243	-10.21	0.123	3.455	-10.768
	630	0.158	3.468	-10.80	0.123	3.168	-10.015
	630	0.158	3.378	-10.57	0.123	3.393	-10.611
	630	0.080	3.541	-10.98	0.060	3.398	-10.624
	630	0.080	3.969	-11.97	0.060	3.764	-11.512
	630	0.080	3.714	-11.39	0.060	3.731	-11.436
MQL	270	0.158	2.865	-9.14	0.123	2.898	-9.241
	270	0.158	2.817	-9.00	0.123	2.770	-8.849
	270	0.158	3.596	-11.11	0.123	2.587	-8.255
	270	0.080	3.129	-9.90	0.060	2.728	-8.716
	270	0.080	2.574	-8.21	0.060	2.785	-8.896
	270	0.080	2.945	-9.38	0.060	2.794	-8.924
	630	0.158	2.914	-9.28	0.123	2.904	-9.259
	630	0.158	3.292	-10.34	0.123	2.864	-9.139
	630	0.158	2.695	-8.61	0.123	3.168	-10.015
	630	0.080	2.909	-9.27	0.060	2.806	-8.961
	630	0.080	3.436	-10.49	0.060	2.899	-9.244
	630	0.080	3.354	-10.51	0.060	2.803	-8.952
Wet	270	0.158	2.963	-9.43	0.123	2.898	-9.241
	270	0.158	3.470	-10.80	0.123	2.870	-9.157
	270	0.158	2.483	-7.89	0.123	2.611	-8.336
	270	0.080	2.988	-9.50	0.060	2.440	-7.747
	270	0.080	2.999	-9.53	0.060	2.721	-8.694
	270	0.080	2.885	-9.20	0.060	2.868	-9.151
	630	0.158	3.409	-10.65	0.123	2.758	-8.811
	630	0.158	2.901	-9.25	0.123	3.113	-9.863
	630	0.158	3.042	-9.66	0.123	2.982	-9.490
	630	0.080	2.930	-9.33	0.060	2.967	-9.446
	630	0.080	2.895	-9.23	0.060	2.602	-8.306
	630	0.080	3.358	-10.52	0.060	3.137	-9.930

Response table for surface roughness with 8.25mm drill bit is shown in table 3.2 below:

Table 3.2: Response table for surface roughness

Level	S/N response (Drill bit: 8.25mm)			Mean response (Drill bit: 8.25mm)		
	Condition's (Dry, MQL, Wet)	RPM (270 & 630 rpm)	Feed (mm/rev)	Condition's (Dry, MQL, Wet)	RPM (270 & 630 rpm)	Feed (mm/rev)
1	-11.212	-10.095	-9.991	3.646	3.230	3.180
2	-9.603	-10.170	-10.273	3.043	3.247	3.297
3	-9.582			3.026		
Delta	1.630	0.075	0.282	0.62	0.017	0.117
Rank	1	3	2	1	3	2

The response table 3.2 for surface roughness of the MS (ASTM A36) gives the clear indication that drilling conditions is the most influential factors then RPM and Feed respectively. The Wet condition, high feed and low

RPM is better for surface roughness. The order of influential factors both for S/N response and mean response are same.

Response table for surface roughness with 10.25mm drill bit is shown in table 3.3 below:

Table 3.3: Response table for surface roughness

Level	S/N response (Drill bit: 10.25mm)			Mean response (Drill bit: 10.25mm)		
	Condition's (Dry, MQL, Wet)	RPM (270 & 630 rpm)	Feed (mm/rev)	Condition's (Dry, MQL, Wet)	RPM (270 & 630 rpm)	Feed (mm/rev)
1	-10.702	-9.370	-9.991	3.437	2.961	3.022
2	-9.037	-9.799	-10.273	2.833	3.106	3.044
3	-9.014			2.830		
Delta	1.688	0.429	2.313	0.607	0.145	0.022
Rank	2	3	1	1	2	3

For the variation in drill bit diameter the S/N response table 3.3 has shown that the feed is the most influential factor rather than drilling conditions which ranked in positions 1. Still, now the Wet condition is better for surface roughness. The mean response indicates that the drilling conditions are the most influential factors. The surface roughness is better at Wet, MQL, dry respectively. Here, 270 rpm is better for surface roughness rather than 630 rpm but their values almost same. The order of influential factors here is drilling conditions, RPM, and Feed respectively.

IV. ANOVA ANALYSIS

a) ANOVA Assumptions

1. Individual differences and errors of measurement are normally distributed within each group.
2. Size of the variance and distribution of individual differences and random errors are identical in each group.
3. Individual differences and errors of measurement are independent of the group to group.

b) ANOVA Hypothesis

1. Null Hypothesis: There is no significant difference between the responses obtained by varying the individual input variables.
2. Alternate Hypothesis: There is a significant difference between the responses obtained by varying the individual input variables.

c) ANOVA Results

For ease of use, the following factors have been coded as below when used in Minitab.

- Dry: Coded as 11
- MQL: Coded as 12
- Wet: Coded as 13
- 270 RPM: Coded as 1
- 630 RPM: Coded as 2

The surface roughness analysis of variance results for drilling mild steel with 8.25 mm drill bit is shown in the following table 4.1

Table 4.1: ANOVA results for surface roughness

General Linear Model: Ra versus Speed, Condition					
<u>Analysis of Variance</u>					
Source	DF	Adjusted SS	Adjusted MS	F-Value	P-Value
Speed	1	0.0163	0.01630	0.24	0.623
Condition	2	15.3869	7.69346	114.42	0.000
Speed*Condition	2	0.1135	0.05675	0.84	0.432
Error	174	11.6990	0.06724		
Total	179	27.2158			
<u>Model Summary</u>					
S	R-sq	R-sq(adj)	R-sq(pred)		
0.259299	57.01%	55.78%	54.00%		
<u>Coefficients</u>					
Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	3.1936	0.0193	165.24	0.000	
Speed					
1	-0.0095	0.0193	-0.49	0.623	1.00
Condition					
11	0.4083	0.0273	14.94	0.000	1.33
12	-0.1474	0.0273	-5.39	0.000	1.33
Speed*Condition					
1 11	0.0110	0.0273	0.40	0.687	1.33
1 12	-0.0347	0.0273	-1.27	0.205	1.33
<u>Regression Equation</u>					
$Ra = 3.1936 - 0.0095 \text{ Speed}_1 + 0.0095 \text{ Speed}_2 + 0.4083 \text{ Condition}_{11} - 0.1474 \text{ Condition}_{12} - 0.2608 \text{ Condition}_{13} + 0.0110 \text{ Speed*Condition}_{11} - 0.0347 \text{ Speed*Condition}_{12} + 0.0237 \text{ Speed*Condition}_{13} - 0.0110 \text{ Speed*Condition}_{211} + 0.0347 \text{ Speed*Condition}_{212} - 0.0237 \text{ Speed*Condition}_{213}$					
<u>Fits and Diagnostics for Unusual Observations</u>					
Obs.	Ra	Fit	Resid.	Std. Resid.	
21	3.0340	3.6034	-0.5694	-2.23	R
30	2.9780	3.6034	-0.6254	-2.45	R
33	3.5960	3.0019	0.5941	2.33	R
62	3.4700	2.9470	0.5230	2.05	R
150	3.6720	3.0904	0.5816	2.28	R
179	3.5330	2.9186	0.6144	2.41	R
R Large residual					

Table 4.1 shows the effect of cutting condition, cutting speed and their interaction on surface roughness. For speed the null hypothesis is accepted, that is, there is no statistically significant difference in the mean between the different groups of independent variables. But for the condition the null hypothesis is rejected, that is, there is a statistically significant difference in the mean between the different groups of

independent variables. The interaction effect is not statistically significant. That is, the effect of cooling condition on surface roughness is not dependent on cutting speed (and vice versa).

The surface roughness analysis of variance results for drilling mild steel with 10.25 mm drill bit is shown in the following table 4.2

Table 4.2: ANOVA for surface roughness

General Linear Model: Ra versus Speed, Condition					
<u>Analysis of Variance</u>					
Source	DF	Adjusted SS	Adjusted MS	F-Value	P-Value
Speed	1	1.6182	1.61824	44.59	0.000
Condition	2	19.4964	9.74819	268.61	0.000
Speed*Condition	2	0.1675	0.08374	2.31	0.103
Error	174	6.3147	0.03629		
Total	179	27.5968			
<u>Model Summary</u>					
S	R-sq	R-sq(adj)	R-sq(pred)		
0.190503	77.12%	76.46%	75.51%		
<u>Coefficients</u>					
Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	3.0778	0.0142	216.76	0.000	
Speed					
1	-0.0948	0.0142	-6.68	0.000	1.00
Condition					
11	0.4598	0.0201	22.90	0.000	1.33
12	-0.1676	0.0201	-8.34	0.000	1.33
Speed*Condition					
1 11	0.0426	0.0201	2.12	0.035	1.33
1 12	-0.0273	0.0201	-1.36	0.176	1.33
<u>Regression Equation</u>					
Ra = 3.0778 - 0.0948 Speed_1 + 0.0948 Speed_2 + 0.4598 Condition_11 - 0.1676 Condition_12 - 0.2923 Condition_13 + 0.0426 Speed*Condition_1 11 - 0.0273 Speed*Condition_1 12 - 0.0153 Speed*Condition_1 13 - 0.0426 Speed*Condition_2 11 + 0.0273 Speed*Condition_2 12 + 0.0153 Speed*Condition_2 13					
<u>Fits and Diagnostics for Unusual Observations</u>					
Obs.	Ra	Fit	Resid	Std Resid	
5	3.0070	3.4854	-0.4784	-2.55	R
21	3.9090	3.4854	0.4236	2.26	R
23	2.9400	3.4854	-0.5454	-2.91	R
27	3.0900	3.4854	-0.3954	-2.11	R
92	3.1680	3.5898	-0.4218	-2.25	R
112	3.1950	3.5898	-0.3948	-2.11	R
120	3.1150	3.5898	-0.4748	-2.54	R
R Large residual					

Table 4.2 shows the effect of cutting condition, cutting speed and their interaction on surface roughness. For the speed and conditions the null hypothesis is rejected, that is, there is a statistically significant difference in the mean between the different groups of independent variables. The interaction effect is not statistically significant. That is, the effect of cooling condition on surface roughness is not dependent on cutting speed (and vice versa).

V. GRAPHICAL ANALYSIS

The performance of MS (ASTM A36) is highlighted in a graphical manner to aid the analysis. The correlation analysis for surface roughness has been shown with respect to the no. of holes drilled under varying drilling conditions. The graphical results support as the results found in both Taguchi and ANOVA.

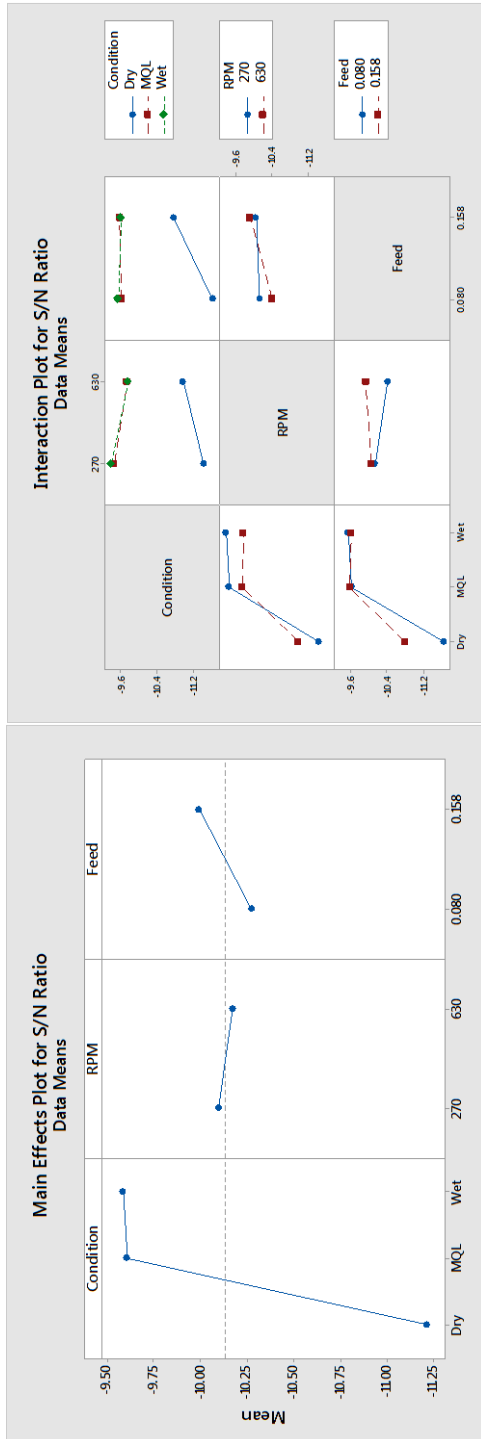


Fig. 5.1: Main effects and interaction effects plot for S/N Ratio

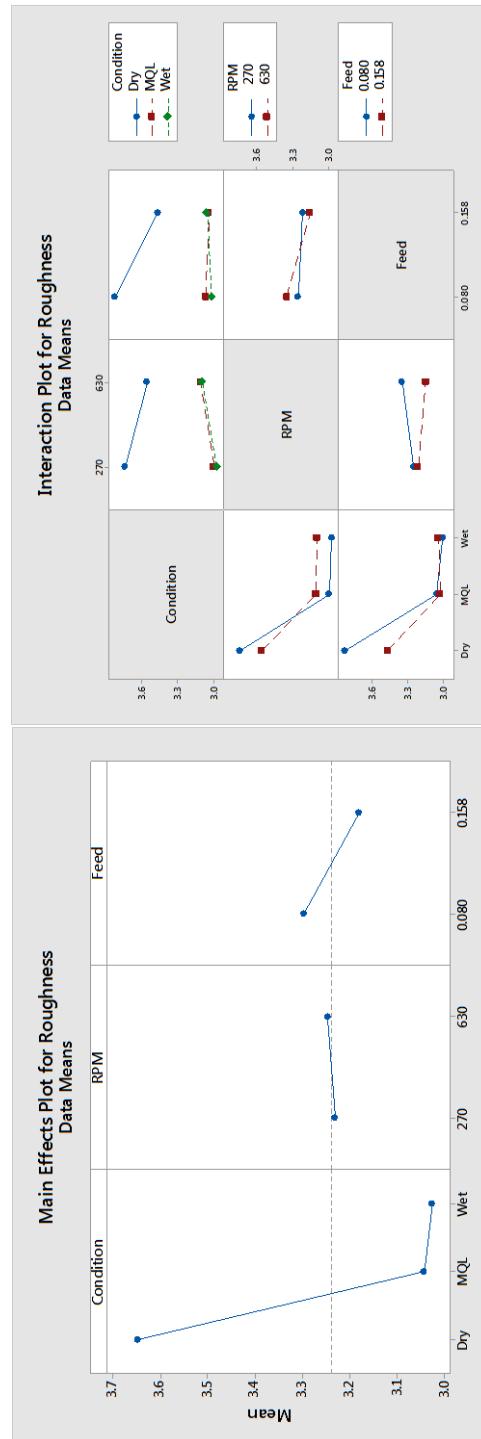


Fig. 5.2: Main effects and Interaction effects plot for surface roughness

From Fig.5.1 Main effects and Interaction effects plot for S/N Ratio, it has been seen that in the wet condition the roughness is better than the MQL and dry respectively. Here the drilling conditions are the most influential factors than RPM and Feed. Also, the high feed and low RPM is better for surface roughness. Performance measure on MQL and wet machining have almost the same results.

From Fig.5.2 Main effects and Interaction effects plot for surface roughness, it has been noticed that for 8.25 mm drill bit, surface roughness varies in the range of 3.034 to 3.962 mm for dry machining. Surface roughness varies in the range of 2.565 to 3.596 mm for MQL machining. Surface roughness varies in the range of 2.458 to 3.47 mm for flood machining. It can be seen from the graph that surface roughness for MQL machining is closer to flood machining than dry machining. For 10.25 mm drill bit, surface roughness varies in the range of 2.940 to 3.909 mm for dry machining. Surface roughness varies in the range of 2.552 to 3.021 mm for MQL machining. Surface roughness varies in the range of 2.425 to 2.898 mm for flood machining. It can be seen from the graph that surface roughness for MQL machining is closer to flood machining than dry machining.

VI. FINDINGS

Taguchi, ANOVA, and graphical analysis results under varying drilling conditions, Drill bit size and RPM are:

- a) Drilling conditions are the most influential factor
- b) Wet machining condition is better for surface roughness
- c) Low rpm (270 rpm) is better for surface roughness
- d) For 8.25mm drill bit, the speed, conditions, and interaction effect are not statistically significant that is there is no statistically significant difference in the mean between the different groups of independent variables.
- e) For 10.25mm drill bit, the speed and conditions have statistical significance but interaction effect is not statistically significant.
- f) Performance measure on MQL and wet machining have almost the same results.

VII. CONCLUSION

Performance analysis of Mild Steel (ASTM A36) at varying drilling conditions, drill bit size and RPM is very useful research work in the field of manufacturing. Statistical tools Taguchi, ANOVA are used to analyze the performance of surface roughness under varying conditions and factors. Drilling conditions are found to be most influential factors rather than drill bit size and RPM. Wet machining conditions and low RPM is better for surface roughness. This research work will help to

further analysis of drilling Mild Steel (ASTM A36) and its performance measure. The obtained results can also be the asset in the respective field. It can easily be derived from the regression line equations what would be the performance for any drilling conditions, drill bit size, and RPM in the next successive operation.

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Total Productive Maintenance to Improve Overall Equipment Effectiveness

By Ujjwal Kalki Mahajan, Pranay Adatiya, Pratik Badhe, Anamika Patsute & Avinash Bhusnar

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Introduction- In today's industrial scenario huge losses/wastage occur on the manufacturing shop floor. This waste is due to operators, maintenance personnel, process, tooling problems and non-availability of components in time etc. Other forms of waste include idle machines, idle manpower, break down the machine, rejected parts etc. are all examples of waste. The quality related waste is of significant importance as they matter the company in terms of time, material and the hard-earned reputation of the company. There are also other invisible wastes like operating the machines below the rated speed, setup-up loss, the breakdown of the machines and bottlenecks in the process. Zero oriented concepts such as zero tolerance for waste, defects, break down and zero accidents are becoming a pre-requisite in the manufacturing and assembly industry. In this situation, a revolutionary concept of Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above-said problem.

GJRE-J Classification: FOR Code: 291899



TOTALPRODUCTIVEMAINTENANCETOIMPROVEOVERALLEQUIPMENTEFFECTIVENESS

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Total Productive Maintenance to Improve Overall Equipment Effectiveness

Ujjwal Kalki Mahajan^α, Pranay Adatiya^σ, Pratik Badhe^ρ, Anamika Patsute^ω & Avinash Bhusnar[¥]

CHAPTER – 1

I. INTRODUCTION

In today's industrial scenario huge losses/wastage occur on the manufacturing shop floor. This waste is due to operators, maintenance personnel, process, tooling problems and non-availability of components in time etc. Other forms of waste include idle machines, idle manpower, break down the machine, rejected parts etc. are all examples of waste. The quality related waste is of significant importance as they matter the company in terms of time, material and the hard-earned reputation of the company. There are also other invisible wastes like operating the machines below the rated speed, setup-up loss, the breakdown of the machines and bottlenecks in the process. Zero oriented concepts such as zero tolerance for waste, defects, break down and zero accidents are becoming a pre-requisite in the manufacturing and assembly industry. In this situation, a revolutionary concept of Total Productive Maintenance (TPM) has been adopted in many industries across the world to address the above-said problem. The goal of any TPM program is to improve productivity and quality along with increased employee morale and job satisfaction. Earlier preventive maintenance was considered as a nonvalue-adding process, but now it is an essential requirement for the longer life cycle of machines in an industry. TPM is an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous operator maintenance through day-to-day activities involving the total workforce. The study reveals that the TPM elements- top management leadership, planned maintenance management, focused improvement, autonomous maintenance and education and training have a significant contribution towards manufacturing performance such as lower cost, higher quality, strong delivery and increased productivity.

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However, the concept of preventive maintenance was taken from the USA. Nippondenso was the first

company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines and the maintenance group was dedicated with work of maintaining those machines, however, with the automation of Nippondenso, maintenance became a problem as more maintenance personnel were required. So the management decided that the routine maintenance of equipment would be carried out by the operators. (This is Autonomous maintenance, one of the features of TPM). Maintenance group took up only essential maintenance works. Thus Nippondenso which already followed preventive maintenance also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This led to maintenance prevention. Thus preventive maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment.

By then Nippon Denso had made quality circles, involving the employee's participation. Thus all employees took part in implementing Productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE). Thus Nippondenso of the Toyota group became the first company to obtain the TPM certification.

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a) Project Industry Introduction



Anupriya Ultratech was established in October 2010. The stepping stone was put up at Ambad, Nashik, and Rich Industrial Green Belt in Nashik. The company is headed by Mr. R Patil. In a Hi-tech world, they at Anupriya Ultratech cater to OEM in many sectors. They Innovate Technology to the customer satisfaction at an optimum cost. A state of art plant to manufacture products by well-qualified personnel's to meet optimum quality levels. A strong research and Development Centre to take up challenging jobs in designing Innovative and world class quality products. The working environment is fully air-conditioned and dust free to meet Lowest Cost at on Optimum quality levels.

To delight our Customers, Stakeholders & Employees by consistently manufacturing high-quality products through Innovation, Research, and Development and by maintaining Global best practices in Quality standards and Safety. Anupriya Ultratech will provide the highest-quality end products to our customers while striving to make them the leaders in their respective industries. To guarantee our continued success we will achieve a reasonable profit, continue to be the leader in our industry through individual and combined dedication, innovation, and integrity. We will give our employees the opportunity for both personal and professional growth.

The mission of the company is to be the market leader in the product engineering with a Global

perspective by exceeding Customer expectations in Quality and Service, attain operational excellence in Manufacturing, Total Quality Management, Safety & Supply Chain facilitated through our fully compliant state-of-the-art manufacturing plant.

Anupriya Ultratech is committed to manufacturing and supply of High Conductivity Aluminium/ Copper/Brass components, shafts, riveting, CNC, VMC and welding jobs and Engineering Applications to meet customer satisfaction in term of quality requirement & on-time delivery. The company management has adopted new management tools, techniques for continuous improvement and to achieve a quality target. This policy will be reviewed periodically and changes made if needed.

With the ISO 9001 Quality System Certification, Anupriya Ultratech established the quality of its products. Effective implementation of Quality Assurance System assures that the products of Anupriya Ultratech are produced in compliance with customer requirements, national and international standards and regulations.

Anupriya Ultratech is small-scale industry, they are a manufacturer of a various mechanical component in which Electrical parts which is specially made up of copper, Racks, angles, pulleys and many more according to order.

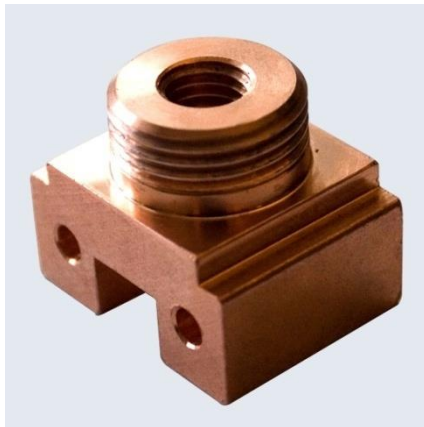




Fig. 1.1: Components manufacture in company

b) Problem Statement

After carrying out several visits and direct observations of machines on the production shop floor and analyzing previous machine utilization records at Anupriya Ultratech. Pvt. Ltd it was found that machines were not operating up to its full production capacity due to following problems associated with the machines.

- Housekeeping of the machines is carried out during machining hours which accounts for production delay.
- Time loss occurs during loading and setting of the job on machines which accounts for setup loss.
- Time loss during the changeover from one job to other on machine accounts for setup loss.
- Breakdowns of machines due to improper cleaning and lubrication of machine parts which accounts for availability loss.
- Lack of planned maintenance schedule for machines which accounts for performance loss.

- Frequent tool breakage due to operator inefficiency which accounts for performance loss.

All the above-mentioned problems are affecting the overall equipment effectiveness of machines on the production shop floor and thereby affecting overall plant efficiency. Hence there is need to implement total productive maintenance strategy in order to overcome the above mention problems and achieve improvement in overall equipment effectiveness.

c) *Objective of the Project*

- To increase the productivity of the product and its equipment with a modest investment in maintenance.
- To increase the overall equipment Effectiveness.
- Improving the effectiveness of machines
- Improving the efficiency, reliability and effectiveness of maintenance of machine
- Scheduling maintenance for avoiding early maintenance
- Involving operation team also in smaller scale maintenance, such as machine checklist inspection before starting and after closing the machines.
- Arrangement of training for amending the skills of employees

d) *TPM Basic Concepts*

TPM seeks to maximize equipment effectiveness throughout the lifetime of the equipment. It strives to maintain the equipment in optimum condition

in order to prevent unexpected breakdown, speed losses and quality defects occurring from process activities. Thus the three ultimate goals of TPM are zero defects, zero accident, and zero breakdowns. Among the principles embraced by TPM to achieve these goals are total employee involvement, autonomous maintenance by operators, small group activities to improve equipment reliability, maintainability and productivity and continuous improvement (kaizen).[2] A structured implementation process is an identified success factor and a key element of TPM programs. These basic practices or programs of TPM are often called “pillars” of TPM.

i. *Pillars of TPM*

The entire edifice of TPM is built and stands on eight pillars[3] which are focused improvement; autonomous maintenance, planned maintenance, training and education, early-phase management, quality maintenance, office TPM, and safety, health, and environment. TPM paves way for excellent planning, organizing, monitoring and controlling practices through its unique eight pillar methodology. These eight pillar implementation plan which is proposed by JIPM results in an increased in labor productivity through controlled maintenance, reduction in maintenance costs and reduced production stoppages and downtimes. [2]

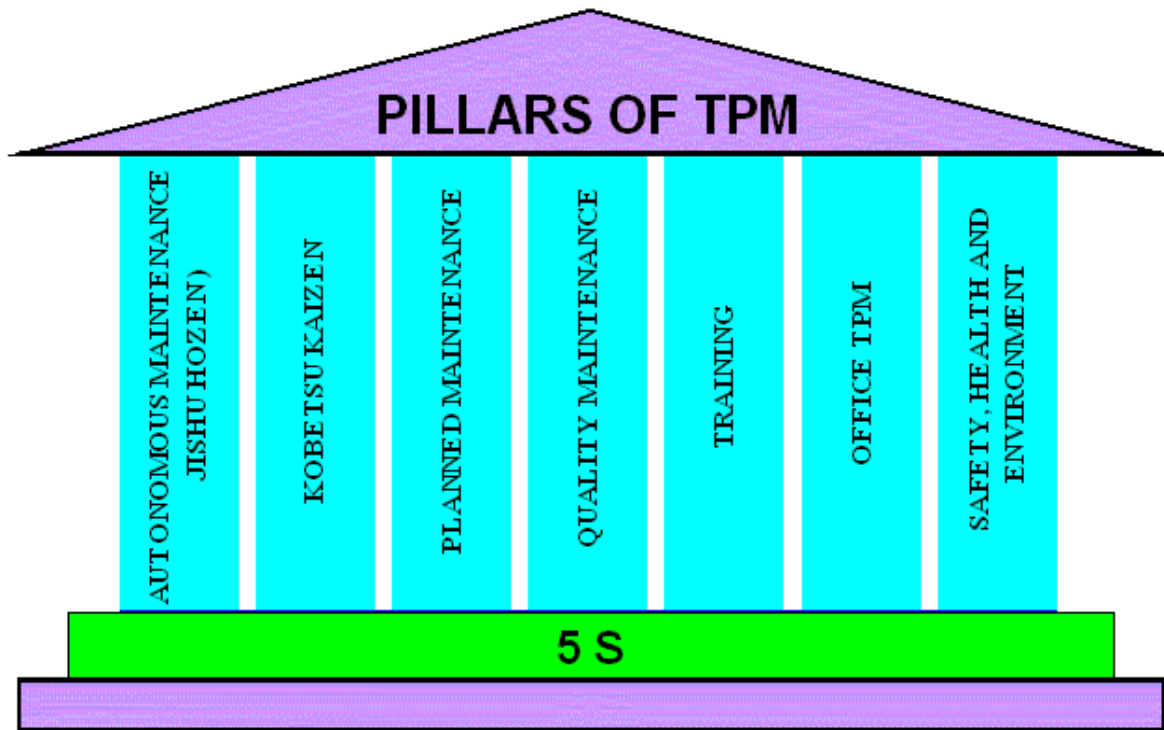


Figure 1.2: Pillars of TPM

• 5S:-

TPM starts with 5S. 5S can be called as foundation stone of TPM implementation. It is a Japanese way of housekeeping. Problems cannot be recognized if the work place is unorganized. Cleaning and organizing the workplace helps us to pop up the problems. Making problems visible and seen to the people gives an opportunity of improvement. If this 5S is not taken up seriously, then it leads to 5D i.e. Delays, Defects, Dissatisfied customers, Declining profits and Demoralized employees. [3]

It is a systematic process of housekeeping to achieve a serene environment in the work place involving the employees with a commitment to sincerely implement and practice housekeeping. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. 5S is a foundation program before the implementation of TPM. [7]

Meaning of each „S“ is explained in Table 2.1.

Table 2.1: Meaning of „S“

<i>Japanese Term</i>	5S Step	Description
<i>Seiri</i>	Sort	Remove all items from the workplace that are not needed for current production (or clerical) operations. Excess material (waste) at the work place can lead to errors and defects.
<i>Seiton</i>	Set in Order	Arrange needed items so that they are easy to locate and use. Label them so that they are easy to find and put away.
<i>Seiso</i>	Shine	Clean floors, equipment, and work stations. The Shine step of 5S also includes identifying and preventing the sources of contamination or dirt. Shine is integrated with daily maintenance tasks to maintain condition as pristine as possible.
<i>Seiketsu</i>	Standardize	Create methods and practices to maintain Sort, Set in Order, and Shine on an ongoing and continuously improving manner.
<i>Shitsuke</i>	Sustain	Make 5S an integral part of standard operating procedure.

• Pillar 1-Autonomous maintenance (JISHUHOZEN)

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating. By use of this pillar, the aim is to maintain the machine in new condition. The activities involved are very simple nature. This includes cleaning, lubricating, visual inspection, tightening of loosened bolts etc. Autonomous Maintenance policy are-uninterrupted operation of equipment“s, flexible operators to operate and maintain other equipment“s, and eliminating the defects at source through active employee participation. Steps in AM are preparation of employees, initial clean-up of machines, take counter measures, fix tentative AM (JISHU HOZEN) standards, general inspection, autonomous inspection, and standardization.

• Pillar 2-Kaizen

“Kai” means change, and “Zen” means good (for the better). Basically kaizen is for small

• Pillar 2-Kaizen

“Kai” means change, and “Zen” means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment. The principle behind is that “a very large number of small improvements are move effective in an organizational environment than a few improvements of large value”. This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

• Pillar 3-Planned maintenance (PM)

It is aimed to have trouble free machines and equipment“s producing defect free products for total customer satisfaction. This breaks maintenance down into four “families” or groups, viz., preventive maintenance, breakdown maintenance, corrective maintenance, and maintenance prevention. With PM we

evolve our efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment. In PM policy are achieve and sustain availability of machines, optimum maintenance cost, reduces spares inventory, and improve reliability and maintainability of machines.

- Pillar 4-Quality maintenance (QM)

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner, much like focused improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality concerns, and then move to potential quality concerns. Transition is from reactive to proactive (quality control to quality assurance). QM activities are to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The condition is checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take countermeasures before hand. In QM policy are defect free conditions and control of equipment's, quality maintenance activities to support quality assurance, focus of prevention of defects at source, focus on Poka-Yoke (fool proof system), in-line detection and segregation of defects, and effective implementation of operator quality assurance. QM targets are achieve and sustain customer complaints at zero, reduce in-process defects by 50percent, and reduce cost of quality by 50percent.

Policy:

1. Defect free conditions and control of equipment's.
2. QM activities to support quality assurance.
3. Focus of prevention of defects at source
4. Focus on poka-yoke. (fool proof system)
5. In-line detection and segregation of defects.
6. Effective implementation of operator quality assurance.

Target:

1. Achieve and sustain customer complaints at zero
2. Reduce in-process defects by 50 %

Data requirements:

Quality defects are classified as customer end defects and in house defects. For customer-end data, we have to get data on

1. Customer end line rejection
2. Field complaints.

In-house, data include data related to products and data related to process

Data related to product:

1. Product wise defects

2. Severity of the defect and its contribution - major/minor
3. Location of the defect with reference to the layout
4. Magnitude and frequency of its occurrence at each stage of measurement
5. Occurrence trend in beginning and the end of each production/process/changes. (Like pattern change, ladle/furnace lining etc.)
6. Occurrence trend with respect to restoration of breakdown/modifications/periodical replacement of quality components.

Data related to processes:

1. The operating condition for individual sub-process related to men, method, material and machine.
2. The standard settings/conditions of the sub-process.
3. The actual record of the settings/conditions during the defect occurrence.

Pillar 5-Training:

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-Why". By experience they gain, "Know-How" to overcome a problem what to be done. This they do train them on knowing "Know-why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skills is phase 1-do not know, phase 2-know the theory but cannot do, phase 3-can do but cannot teach, and phase 4-can do and also teach. Training policy's are focus on improvement of knowledge, skills and techniques, creating a training environment for self-learning based on felt needs.

Policy:

1. Focus on improvement of knowledge, skills and techniques.
2. Creating a training environment for self learning based on felt needs.
3. Training curriculum / tools /assessment etc conducive to employee revitalization
4. Training to remove employee fatigue and make work enjoyable.

Target:

1. Achieve and sustain downtime due to want men at zero on critical machines.
2. Achieve and sustain zero losses due to lack of knowledge / skills / techniques
3. Aim for 100 % participation in suggestion scheme.

Steps in Educating and training activities:

1. Setting policies and priorities and checking present status of education and training.

2. Establish of training system for operation and maintenance skill up gradation.
 3. Training the employees for upgrading the operation and maintenance skills.
 4. Preparation of training calendar.
 5. Kick-off of the system for training.
- Pillar 6-Office TPM:

Office TPM should be started after activating four other pillars of TPM (AM, Kaizen, PM, and QM). Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addresses twelve major losses, they are processing loss; cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories; communication loss; idle loss; set-up loss; accuracy loss; office equipment breakdown; communication channel breakdown, telephone and fax lines; time spent on retrieval of information; non availability of correct on line stock status; customer complaints due to logistics; and expenses on emergency dispatches/purchases. Office TPM and its benefits are involvement of all people in support functions for focusing on better plant performance, better utilized work area, reduce repetitive work, reduced administrative costs, reduced inventory carrying cost, reduction in number of files, productivity of people in support functions, reduction in breakdown of office equipment, reduction of customer complaints due to logistics, reduction in expenses due to emergency dispatches/purchases, reduced manpower, and clean and pleasant work environment.

- *Pillar 7-Safety, health and environment*

In this area focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis. safety, health and environment target are zero accident, zero health damage, and zero fires.

A committee is constituted for this pillar, which comprises representative of officers as well as workers. The committee is headed by senior vice president (technical). Utmost importance to safety is given in the plant. Manager (safety) looks after functions related to safety. To create awareness among employees various competitions like safety slogans, quiz, drama, posters.

- ii. *Overall equipment efficiency (OEE) Calculation for the product*

OEE calculation is based on a composite of the six big losses of your equipment broken down into three main areas; Availability, performance and quality. It is a very simple calculation in reality;

$$\text{OEE} = \text{Availability}\% \times \text{Performance}\% \times \text{Quality}\%$$

OEE (Overall Equipment effectiveness) is the main

performance measure that drives action within Total Productive Maintenance (TPM) and is used by the teams to focus their continuous improvement activities as well as identifying those areas that require resource.

TPM Six Losses

There are six equipment losses identified within TPM that are used to calculate your OEE;

- *Availability*

1. Breakdowns:-Breakdown losses categorized as time losses and quantity losses caused by equipment failure or breakdown.
2. Changeovers:-Set up and adjustment losses occur when production is changing over from requirement of one item to another.

- *Performance*

1. Minor Stoppages:-Idling and minor stoppage losses occur when production is interrupted by temporary malfunction or when machine is idling.
2. Reduced Speed:-Reduced speed losses refer to the difference between equipment design speed and actual operating speed.

- *Quality*

1. Defects:-Quality defects and rework are losses in quality caused by malfunctioning production equipment.
2. Start-up:-Reduced yield during start-up are yield losses that occurred from machine start up to stabilization.

CHAPTER -2

II. LITERATURE REVIEW

Early TPM implementation in Japan was primarily within the automotive industry, particularly within Toyota and their associated component suppliers (Robinson and Ginder, 1995). However, not many Japanese companies initiated TPM in the beginning and earlier TPM implementation was met with limited success (Tajiri and Gotoh, 1992). This all changed in the 1970's when Japan faced a worsening economic climate and adoption of TPM began to accelerate as a means to improve manufacturing productivity. Structured and phased implementation processes such as those developed by Nakajima (1989) provided standardized and repeatable methodology for TPM. (Nakajima, 1989).[1]

TPM represents a radical change in the way maintenance is being look at. It is a methodology and philosophy of strategic equipment management focused on the goal of building product quality by maximizing equipment effectiveness. Originally introduced as a set of practices and methodologies focused on manufacturing equipment performance improvement, TPM has matured into a comprehensive

equipment-centric effort to optimize manufacturing productivity (Ahuja and Pankaj, 2009). The goal of TPM or also known as Total Productive Manufacturing is to continuously improve all operational conditions of a production system by stimulating daily awareness of all employees.[2]

In 2012 Ranteshwar Singh and their team did the study of Total Productive Maintenance (TPM) Implementation in a Machine Shop, they stated that Quality and Maintenance of manufacturing systems are closely related functions of any organization. Over a period of time two concepts have emerged which are Total Productive Maintenance (TPM) and Total Quality Management (TQM) along with other concepts to achieve World Class Manufacturing system. In this paper experience of implementing Total Productive Maintenance is shared and investigated for a company manufacturing automotive component. Concept is implemented in the machine shop having CNC turning centers of different capacity. Overall Equipment Effectiveness is used as the measure of success of TPM implementation. The losses associated with equipment effectiveness are identified. All the pillars of TPM are implemented in a phased manner eliminating the losses and thus improving the utilization of CNC machines and they got results Overall Equipment Effectiveness has improved from 63% to 79% indicating the improvement in productivity and improvement in quality of product.[3]

Also according to Prof Pradeep Kumar, Total productive maintenance is practical technique aimed at maximizing the effectiveness of facility that we use within our organization .Total productive maintenance establishes a system of productive maintenance, covering the entire life cycle of equipment, covers all department, involves participation of all employees from top to bottom and promotes small group autonomous activities. During high growth era companies are making technical progress in automation and centralization of the plants, which needs large amount of manual work to maintain the automation systems. Framework of total productive maintenance TPM seeks to maximize equipment effectiveness throughout the lifetime of the equipment. It strives to maintain the equipment in optimum condition in order to prevent unexpected breakdown, speed losses, and quality defects occurring from process activities. There are three ultimate goals of TPM: zero defects, zero accident, and zero breakdowns. [4]

In 2013 Prasanth S. Poduval explains Barriers in TPM Implementation in Industries, As mentioned in his research, TPM implementation though easy on paper, is difficult to achieve and this is mainly due to reluctance by the organization to understand and implement the concepts of TPM and failure to realize the benefits obtained by implementation of TPM. Let us look at the various factors: Lack of top management commitment,

Organization resistance to change, Unwillingness to commit resources, Work culture, Resistance by employees due to this they faced alot of barrier to implement TPM. [5]

Bupe. G. Mwanza , Charles Mbohwa in 2015 Design of a total productive maintenance model for effective implementation in a chemical manufacturing company, and they found that TPM is designed to maximize equipment effectiveness (improving overall efficiency) by establishing a comprehensive productive-maintenance system covering the entire life of the equipment, spanning all equipment-related fields (planning, use, maintenance, etc.) and, with the participation of all employees from top management down to shop-floor workers, to promote productive maintenance through motivation management or voluntary small group activities. The company should involve achieving the company goal through the implementation of operator initiated daily maintenance consisting of cleaning, adjustment, and regular inspections, as well as improvement activities and minor restoration of equipment. And the maintenance men should only participate in inspection and restoration of equipment which requires high skill and specialization. Empowering the operators and maintenance personnel through training. This should be conducted in sustainable manner to maximize the efficiency of the equipment in order to eliminate the operators“ mistakes and improper repair. [6]

CHAPTER -3

III. METHODOLOGY USED AND PRODUCT INFORMATION

Anupriya Ultratech runs either in two shifts or in three shifts depending upon the work load. Usually the shifts are of 8 hours which includes a 35 minutes break for lunch or dinner. Our primary study involved tabulation of all factors leading to the calculation of the Overall Equipment Efficiency and Productivity of the system and its direct influence in determining the efficiency of the existing system. Following chart shows Methodology used for this study.

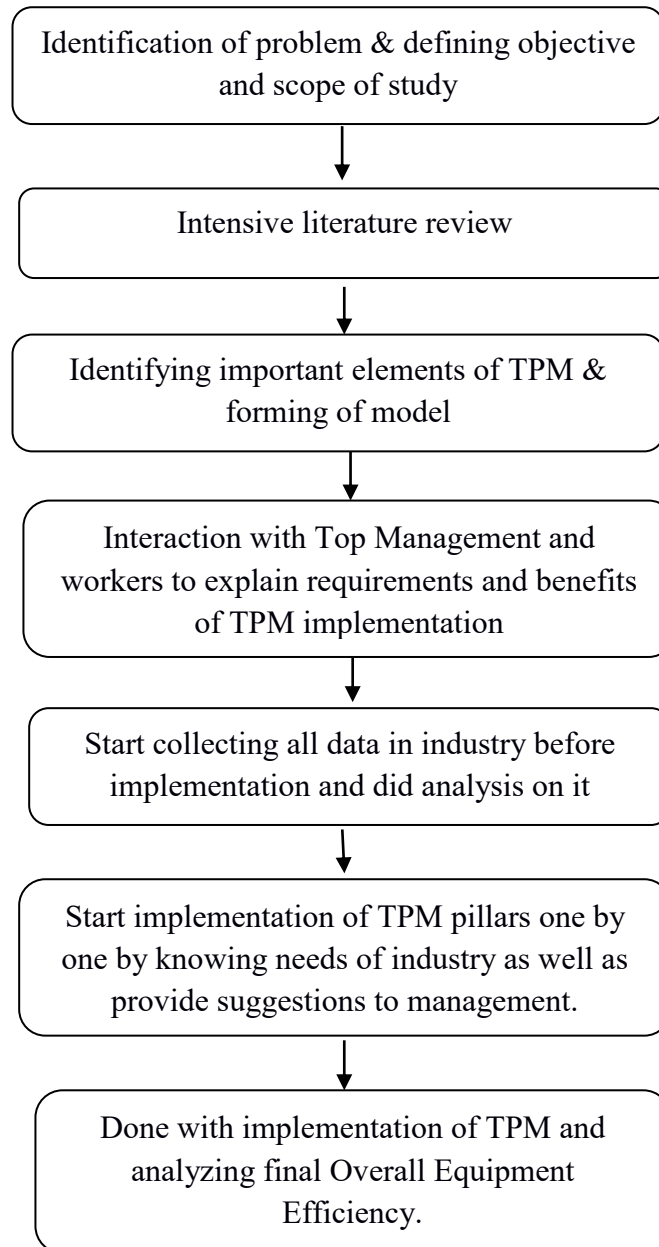


Fig. 1.3: Methodology used for this study

a) *TPM Model*

TPM Model is used to identify the components of the elements or strategies of TPM and manufacturing performance dimension. Each component will be studied in detail together with the theory that supports it. The relationship between these TPM elements and manufacturing performance will be analyzed to develop an understanding of contribution of TPM implementation element emphasis on manufacturing performance dimension. Figure 3.2 shows the proposed model for evaluating the relationship between TPM elements/strategies and manufacturing performance.

TPM
Elements/Strategies

Manufacturing
performance dimension

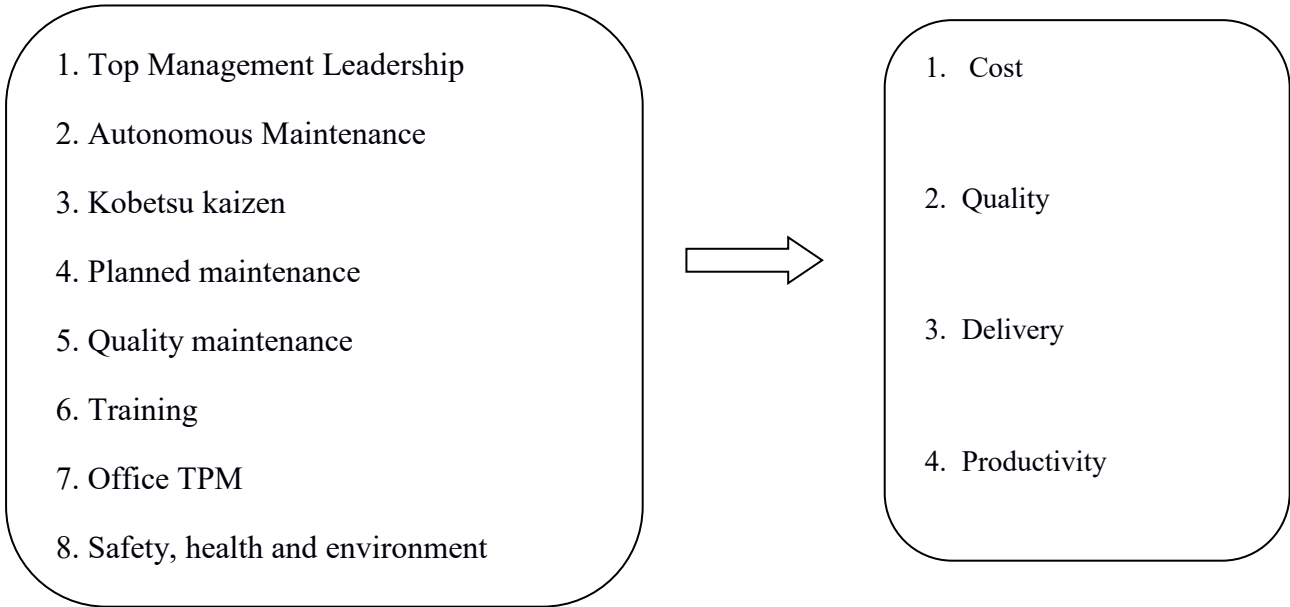
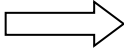

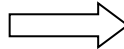


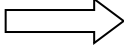



Figure 1.4: Proposed models for evaluating the relationship between TPM elements/strategies and manufacturing performance

b) Product Drawing and Process flow chart

Table 3.1: Process flow chart

Name	Symbol	Time (min)	Action
Transport		1	Storage to cutting machine
Operation (Cutting)		0.5	cutting operation
Transport		1	To CNC 1 for further operation
Operation (CNC 1)		3.5	Operations like facing, tapper, groove
Operation (CNC 2)		3.5	Same operation on another side
transport		0.5	To hydraulic press to fixed bearing in it
Operation (Hydraulic Press)		1	Bearing fixed by use of hydraulic press

Based on this method and collection of data from the industry OEE of the selected product is calculated very carefully.

Table 3.2: Calculation of OEE%

Sr. No.	Category	Before Implementation		
		Week 1	Week 2	Week 3
1	Shift time	960min/day	960 min/day	960min/day
2	Total production in a shift	155parts	154 parts	152 parts
3	scheduled break	70min	70 min	70 min
4	Non-scheduled break	12min	15 min	15 min
5	Breakdown	25min	20 min	30 min
6	Cleaning, inspecting & tightening of insert	20min	20 min	20 min
7	Operator absent	45min	65 min	50 min
8	Non-conforming product	8parts	9 parts	10 parts
9	Changeover or Setup	60 min	60 min	60 min

Calculating Availability:-

Availability is the percentage of time available to run the machine within a shift after losses due to setups and breakdowns. It is calculated by recording the time lost due to breakdowns (unplanned stoppages of more

than 10 minutes) in minutes and the time lost during setup (Last good part of one product to the first good part of the next) also in minutes, we then compare this to the total available time within the shift.

$$\frac{\text{Total time available} - \text{Breakdowns} - \text{Changeover}}{\text{Total Time Available}} \times 100$$

Performance Calculation:-

The performance percentage is based around the total number of parts that are produced within your available time compared to how many you should have made if you produced at the planned (design) rate. So in our example above with 410 available minutes, if our production rate is designed to be 1 part per minute we should have produced 410 parts. However this is often reduced by reduced speed losses (running machines slower than design speed) and minor stoppages (such as small jams that have to be cleared). In our example our actual production is only 350 parts, so our performance percentage is;

$$\frac{\text{Total Number of parts produced}}{\text{Available time X production rate}}$$

Quality Calculation:-

Your percentage calculation for quality within your OEE measure compares the total number of parts produced and the total number of good parts. Product losses can be due to either bad quality parts produced during normal production or parts produced during a setup for a new product. In our example we have produced 350 parts, but of these 15 were lost through setup and 15 were defective products. Our quality percentage therefore becomes;

$$\frac{\text{Good Parts}}{\text{Total Number of Parts Produced}} \times 100$$

Table: OEE%

Sr no.	Category	Before Implementation		
		Week 1	Week 2	Week 3
1	Availability (A)	84%	82%	82.58%
2	Performance Efficiency(PE)	96%	95%	93.82%
3	Quality Rate(QR)	95%	94%	93.42%
4	OEE (A × PE × QR)	76.60%	73%	72.37%

After calculation of OEE we decided to implement TPM (Total Productive Maintenance), according to TPM we should first identify the problematic areas in industry, In next chapter we explain all identified problems which is causes low OEE %. And TPM will implement according to problem identified.

Total Productive Maintenance can be implied. There were some issues where implementation of the particular was necessary. Such areas have been identified in this chapter.

CHAPTER – 4

IV. IDENTIFICATION OF PROBLEMATIC AREAS

While observing the industry, we came along a lot of areas where improvement can be done or say



Crane used to load chuck for bell housing is still kept in between CNC machines even after its use is over.



Waste bins, plastic bag and rejected parts are placed in corner near the staircase.



Waste boxes, bins and plastic bag are kept behind CNC- 01



Unwanted angles and pipes are kept near machine shop.



Rejected parts are kept besides machine and there are no red tags on them.



Earlier patches on the floor were disturbing material movement using trolley.



No labeling is done and tools are placed randomly in racks.



Allen keys, nut bolts and other tools are keep randomly.



CNCs are not cleaned from top side.



Coolant overflow from the tank is spilled on the ground without any provision to clean it.



Jaws and blocks are kept randomly.



To be dispatched parts are kept randomly.

Other areas which are identified include –

- No operator is writing hourly report.
- Employee details are not displayed on the notice board.
- No working information is displayed on the notice board.
- Maintenance sheets of the machines and equipment's is not maintained.
- Workers/operators don't have awareness for maintenance of the machines they are operating.
- Fire extinguishers are in limited number also training is not provided to workers for how to operate it.

CHAPTER -5

V. IMPLEMENTATION OF TPM

A detailed analysis of all the problems is done and techniques are identified to overcome this problems and to deal with them. Thus subset of TPM are implemented for overcoming different issues in the industry as follows.

5.1 5S:-

a) Sort /Arrangement (SEIRI)

(Eliminate unnecessary items) Through the suitable sorting it can be identified the materials, tools, equipment and necessary information for realization the tasks. Sorting eliminates the waste material (raw materials and materials), nonconforming products, and damaged tools. It helps to maintain the clean workplace and improves the efficiency of searching and receiving things, shortens the time of running the operation. The 1S rules proceedings.

- A. On the first stage one should answer to so called Control Questions:
- Are unnecessary things causing the mess in the workplace?
 - Are unnecessary remainders of materials thrown anywhere in the workplace?
 - Do tools or remainders of materials to production lie on the floor (in the workplace)?
 - Are all necessary things sorted, classified, described and possess the own place?
 - Are all measuring tools properly classified and kept?

On the basis of the answer to the above questions it is possible the estimation of the workplace in terms of the 1S rule so littering the workplace. If on any question answer is yes, it should execute sorting of things, which are in the workplace.

- B. On the second stage one should execute there view of all things which are in the workplace and group them according to the definite system. According to carried out sorting it should execute elimination from the workplace the things, which were found unnecessary.
- C. To permanent usage the 1S rule is so-called the Programmed of the Red Label. It means giving the red label to things, which operator will recognize as useless within his workplace. This label will make possible not only the elimination of the given thing, but through its own formula will make possible the liquidation of the reasons of appearing on the workplace this given thing.



Before - Crane used to load chuck for bell housing is still kept in between CNC machines even after its use is over.



After - Crane is taken to the corner of the shop floor after its use is over thus eliminating the interference during normal operation.



Before - Waste bins, plastic bag and rejected parts are placed in corner near the staircase.



After - The place is utilized by finished good material storing rack.



Before - Unwanted angles and pipes are kept near machine shop.



After - That much area is used to keep accepted and rejected parts.



Before - Coolant tank which was delivered by CNC manufacturer by mistake was lying in machine shop.



After - Tank is stored in central store room. The space is free for storing accepted parts.



Before - Chip conveyor tank which was delivered by CNC manufacturer by mistake and lying in machine shop.



After - Tank is stored in central store room. The space is free for storing defective parts.



Before - To be dispatched parts are kept randomly.



After - The parts are covered packed and kept at proper place and stands.

b) Set in Order/Neatness (SEITON)

Efficient and effective storage method Especially important is visualization of the workplace (eg. painting the floor helps to identify the places of storage of each material or transport ways, drawing out the shapes of tools makes possible the quick putting

aside them on the constant places, colored labels permitted identify the material, spare parts or documents etc.). Implementing the 2S rule It should execute the segregation of things and mark the places of their storing.



Before - No labeling is done and tools are placed randomly in racks.



After - Labeling is done and materials are stored in their respective places identified.



Before- Earlier patches on the floor were disturbing material movement using trolley.



After - Patches are filled with Cement thus helping smooth material flow.



Before - Plastic bags and waste cotton is randomly kept.





After - They are kept systematically, unnecessary thing thrown away and space freed.



Before - Trolleys are randomly placed anywhere.



After - Space is dedicated for keeping trolleys whenever not needed.

c) *Shine/Cleanliness (SEISO)*

(Thoroughly clean the workplace) Regular cleaning permits to identify and to eliminate sources of disorder and to maintain the clean workplaces. During cleaning It is checked the cleanness of machine,

workplace and floor, tightness of equipment, cleanness of lines, pipes, sources of light, current data, legibility and comprehensibility of delivered information etc. Indispensable is also taking care of and maintenance the personal tidiness of the operator.



Before - CNCs are not cleaned from top side.



After - CNCs are cleaned from the top as well as covered to avoid unwanted contamination.



Before - Coolant overflows from the tank.



After - It is cleaned and overflow problem is solved.

d) *Standardize / Order (SEIKETSU)*

(Order and control to be established for) Worked out and implemented standards in the form of procedures and instructions permit to keep the order on the workplaces. Standards should be very communicative, clear and easy to understand. Regarding this during preparation and improving, it should be involved all participants of the process on the given workplace, it means direct workers. The group knows the best specificity of its own activities, and process of elaboration and after that, usage gives them possibility of understanding the essence and each aspect of the operation. In the aim of assuring all the easy access, obligatory standards should be found in constant and visible places. It is assumed that standards should not be implemented only in the typical operational processes e.g. production, movement maintenance, storing, but also in the administrative processes, for example: book-keeping, customer service, human resources management, or secretariat service.

Before:-

1. No operator is writing hourly report.
2. Employee details are not displayed on the notice board
3. No working information is displayed on the notice board

After:-

1. Writing hourly report is compulsory

2. Employee details are displayed on the notice board
3. Working instructions, control process plan daily maintenance sheet and part drawing are displayed on each CNC.

e) *Sustain / Discipline (SHITSUKE)*

(Sustain new status quo everything in its place) Implementing the idea of the 5S will demand from workers the compact self-discipline connected with implementing and obeying the rules of regularity incleaning and sorting. It leads to increasing the consciousness of staff, and decreasing the number of non-conforming products and processes, improvements in the internal communication, and through this to improvement in the human relations. It is also important to understand the need of executing the routine inspections of usage the 5Srule. This inspection is executed by helping of so-called check List and created on its basis the radar graph of the 5S, which serves to estimation of the workplace. The inspection of realization of the 5Srule is executed once a month by chosen team implementing the 5S rule – the control team.

Before:-

1. Company s Mission and Vision statements are not displayed.
2. No suggestion scheme

After:-

1. Company*s Mission and Vision statements are displayed in Hindi as well as Gujarati.

2. Suggestion scheme stating that whoever gives the best suggestion will be given reward of Rs 500/-.

periodic basis. Autonomous Maintenance is very crucial important in improving Equipment efficiency.

f) *Autonomous maintenance (JISHU HOZEN)*

The workers are to be self aware of the machines they are operating. They should learn to take care of the machines themselves on the daily and

For implementation of Autonomous Maintenance we took following steps and did work which is expressed in following table

Table 5.1: AM seven Step Implementation Methodologies

Autonomous maintenance seven step Implementation report	
Step	Work done
1.Cleaning and Inspection	Remove all dirt and grime from the machine
	Uncovered and highlighted all problems within the machine.
	All fluids drained and covers removed so that every part of the machine can be inspected and cleaned.
	Used Red/green Tags to highlight any problems,
	Cleaned machine by Operator as well as Maintenance persons.
2.Remove Causes of Contaminationandimprove Access	After cleaning, Identified root cause of contamination
	Identified inaccessible areas
3.Cleaning and Lubrication standards	Prepared Cleaning, Lubricating, Re-tightening, Inspection (CLRI) check sheet.
	Mapped cleaning frequency for Big machines
4.Train for general Inspections	Conduct in depth training with the operators to explain the function and purpose of each component of the machine as wells training in problem solving skills such as the Cause & effect and 5 whys.



	We then have the operators re-inspected the machines with their new-found knowledge and highlighted new problems discovered in much the same way that we did in step one.
5. Conduct Autonomous Inspections	With what they have learned in stage 4 the operators modified the standards and instructions that they put in place for the first three stages of autonomous maintenance to streamline and improve their maintenance tasks.
	The tasks at this stage are also compared and rationalized with the maintenance departments own maintenance schedules allowing tasks to be allocated correctly and prevent duplication of effort.
6. Implement Visual Maintenance Management	Provides Green/Red marks on Pressure gauges, oil level indicators.
	stickled JH stickers that what to clean by which Tool
	Fix Machine area Dashboard which Displays all the details regarding that machine
	Highlight the direction of flow of fluids through pipe work.
7. Continuous Improvement (KAIZEN)	highlighted “safe” and “normal” operating values on gauges and sight glasses in green and undesirable readings in red
	Repeated and improved on all that we have found and done in the previous stages to continually improve and reinforce what done with autonomous maintenance
	Team leaders, managers and maintenance technicians audited the work done by the operators on a regular basis and both congratulated the operators on a job well done and to give them the benefits of their knowledge.

g) *Kaizen*

“Kai” means change, and “Zen” means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and

involve all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment. The principle behind is that “a very large number of small improvements are more effective

in an organizational environment than a few improvements of large value". This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

- *Poka Yoke Device:-*

Arrangement of the tools in proper order so that no time is wasted in searching them and also that tools are prevented from unnecessary wear and tear. A tool board is to be prepared as shown below in the figure.



Fig.1.5: Arranged all tools by poke yoke concept

- *Coolant leakage problem:-*

Coolant leakage was a major issue and all the leakage is clearly visible on the ground and causing trouble in the movement of workers as well as flow of material and parts. A keen observation is done to find

out the reason of this leakage, the risk associated with the leakage and what preventive measures should be taken to avoid it. And a fish bone diagram is prepared showing the reasons for the leakage.



Fig. 1.6: Coolant leaked problem

To identify the reasons of coolant leakage fish bone diagram is prepared

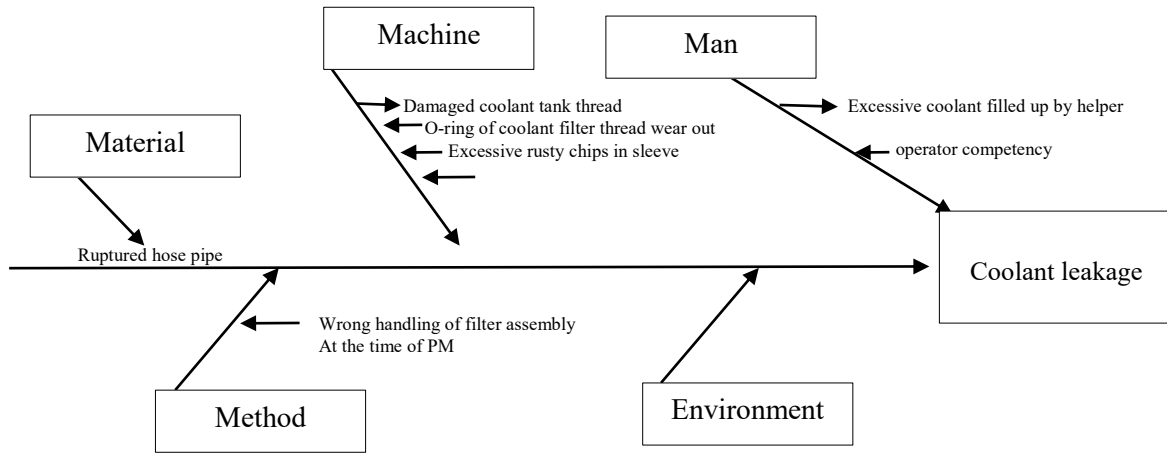


Fig. 1.7: fish bone diagram

The following table shows complete analysis of the coolant leakage problem and how it can be eradicated. The corrective measures that should be taken are also highlighted.

Table 5.2: Analysis of fish bone diagram

Problem	Occurrence	Risk	Severity	Corrective Action
Coolant leakage from filter	1. Due to O-ring (gasket) in the filter head got damaged	Moderate	High	New O-ring has been ordered.
	2. While tightening filter back into filter head is filter is not held at 90° and because of aluminum casted body and cross taper its threads are damaged.			Proper training is given to helpers who are doing Weekly preventive maintenance.
Coolant leakage from tank	1. One of the punching nut of coolant tank got damaged may be due to application of over pressure on the nut while tightening it.	Moderate	High	Gasket in the tank is changed and new punching nut is installed.

	2. Overflow from tank due to Overfilling of coolant by helper.			Training and number of bucket to be filled is clearly specified to the helper
Coolant leakage from hose pipe	Due to it's to and fro motion along with turret and it has certain life span after which it gets ruptured.	Low	Low	Installing new hose pipe

h) Planned maintenance (PM)

As we know it is aimed to have trouble free machines and equipment's producing defect free products for total customer satisfaction. This breaks maintenance down into four "families" or groups, viz., preventive maintenance, breakdown maintenance, corrective maintenance, and maintenance prevention.

Six steps in planned maintenance:

1. Equipment evaluation and recoding present status.
2. Restore deterioration and improve weakness.
3. Building up information management system.
4. Prepare time based information system, select equipment, parts and members and map out plan.
5. Prepare predictive maintenance system by introducing equipment diagnostic techniques and Evaluation of planned maintenance.

To prevent all breakdowns and for maintenance of plant and machineries we provide them maintenance sheets which is on Daily, Weekly and Monthly basis. Due to maintenance sheets they found tremendous change in their system because they are not used this maintenance sheets before. Due to sheets many of breakdowns are cleared and time are saved which is shown in calculations in final implementation analysis. The product that we have considered requires three major machines for its production namely CNC, Cutting Machine and Hydraulic press. The charts for the maintenance of these machines. The parameters that affect the machines are written down in the charts and classified on the basis of maintenance requirement where they are to be changed or serviced on daily, monthly and quarterly basis.

i. For CNC machines

Daily basis – Three types of maintenance are to be done on daily basis mainly Checking, Cleaning, areas like tool holders and spindle. The operators in that particular shift is supposed to fill the form and submit it to the production manager. The maintenance is to be done at

the end of the shift. Tick mark is to be done in the column when its done.



Table 5.3: For Daily maintenance of CNC

ANUPRIYA ULTRATECH - Daily maintenance report for CNC															
Month :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CHECKING															
Hydraulic pressure															
Chuck pressure															
Lube levels															
Coolant levels															
leaks															
CLEANING															
Chips															
Grease parts															
Windows															
Doors															
CUTTING TOOLS & TOOL HOLDERS															
Tighten the drawbar															
Tighten work holder devices															
Replace worn tool pump and motor															
SPINDLE															
Clean the spindle taper															
Test run the spindle															
Name of the operator :															
Submitted on :															
REMARKS :															

Monthly basis - There are some parameters that does not need to be checked on daily basis because they can sustain for a month at least. They are to be checked every month to avoid the further failure. This is a part of the preventive Maintenance.

Table 5.4: For monthly Maintenance of CNC

ANUPRIYA ULTRATECH - Monthly maintenance report for CNC												
Month :	oct	nov	dec	jan	feb	march	april	may	june	july	Aug	Sept
Mechanical												
Tool holders												
Check for breakage and Thread damage												
Inspect way covers and wipers												
Check dawbar height												
Electrical												
Motor Check for condition and testing												
Check for condition and testing												
Check voltages												
Check limit switches/safety locks												
General Note												
Check entire machine for loose or missing fasteners												
All of the oily matter, chips, etc, on the machine should be removed completely and put a thin lubricating oil on the sliding surface of machine to prevent the corrosion.												
Name of the operator :												
Submitted on :												
REMARKS :												

Quarterly basis –

Table 5.5 : Quarterly maintenance report for CNC ANUPRIYA ULTRATECH - Quarterly maintenance report for CNC

ANUPRIYA ULTRATECH - Quarterly maintenance report for CNC

Month :	Yes	No	Remarks
1. Clean coolant tank of sludge, chips, and oil			
2. Clean chuck and jaws			
3. Drain hydraulic tank and replace hydraulic oil			
4. Change line filter and suction filter			
5. Clean radiator and straighten any bent fins			
6. Drain and clean lubrication unit, add fresh way lube			
7. Drain and refill cooling unit			
8. Ensure the machine is level, adjust if necessary			
9. Clean and inspect way wipers, replace damaged ones			
Name of the operator :			
Submitted on :			
REMARKS :			

ii. For Cutting machine

On daily basis – Blades, Oil, Belt and below mentioned parameters needs to be changed in a cutting machine more often. Thus a sheet is to be maintained to keep the

track of changed things. Moreover to prevent unwanted breakdown they are to be changed and checked from time to time.

Table 5.6: For maintenance of Cutting machine

ANUPRIYA ULTRATECH - Quarterly maintenance report for Bensaw Cutting Machine															
Month :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Changing															
Blade															
Belt															
Hydraulic oil															
Gear Oil															
Coolant															
Name of the operator :															
Submitted on :															
REMARKS :															

iii. For Hydraulic press machine

On daily basis – Cleaning of filters, checking oil level, water and oil leaks, checking for loose fasters, pressure adjustments etc are being checked.

ANUPRIYA ULTRATECH - Daily maintenance report for hydraulic press machine

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Clean filters															
Oil level/Quality															
Oil leaks															
Water leaks															
Check for missing fasteners															
Check for loose fasteners															
Check for lubrication															
Check for pressure															
Removal of oily matter															
Name of the Operator :															
Submitted on :															
REMARKS :															

iv. For Hydraulic press machine

On monthly basis – Following criterias are to be checked on monthly basis.

i) Training

Continuous improvement is possible only through continuous improvement in knowledge and skill of the people as different levels. To reduce the defects training is provided to the concerned as show below:

- Training given for 100% visual inspection to detect visual defects
- Training given for using "Go and No go" gauges for 100% inspection and also for educating them how to use measuring instrument for e.g. verniercaliper, screw gauge and dial gauge etc.
- Training given by shop floor in charge regarding necessary force required to clamp the job into the chuck.
- Training given optimum set up for machine including how to mount chuck on the machine, in which order reduction sleeves, blocks and jaws should be installed etc.
- They are also advised to do setting at mean value given in the control copy of the drawing, earlier they setting machine at minimum value or we can say lower control limit, and thus causes rejection

j) Office TPM

- Now operators are writing daily rejected quantities in their daily report, so that time required in getting data for daily rejection from Quality department is reduced.
- New computer system is proposed for Maintenance department because Maintenance department is writing its daily report in a notebook and then that notebook is given to administration and then they document it and also for making schedules for maintenance they have to wait for person in administration to document it and take its hardcopy. And also their chance of loss of old records having valuable data.
- Earlier daily insert usage report was maintained in a notebook, and at the end of the month the person has to sit along with calculator to sum up the monthly consumption. Now the report is prepared in MS Excel saving lots of time and effort.
- Now employee details are displayed on the notice board having information like their name, designation, phone number so that whenever anybody need to consult them can reach them on their mobiles, without wasting time.

k) Safety, Health and Environment

- Sufficient number of fire extinguisher is provided all over CNC shop floor.

- Training is given to each and every individual about how to use fire extinguisher in case of emergency in every 6 months.
- Management is given suggestion for giving training to employee what to do in case of emergency? What should be the exit plan?
- Management is also given suggestion to conduct mock drill once in a year.
- Earlier water camper in the shop floor was washed weekly now helpers are advised to wash it within 2 days.

Workers are advised to maintain cleanliness of toilets, regular cleaning of toilets is also done. Workers are also advised not to chew tobacco and spit it in CNC shop floor and not to smoke within company premises.

CHAPTER -6

VI. CONCLUSION

After implementation of all the tools and techniques of Total Productive maintenance, again the data of the same product is collected and this time again the OEE (overall equipment efficiency) is calculated as below.

Table 6.1: Calculation of OEE%

Sr. No.	Category	After implementation
1	Shift time	960min/day
2	Total production in a shift	155 parts
3	scheduled break	70 min
4	Non-scheduled break	20 min
5	Breakdown	15 min
6	Cleaning, inspecting & tightening of insert	20 min
7	Operator absent	10 min
8	Non-conforming product	4 parts
9	Changeover or Setup	62 min

Table 6.2: OEE% After implementation

Sr. no.	Category	After implementation
1	Availability (A)	79.03%
2	Performance Efficiency(PE)	95.25%
3	Quality Rate(QR)	96.12%
4	OEE (A × PE × QR)	72.07%

Thus we can say that after implementation of TPM all the objective of the project are fulfilled mainly the productivity is increased, The overall equipment efficiency is increased, The task of timely Maintenance

of the machines is achieved. Unnecessary breakdown of machines is drastically reduced. Workers are given training and knowledge of the importance of timely maintenance of the machine.

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An Innovative Index for Evaluating the Temporal-Physicochemical Classification Pattern (Case Study: Garmabdasht, North of Iran)

By Milad Kurdi, Taymour Eslamkish & Faramarz Doulati Ardejani

Amirkabir University

Abstract- This study has been focused on investigating a new index for the assessment of major ion enrichment. Also, this study has examined the temporal-physicochemical classification Model of parameters and the temporal- IEI (Ion Enrichment Index) Model from 1986-2010. The results have been presented in this study based on physicochemical water quality parameters determined in the Garmabdasht River in Golestan province. For the evaluation and classification of the Model, WHO recommendation has been used. Temporal physicochemical Model results have been examined, and most of the samples were less than authorized in the Model of pH, Cl, K, Mg, Na, and SO₄ but in the Ca and HCO₃ Model, approximately more than 70 percent of the samples were suitable. In addition, the TDS Model shows that in most cases, high TDS from tap water was dominated.

Keywords: *IEI (Ion Enrichment Index); temporal physicochemical classification. Model; Garmabdasht; IEI_{total} ; vulnerable samples.*

GJRE-J Classification: *FOR Code: 291899p*



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An Innovative Index for Evaluating the Temporal-Physicochemical Classification Pattern (Case Study: Garmabdasht, North of Iran)

Milad Kurdi^α, Taymour Eslamkish^σ & Faramarz Doulati Ardejani^ρ

Abstract- This study has been focused on investigating a new index for the assessment of major ion enrichment. Also, this study has examined the temporal-physicochemical classification Model of parameters and the temporal- IEI (Ion Enrichment Index) Model from 1986-2010. The results have been presented in this study based on physicochemical water quality parameters determined in the Garmabdasht River in Golestan province. For the evaluation and classification of the Model, WHO recommendation has been used. Temporal-physicochemical Model results have been examined, and most of the samples were less than authorized in the Model of pH, Cl, K, Mg, Na, and SO₄ but in the Ca and HCO₃ Model, approximately more than 70 percent of the samples were suitable. In addition, the TDS Model shows that in most cases, high TDS from tap water was dominated. Results of the temporal-IEI Model, because of the vulnerable samples, showed better classification than the temporal-physicochemical Model. Results of the temporal Model based on IEI_{total} that has been examined in order to give a comprehensive Model, showed that all of the samples were relatively satisfactory and less than the extent permitted, but approximately half of the samples are vulnerable.

Keywords: IEI (Ion Enrichment Index); temporal-physicochemical classification Model; Garmabdasht; IEI_{total}; vulnerable samples.

I. INTRODUCTION

Since the 1930s, the quality of water has been one of the most important subjects of environmental sciences. Since the 1980s, global water quality changes have been added to water quality sciences (Xing-hui et al. 2001). Generally, the quality of water in surface water is a function of anthropogenic impact and natural processes (Olade 1987).

To examine the water quality situation, it is important to have detailed information about the physicochemical conditions. There are many hydro chemical assessment methods. Many methods have

been presented to examine the environmental quality condition, such as contamination indices and PCA (Cheng et al. 2007). One of the most important factors in making a right decision is selecting the proper method to examine quality (Qingjie et al. 2008). Many water quality models have been made by using physicochemical parameters and trend and time series analysis (Prasad et al. 2014).

Environmental quality indices are significantly implemented for processing and analyzing environmental information (Ramos et al. 2004). There are many studies on pollution indices especially by trace elements in geochemistry investigation such as contamination factor (C_i) and ecological risk factor (Er) suggested by Hakanson (1980), element enrichment factor (EF) suggested by Duce et al. (1975), index of geo-accumulation (I_{geo}) originally suggested by Banat et al., (2005), sum of pollution index (PI_{sum}) by Kwon and Lee (1998), degree of contamination (C_d) for background enrichment index by Caeiro et al. (2005), pollution load index (PLI) for ecological risk index by Wilson and Jeffrey (1987), marine sediment pollution index (MSPI) suggested by Shin and Lam (2001), index of metal pollution in marine sediments for the contamination index suggested by Satsmadjis and Voutsinou Taliadouri (1985), index for chemistry of the sediment quality (I) suggested by Chapman (1990), metal pollution index (MPI) as a contamination index suggested by Usero et al. (1996), Index for chemistry of sediment quality suggested by DelValls et al. (1998), sediment quality guideline quotient (SQG-Q) as an ecological index suggested by Long and MacDonald (1998), standard ion index (SII) suggested by Şen (2011), and metal enrichment index (SEF) suggested by Riba et al. (2002).

All of these indices have been proposed based on special condition or parameters regarding application of the indices to determine water quality and their classification. However, in these indices, there is no emphasis on physicochemical parameters, especially for EC, pH, and TDS. Although such indices have provided useful information, visual data presentation can be useful especially by considering

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physicochemical parameters. According to this motivation, a visual presentation of an index is suggested in this study as a general evaluation mechanism with special emphasis on the temporal - spatial variations of physicochemical parameters

These indices evaluate the degree of chemical status which may have a negative effect on water quality. These quality indices propose changes in various indicator factors in a single merge index that attempts to describe the water quality (Mourhir et al. 2014). The indices also grade and prioritize the areas or the ions for further research (Iwuoha et al. 2012).

Water paucity is one of the major problems in the reduction of crop production in the arid and semi-arid regions of Iran. Golestan province is the third largest cereal producer in Iran (Kurdi et al. 2014). The results presented in this study are based on physicochemical water quality parameters determined in Garmabdasht River in Golestan province, during a period of 25 years (1986-2010). This paper has focused on investigating a temporal-physicochemical classification Model based on physiochemical parameters in Golestan province. In order to achieve this purpose, each parameter was classified based on the standards and the map of the parameters based on sampling time (month versus year) has been drawn. In addition, this paper has suggested an index based on ions which can help the water quality classification. The new suggested method has mentioned *Ion Enrichment Index (IEI)*. In order to obtain such an overview indicating the ion status in Golestan province at Garmabdasht River, a classification model based on IEI has been examined. The temporal-physicochemical classification

Model suggested in the present study can provide beneficial information about the past, present and future status of ion changes in the study area understood by non-scientists.

II. MATERIALS AND METHODS

This paper focuses on Golestan province, the southern part of the Caspian Sea, in the Qareh Sou basin (Fig 1). The Garmabdasht is located on the northern slopes of the Alborz Mountains and the Alborz Mountains are the most important sources of water for Garmabdasht River and Qareh Sou basin. The bed of this basin is different with a source and estuary which follows from the geological status of this region and with respect to morphology the river, the region is divided into mountain and plain (Kurdi et al. 2014). As far as geological issues are concerned, in the source of river Precambrian sediments consist mainly of dark green metamorphic schist (mica schist, chlorite schist, quartzite, marble, and slate) with bright green Gorgan green schist and Mesozoic sediments are mostly limestone and dolostone with layers of marl in the upper Jurassic. In some places, there are loose sandy Quaternary sediments. However, the bed of the basin almost consists mainly of young alluvium, young terraces, and gravel fans. The climate of this area has been classified as warm and temperate. The average annual temperature in Garmabdasht is about 14.6 °C and annual rainfall is approximately 750 mm. Rainfall in the winter is more than summer in Garmabdasht and the most precipitation rate occurs in October. During the year, the average temperatures vary by 19.0 °C.

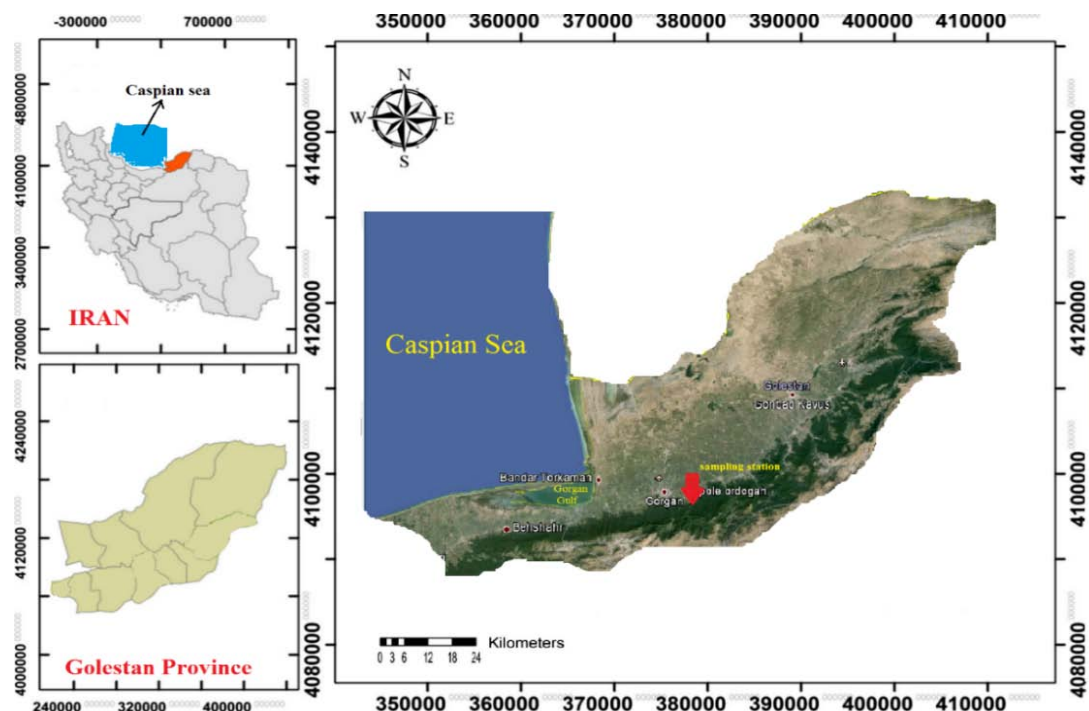


Fig. 1: Study area and sampling location

In this study, we used Pole-ordogah hydrometric station in Garmabdasht River. For examination of Garmabdasht water quality from 1986-2010, 241 samples were analyzed overall. Electrical conductivity (EC), total dissolved solid (TDS) and pH were measured by a water checker portable meter (hatch model HQ40D53000000). The bicarbonate (HCO₃⁻) had been measured by the alkalinity measurement method. Sodium (Na⁺), potassium (K⁺), magnesium (Mg²⁺), calcium (Ca²⁺), chlorine (Cl⁻) and sulfate (SO₄²⁻) were measured by Graphite atomic absorption (furnace 4100) using standard methods.

In order to examine the classification of physicochemical parameters to achieve the Model, WHO (2006) recommendation as a worldwide standard and standard of Institute of Standards and Industrial Research of Iran (ISIRI) as local standard (Fallahzadeh et al. 2016) were used in this study. Since ISIRI values in most of the parameters are as same as WHO except for Ca and Na and also the local standard presents no standard for bicarbonate, EC, and potassium, WHO thresholds have been used for the model. The comparison of WHO and ISIRI has been presented in Table 1.

Table 1: Comparison threshold of parameters between WHO and ISIRI

Variable	WHO 2006	ISIRI 2016
pH	6.5-8.5	6.5-8.5
EC(μS/Cm)	1400	-
Cl (mg/l)	250	250
HCO ₃ (mg/l)	250	-
Ca (mg/l)	75	300
Mg(mg/l)	50	30
Na(mg/l)	50	200
K(mg/l)	10	-
SO ₄ (mg/l)	250	250

III. RESULTS AND DISCUSSION

The pH is one of the most important variables in water quality assessment. Variation in pH may reveal the attendance of some sewage, particularly when it is continuously measured and recorded (Chapman 1996). The temporal Model of pH value from 1986 to 2010 has been demonstrated in Fig 2.a. As the Model indicates, most of the investigated samples are suitable in terms of pH (the green squares). Only from 1987 to 1989, especially in the first half of the year, some of the samples were acidic (the red squares).

The total dissolved solids (TDS) correspond to the filterable residue (Chapman 1996). For TDS, Hem

(1985) has released a classification of 7 classes. Ideal drinking water (0-50, *very pale blue* squares), mountain spring and aquifers (50-100, *blue* squares), hard water (100-200, *dark blue* squares), marginally acceptable (200-300, *violet* squares), high TDS from tap water (300-500, *green* and *yellow* squares) and the contaminated level (>500, *red* squares). The temporal Model of TDS from 1986 to 2010 has been shown in Fig 2.b. As the Model shows, in most cases, high TDS from tap water is dominated. In some cases, TDS exceeded more than 500 which shows the contamination of TDS.

Calcium is easily dissolved from rocks rich in calcium particularly limestone and gypsum (Chapman 1996). Based on WHO recommendation, 75 milligrams per liter Ca is normal for water. The temporal Model of Ca from 1986 to 2010 has been illustrated in Fig 2.c. As the Model shows, more than 70 percent of samples are suitable (the *green* squares). But in some samples, especially in the second half of the year, calcium is over the limit (the *red* squares).

Chlorine takes the place of chloride in the solution (Chapman 1996). Based on WHO recommendation, 250 milligrams per liter Cl is normal for water. The temporal Model of Cl from 1986 to 2010 has been shown in Fig 2.d. The Model shows that all of the samples are less than authorized (the *green* squares).

Bicarbonate is the most common form of inorganic carbon usually found as a dominated ion between pH of 6 to 8.2. When the river basin consists no carbonate rocks, the HCO₃⁻ is derived from soil CO₂ (Chapman 1996). According to WHO, up to 250 milligrams per liter HCO₃⁻ is allowed for water. The temporal Model of HCO₃⁻ from 1986 to 2010 has been shown in Fig 2.e. The Model shows that more than 75 percent of samples are suitable (the *green* squares). However, in some samples, especially in the last second season of 1992, HCO₃⁻ is over the limit (the *red* squares).

Potassium with low concentration can be found in natural waters from rocks which consist of potassium. These rocks are relatively stable to weathering (Chapman 1996). Corresponding to WHO, 10 milligrams per liter potassium is allowed for normal water. The temporal Model of K from 1986 to 2010 has been demonstrated in Fig 2.f. The Model shows that most of the investigated samples are suitable in terms of K (the *green* squares).

Magnesium comes mainly from the weathering of ferromagnesian minerals, carbonate rocks and organometallic and organic matter (Chapman 1996). Based on WHO recommendation, 50 milligrams per liter magnesium is permissible. The temporal Model of Mg from 1986 to 2010 has been presented in Fig 2.g. As the Model shows, almost all samples (except one sample in 1995, the *red* square) are appropriate (the *green* squares).



All natural water sources include an unspecified number or amount of sodium. Increased concentrations of sodium in surface waters may come from sewage and industrial effluents (Chapman 1996) and it also may be derived from halite and silicate minerals. Based on the WHO standard, 50 milligrams per liter of sodium is permissible. In the temporal Model of Na from 1986 to 2010, similar to Cl, all of the samples are less than the permitted amount (Fig 2.h).

Sulfate occurs from the leaching of sulfur compounds and sulfate minerals such as gypsum and pyrite (Chapman 1996). Based on WHO recommendation, 250 milligrams per liter sulfate is permissible. According to the temporal Model of SO₄ from 1986 to 2010, similar to Cl and Na, all of the samples are less than the permitted amount (Fig 2.i).

The quality index can be used to assess water quality changes based on the annual survey. A water quality index is a simplified expression of a complex set of variables that is calculated by collecting some water quality measurements into one number (Chapman 1996). The IEI (Ion Enrichment Index) represents a value between -1 and 1 that has been developed to assess the trend of ion changes in the study area. The proposed index can be calculated by the following equation:

$$\text{Ion Enrichment Index} = \text{IEI} = \frac{I_k - I_0}{I_0}$$

Where:

I_k = is the total concentration of each ion

I_0 = the ion background level (based on WHO (2006))

Four categories would be recognizable based on IEI:

- $-1 < \text{IEI} < -0.5$, very low enrichment, suitable, *green* squares;
- $-0.5 \leq \text{IEI} < 0$, moderate enrichment, good, *yellow* squares;
- $0 \leq \text{IEI} < 0.5$, significant enrichment, impermissible, *red* squares;
- $0.5 \leq \text{IEI}$, very high enrichment, harmful, *dark brown* squares.

Although the IEI has been initially developed for surface waters, it can be used for ground waters and sea waters.

In order to evaluate the ion contamination and enrichment with the passage of time, the temporal classification Model of IEI for each ion has been investigated (Fig 3). As shown, these Models have shown perfect conformity with the temporal Model that is prepared based on the standards.

It is important to note that in the physicochemical temporal Model based on IEI there is a different category compared to the physicochemical Model based on the standard. For instance, the samples that are located in moderate enrichment and have been shown as *yellow* squares are good but these

samples are more vulnerable than the others because these areas are at risk of passing the limit. In addition, the samples which have been shown in dark brown and are categorized in the harmful class, are different from the IEI Model. These samples actually represent the occurrence of a particular incident in a certain time interval.

As shown in Fig 3, the Model of Calcium and bicarbonate are likely and have many events which show moderate and sometimes significant enrichment. These enrichments may have been caused by the effect of geology and sedimentary rocks in the bed of the basin. For potassium and magnesium, based on IEI Model, there is one significant enrichment (October of 1999) and two very high enrichment events (April/2000 and June/2001). The only especial judgment which we can have for these events can be some guess about the source of these enrichments. As presented, the source of these enrichments for K and Mg were same and an especial factor controlled the solubility of these ions in natural water.

For the purpose providing a comprehensive Model of physicochemical parameters based on the index IEI, at any specific timeframe, the average IEI index of all the ions has been calculated. Then a temporal Model based on IEI has been examined. Fig 4 has shown an IEI_{total} - temporal Model. As the Model shows, at all timeframes of the sampling, the IEI_{total} index is relatively good and less than the extent permitted. But for approximately 50 percent of the samples, the status is close to the latest limit permitted and is vulnerable.

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IV. CONCLUSION

This study has been focused on proposing a new index based on ions and examining temporal-physicochemical and temporal IEI Models in Garmabdasht River in the southern part of Golestan Province in Iran.

Indices are a simplified declaration of a compound set of variables that can be used for a variety of targets such as water quality information to the public and decision makers, planning tool for managing, evaluating changes in quality, identifying quality problems and assessing the performance of contamination (Chapman 2006).

The temporal-physicochemical Model results showed that:

- In the pH, Cl, K, Mg, Na, SO₄ Model, most of the samples are less than authorized.
- In the Ca and HCO₃ Model, approximately more than 70 percent of the samples are suitable.
- The TDS Model shows that in most cases, high TDS from tap water is dominated.

In order to examine the ion enrichment, IEI for each ion has been proposed. For the purpose of evaluating IEI by the passage of time, the temporal-IEI Model has been developed. Results of this Model show better classification than the temporal-physicochemical Model because the vulnerable samples have been shown in this Model.

Results of the temporal Model based on IEI_{total} examined in order to give a comprehensive Model, indicates that all of the samples are relatively good and less than the extent permitted, but approximately half of the samples are vulnerable.

It should be noticed that if only one parameter presented the water quality exceeds the maximum limit, the water should not be used as drinking water. By using IEI_{total}, increasing one parameter would be covered by decreasing another parameter. With regarding this problem, we recommended using Temporal-Physicochemical Model of each parameter, Ion Enrichment Index for each parameter and IEE_{total} simultaneously to have the best judgment about the quality of water.

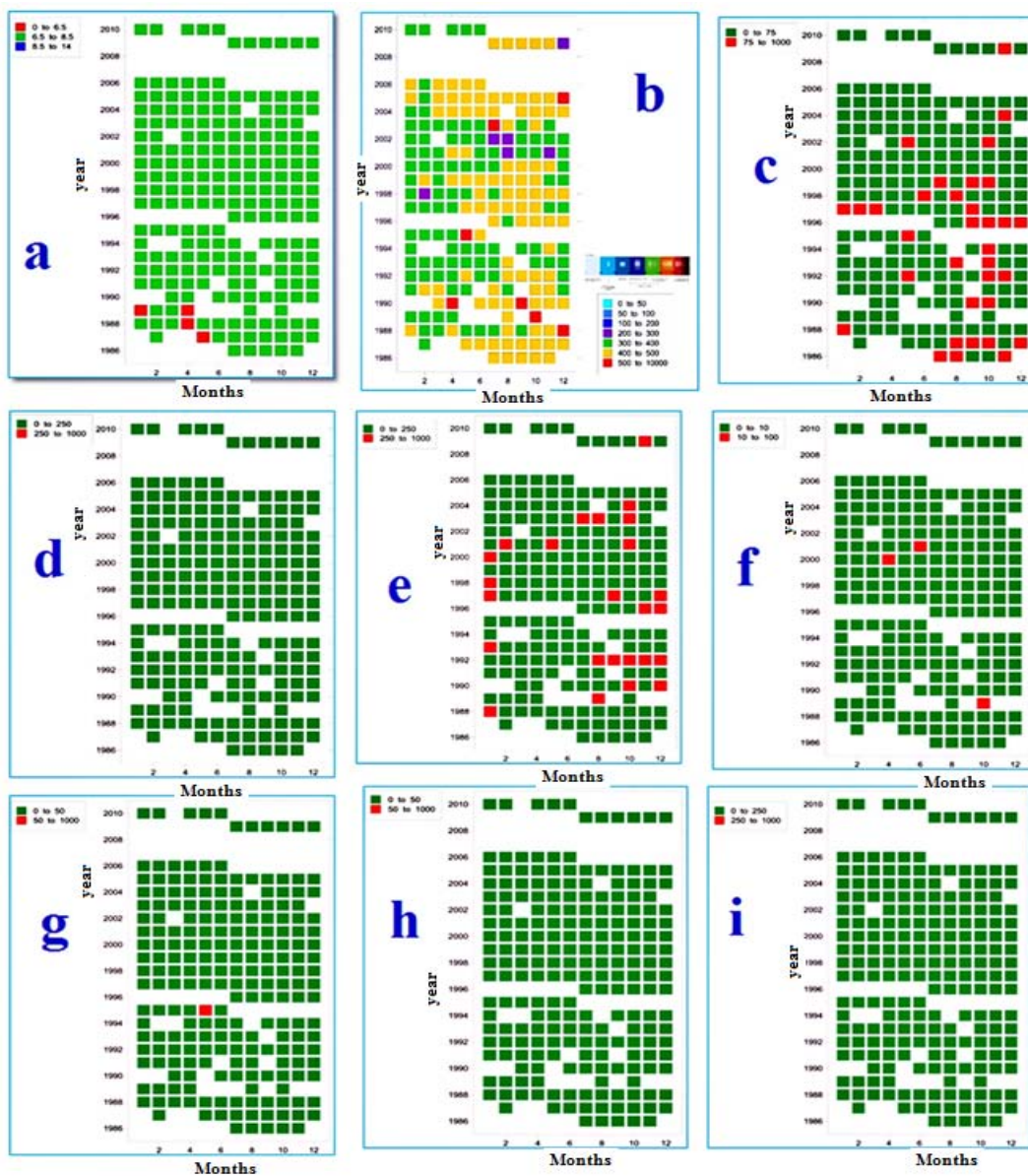


Fig. 2: Temporal-physicochemical pattern of Garmabdasht from 1986 to 2010; a) pH; b) TDS; c) Ca; d) Cl; e) HCO₃; f) K; g) Mg; h) Na and i) SO₄

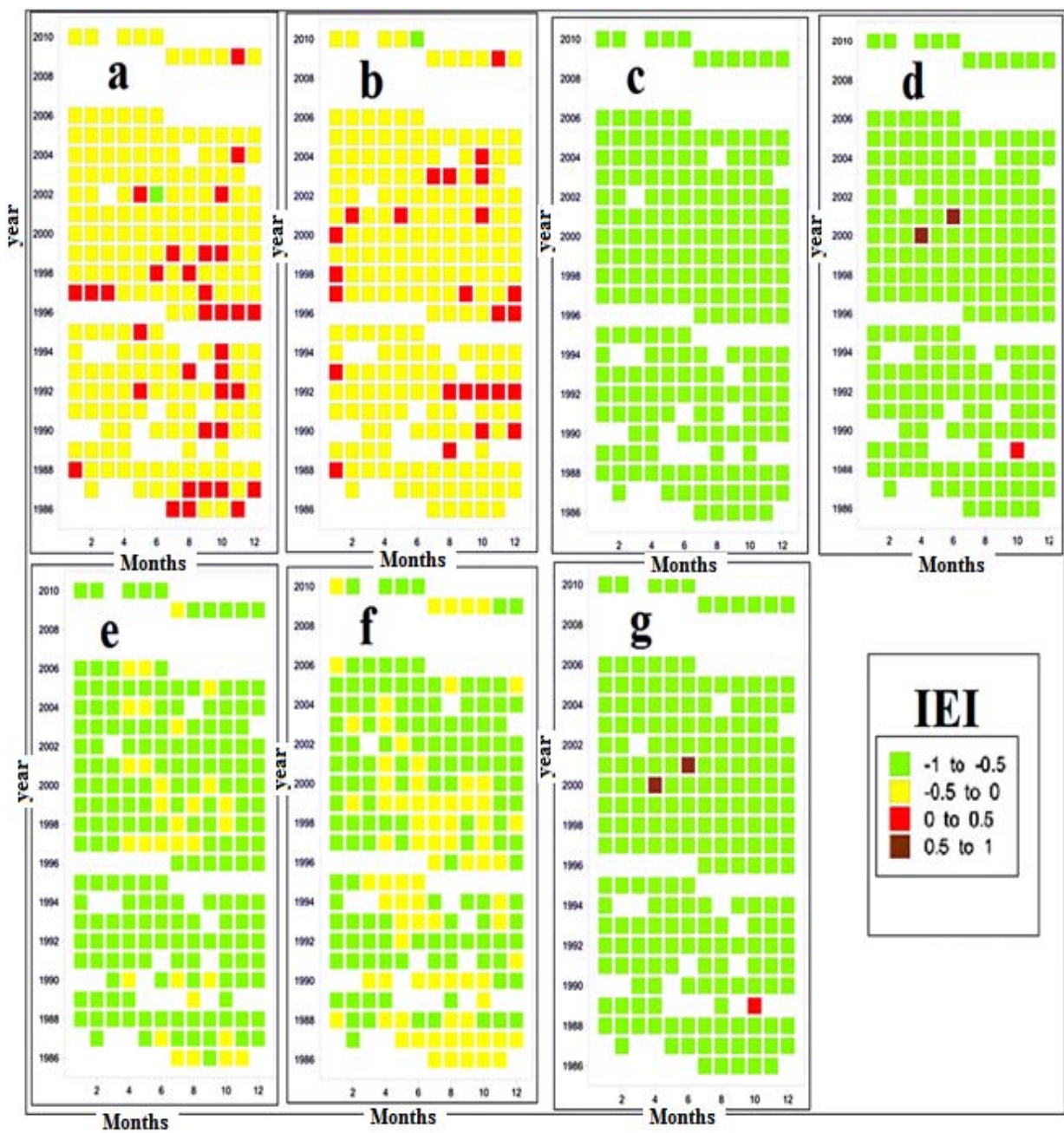


Fig. 3: Temporal pattern of Garmabdasht from 1986 to 2010 based on IEI; a) Ca; b) HCO₃; c) Cl; d) K; e) Na; f) SO₄ and g) Mg



Fig. 4: Temporal - IEI_{total} pattern of Garmabdasht from 1986 to 2010

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Application of Different Inorganic Salts as Exhausting Agent for Dyeing of Cotton Knitted Fabric with Reactive Dye

By Kamrunnahar

Northern University

Abstract- Aplenty of textile substrate especially cotton fabric dyed with reactive dyes because they produce a extensive gamut of bright colors with excellent colorfastness. As the reactive dye requires considerable quantities of salt and alkali for efficient application of colorants, this study is providing an assortment of knowledge about dyeing fabric with reactive dye and using some of the inorganic salts such as glauher salt, sodium chloride, zinc sulfate, aluminum sulfate, ammonium chloride and copper sulfate as an exhausting agent. Color strength measurements and colorfastness properties investigated here. In addition to, visage variation of dyed fabric also included in this study. In this experiment, 5 gm weights of samples dyed with 2% shade of a reactive dye at 600c within 60 minutes where salts applied in three different concentrations like 50 gm/l, 20 gm/l and lastly 10 gm/l. It has observed that colorfastness of the reactive dyed sample with sodium chloride and zinc sulfate is slightly higher though the color strength of fabric dyed with glauher salt and sodium chloride are better than rest other salts.

Keywords: reactive dye, inorganic salt, colorfastness, color strength.

GJRE-J Classification: FOR Code: 091599



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Keywords: reactive dye, inorganic salt, colorfastness, color strength.

I. INTRODUCTION

After the completion of three process that is adsorption, sorption and desorption then dye molecules saturated into the fabric and the overall procedure is known as exhaustion. The presence of dye alone in the dye bath does not fully dissipate in the fibers. For this reason, salt used as an exhausting agent with different colorants (direct dye, reactive dye) in textile dyeing process [1].

During the dyeing process of cellulosic fabric like as cotton, viscose or linen, after soaking into dye liquor the surface of the textile substrate get covered in negative ions and on the other hand some dyestuff such as direct dye or reactive dye also developed a negative charge which acts as a zeta potential [2]. As a result, the dye molecules are incapable to show a chemical reaction to the textile substrate and roll off the fabric surface that hinders the color changing capacity of the substrate. Salts play the role of glue that holds the dye molecules into the fabric and with the addition of alkali, certain percentage of dyestuff fixed with textiles.

Based on using salts as electrolyte various studies carried out. M.A Salam, P.K Sheik, F.I Faruoique observed the effects of salt on jute fabric dyeing with reactive, direct and mordant dyes [3] as well as Awais Khatri experimented to improve the process substantivity of cotton with reactive dyes in the presence of biodegradable organic salts [4].

Reactive dyes are the leading class of dyestuff in the textile industries, and 50% of cellulosic materials dyed with it. They are also increasingly gaining importance for wool and polyamide fibers. Worldwide consumption of reactive dyes for cellulosic materials in the mid-1980s was about 10-12% [5]. As reactive dye reached the acme among various dyestuff so, now it is renowned for cotton dyeing with its superior fastness properties and a wide range of applications [6]. The reason of the excellent washing fastness is due to the covalent bonding between the fiber polymers and the dye molecules under alkaline pH conditions [7], and reactive dye is the only class of dyes amongst all the dyestuffs that makes covalent bond with the fiber and becomes a part of it. Nevertheless, it has some drawbacks for example; large amounts of salt are required to force its deposition on the fabric due to its low affinity of substrate. In addition to that, to fix up the dye with the textiles materials, fixing agent is needed and dye hydrolysis (20-70%) is another demerit of reactive dye [8,9]. To overcome the shortcomings of reactive dyes one experiment carried out by adopting lower liquor ratio [10]. Divyesh R. Patel, Jigna A. Patel, Keshav C. Patel had worked in another article on Synthesis and evaluation of a series of symmetrical hot brand bis azo reactive dyes [11]. Therefore, to minimize the drawbacks of reactive dye, the motive of this experiment is observing that within six inorganic salts that which one gives the best results at optimum salt concentration.

II. MATERIALS AND METHODOLOGY

a) Materials

i. Fabric

100% cotton knitted single jersey (160 GSM) scoured, and the bleached fabric collected from

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Impress Newtex composite mills Limited and used without any further treatment.

ii. *Dye Stuff and Chemicals*

The chemicals and dyestuff collected from Impress Newtex composite mills Limited.

Dye: Reactive dye- Solazol red SP2B:2%

Electrolyte:

1. Glauber salt ($\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O}$): 50, 20, 10 gm/l
2. Sodium Chloride (NaCl): 50, 20, 10 gm/l
3. Zinc sulfate (ZnSO_4): 50, 20, 10 gm/l
4. Aluminum sulfate [$\text{Al}_2(\text{SO}_4)_3$]: 50, 20, 10 gm/l
5. Ammonium Chloride (NH_4Cl): 50, 20, 10 gm/l
6. Copper sulfate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$): 50, 20, 10 gm/l

Alkali:

1. Soda ash (Na_2CO_3): 5 gm/l
2. Sodium hydroxide (NaOH): 0.2 gm/l

Soaping agent (A340ND): 2 gm/l

Acetic acid (CH_3COOH): 1 gm/l

Temperature: 60° c

Time: 60 min

M: L-1:8

b) *Methodology*

i. *Dyeing with Reactive dyes*

The dyeing of cotton fabric carried out by alkali controllable reactive dye (Solazol red Sp-2B) on Fong's sample dyeing machine. Keeping the material to liquor ratio 1: 8 for the shade percentage 2%.

The process sequence of cotton fabric with reactive dye (Solazol red Sp-2B):

Dyeing started in the neutral condition and at the ambient or room temperature (30°c).

↓
Required water pureed in the dye pot as M: L ratio.

↓
Add salt to the dye pot and check the pH

↓
Linear dosing of dye at 10-20 minutes and raise the temperature at 3°c/min.

↓
Add soda ash and sodium hydroxide.

↓
After temperature reached, 60° c run the machine for 60 minutes at this temperature.

↓
Then drain the machine, and rinse the sample at 30°c for 10 minutes.

↓
At last, a hot wash done using a soaping agent at 90°c for 10 minutes.

ii. *Measurement of color strength*

The reflectance value of the dyed samples measured in the wavelength of 400-700 nm with 10 nm intervals using Data color 650® Spectrophotometer. This reflectance value is putting into the Kubelka Munk's theory to find out the color strength (K/S) of each specimen.

$$\text{Color Strength, K/S} = (1-R)^2 \div 2R.$$

iii. *Measurement of colorfastness*

To measure colorfastness properties of the dyed sample. Following fastness test done:

1. Colorfastness to wash: According to ISO Test Method, ISO 105-C10-2006.
2. Colorfastness to rubbing (Dry and Wet): According to ISO Test Method, ISO 105×12
3. Colorfastness to perspiration (Acid, Alkali): According to ISO Test Method, ISO 105×E04

Each sample tested for colorfastness to washing, rubbing, and perspiration that were prepared using Society of Dyers and Colourists (SDC) standard. As well as for assessing color change (ISO 105 A02) and color staining (ISO105 A03) standard grey scales utilized to obtain ratings of fastness test.






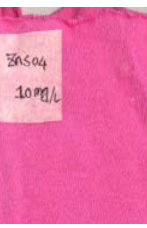
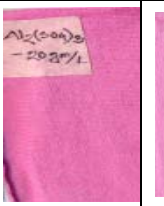


III. RESULTS AND DISCUSSION

The experimental results represented in a series of tables and charts. Which provides information about the activity of salts acts as exhausting agent with respect to their various concentration. Color strength assessed instrumentally, and colorfastness considered on visual experience regarding grey scale rating.

a) *Visual appearance*

Although all the samples dyed with 2% shade of reactive dye, and higher variation observed in their look in the presence of different inorganic salt.

Table 3.1: Visual changes of dyed fabric using different salts with respective concentrations

Name	50gm/l salt	20 gm/l salt	10 gm/l salt
Sodium Chloride	 Raspberry	 Deep pink	 Cerise
Glauber salt	 Ruby	 Rose	 Cerise
Zinc sulfate	 Lavender pink	 Light hot pink	 Deep hot pink
Aluminum sulfate	 Thulian pink	 Amarnath pink	 Carnation pink
Ammonium Chloride	 Hot pink	 Thulian pink	 Amarnath pink



It mentioned earlier that all the samples are dyed in the shade %, so their hue should be the same at equal salt concentration. Nevertheless, their look is far different to each other. In addition to, it observed that zinc sulfate and ammonium chloride give bright shade at lower salt concentration while rest of the salts yield vivid color with higher salt concentration. The main reason for this fact is –

The dye Solazol red SP-2B belongs to the vinyl sulphone functional group. Moreover, it works well in the alkaline media. It noticed from the following tabulated data prior dyeing only glauber salt exhibits basic media of salt solution then the sodium chloride is in slightly high pH condition, and other salt solutions are in the state of acid condition.

Table 3.2: Before adding dye in water liquor the P^H of the salt solution mentioned in the following table

Name of the salt	P ^H at different salt Concentration after adding salt		
	50 gm/l	20 gm/l	10 gm/l
Glauber salt	8.86	8.40	7.88
Sodium Chloride	7.18	7.46	7.61
Zinc sulphate	4.63	6.14	6.81
Aluminum sulphate	3.05	3.44	3.61
Ammonium Chloride	6.3	6.6	6.8
Copper sulphate	4.21	4.84	5.11

b) Color Strength (K/S) Analysis

The color strength of sample dyed with sodium chloride and glauber salt are nearly same for 50 gm/l salt that is 9.1 and 9.2 respectably. However, the k/s value of sample using 20 gm/l salt is 5.2, and 10 gm/l salt is 4.7 for sodium chloride; whereas the k/s value of sample dyes with 20 gm/l is 6.5 and 10 gm/l is 5 in respect of glauber salt.

The color strength of dyed sample using ammonium chloride is not so high; nevertheless, it is higher than copper sulfate and zinc sulfate.

So the series of salt regarding color strength-

Glauber salt > Sodium chloride > Ammonium Chloride > Zinc sulfate > Aluminum Sulfate > Copper sulfate.

Table 3.3: Maximum k/s value with respective wavelength for different salt concentration

Name of the salt	50gm/l salt concentration		20gm/l salt concentration		10gm/l salt concentration	
	Wavelength	k/s value	Wavelength	k/s value	Wavelength	k/s value
Glauber salt	540	9.2	540	6.5	540	5
Sodium chloride	540	9.1	540	5.2	540	4.7
Zinc sulfate	550	0.45	550	1.8	540	2.3
Aluminum sulfate	554	1.15	550	1	550	0.48
Ammonium chloride	550	3	550	4.8	550	2
Copper sulfate	540	0.75	540	0.7	540	0.65

c) Evaluation of Colorfastness Properties

i. Colorfastness to Wash

Wash fastness of sample dyed with sodium chloride, zinc sulfate and glauber salt are comparatively higher than sample dyed with other salts.

Figure 3.1 shows that color fastness to washing (regarding color change) of dyed sample with six inorganic salts at different concentration. It observed that for 50 gm/l salt glauber salt and sodium chloride have higher (5) rating than another salt while zinc sulfate and aluminium sulfate show high rating (4.5) for 20 gm/l and 10 gm/l salt conc.

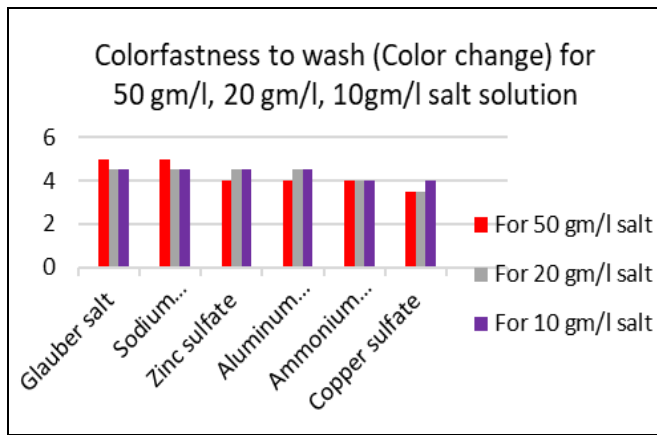


Figure 3.1: Bar chart of colorfastness to wash for color change

Color staining of wash colorfastness of dyed sample using different inorganic salts according to their salts concentration shown in figure 3.2. For 50gm/l, 20gm/l, 10 gm/l salt solution, zinc sulfate shows outstanding color staining wash fastness and copper

sulfate exhibit lower color staining fastness grading. On the other hand, moderate fastness observed for sodium chloride and glauber salts.

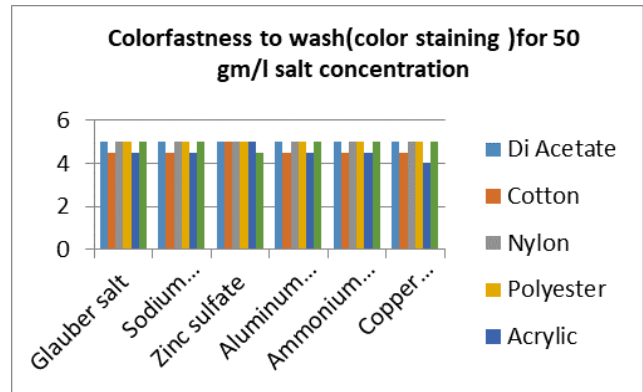


Figure 3.2: Color fastness to wash for color staining at 50 gm/l salt concentration

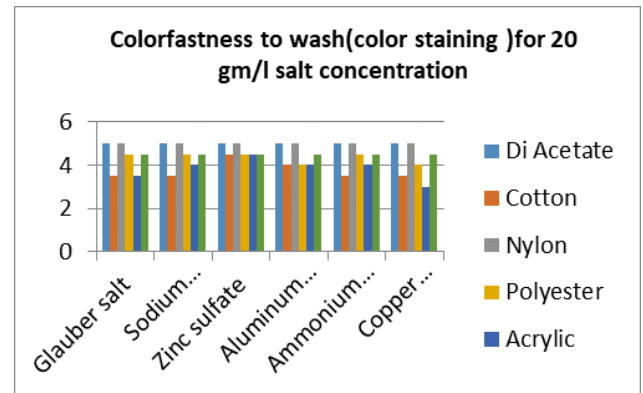


Figure 3.3: Colorfastness to wash for color staining at 20 gm/l salt concentration

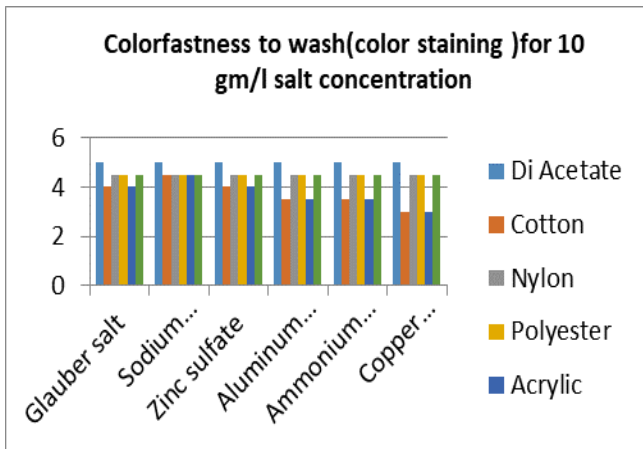


Figure 3.4: Colorfastness to wash for color staining at 10 gm/l salt concentration

ii. *Colorfastness to rubbing*

Dry rubbing fastness of the entire sample dyed with various salt is same. That is for 50 gm/l, 20 gm/l and 10 gm/l salt concentration in the fastness grading of dry rubbing is 5.

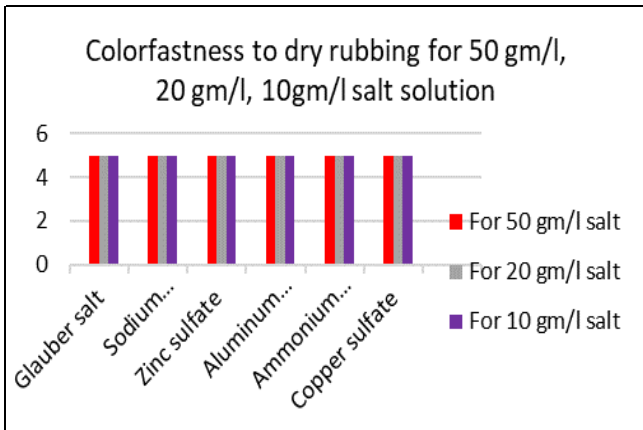


Figure 3.5: Colorfastness to dry rubbing at 50gm/l, 20 gm/l and 10 gm/l concentration

Figure 3.4 shows that wet rubbing fastness of the sample dyed with zinc sulfate is relatively better (grade 5) than fabric colored with other salt and which is same for all three concentration. Though wet rubbing fastness of 20 gm/l and 10 gm/l glauher salt and sodium chloride shows equal grading like as zinc sulfate and both have lower fastness rating at 50 gm/l than zinc sulfate.

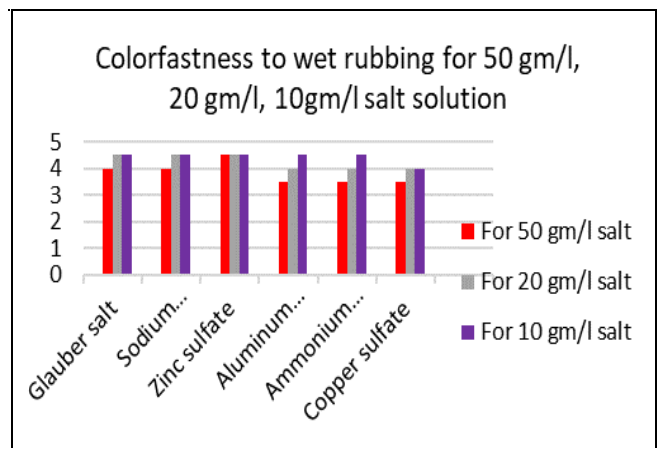


Figure 3.6: Colorfastness to wet rubbing at 50gm/l, 20 gm/l and 10 gm/l salt concentration

iii. *Colorfastness to acid perspiration*

For 50 gm/l salt solution, color change to acid Perspiration of sample dyed with zinc sulfate is higher (grade 5), but in case of 20 gm/l and 10 gm/l, both glauher salt and sodium chloride expose grade 5 in rating scale for color change.

Regarding color staining, acid perspiration, fastness of colored fabric is better for zinc sulfate at 50 gm/l however; at 20 gm/l and 10 gm /l salt concentration, acid perspiration fastness is good for sodium chloride and glauher salt respectively.

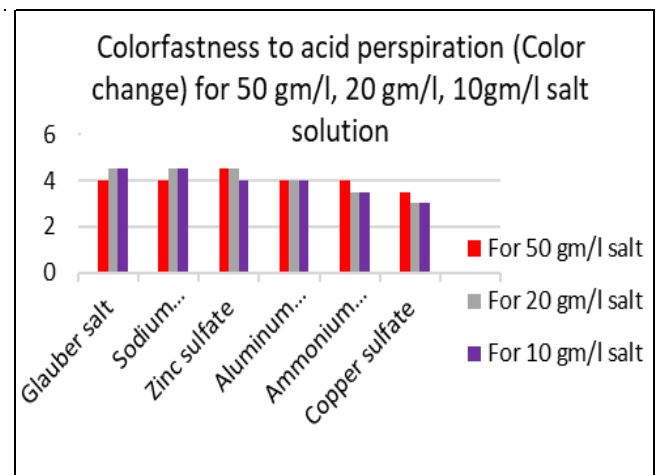


Figure 3.7: Colorfastness to acid perspiration for color change at various salts concentration

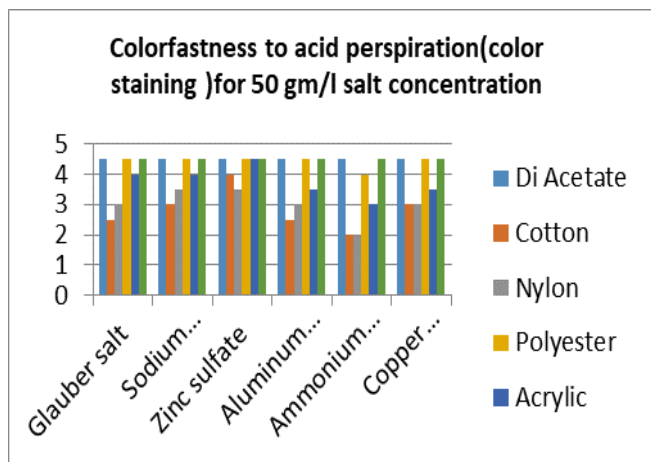


Figure 3.8: Colorfastness to acid perspiration for color staining at 50 gm/l salt

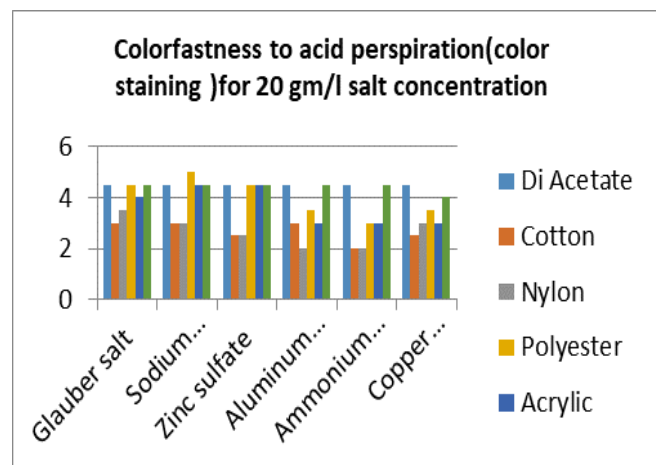


Figure 3.9: Colorfastness to acid perspiration for color staining at 20 gm/l salt

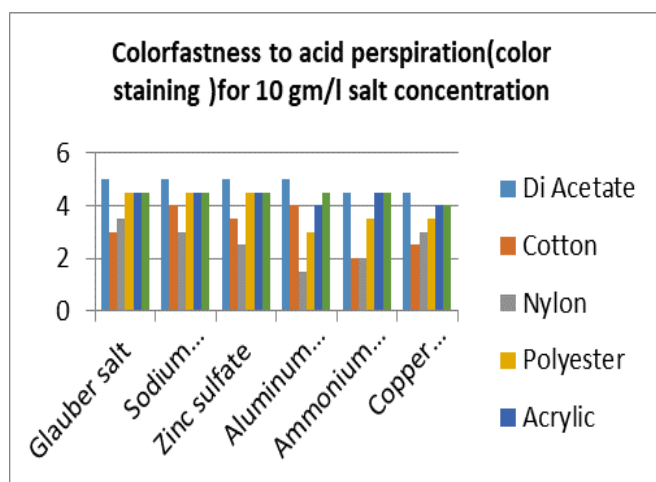


Figure 3.10: Colorfastness to acid perspiration for color staining at 10 gm/l salt

iv. Color fastness to alkali perspiration

For colorchange of alkali perspiration fastness, sample dyed with both zinc sulfate and aluminum sulfate is good(4.5) at 50 gm/l concentration but at 20 gm/l and 10 gm/l salt concentration fabric dyed with zinc sulfate, sodium chloride show equal color grading.

On the other side of the coin, alkali perspiration of color staining grading is good for dyed fabric with zinc sulfate at 50 gm/l and 20 gm/l, but sample dyed with sodium chloride has moderate color staining grade at those salt concentration, and at 10 gm/l, it shows good fastness properties for color staining.

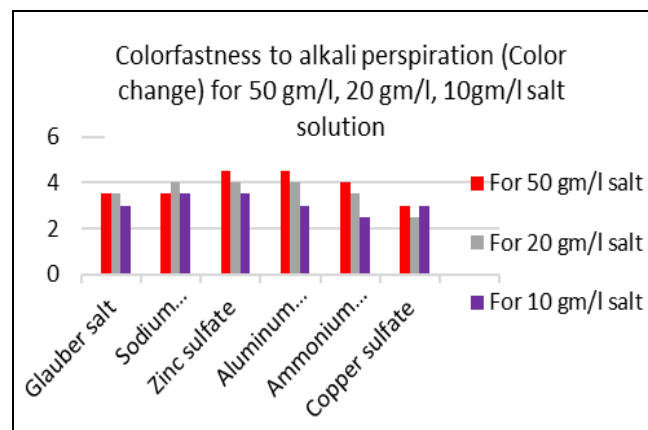


Figure 3.11: Colorfastness to alkali perspiration for the color change at various salts concentration

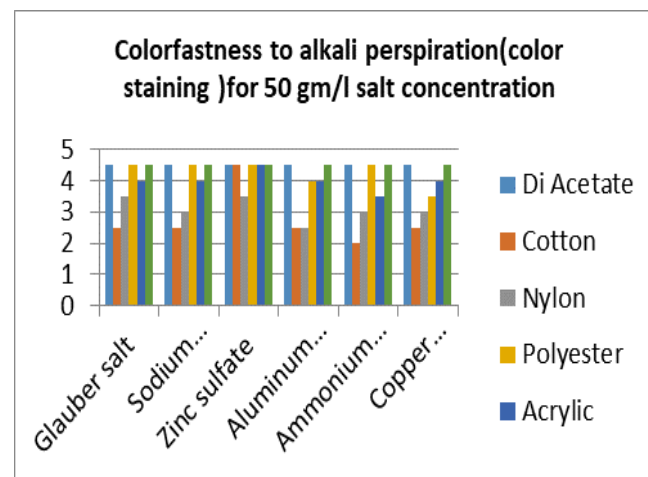


Figure 3.12: Colorfastness to alkali perspiration for color staining at 50 gm/l salt

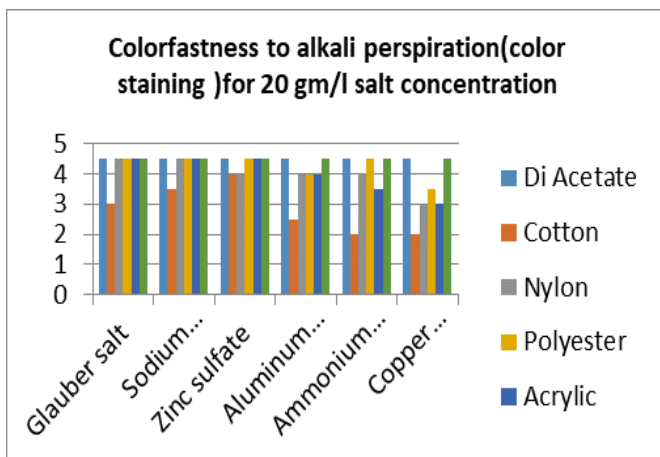


Figure 3.13: Colorfastness to alkali perspiration for color staining at 20 gm/l salt

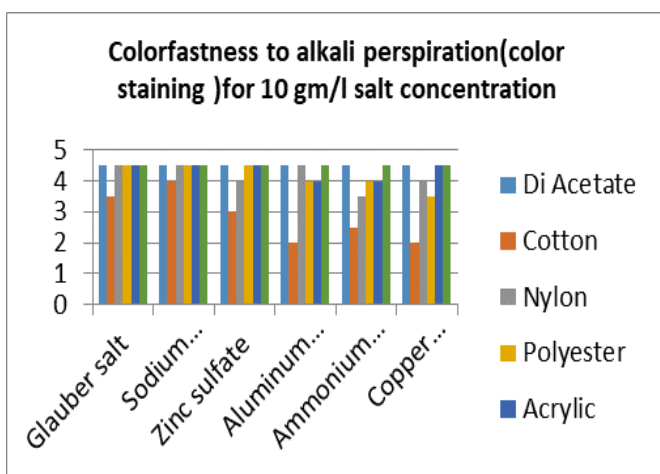


Figure 3.14: Colorfastness to alkali perspiration for color staining at 10 gm/l salt

IV. CONCLUSION

This study has demonstrated that appropriate salt is an essential factor in the reactive dyeing process. After completing all experimental tests, it revealed that all color fastness properties of zinc sulfate is higher than sodium chloride and glauber salt but the color strength is incredibly lower. So concerning to the color strength and fastness properties, sodium chloride is the best electrolyte as an exhausting agent for reactive dye and then glauber salt come to the next among all salts.

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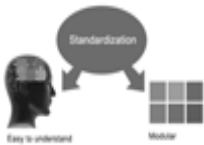
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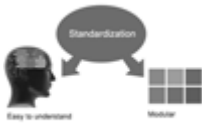
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We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth \$ 2376 USD.

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- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.



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- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in-depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

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- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of “Difference of Opinion [if any]” among the Board members, our decision will be final and binding to everyone.

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PREFERRED AUTHOR GUIDELINES

We accept the manuscript submissions in any standard (generic) format.

We typeset manuscripts using advanced typesetting tools like Adobe In Design, CorelDraw, TeXnicCenter, and TeXStudio. We usually recommend authors submit their research using any standard format they are comfortable with, and let Global Journals do the rest.

Alternatively, you can download our basic template from <https://globaljournals.org/Template.zip>

Authors should submit their complete paper/article, including text illustrations, graphics, conclusions, artwork, and tables. Authors who are not able to submit manuscript using the form above can email the manuscript department at submit@globaljournals.org or get in touch with chiefeditor@globaljournals.org if they wish to send the abstract before submission.

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Authors must ensure the information provided during the submission of a paper is authentic. Please go through the following checklist before submitting:

1. Authors must go through the complete author guideline and understand and *agree to Global Journals' ethics and code of conduct*, along with author responsibilities.
2. Authors must accept the privacy policy, terms, and conditions of Global Journals.
3. Ensure corresponding author's email address and postal address are accurate and reachable.
4. Manuscript to be submitted must include keywords, an abstract, a paper title, co-author(s) names and details (email address, name, phone number, and institution), figures and illustrations in vector format including appropriate captions, tables, including titles and footnotes, a conclusion, results, acknowledgments and references.
5. Authors should submit paper in a ZIP archive if any supplementary files are required along with the paper.
6. Proper permissions must be acquired for the use of any copyrighted material.
7. Manuscript submitted *must not have been submitted or published elsewhere* and all authors must be aware of the submission.

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- Words (language)
- Ideas
- Findings
- Writings
- Diagrams
- Graphs
- Illustrations
- Lectures



- Printed material
- Graphic representations
- Computer programs
- Electronic material
- Any other original work

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Changes in Authorship

The corresponding author should mention the name and complete details of all co-authors during submission and in manuscript. We support addition, rearrangement, manipulation, and deletions in authors list till the early view publication of the journal. We expect that corresponding author will notify all co-authors of submission. We follow COPE guidelines for changes in authorship.

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Unless specified in the notification, the Editorial Board's decision on publication of the paper is final and cannot be appealed before making the major change in the manuscript.

Acknowledgments

Contributors to the research other than authors credited should be mentioned in Acknowledgments. The source of funding for the research can be included. Suppliers of resources may be mentioned along with their addresses.

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Global Journals is in partnership with various universities, laboratories, and other institutions worldwide in the research domain. Authors are requested to disclose their source of funding during every stage of their research, such as making analysis, performing laboratory operations, computing data, and using institutional resources, from writing an article to its submission. This will also help authors to get reimbursements by requesting an open access publication letter from Global Journals and submitting to the respective funding source.

PREPARING YOUR MANUSCRIPT

Authors can submit papers and articles in an acceptable file format: MS Word (doc, docx), LaTeX (.tex, .zip or .rar including all of your files), Adobe PDF (.pdf), rich text format (.rtf), simple text document (.txt), Open Document Text (.odt), and Apple Pages (.pages). Our professional layout editors will format the entire paper according to our official guidelines. This is one of the highlights of publishing with Global Journals—authors should not be concerned about the formatting of their paper. Global Journals accepts articles and manuscripts in every major language, be it Spanish, Chinese, Japanese, Portuguese, Russian, French, German, Dutch, Italian, Greek, or any other national language, but the title, subtitle, and abstract should be in English. This will facilitate indexing and the pre-peer review process.

The following is the official style and template developed for publication of a research paper. Authors are not required to follow this style during the submission of the paper. It is just for reference purposes.



Manuscript Style Instruction (Optional)

- Microsoft Word Document Setting Instructions.
- Font type of all text should be Swis721 Lt BT.
- Page size: 8.27" x 11", left margin: 0.65, right margin: 0.65, bottom margin: 0.75.
- Paper title should be in one column of font size 24.
- Author name in font size of 11 in one column.
- Abstract: font size 9 with the word "Abstract" in bold italics.
- Main text: font size 10 with two justified columns.
- Two columns with equal column width of 3.38 and spacing of 0.2.
- First character must be three lines drop-capped.
- The paragraph before spacing of 1 pt and after of 0 pt.
- Line spacing of 1 pt.
- Large images must be in one column.
- The names of first main headings (Heading 1) must be in Roman font, capital letters, and font size of 10.
- The names of second main headings (Heading 2) must not include numbers and must be in italics with a font size of 10.

Structure and Format of Manuscript

The recommended size of an original research paper is under 15,000 words and review papers under 7,000 words. Research articles should be less than 10,000 words. Research papers are usually longer than review papers. Review papers are reports of significant research (typically less than 7,000 words, including tables, figures, and references)

A research paper must include:

- a) A title which should be relevant to the theme of the paper.
- b) A summary, known as an abstract (less than 150 words), containing the major results and conclusions.
- c) Up to 10 keywords that precisely identify the paper's subject, purpose, and focus.
- d) An introduction, giving fundamental background objectives.
- e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition, sources of information must be given, and numerical methods must be specified by reference.
- f) Results which should be presented concisely by well-designed tables and figures.
- g) Suitable statistical data should also be given.
- h) All data must have been gathered with attention to numerical detail in the planning stage.

Design has been recognized to be essential to experiments for a considerable time, and the editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned unrefereed.

- i) Discussion should cover implications and consequences and not just recapitulate the results; conclusions should also be summarized.
- j) There should be brief acknowledgments.
- k) There ought to be references in the conventional format. Global Journals recommends APA format.

Authors should carefully consider the preparation of papers to ensure that they communicate effectively. Papers are much more likely to be accepted if they are carefully designed and laid out, contain few or no errors, are summarizing, and follow instructions. They will also be published with much fewer delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and suggestions to improve brevity.

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It is necessary that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

All manuscripts submitted to Global Journals should include:

Title

The title page must carry an informative title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) where the work was carried out.

Author details

The full postal address of any related author(s) must be specified.

Abstract

The abstract is the foundation of the research paper. It should be clear and concise and must contain the objective of the paper and inferences drawn. It is advised to not include big mathematical equations or complicated jargon.

Many researchers searching for information online will use search engines such as Google, Yahoo or others. By optimizing your paper for search engines, you will amplify the chance of someone finding it. In turn, this will make it more likely to be viewed and cited in further works. Global Journals has compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Keywords

A major lynchpin of research work for the writing of research papers is the keyword search, which one will employ to find both library and internet resources. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining, and indexing.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy: planning of a list of possible keywords and phrases to try.

Choice of the main keywords is the first tool of writing a research paper. Research paper writing is an art. Keyword search should be as strategic as possible.

One should start brainstorming lists of potential keywords before even beginning searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in a research paper?" Then consider synonyms for the important words.

It may take the discovery of only one important paper to steer in the right keyword direction because, in most databases, the keywords under which a research paper is abstracted are listed with the paper.

Numerical Methods

Numerical methods used should be transparent and, where appropriate, supported by references.

Abbreviations

Authors must list all the abbreviations used in the paper at the end of the paper or in a separate table before using them.

Formulas and equations

Authors are advised to submit any mathematical equation using either MathJax, KaTeX, or LaTeX, or in a very high-quality image.

Tables, Figures, and Figure Legends

Tables: Tables should be cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g., Table 4, a self-explanatory caption, and be on a separate sheet. Authors must submit tables in an editable format and not as images. References to these tables (if any) must be mentioned accurately.



Figures

Figures are supposed to be submitted as separate files. Always include a citation in the text for each figure using Arabic numbers, e.g., Fig. 4. Artwork must be submitted online in vector electronic form or by emailing it.

PREPARATION OF ELETRONIC FIGURES FOR PUBLICATION

Although low-quality images are sufficient for review purposes, print publication requires high-quality images to prevent the final product being blurred or fuzzy. Submit (possibly by e-mail) EPS (line art) or TIFF (halftone/ photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Avoid using pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings). Please give the data for figures in black and white or submit a Color Work Agreement form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution at final image size ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs): >350 dpi; figures containing both halftone and line images: >650 dpi.

Color charges: Authors are advised to pay the full cost for the reproduction of their color artwork. Hence, please note that if there is color artwork in your manuscript when it is accepted for publication, we would require you to complete and return a Color Work Agreement form before your paper can be published. Also, you can email your editor to remove the color fee after acceptance of the paper.

TIPS FOR WRITING A GOOD QUALITY ENGINEERING RESEARCH PAPER

Techniques for writing a good quality engineering research paper:

1. Choosing the topic: In most cases, the topic is selected by the interests of the author, but it can also be suggested by the guides. You can have several topics, and then judge which you are most comfortable with. This may be done by asking several questions of yourself, like "Will I be able to carry out a search in this area? Will I find all necessary resources to accomplish the search? Will I be able to find all information in this field area?" If the answer to this type of question is "yes," then you ought to choose that topic. In most cases, you may have to conduct surveys and visit several places. Also, you might have to do a lot of work to find all the rises and falls of the various data on that subject. Sometimes, detailed information plays a vital role, instead of short information. Evaluators are human: The first thing to remember is that evaluators are also human beings. They are not only meant for rejecting a paper. They are here to evaluate your paper. So present your best aspect.

2. Think like evaluators: If you are in confusion or getting demotivated because your paper may not be accepted by the evaluators, then think, and try to evaluate your paper like an evaluator. Try to understand what an evaluator wants in your research paper, and you will automatically have your answer. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

3. Ask your guides: If you are having any difficulty with your research, then do not hesitate to share your difficulty with your guide (if you have one). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work, then ask your supervisor to help you with an alternative. He or she might also provide you with a list of essential readings.

4. Use of computer is recommended: As you are doing research in the field of research engineering then this point is quite obvious. Use right software: Always use good quality software packages. If you are not capable of judging good software, then you can lose the quality of your paper unknowingly. There are various programs available to help you which you can get through the internet.

5. Use the internet for help: An excellent start for your paper is using Google. It is a wondrous search engine, where you can have your doubts resolved. You may also read some answers for the frequent question of how to write your research paper or find a model research paper. You can download books from the internet. If you have all the required books, place importance on reading, selecting, and analyzing the specified information. Then sketch out your research paper. Use big pictures: You may use encyclopedias like Wikipedia to get pictures with the best resolution. At Global Journals, you should strictly follow [here](#).



6. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right? It is a good habit which helps to not lose your continuity. You should always use bookmarks while searching on the internet also, which will make your search easier.

7. Revise what you wrote: When you write anything, always read it, summarize it, and then finalize it.

8. Make every effort: Make every effort to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in the introduction—what is the need for a particular research paper. Polish your work with good writing skills and always give an evaluator what he wants. Make backups: When you are going to do any important thing like making a research paper, you should always have backup copies of it either on your computer or on paper. This protects you from losing any portion of your important data.

9. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several unnecessary diagrams will degrade the quality of your paper by creating a hodgepodge. So always try to include diagrams which were made by you to improve the readability of your paper. Use of direct quotes: When you do research relevant to literature, history, or current affairs, then use of quotes becomes essential, but if the study is relevant to science, use of quotes is not preferable.

10. Use proper verb tense: Use proper verb tenses in your paper. Use past tense to present those events that have happened. Use present tense to indicate events that are going on. Use future tense to indicate events that will happen in the future. Use of wrong tenses will confuse the evaluator. Avoid sentences that are incomplete.

11. Pick a good study spot: Always try to pick a spot for your research which is quiet. Not every spot is good for studying.

12. Know what you know: Always try to know what you know by making objectives, otherwise you will be confused and unable to achieve your target.

13. Use good grammar: Always use good grammar and words that will have a positive impact on the evaluator; use of good vocabulary does not mean using tough words which the evaluator has to find in a dictionary. Do not fragment sentences. Eliminate one-word sentences. Do not ever use a big word when a smaller one would suffice.

Verbs have to be in agreement with their subjects. In a research paper, do not start sentences with conjunctions or finish them with prepositions. When writing formally, it is advisable to never split an infinitive because someone will (wrongly) complain. Avoid clichés like a disease. Always shun irritating alliteration. Use language which is simple and straightforward. Put together a neat summary.

14. Arrangement of information: Each section of the main body should start with an opening sentence, and there should be a changeover at the end of the section. Give only valid and powerful arguments for your topic. You may also maintain your arguments with records.

15. Never start at the last minute: Always allow enough time for research work. Leaving everything to the last minute will degrade your paper and spoil your work.

16. Multitasking in research is not good: Doing several things at the same time is a bad habit in the case of research activity. Research is an area where everything has a particular time slot. Divide your research work into parts, and do a particular part in a particular time slot.

17. Never copy others' work: Never copy others' work and give it your name because if the evaluator has seen it anywhere, you will be in trouble. Take proper rest and food: No matter how many hours you spend on your research activity, if you are not taking care of your health, then all your efforts will have been in vain. For quality research, take proper rest and food.

18. Go to seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

19. Refresh your mind after intervals: Try to give your mind a rest by listening to soft music or sleeping in intervals. This will also improve your memory. Acquire colleagues: Always try to acquire colleagues. No matter how sharp you are, if you acquire colleagues, they can give you ideas which will be helpful to your research.

20. Think technically: Always think technically. If anything happens, search for its reasons, benefits, and demerits. Think and then print: When you go to print your paper, check that tables are not split, headings are not detached from their descriptions, and page sequence is maintained.



21. Adding unnecessary information: Do not add unnecessary information like "I have used MS Excel to draw graphs." Irrelevant and inappropriate material is superfluous. Foreign terminology and phrases are not apropos. One should never take a broad view. Analogy is like feathers on a snake. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Never oversimplify: When adding material to your research paper, never go for oversimplification; this will definitely irritate the evaluator. Be specific. Never use rhythmic redundancies. Contractions shouldn't be used in a research paper. Comparisons are as terrible as clichés. Give up ampersands, abbreviations, and so on. Remove commas that are not necessary. Parenthetical words should be between brackets or commas. Understatement is always the best way to put forward earth-shaking thoughts. Give a detailed literary review.

22. Report concluded results: Use concluded results. From raw data, filter the results, and then conclude your studies based on measurements and observations taken. An appropriate number of decimal places should be used. Parenthetical remarks are prohibited here. Proofread carefully at the final stage. At the end, give an outline to your arguments. Spot perspectives of further study of the subject. Justify your conclusion at the bottom sufficiently, which will probably include examples.

23. Upon conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium through which your research is going to be in print for the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects of your research.

INFORMAL GUIDELINES OF RESEARCH PAPER WRITING

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form which is presented in the guidelines using the template.
- Please note the criteria peer reviewers will use for grading the final paper.

Final points:

One purpose of organizing a research paper is to let people interpret your efforts selectively. The journal requires the following sections, submitted in the order listed, with each section starting on a new page:

The introduction: This will be compiled from reference matter and reflect the design processes or outline of basis that directed you to make a study. As you carry out the process of study, the method and process section will be constructed like that. The results segment will show related statistics in nearly sequential order and direct reviewers to similar intellectual paths throughout the data that you gathered to carry out your study.

The discussion section:

This will provide understanding of the data and projections as to the implications of the results. The use of good quality references throughout the paper will give the effort trustworthiness by representing an alertness to prior workings.

Writing a research paper is not an easy job, no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record-keeping are the only means to make straightforward progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear: Adhere to recommended page limits.

Mistakes to avoid:

- Insertion of a title at the foot of a page with subsequent text on the next page.
- Separating a table, chart, or figure—confine each to a single page.
- Submitting a manuscript with pages out of sequence.
- In every section of your document, use standard writing style, including articles ("a" and "the").
- Keep paying attention to the topic of the paper.

- Use paragraphs to split each significant point (excluding the abstract).
- Align the primary line of each section.
- Present your points in sound order.
- Use present tense to report well-accepted matters.
- Use past tense to describe specific results.
- Do not use familiar wording; don't address the reviewer directly. Don't use slang or superlatives.
- Avoid use of extra pictures—include only those figures essential to presenting results.

Title page:

Choose a revealing title. It should be short and include the name(s) and address(es) of all authors. It should not have acronyms or abbreviations or exceed two printed lines.

Abstract: This summary should be two hundred words or less. It should clearly and briefly explain the key findings reported in the manuscript and must have precise statistics. It should not have acronyms or abbreviations. It should be logical in itself. Do not cite references at this point.

An abstract is a brief, distinct paragraph summary of finished work or work in development. In a minute or less, a reviewer can be taught the foundation behind the study, common approaches to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Use comprehensive sentences, and do not sacrifice readability for brevity; you can maintain it succinctly by phrasing sentences so that they provide more than a lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study with the subsequent elements in any summary. Try to limit the initial two items to no more than one line each.

Reason for writing the article—theory, overall issue, purpose.

- Fundamental goal.
- To-the-point depiction of the research.
- Consequences, including definite statistics—if the consequences are quantitative in nature, account for this; results of any numerical analysis should be reported. Significant conclusions or questions that emerge from the research.

Approach:

- Single section and succinct.
- An outline of the job done is always written in past tense.
- Concentrate on shortening results—limit background information to a verdict or two.
- Exact spelling, clarity of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else.

Introduction:

The introduction should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable of comprehending and calculating the purpose of your study without having to refer to other works. The basis for the study should be offered. Give the most important references, but avoid making a comprehensive appraisal of the topic. Describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will give no attention to your results. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here.

The following approach can create a valuable beginning:

- Explain the value (significance) of the study.
- Defend the model—why did you employ this particular system or method? What is its compensation? Remark upon its appropriateness from an abstract point of view as well as pointing out sensible reasons for using it.
- Present a justification. State your particular theory(-ies) or aim(s), and describe the logic that led you to choose them.
- Briefly explain the study's tentative purpose and how it meets the declared objectives.



Approach:

Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done. Sort out your thoughts; manufacture one key point for every section. If you make the four points listed above, you will need at least four paragraphs. Present surrounding information only when it is necessary to support a situation. The reviewer does not desire to read everything you know about a topic. Shape the theory specifically—do not take a broad view.

As always, give awareness to spelling, simplicity, and correctness of sentences and phrases.

Procedures (methods and materials):

This part is supposed to be the easiest to carve if you have good skills. A soundly written procedures segment allows a capable scientist to replicate your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order, but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt to give the least amount of information that would permit another capable scientist to replicate your outcome, but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section.

When a technique is used that has been well-described in another section, mention the specific item describing the way, but draw the basic principle while stating the situation. The purpose is to show all particular resources and broad procedures so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step-by-step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

Materials may be reported in part of a section or else they may be recognized along with your measures.

Methods:

- Report the method and not the particulars of each process that engaged the same methodology.
- Describe the method entirely.
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures.
- Simplify—detail how procedures were completed, not how they were performed on a particular day.
- If well-known procedures were used, account for the procedure by name, possibly with a reference, and that's all.

Approach:

It is embarrassing to use vigorous voice when documenting methods without using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result, when writing up the methods, most authors use third person passive voice.

Use standard style in this and every other part of the paper—avoid familiar lists, and use full sentences.

What to keep away from:

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings—save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part as entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Use statistics and tables, if suitable, to present consequences most efficiently.

You must clearly differentiate material which would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matters should not be submitted at all except if requested by the instructor.



Content:

- Sum up your conclusions in text and demonstrate them, if suitable, with figures and tables.
- In the manuscript, explain each of your consequences, and point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation of an exacting study.
- Explain results of control experiments and give remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or manuscript.

What to stay away from:

- Do not discuss or infer your outcome, report surrounding information, or try to explain anything.
- Do not include raw data or intermediate calculations in a research manuscript.
- Do not present similar data more than once.
- A manuscript should complement any figures or tables, not duplicate information.
- Never confuse figures with tables—there is a difference.

Approach:

As always, use past tense when you submit your results, and put the whole thing in a reasonable order.

Put figures and tables, appropriately numbered, in order at the end of the report.

If you desire, you may place your figures and tables properly within the text of your results section.

Figures and tables:

If you put figures and tables at the end of some details, make certain that they are visibly distinguished from any attached appendix materials, such as raw facts. Whatever the position, each table must be titled, numbered one after the other, and include a heading. All figures and tables must be divided from the text.

Discussion:

The discussion is expected to be the trickiest segment to write. A lot of papers submitted to the journal are discarded based on problems with the discussion. There is no rule for how long an argument should be.

Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implications of the study. The purpose here is to offer an understanding of your results and support all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of results should be fully described.

Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact, you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved the prospect, and let it drop at that. Make a decision as to whether each premise is supported or discarded or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."

Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work.

- You may propose future guidelines, such as how an experiment might be personalized to accomplish a new idea.
- Give details of all of your remarks as much as possible, focusing on mechanisms.
- Make a decision as to whether the tentative design sufficiently addressed the theory and whether or not it was correctly restricted. Try to present substitute explanations if they are sensible alternatives.
- One piece of research will not counter an overall question, so maintain the large picture in mind. Where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.



Approach:

When you refer to information, differentiate data generated by your own studies from other available information. Present work done by specific persons (including you) in past tense.

Describe generally acknowledged facts and main beliefs in present tense.

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<i>Discussion</i>	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
<i>References</i>	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring



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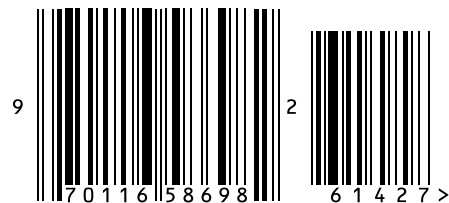


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