Productivity Improvement Using Industrial Engineering Tools – Case Study Of a Typical Spinning Mill

[1]Amal S Das, [2]P V Gopinadhan
[1]M.Tech student, [2]Professor
[1]Department of Production Engineering,
[1]Government Engineering College Trichur, Thrissur, India

***Abstract*— Spinning mill industries continue to face the challenges of improving productivity, in order to remain successful, in a highly competitive industry. As year on year, every input cost goes higher, it is important to provide better products at lower costs to the end consumer by improving the efficiency of the plant. The project site is a spinning and weaving mill. Today the company has a production capacity of almost 85680 spindles per day. This capacity cannot be utilized properly due to various losses. The project aims at identifying the root cause of these losses and to propose methods to increase the productivity. DMAIC technique is used for productivity increase with why - why analysis in the analysis stage to find out the root causes of losses. Pareto chart is used to plot various factors that affect productivity. This project mainly focuses on reasons for power failure and absenteeism, which is a threat to the organization. In order to improve the productivity of the organization, suggestions were made to manage the power failure and absenteeism, thus a better system was proposed for the organization under study.**

***Index Terms*—DMAIC analysis, Pareto chart, styling, productivity**.

I. INTRODUCTION

In today's competitive world, planning productivity is one of the main components of successful industrial organizations. Increase in productivity can reduce the cost of work on the production unit or an increase in output. Productivity depends on various factors like labour, machinery, capital, temperature, raw materials, quality etc. so each and every factor has its own contribution. The focus of this study, productivity of yarn has a great influence in textile industry. Optimizing the output is a big challenge; to achieve this goal the role of every worker regarding the production department has a great importance. In this environment, company managers have to tackle various problems regarding men and machines. In present scenario the operating costs are increasing and the sales are decreasing, while customers have turned out to be more selective and demanding. Spinning industry managers must thus consider how to maintain profitability in a declining market, while providing high quality products to increasingly sophisticated customers. Firms can concentrate on different methods to improve the productivity and operational efficiency of the system.

II. LITERATURE REVIEW

DMAIC is an abbreviation of the five improvement steps comprising of Define, Measure, Analyze, Improve and Control. This method is often described as an approach to problem solving. DMAIC is applicable to empirical problems ranging from well-structured to semi-structured, but not to ill-structured problems or pluralistic messes of subjective problems. The advantage of such methods is that they are very versatile [7]. DMAIC is a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC improvement cycle is the core tool used to drive Six Sigma projects. However, DMAIC is not limited to Six Sigma and can be used as the framework for other improvement applications. DMAIC is similar in function as its predecessors in manufacturing problem solving, such as Plan-Do-Check-Act and the Seven Step method of Juran and Gryna. The DMAIC method is consistent with the problem-solving steps of the PDCA model and places more emphasis on integrating specific tools into each step of the method. Originally described as a method for variation reduction, DMAIC is applied in practice as a generic problem solving and improvement approach [3].

III. PROBLEM DEFINITION

The production capacity of the plant is 2570400 Spindles per month. But the actual production rate is only 2010540 Spindles per month. Thus plant has a loss around 559860 Spindles per month, which in all together causes a huge loss in terms of productivity and thereby in profit ratio. From the study conducted at the company, it is evident that the production line is almost perfect but there exists compressed air losses in pipe lines. The ultimate objective of this project is to conduct a detailed study of various factors reducing productivity and increase the productivity by reducing various losses at the critical processes. Also it aims to find out different problems facing employees and impact of working environments on employee performance.

IV. RESEARCH METHODOLOGY

The project aims at eliminating various losses causing low yield or productivity. Various factors of men and machines is to be observed and analysed. In this project DMAIC technique is used. It includes an overview of process, current situation analysis, scope

for improvement targeting, implementation of countermeasures. Pareto chart and why- why analysis is used to get an outline of the various root causes of losses in these sectors. Cost estimation and payback analysis are used to analyse the cost and payback period of the proposed new system.

V. DATA ANALYSIS AND DISCUSSIONS

a) Define

This step focuses on the plant layout, problem identification, productivity analysis, goal, project scope and project timeline..

Plant Layout

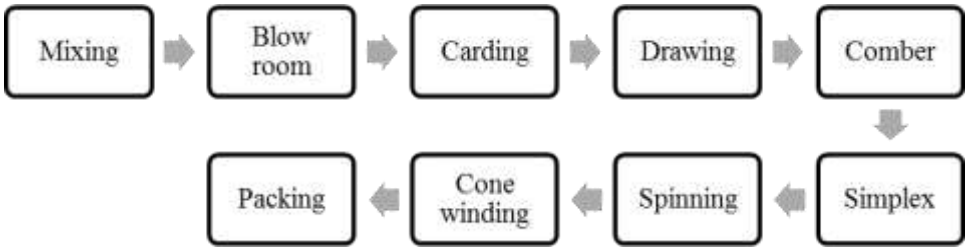

Fig 1 plant layout

b) Measure

In this step data is collected to establish process performance baselines. The actual capacity of the plant in various months was measured and tabulated. Plant capacity defined as the measure of spindle per unit of time. It can be calculated by calculating the capacity of Spindle per month.

Thus plant capacity is found by the following method:

Total number of frames available = 34

Number of spindles available in 1 frame = 840

Total number of spindles available= 840 * 34 = 28560

If 100% of spindle run in a day, spindles can be changed 3 times,

Therefore, total number of spindles available in day = 28560*3 = 85680

In a month total number of spindles available = 85680 * 30 = 2570400

So total Plant capacity =2570400 Spindles / month

Utilization Factor = $\frac{\text{Actual spindles worked in a month}}{2570400}$ 100

Actual Production Rate

Data regarding actual production rate is taken from the industry.

Table 1 Average no. of spindles and utilization factor for 8 months

Month	No. of spindles	Utilisation
Apr-15	1891260	81.75
May-15	2198700	85.54
Jun-15	2239860	87.14
Jul-15	2312100	87.05
Aug-15	1279740	62.23
Sep-15	1897560	85.63
Oct-15	2131920	82.94
Nov-15	2133180	82.99
Average	2010540	81.90875

The plant capacity is defined as the measure of number of spindles produced per month. The total production capacity of the plant is 2570400 spindles per month. By analysing monthly production statement about 8 months we got the average production rate as 2010540 spindles per month, thus has a loss around 559860 spindles per month. By evaluating the data we got the utilization factor of the plant for 8 months as 81.90%.

So the next step is to identify the critical factors that reduce the productivity and to analyse how to reduce these losses and thus to improve productivity

c) Analysis

In the analysis stage, monthly cause wise stoppages are found out and calculated its percentage of occurrence using Pareto chart analysis. Using WHY–WHY analysis, critical factors that reduce productivity was found out.

Table 2 Monthly Cause-wise stoppage

Month	Maintenance and repair		Power failure		want of hands		others		BS stoppage	
	Spindle	%	spindle	%	spindle	%	spindle	%	Spindle	%
Apr-15	39900	1.73	219240	9.48	12600	0.54	150360	6.5	0	0
May-15	55780	2.22	224370	8.74	28560	1.11	62990	2.39	0	0
Jun-15	61320	2.38	223440	8.69	23520	0.92	22260	0.87	0	0
Jul-15	63420	2.44	206220	7.76	45780	1.72	28560	1.03	0	0
Aug-15	36960	1.79	134820	6.56	31920	1.55	21000	1.03	551880	26.84
Sep-15	70980	2.76	197400	7.68	212520	8.27	159600	4.08	32340	3.39
Oct-15	57960	2.26	163380	6.36	177240	6.9	39900	1.56	0	0
Nov-15	65520	2.55	257460	10.02	77280	3.01	36960	1.43	0	0
Average	56480	2.26	203291.3	8.161	76177.5	3.002	65203.75	2.361	73027.5	3.77875

Pareto Chart Analysis

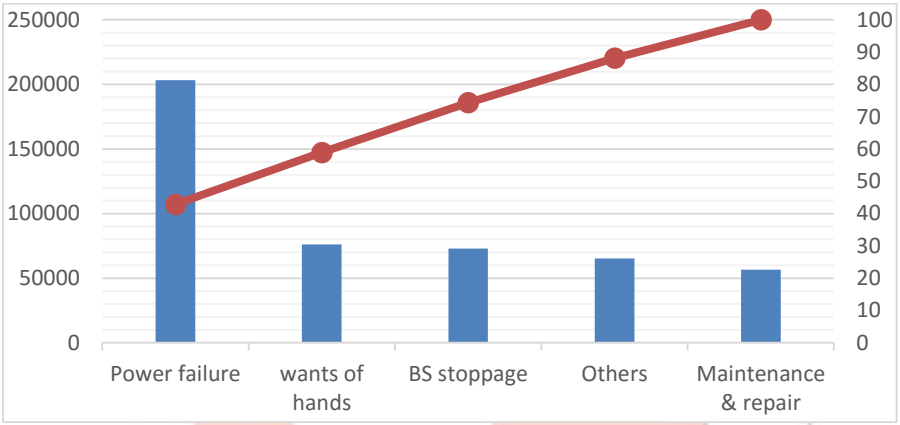

Fig 2 Pareto chart analysis of cause wise stoppage of Spindle

By Pareto chart analysis, we can say that more than 60% of total loss of productivity are due to power failure and absenteeism. Back step shortage is occurred only for 2 months. It is because of the sudden change of product and industry has their own reason for that. We can neglect productivity loss due to Maintenance and repair, other reasons as it accounts for only a small percentage. So we can say that in the spinning mill industry the main factors that contributes to lower productivity is power failure and absenteeism

Why-Why Analysis

As major reasons for loss of productivity was identified as power failure and worker absenteeism, why-why analysis was conducted on these problems to find out the real causes regarding these problems.

Table 3 why-why analysis

Reason	Why	Why	Why	Why	Why
Productivity loss	Absenteeism	Morale drop	Working condition	Hot atmosphere	Poor ventilation
		Attitude	Remuneration Paid	Lack of incentives	Company policy
		Skill gap	New workers	Lack of training	Lack of commercial integration
	Power failure	Drop in compressed air pressure	Leakage in piping system	Old GI piping network	Lack of maintenance of underground piping network

Root Cause Analysis of Absenteeism

There is a 4% loss of productivity accounted by absenteeism of the employees. When there is a chance such that the main operator is absent without permission, the hold passes to another worker who has a less experience in the concerned machinery. This will lead to a reduced production rate owing to lesser productivity. Morale drops of worker's is a cause for absenteeism. Due to the noisy, polluted and hot atmosphere, the workers are reluctant to work resulting in absenteeism. Polluted air with cotton dust particles makes

the working environment worse. Humidity is another problem of the plant. Due to lack of incentive policy and less remuneration paid are the reasons that reduces the attitude of the workers.

Questionnaire Survey

A questionnaire survey was conducted among a total of 280 workers considering some of the core factors affecting worker's absenteeism. The questionnaire is designed on the bases of previous literatures and study related to labour absenteeism and job satisfaction. The analysis is done by a weighted average method based on the information taken from the questionnaire survey. This questionnaire is based on 5 points Likert scale. In this, the weighted average values 5, 4, 3, 2, and 1 are taken as 'Strongly agree', 'Agree', 'Neutral', 'disagree', and 'Strongly disagree' respectively. 3 is a neutral value, which indicates it has no effect of variable. Mean score more than 3 indicates a positive effect of the variable. But the mean score less than 3 indicates a negative effect of the variable.

Table 4 response summary and calculated weighted average

Question	Calculated weighted average
Level of satisfaction with working environment	2.34
Relationship with supervisors and management	3.12
Opinion about the welfare activities provided	2.52
Training and development program	3.14
Level of job satisfaction	2.56
Communication and relation with co-workers	3.50
Opinion about the remuneration paid	2.30

By weighted average method, it is found that workers are dissatisfied with their working conditionS, remuneration Paid, welfare facilities in the organization. By improving these areas we can reduce the rate of absenteeism to an extent.

Root Cause Analysis of Power Failure

The plant has basically 4 transformers for the normal working of the plant. There are three 500KvA and one 750KvA transformer. These generate a power of around 2250KvA. During unplanned or planned power shortage the plant runs on a generator rated at 1010KvA. This is only employed when there is a power failure for more than 10minutes. When there is a planned power shortage, the sub-station will inform about the same. Then the generators come into play. The main problem while employing generators are that only a part of spinning and cone winding operations can be accomplished using this power. All other operations will come to a standstill resulting in a loss of productivity. Also, it takes around 20 minutes to 30 minutes for the full-fledged operation of the spindle to take place, resulting in a loss of total production. The spinning motors gain momentum only after a stipulated time that to operate separately manually.

Drop in compressed air pressure is another problem. The operating line pressure is 7.4 bar. But the compressor pressure drops to 7 bar after 10 minutes of power failure. GI pipes are used in the piping system. Corrosion and leakage in pipes is the main reason of drop in pressure. This results in an 8% reduction in the total productivity.

c) Improve & control

The purpose of this step is to identify, testing and implementation of alternative solutions to the problem; in part or in whole. Identify feasible solutions to reduce the key root causes with the aim of fix and prevent process problems. Here the root causes of men and machine are improved.

Improvement is mainly done by

a) Suggestion of a new productivity gain sharing scheme
b) Suggestions to improve the working environment and motivation of workers.
c) Suggestion of a new compressor pipeline layout

Suggestion of a new productivity gain sharing scheme

Absenteeism is one of the major issues that faced by the company. So attendance factor is also included for the recommended productivity gainsharing model so that the benefits of improved productivity, fully get to those employees who attend regular duty. By adding attendance factor with the proposed model helps to restrict the benefits of incentive to ineligible employee.

Incentive = (Labour cost-to-sales ratio*sales – wages and salaries already paid) * (1- reserve ratio) * (no .of days attend duty/ total no .of duty days)

Step 1: Labour cost-to-sales ratio = (Salaries, wages, benefits) / Sales. Labour cost-to-sales ratio was determined based on historical data.

Step 2: Calculate amount of theoretical wages and salaries to be paid. It is obtained from (Labour cost-to-sales ratio *sales) Here sales mean sales of current month / year

Step 3: Subtract the actual amount of wages and salaries paid

This will determine the amount of labour costs saved due to higher productivity. The amount that is saved will form the extra fund available for distribution.

Step 4: calculate the "reserve ratio".

The percentage of the extra fund to set as a reserve – so that some bonus could still be paid out even in a recession.

Step 5: Multiply the amount of bonus fund computed under Step 3 by "1 – Reserve ratio", to arrive at the amount to be distributed between the organisation and the employees.

Step 6: Multiply attendance benefit to each employee benefit to calculate individual's incentive

Attendance factor = (no .of days attend duty/ total no .of duty days)

By adding attendance factor with the proposed model helps to restrict the benefits of incentive to ineligible employee

Suggestion to Improve Working Environment and Motivation of Workers.

- Provide a better working environment for employees in order to fulfil their requirements.
- Good relation of employees with their superiors should be continued.
- The management should be aware of the effort of employees and should motivate them so as to bring satisfaction with their work.
- Safety awareness programmes should be conducted to ensure that training and knowledge is not just brought as an annual activity, instead it is used to keep up a high level of safety awareness on a daily basis.
- The management should provide ear muffler and respiratory masks to employees for their safety. It will help the employees to work in noisy and dusty environment.
- The personnel policies of the employees did not match to their work and the company need to take some measures to match the policies with their work.
- Management should take some initiatives to increase the payment of employees. So that there is a chance to reduce absenteeism

Suggestion of New Compressor Pipe Line Layout

Textile industries rely on compressed air in the yarn production process. Improved usage of compressed air can provide significant economic benefit to the industry. By properly configuring and maintaining the compressed air system, wastage of energy can be reduced and thus the system can be made more efficient. In the case of Mahe spinning Mills, reconfiguring the compressor piping system, matching air supply with air demand, implementing a proper control strategy, and eliminating moisture carry over can increase the efficiency of the compressed air system. Eliminating leakage in the compressed air piping system is most cost-effective steps in energy conservation. It can be done by

- Change the piping system from GI pipes to aluminum composite pipes, thereby we can reduce the loss of compressed air
- Some alterations in current layout of piping network

The proposed new compressed air pipeline layout mainly aims to reduce air leakage and to maintain a stable pressure level. In old layout, the plant has 2 compressors, one main compressor system (ELGI 75 kW, 2000 lit receiver, 500cfm drier) placed adjacent to blow room and an auxiliary compressor system (ELGI 22 kW, 1000 lit receiver, small drier) placed adjacent to the cone winding section. In the new layout, there is a slight change in the compressor arrangement and pipeline layout. The two compressor systems are interchanged each other. This would be helpful, as the generator in the plant has capacity only to run some part of cone winding and spinning sections during power failure. So if the main compressor is nearer to the cone winding section and by installing ring-main with 2'' aluminium composite pipes in cone winding and spinning section, during power failures by closing valves, the compressed air can be circulated only to the required sections easily. Also, it would be helpful to maintain a steady air pressure.

The aluminium composite pipe is a composite of aluminium and polyethylene composite that combines the best features of both materials to form a pipe which is light, strong and corrosion resistant. By combining 2 materials along with adhesive layers, these pipes avoid unexpected thermal expansion and deformation. At the same time it retains the flexibility, frost resistance and ease of use. 2" multilayer aluminium composite pipes are used for the main supply,1" multilayer aluminium composite pipes are used, 1/2" multilayer aluminium composite pipes are used in drop lines to the machines. These pipes and fittings can be joined by using compression/crimp fittings with internal sealing arrangement.

The following precautions should be considered while erecting proposed pipe lines for compressed air:

- While laying out the main line, along the walls, provide 1 in 50 or 1 in 100 slopes – sloping down along the pipeline, so that water collected in the pipes flows out in the slope.
- Always take tapping from the main line at the top of the line. This is mainly "not to tap" the water flowing at the bottom of the main pipeline.
- The end of the main line is to be dropped down with a drain valve.
- Use piping adaptor, which will help faster maintenance work and prevent damage of the air preparation unit during handling while maintenance.

Cost Estimation and Payback Analysis

The cost analysis of men and material was calculated to install the compressor pipe line.

Total cost = material cost + labour charge

= 274414 + 124900 = Rs 399314

The payback period can be identified by calculating the present gain per spindle.

The present gain per spindle = Rs 5.38

For every 2 months power failure occurs around 48 times. To attain full cycle spinning operation, it takes around 20 minutes. By implementing new pipe layout, we can save around 10 minutes per power failure. That means for every 2 months we can save around 480 minutes, which is 8 hours that is the time period of one shift.

For 1 shift, number of working spindles = 28560

Total gain per shift we can obtain for every 2 months= 28560*5.38= 153652

I.e., for every 1 month gain obtained= Rs 76826
Total payback period = total implementation cost/gain per month = 5.2 months
The payback period required to obtain an amount of Rs 399314 is 5.2 months.

VI. Results and Conclusion

Spinning and weaving mill, under the study faces many issues related to productivity loss. By DMAIC analysis the root causes were identified. The study identifies power failure and worker absenteeism as the major cause for loss of productivity. The causes and the recommended suggestions for both causes is discussed below.

Job satisfaction of employees in the Spinning Mill, was studied and it was observed that the pay structure and benefits were the factors that created dissatisfaction among the employees in the company. A productivity based incentive scheme was recommended to the company that may help them to reduce absenteeism rate and thus improve the productivity.

Power failure was another problem in the industry that reduced the productivity. The generator in the plant has capacity only to run cone winding and spinning sections during power failures. All the other operations will come to a standstill resulting in a loss of productivity. Also, it takes around 20 minutes to 30 minutes for the full-fledged operation of the spindle to take place, resulting in a loss of total production. This was mainly due to the leakage of compressed air in the pipe lines. The new pipeline layout was proposed with some alterations in the existing pipeline layout. Cost estimation and payback analysis for the new layout was calculated. The estimated cost for the proposed layout of compressed air piping system is Rs 39,99,314. The payback period for obtaining the estimated cost is 5.2 months.

By implementing the suggestions, the industry can obtain an extra shift of work for every 2 months, which implies the industry can run extra 28560 spindles every 2 months. The utilization of spindles can be increased around 4%. After the payback period, the company can obtain a gain of Rs 949190 more per annum.

VII. Acknowledgment

I would like to thank all the employees and management of the organization under study for their immense contribution towards this research.

References

[1] T.B.Pankhania, P.M.George, A.H.Jariya, V.K.Modi4, ‘‘Attributes enhancing industrial productivity an empirical analysis’’, IJRET: International Journal of Research in Engineering and Technology: pp: 2321-7308

[2] Sachidanand S. More1, Dr. Maruti S. Pawar2,(2013), ‘Performance Improvement of Textile Sector by Implementing Quality Six Sigma (QSS)’, International Journal of Application or Innovation in Engineering & Management, Volume 2, Issue 12, pp 352

[3] Rodney McAdam, Brendan Lafferty, (2004) "A multilevel case study critique of six sigma: statistical control or strategic change?", International Journal of Operations & Production Management, Vol. 24, pp.530 – 549

[4] Neha Gupta, (2013), ‘ An Application of DMAIC Methodology for Increasing the Yarn Quality in Textile Industry’, *IOSR Journal of Mechanical and Civil Engineering Volume 6, Issue 1 (Mar. - Apr. 2013), PP 50-65*

[5] Mr.A .A. Attar, Prof. A.K. Gupta,Prof.D.B.Desai,, ‘A Study of Various Factors Affecting Labour Productivity and Methods to Improve It’, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), PP: 11-14

[6] Harikrishnan R P, Pradeep Kumar P(2013), ‘Productivity Gainsharing Incentive Scheme for a Spinning Mill Industry’, International Journal of Innovative Research in Science, Engineering and Technology, Volume 2, Special Issue 1

[7] Chakravorty, S.S., 2009. ‘Six Sigma programs: an implementation model’, International Journal of Production Economics, Volume 119, pp1–16

[8] B. Naveen, Dr. T. Ramesh Babu, ‘Productivity Improvement in Manufacturing Industry Using Industrial Engineering Tools’, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), PP 11-18

[9] Awad S. Hanna, M.ASCE1; Cindy L. Menches, M.ASCE2; Kenneth T. Sullivan3; and Joseph R. Sargent4 (2005), ‘Factors Affecting Absenteeism in Electrical Construction’, journal of construction engineering and management © asce, pp1217

[10] Harry Rever, MBA, PMP, CSSMBB, CQM, CQC, Applying the DMAIC Steps to Process Improvement Projects “Define, Measure, Analyze, Improve, Control” is the Roadmap to Improving Processes,