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PRODUCTIVITY IMPROVEMENT USING QMPS IN A MANUFACTURING UNIT – A CASE STUDY

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ABSTRACT:

Numerous organizations around the globe have actualized QMPs (Quality Management Practices) as a critical thinking approach particularly valuable for managing repeating issues in business forms. This study is an attempt to assess the performance of QMPs viz. six sigma in the case company under study. The data collection before and after implementing QMP has been critically analyzed to ascertain the benefits occurred. Results indicated that the breakdown incidences per month were reduced drastically from 1.4 incidences to 11, OEE (Overall Equipment Efficiency) was enhanced from 63% to 84% and a net savings of rupees 349.68 lacs annually has been achieved.

KEYWORDS: QMPs (Quality Management Practices), Six Sigma and OEE.

1. INTRODUCTION

Amid the previous decade, administrative worry for quality achieved phenomenal levels. Today, an expanding number of administrators in more associations than ever before view "quality as of bedrock strategic importance, rather than an abstract to be pulled out of the platitudes file and given lip service at the annual general meeting". Quality has been appeared to add to more noteworthy pieces of the overall industry and rate of return and also bring down manufacturing costs over the long haul and enhanced profitability. In spite of the fact that imparting higher quality attributes in an item may bring about higher assembling costs in the short run, and consequently result in higher costs for an item, this won't really negatively affect customer request. At the point when faced with substitutes for items, buyers would like to pay reasonably higher costs to guarantee the buy of a quality item (Deming, 1981).

Quality is currently all around acknowledged as a noteworthy worry for each association. In spite of the fact that over the most recent two decades various quality administration theories, techniques, practices and apparatuses have been planned, created and connected, just as of late has data with respect to the degree and nature of their commitment to hierarchical execution come into view. Consequently, the writing on quality procedures has of late been enhanced through numerous observational research ponders, managing application issues of quality management (QM). A fundamental target of some of these works was to characterize and measure an assortment of QM components (Benson et al., 1991). The purpose of this case study is to study "QM activities" and to create a "Six Sigma" based project. The data collection was based on literature regarding Project Management, Six Sigma as well as internal documents of the manufacturing unit.

2. LITERATURE REVIEW

Sousa and Voss (2002) claimed that Quality Management (QM) is one of the most prevalent and established set of Operations-related organizational practices. This study focused specifically in the following goals: analyzing of the antecedents of absorptive capacity in greater depth, determining the effects of the different Quality management Practices (QMP) on absorptive capacity, and analyzing the influence of absorptive capacity on innovation performance.

Shrivastava et al. (2006) examined the need for establishing linkages between factors affecting TQM, as well as organisational performance and suggests a comprehensive assessment framework. A diagnostic instrument has been designed to test in Indian industries that have implemented TQM during the last decade. The result of this empirical study establishes the strong and weak linkages and helps to derive a few propositions for furtherance of the state-of-the-art in TQM. Such a study has the potential to contribute in providing feedback to manage and improve the TQM programs to better meet the needs of the organisation.

Demirbag et al. (2006) investigated the relationship between the implementation of TQM practices and organizational performance in Turkish organizations. Data analysis revealed that there is a strong positive relationship between TQM practices and non-financial performance of SMEs, while there is only weak influence of TQM practices on financial performance of SMEs. With only a mediating effect of non-financial performance that the TQM practices has a strong positive impact on financial performance of SMEs.

Jain and Samrat (2015) had undertaken a pragmatic study on the Real Quality Practices of Gujarat based Manufacturing Industries. During the course of this research we have planned to Interview various manufacturing organizations' Top

Management & Second Line Managers with the predefined Questionnaire. The questionnaire is in parts including: Organizations' own QMS Practices and, Organizations' Suppliers' QMS Practices (perceived by Organization's persona). The research covers topics including the QMS practices like, Quality Plan, Testing & Recording; Supplier Assessments & Evaluations; Consultants & Certifications Practices; Customer Satisfaction; Documentation; etc. The outcome of this research will help gauge the level of Quality Practices which also may lead to the suggestive steps to be implemented by other Organizations in the Country as a whole.

Helleno et al. (2017) aimed to propose a conceptual method to integrate a new group of sustainability indicators into the QMP tool to assess manufacturing processes. The development of sustainability indicators was performed through analysis of the assessment models of sustainability and sustainability indicators in the period of 2009 to 2014. The method was applied in three case studies, and the results demonstrated that the proposed method identified different levels of sustainability of manufacturing processes and thus enabled the development of improved scenarios. In this sense, the results contributed to the literature with the proposition of new sustainability indicators related to the manufacturing process. The case studies enabled evaluation of the interaction of a new group of sustainability indicators in different manufacturing processes.

3. CRITERIA OF INTRODUCTION TO THE INDUSTRY, QMPS TOOLS AND SELECTION INDUSTRY

Company ABC was Founded in 1945 as a steel trading company, and then entered automotive manufacturing in 1947 to bring the iconic Willys Jeep onto Indian roads. Over the years, they have diversified into many new businesses in order to better meet the needs of our customers. They follow a unique business model of creating empowered companies that enjoy the best of entrepreneurial independence and Group-wide synergies. This principle has led our growth into a US \$12.5 billion multinational group with more than 119,000 employees in over 100 countries across the globe. Today, there operations span 18 key industries that form the foundation of every modern economy: aerospace, aftermarket, agribusiness, automotive,

components, construction equipment, consulting services, defense, energy, farm equipment, finance and insurance, industrial equipment, information technology, leisure and hospitality, logistics, real estate, retail, and two wheelers. Company federated structure enables each business to chart its own future and simultaneously leverage synergies across the entire Group's competencies. In this way, the diversity of our expertise allows us to bring our customers the best in many fields. The Company has ten business sectors- Aftermarket, Automotive & Farm Equipment, Defence Systems, Financial Services, Hospitality, Information Technology, Real Estate & Infrastructure, Sys tech, Two Wheelers and Mahindra Partners with a presence in 18 industries. Employees across the Group constantly challenge conventional thinking to create solutions that make a significant difference in the lives of our customers. That's why everything they build- be it a tractor, financial service, solar-powered lamp, or software is designed to empower you to reach your potential. The industrial units selected for conduction of case study have been selected on the following basis:

- The units to be illustrative of the assembling business i.e. a large portion of the activities and process are pervasive in that unit.
- The unit is pending and helpful for leading contextual analysis
- Convenience sampling technique has been used
- Small incremental changes are effortlessly open in the Industry.

In the 1960s, Japanese merchandise were synonymous with affordability and low quality, yet after some time their quality activities started to be effective, with Japan accomplishing large amounts of value in items from the 1970s forward. For example, Japanese cars regularly top the J.D. Power customer satisfaction ratings. The 1980s Deming was asked by Ford Motor Company to begin a quality activity after they understood that they were falling behind Japanese makers. Various profoundly fruitful quality activities have been created by the Japanese. These methods are now adopted by the same western countries that decades earlier derided Japanese methods. Table 1. shows different QMPs used by modern manufacturing Industry.

Table 1 QMP tools (Motwani et al., 1994)

<i>QFD</i> — quality function deployment, also known as the house of quality approach.
<i>Kaizen</i> — Japanese for change for the better, the common English term is continuous improvement.
<i>Zero Defect Program</i> — created by NEC Corporation of Japan, based upon statistical process control and one of the inputs for the inventors of Six Sigma.
<i>Six Sigma- 6σ</i> , Six Sigma combines established methods such as statistical process control, design of experiments and failure mode and effects analysis (FMEA) in an overall framework.
<i>Quality circle</i> — a group (people oriented) approach to improvement.
<i>TQM</i> — total quality management is a management strategy aimed at embedding awareness of quality in all organizational processes. First promoted in Japan with the Deming prize which was adopted and adapted in USA as the Malcolm Baidrige National Quality Award and in Europe as the European Foundation for Quality Management award (each with their own variations).
<i>TPM</i> — meaning Total Productive Maintenance aimed at maximizing reliability of plant and machinery by aiming at zero Breakdown, Zero Accident, Zero Defects.
<i>BPR</i> — business process reengineering, a management approach aiming at optimizing the workflows and processes within an organization.

4. IMPLEMENTATION OF QMPS

The implementation of QMPs viz. Six Sigma is done in 5 stages as discussed below:

4.1 Define Phase

In this phase, the problems the existing manufacturing

operations are identified and projects are done on the basis of problem. Figure 1. shows the importance & relativity of project and it's linkage with company's vision, strategies, functional strategies and TQM activities.



Fig. 1 Linkage of project with company's vision & objectives

Under our KPI (key pillar indices) of improving the tractor quality, one of the KAI (key Activity indices) is to

reduce the no. of DPR (Direct Pass ratio) defects as shown in Fig. 2.

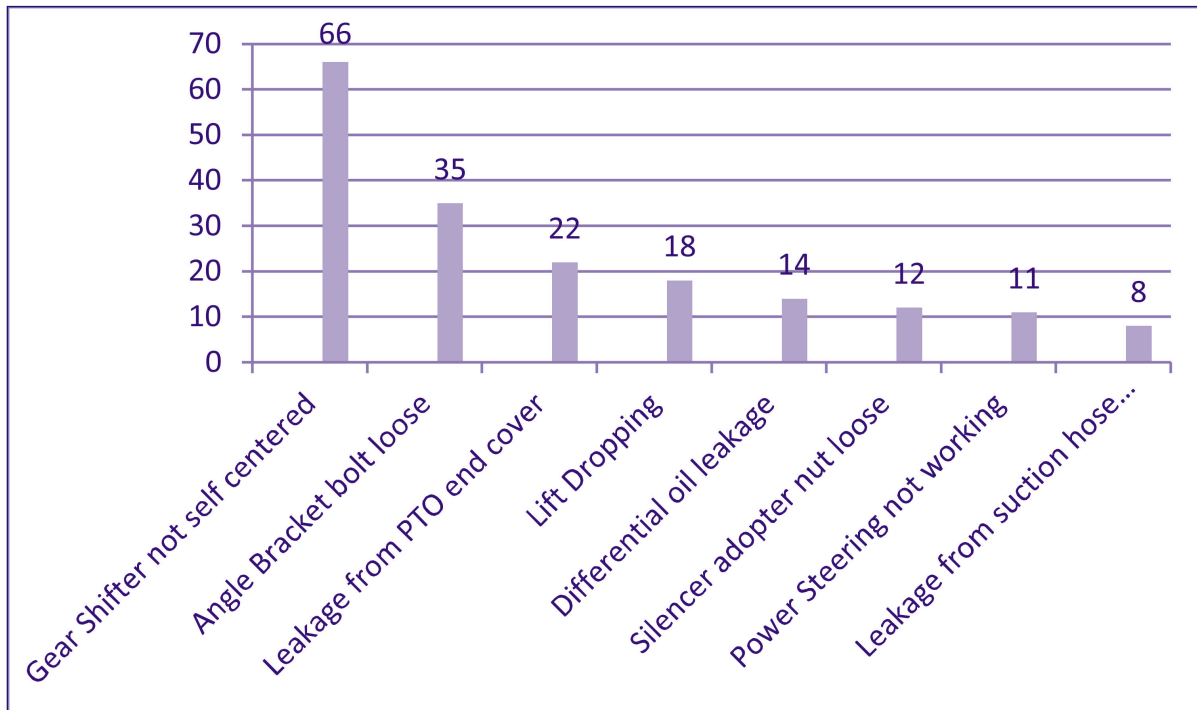


Fig. 2. Graph showing defects recorded in F13Q3

After making the graph the defects were also arranged as in Fig. 2. in order depending upon their S.O.D. (Severity Of Defect) rating so as to prioritize the defects based upon severity, occurrence and detection also. Since the gear shifter not self centering is at the top position in the graph and is also among the top 5 defects according to the S.O.D. rating so this problem was taken up for the improvement.

4.2 Measure Phase

The gear shifter is required to be self centering and smoothly operating just like the car gear shifting system. The rework of the problem would take half an hour for rectification. Also, the no. of cases being reported was high.

So, the symptoms of the problems were:

- High no. of vehicles in hut.

- Higher no. of major rework tractors.
- High Rework Time.
- Gear shifter Housing Bore undersize
- Cross Rod diameter oversize.
- Top Cover Bore diameter undersize
- Wrong spring fitment
- Oil Seal pressed in inclined position

4.3 Analyze Phase

In analyze phase the probable causes of the identified and analyzed. After Brainstorming and activity that following causes were taken up for further analysis:-

Table 2. Cause verification/Testing Table

S.No.	Probable causes	Testing and observations	Remarks
1.	Gear shifter housing, Bore undersize	<ul style="list-style-type: none"> • Gear shifter Housing Core diameter was observed in 5 defective tractors. • Specification: $18+0.110/+0.150$ mm • Observation: 18, 12 .. 	Invalid
2.	Cross Rod diameter oversize.	<ul style="list-style-type: none"> • Cross Rod outer diameter was observed in 5 defective tractors. • Specification: $18 -0.115/ -0.158$ mm • Observation: $18-0.120/-0.145$ mm 	Invalid
3.	Top Cover Bore undersize.	<ul style="list-style-type: none"> • Cross Rod (Outer diameter was observed) 5 defective tractors. • Specification: $18+0.095/+0.138$ • Observation: $18+0.100/+0.135$ mm 	Invalid
4.	Wrong spring fitment	<ul style="list-style-type: none"> • 5 defective tractors were checked for the correct spring fitment. In 3 tractors hard spring was found in the place where the soft spring was to be fitted. 	Valid
5.	Oil Seal pressed in inclined position.	<ul style="list-style-type: none"> • 5 of the defective tractors were checked for the oil seal fitment in correct orientation. Found the orientation to be correct without any inclination. 	Invalid

In the Cause verification (Table.2), hard spring was found to be fitted in place of soft spring. In place of soft spring, that was to be fitted over the gear shifting cross rod, was found to be missing in 3 out of 5 defective tractors and in place of soft spring, the hard spring was fitted thereby rendering the gear shifter not self centering. Both the springs were of almost same size and colour and thus there were chances of mixing error. Operator training was done and colour coding of hard springs

with blue colour was also done. The trials were taken up after the correct fitment of soft springs in the top cover and a pilot batch of 10 tractors was again made. But again, the problem was observed in 3 tractors. Thus PM (Physical Mechanism) analysis was used to find out the solution to the problem PM Analysis Phenomena; Gear shifting lever not returning to centre of neutral position on its own when displaced to one side. Table 3 helps in Understanding the operating Principle & standard.

Table 3. PM (Physical Mechanism) analysis

Phenomena	Operating principle	Operating standard
Gear shifting lever not returning to centre of neutral position on its own when displaced to one side	If the frictional forces are greater than the spring force, then the gear shifting lever will not come back to centre of neutral position	Frictional force should be less than the spring force

Measurements were also made for the effective spring force available, and the frictional forces present in the good and bad

assemblies. Theoretical designed spring force calculations were done as shown in Table 4.

Table 4. Spring Force calculations

Spring free height	60mm
Spring consent	0.297kg/mm
Compression of spring during lever displacement	10mm
Spring compression at the neutral position	12mm
Spring at the neutral position	3.564kg
Spring force due to displacement	2.97kg
Spring force at the release of gear shifting lever due to the compressed spring	6.534kg
Spring force at the release of gear shifting lever due to the elongated spring	0.594kg
Net spring force at the release of gear shifting lever alone end	5.94kg= 6kg

Further practically force required to centre gear shifter knob was measured and recorded the variation between

force required in Good/Bad parts was clear as shown in Table 5.

Table 5. Good Parts & Bad parts force variations

Force required to push the gear shifting lever to one side (measured by push-pull meter)		Force required to push the gear shifting lever to one side (measured by push-pull meter)	
1	5.4kg	1	6.6kg
2	5.2kg	2	6.8kg
3	4.6kg	3	7.1kg
4	4.5kg	4	7.2kg
5	5.1kg	5	8.2kg

The frictional forces in the bad sub-assemblies were much higher than the effective spring force available and thus the problem of gear shifter not self-centering. During the neutral position, the cross rod moves to and fro inside the gear shifter housing and top cover & the 2 off springs brings the cross rod to the centre position. Hence, these are the interacting elements. For the parameters whose standard values were not mentioned in the drawing, the ideal values required for the correct functioning of the gear shifting lever were found out by the measurement of these parameters in good and bad sub-assemblies, keeping all the other parameters constant within the

respective standard values required. Trials were taken with all these improvements in another pilot batch but the problem was still there in few cases. So with these improved assemblies good bad analysis was done to found the remaining abnormality.

4.4 Improve Phase

In this phase, actions are taken to improve the processes. The different problems and their root cause identified in the previous phases are taken in action in this phase. Table 6. shows actions taken to improve the processes or monitoring of different parameters.

Table 6. Monitoring of parameters

Parameter to check	Measurement method	Standard Values	Measured Values	Evaluation	Improvement	Result
Cross Rod bent/straightness	Dial Gauge	0.08 mm	0.02-0.2 mm	Improvement required	Part straightness to be maintained within 0.05 mm.0.05 mm	Confirmed within 0.05mm
Cross Rod Hole shifted with respect to fork cent	Height gauge/vernier	0.1 mm	0.05-0.3 mm	Improvement required	Toggle Clamp provided for proper resting of cross rod on fixture blocks during welding to maintain Cross rod hole alignment within 0.1 mm	Confirmed to be within 0.1 mm
Top cover Bore perpendicularity is more	Surface table and Dial Gauge	0.08 mm	0.05-0.2 mm	Improvement required	Machining Fixture validated and corrected gang milling done before boring operation	Confirmed to be within 0.08 mm
Hard spring fitted in place of soft spring	Visual	Soft spring to be fitted	Hard spring fitted in few cases	Improvement required	Operator educated	Correct spring assembly confirmed
Less clearance between gear shifter housing and the cross	Good Bad Analysis	0.0112 - 0.154 mm	Good Assembly 0.14-0.154 Bad Assembly 0.11-0.122	Improvement required	Clearance increased by 0.060 mm	Cross Rod move easily under action of spring force.

4.5 Control Phase

In this phase, control over the different monitoring parameters has been done. The problems including Gears shifter Housing Bore undersize, Cross Rod diameter oversize, Top Cover Bore diameter undersize, Wrong spring fitment Oil Seal pressed in inclined position are standardized by modifying drawings. The quality management hone shows to enhance stratum too raise interior and outer client's compensation, upgrade fabricating forms in context of diminishing or disposing of deformities, making society of never-ending change, however it needs right concentration and duties. The following steps taken to maintain control over the process:

- Drawing for gear shifter housing changed to increase the bore diameter from 18.11/18.5mm to 18.17/18.21 mm.
- Standard Operating Procedure has been followed.

5. ECONOMIC ANALYSIS

Based on these QMP projects, One GB (Green belt) and one BB (black belt) project was taken up to understand course and techniques of Six Sigma DMAIC projects. Furthermore extensive study and data stratification was done to understand the overall benefits of QM activities to organization and individual benefits due to Six Sigma/QC story projects to understand the importance of these in growth and raise story of case company. The following benefits are occurred after

implementing

QMPs:

- Tooling cost per tractor was significantly reduced to Rupees 620.
- Oil cost saving was brought down to Rupees 207 from Rupees. 368 in span of 5 years predominantly.
- Power consumption per tractor was significantly brought down from 471 units to 384 units.
- OEE (Overall Equipment Efficiency) was enhanced from 63% to 84%.

Net savings of Rupees 349.68 lacs annually has been achieved after implementing QMPs in the case company.

6. CONCLUSIONS, NOVELTY AND LIMITATIONS

Six Sigma as a powerful business strategy has been well recognized as an imperative for achieving and sustaining operational (process) effectiveness, producing significant savings to the bottom line, and thereby achieving organizational excellence. The present company was suffering from wrong fitment of hard spring in place of soft spring. Thus PM (Physical Mechanism) analysis was used to find out the solution to the problem and force analysis has been performed on spring. Systematic DMAIC methodology has been applied to identify and eliminate the problem by us and team of experts and finally standard operating procedure has been prepared so that problem does not arise again. Results of investigation demonstrated that QMPs have a strong tradition in manufacturing firms but are mainly applied within the production process. QMP viz. Six Sigma project has been performed in the case company through implementation of DMAIC cycle in a systematic manner and results are highly encouraging. Oil consumption, tooling cost and power consumption has been reduced, and OEE has been improved. The net savings of rupees 349.68 lacs has been obtained after implementing QMPs in the case company. Yellow Belt projects (Starter level Projects using 7 QC tools) from all the 5 divisions of case company can be reviewed and analyzed on basis of methods & tools used to draw tangible and intangible benefits in terms of Production, Quality, Cost, Delivery, Safety and Morale. From the results of the study, it is concluded that Six Sigma improvement methodology, viz. DMAIC cycle, is highly helpful in improving the performance of the company to increased level overall equipment effectiveness which further leads to the net savings. Furthermore Six Sigma technique can be compared with some other QM technique to calculate improvement in terms of rise in productivity of an organization. Similarities and differences between Six Sigma /QC Story approaches and other similar project oriented QM activities can be extensively studied.

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