Quality Improvement of Intermediate Shaft used in Steering Column through TQM: A Case Study

Ankesh Mittal
Sant Longowal Institute of Engineering & Technology, Sangrur, India
ankeshmittal07@gmail.com

Pardeep Gupta
Sant Longowal Institute of Engineering & Technology, Sangrur, India
pardeepmech@yahoo.co.in

Abstract

The aim of this paper is to present a case study on the implementation of a Quality Circle project under TQM in an auto component manufacturing industry ABC Ltd. (name changed) situated in Gurugram, India to highlight the benefits gained by the company. The TQM implementation at ABC Ltd. was initiated in 1998 and completely implemented by 2003 in a phased manner. Quality Circle is not only a problem solving tool, but it may be treated as a communication tool also which helps the organization for continual improvement. The rejection rate of intermediate shafts used in steering column of cars was significantly high and particularly the rejection of Nissan intermediate shafts was 68.5% of the total rejections. The company was interested to decrease this high rejection rate using the Quality Circle approach. After successfully implementing the countermeasures proposed by QC, the rejection rate of Nissan Intermediate Shaft (IMS) reduces to zero with in a period of five months.

Keywords

Quality Circle, Total Quality Management, customer satisfaction, and continuous improvement.

1. Introduction

In the present scenario various management practices such as Total Quality Management (TQM), Total Productive Maintenance (TPM), Six-Sigma, Just in Time (JIT), Enterprise Resource Planning (ERP) etc. are in use by industry to improve their operational capabilities. In TQM, the companies deploy some of the statistical and management tools which are further oriented towards assisting the teams in finding solutions for enhancing organizational capabilities. Quality control circle is a group of people of all levels, who work together on solving the problem or issues to propose the best possible solutions. Quality circles not only improve the performance but also boost the morale and skill of the employees.

A good number of researchers have reported the applications and advantages of Quality Control Circle's (QCC) with the presentation of case studies. The development of employees at all levels is the first and most important priority of the Quality Circle program (Alexander, 1981). (Ross & Ross, 1982) suggested Quality circle activities improved the three main areas: quality, productivity and attitude. The success of quality circle in an organization depends upon the support of the senior management (Cole, 1984). Employee productivity and absenteeism rates also improved where quality circles were active (Grady Jr. 1986). Fukui et al. 2003 state that the philosophy of QCC is based on the concepts of participative management and humanistic management. Quality Circles develop positive attitude among employees and encourage total employee participation concept (M.Y. Ismail 2006). Employee's participation and communication have significant and positive effect on employee's job satisfaction (Azadeh Tourani 2012). Chitra Sharma (2013) reported the use of quality circles in many manufacturing organization for drawing cost saving or quality improvement goals. Quality circle activities have positive and significant relationship with job satisfaction, commitment and participation in decision making of QCs members (Subbulakshmi et al. 2015). Rajesh Choudhary & Lalit Yadav (2012) suggested focusing on the implementation of Quality circles towards employees and organization. It leads to overall improvement in organizational culture as

well as performance of employees. From literature review it can be reviewed that quality circle is one of the employee participation technique that has been highly developed as an effective technique for rectifying both quality and productivity concerns.

2. Case Study Project

An auto components manufacturing industry situated in Gurgaon namely ABC Ltd. (name changed) implemented the TQM initiatives to achieve manufacturing excellence. Kaizens, QCC projects, etc. were carried out to improve the processes and products. To improve the quality of Nissan Intermediate shaft (IMS) was the one of the major issues of the company. Quality Circle a problem solving technique was used by project team to minimize the rejections of IMS, which is discussed in this paper as a case study. It was found that the rejection of IMS was taking place because of error in machining and material. The Complete details of Nissan Intermediate Shaft of Steering are presented by Fig.1.

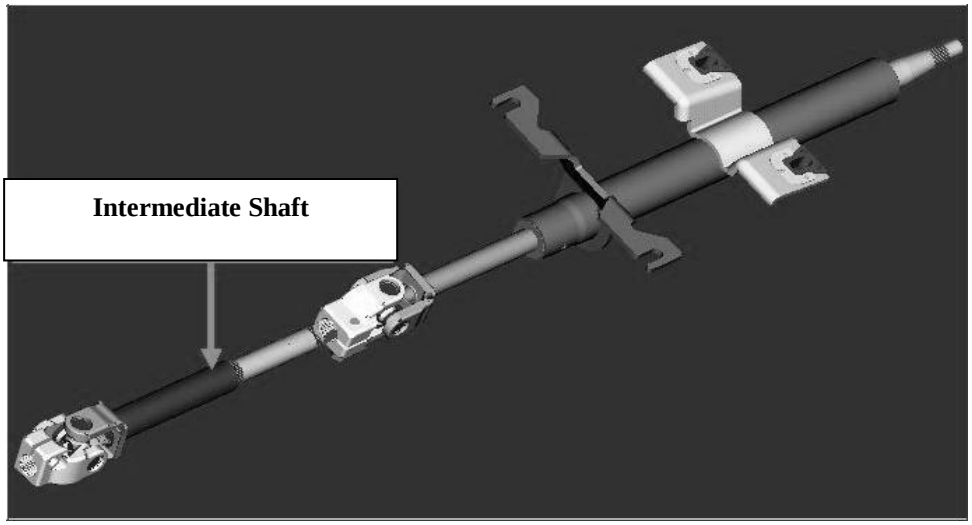


Figure1. Complete Details of Nissan Intermediate shaft of steering column

In steering mechanism, the intermediate shaft connects the steering column to the steering gear and transmits the torque. The process flow to assemble Nissan Intermediate Shaft is as shown in the Fig. 2.

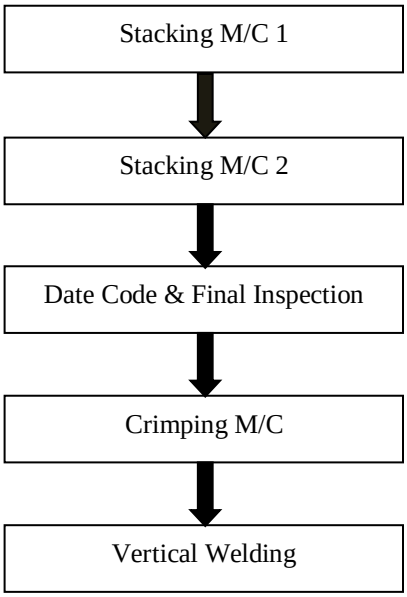


Figure 2. Process Flow Diagram of Nissan Intermediate Shaft

The project team planned the project schedule for three months from February 2016 to April 2016, as shown in Table- 1.

S.no.	PROJECT PLAN	MONTH											
		FEB-16				MAR-16				APR-16			
		W1	W2	W3	W4	W1	W2	W3	W4	W1	W2	W3	W4
1.	Define Problem	→											
2.	Project Target Setting			→									
3.	Analyze Causes					→							
4.	Countermeasure							→					
5.	Standardize Results									→			
6.	Check Results											→	

Table-1: Project Plan

The seven major steps performed under QC are: Define Problem, Project target setting, Analyze causes, Countermeasures, Standard results, Check results and Conclusion. The stage wise activities carried out to find out the most suitable solution are discussed in following sections.

2.1 Define problem

Three different models of Intermediate Shaft (IMS) were manufactured on different production lines; data of rejection units was compiled for five months i.e. from the month of September 2015 to January 2016. Rejection rate of Nissan IMS was observed to be high as comparison to other model. The compiled data of rejection units of each IMS model, to the corresponding month is as shown in the Table 2.

Table - 2: Rejection Data of five months period from SEP 2015 - JAN 2016

Line Name	**Sep-15**	**Oct-15**	**Nov-15**	**Dec-15**	**Jan-16**	**Total Rejection of five Months**	**Percentage Contribution of Rejection of five Months**
EZGO IMS	19	43	24	130	20	236	12.0%
Nissan IMS	372	389	154	227	207	1349	68.5%
IMV IMS	63	42	61	173	45	384	19.5%
	TOTAL					1969	

The percentage rejection of Nissan IMS model was observed to be the highest among all and it was 68.5% of the total rejected parts in the five months duration. So project team has decided to primarily focus on to reduce the rejection rate of Nissan IMS model, later to work on other models of Intermediate shaft.

2.2 Project Target Setting

For the reasons of rejection data of 5 successive months (i.e. from September 2015 to January 2016) of Nissan IMS model were collected, and the corresponding number of quantity contributing to the rejection of Nissan IMS model.

Compiled data for the type of defect, with their rejection quantity and their cumulative percentage are as shown in the Table 2. From the data, a target was set by Project team to reduce the rejection of Nissan IMS model.

Table 2: Data Collection of Nissan IMS for five months

S. No.	Type of defects Found in Nissan Intermediate Shaft	Rejection quantity of five months from Sep-15 to Jan-16	Percentage Contribution of Five months from Sep-15 to Jan-16	Cumulative Percentage of five months from Sep-15 to Jan-16
1	Jerky feeling NG	723	53.59%	53.59%
2	Needle out	402	29.79%	83.38%
3	Stacking NG	93	6.89%	90.29%
4	Bearing Crack	70	5.18%	95.45%
5	Weld appearance NG	23	1.70%	97.15%
6	Angle NG	19	1.40%	98.55%
7	Weld Blow hole	12	0.85%	99.40%
8	Bearing missing	7	0.60%	100%
Total Rejection Qty		1349		

It was observed from the data that the cumulative percentage of Jerky feeling NG (Not Good) and Needle out defects found in Nissan IMS model is high which is near by about 83.38 % of total number of defects. So, it was decided by project team to rectify Jerky feeling NG and Needle out defect in Nissan IMS model to reduce rejection rate, instead of working on all the eight defects. The Jerky feeling NG occurred due to degree of freeness between spider and yoke, and needle out occurred due to needle coming out of bearing casing as shown in Fig. 3.

Spider and Yoke joint	Needle Bearing
	

Figure 3: Spider & Yoke joint and Needle Bearing

The graphical representation of rejection trend of Nissan IMS model for the period of five months (September 2015 to January 2016) shows in Fig. 4. The graphical representation shows that the average rejection quantity of the Nissan IMS model for five months was 270 units. The target was set by the project team to reduce reduction rate up to 90% i.e. from 270 to 27 units by April 2016.

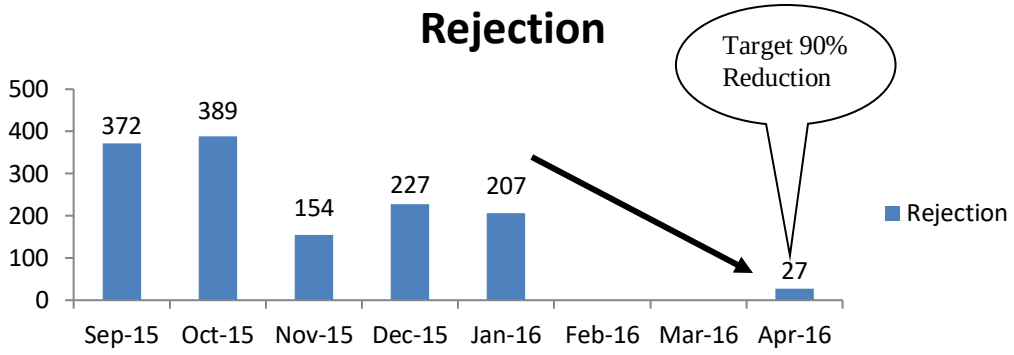


Fig 4. Bar Chart of Rejection

2.3 Analyze Causes

To understand the causes of higher rejection, Brainstorming & Cause and effect diagram (Fishbone diagram) techniques were used by the project team. From the possible causes, the project team identified three potential causes as critical which needed to be attending first as shown in Fig.5.

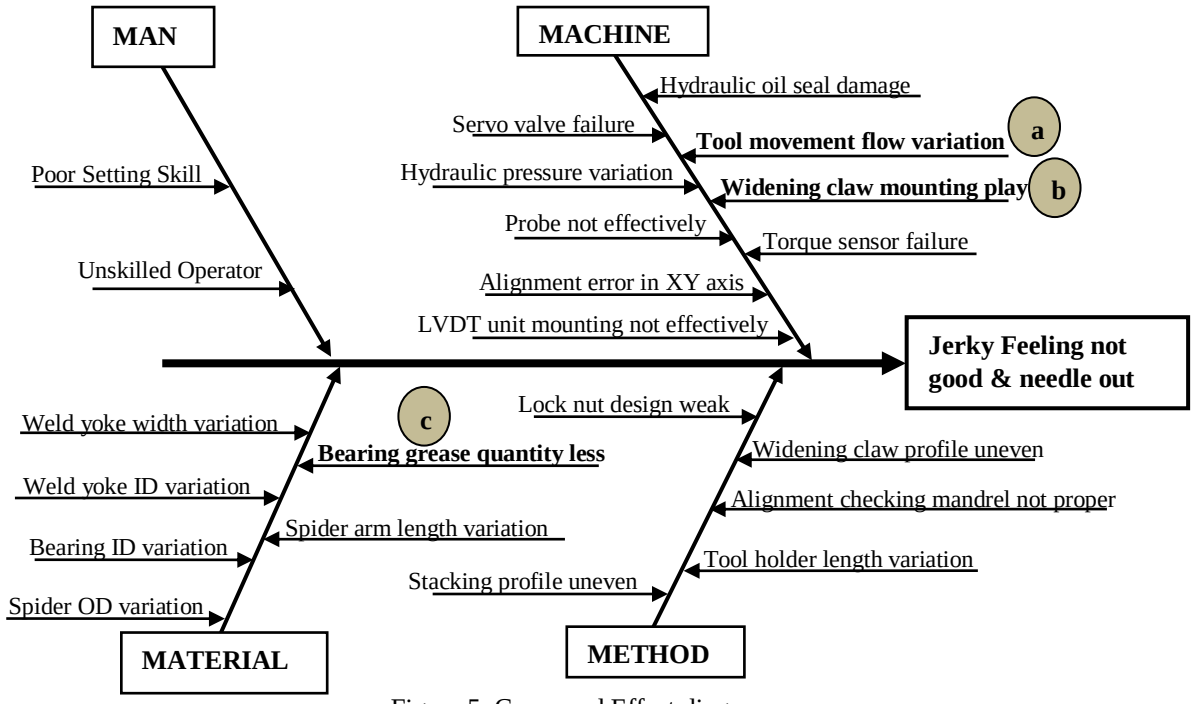


Figure 5. Cause and Effect diagram

The potential causes which were considered to be responsible for the higher rejection rate were identified as:

a) Widening Claw Play
b) Tool Flow Variation
c) Bearing Grease Quantity Variation

2.4 Countermeasures

To identify the root causes of the problem and implement the countermeasure, why-why analysis technique was used. This technique requires employees to pose question “why?” five times every times a problem is encountered. The employee should go a deeper and more detailed level with each “why?” and become closer to locating the root

cause of the problem. The why-why analysis as presented in table-3 is critical because countermeasures can only be identified when the root causes of the problem is understood.

Table 3: Why-Why Analysis of Potential Causes

Sno.	Potential Cause	Why-Why	Root Cause	Counter Measure
1.	Widening Claw Play	i. Yoke Stacking point alignment mismatch ii. Widening claw height variation iii. Widening claw mounting unit play iv. Mounting align bolt loose or thread worn-out during vibration	Weak design-while machine running condition widening claw position disturbed	Both side mounting unit Dowell pin provided
2.	Tool Flow Variation	i. Bearing inserting depth variation ii. Forward Tool movement uneven iii. Flow control valve disturbed iv. Manual adjustment for tool flow movement	There is no method to ensure Stacking Tool speed	Hydraulic Pressure Gauge provided in Both Side in front of the operator and interlinked with machine
3.	Bearing Grease Quantity Variation	i. While bearing inserting surface contact is high between Needle bearing & Spider ii. More friction between Needle bearing & spider iii. Insufficient grease inside bearing case iv. Bearing defined in less qty grease	Needle bearing grease quantity less	Needle bearing grease volume increased from 0.23 gram to 0.35 gram

a) Before any modifications it was found that potential cause no. 1 widening claw play was high in machine. After applying why-why technique, implement the countermeasure by placing Dowel pins on both sides of the machine unit thereby minimizing the widening claw play. Modifications made in the machine unit by using Dowel pin are shown below in Fig.6.

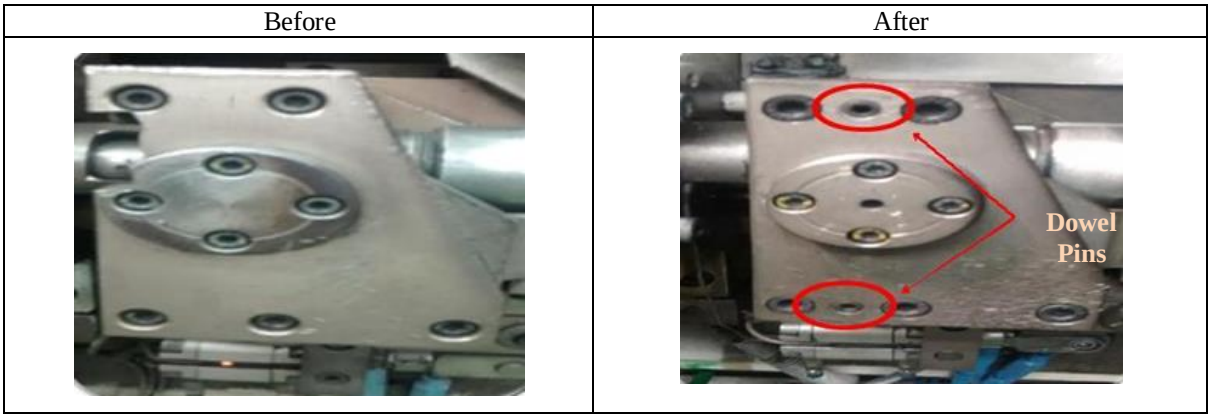


Figure 6. Before and after placing Dowel pins on both sides of the machine unit

b) For the potential cause no. 2 tool flow variation modifications made in the machine unit by mounting Hydraulic Pressure Gauge are shown below in Fig.7.

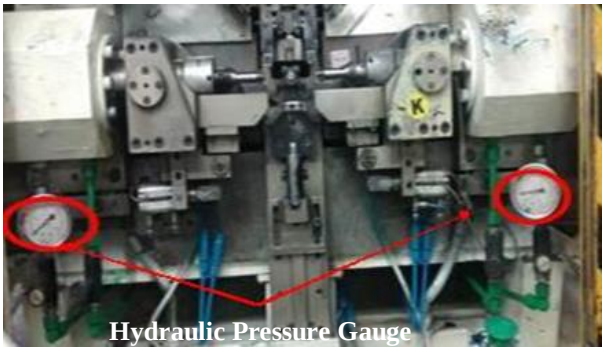
Before	After
	

Figure 7. Before and after mounting Hydraulic Pressure Gauge to the machine unit

c) For the potential cause no. 3 increased the quantity of grease from 0.23 gram to 0.35 gram as shown in Fig. 10.

2.5 Standardize Results

Standardization helps to minimize variations in materials, methods, equipment, and strategies. It establishes the base to improve the quality of a product. After improvement it is again standardized in processing condition, accuracy standard and other reference documents which give continual improvement. To Standardize results (What, Where, Which, Why, Who and How) was used as shown in Table 4.

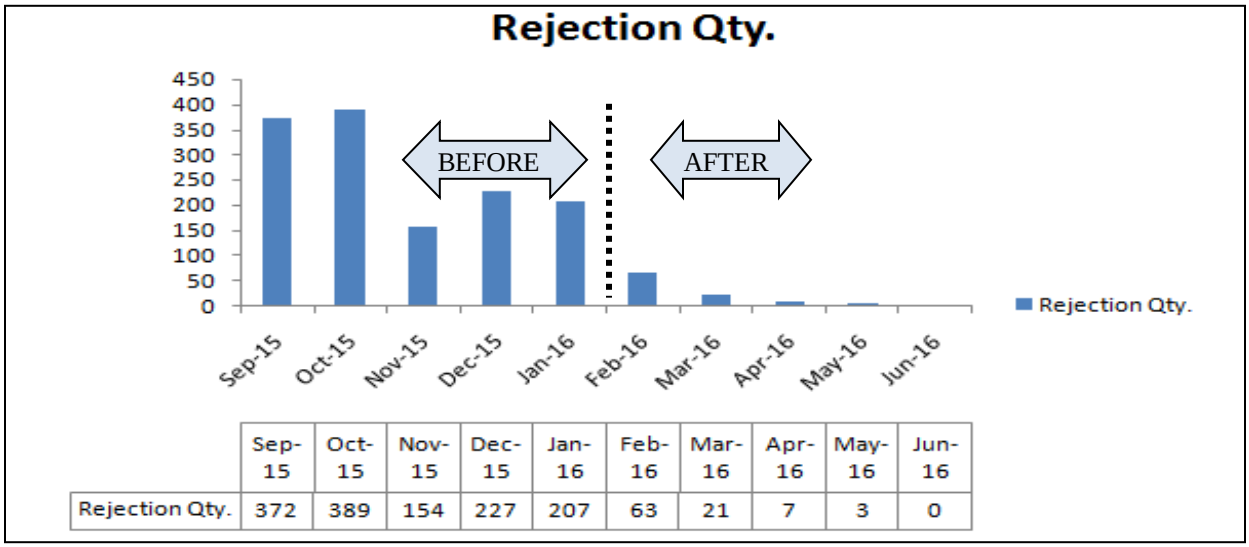
Table 4: Standardization of Results

S.No.	WHAT	WHERE	WHICH	WHY	WHO	HOW	Remarks
1	Widening claw play	Nissan IMS	Stacking machine 1 & 2	Weak Design-While machine running condition widening claw position disturbed	Production/ Maintenance	Both side mounting unit Dowell pin provided	Completed
2	Tool flow variation	Nissan IMS	Stacking machine 1 & 2	There is no method to ensure Stacking Tool Speed	Maintenance	Hydraulic Pressure Gauge provided in the front of the Operator and Interlinked with machine(FM-CORP-150)	Completed
3	Bearing Grease Quantity Less	Nissan IMS	Stacking machine 1 & 2	Needle bearing grease qty less	SQA/ Production	Needle bearing grease Volume increased from 0.23 gram to 0.35 gram (FM-CORP-258)	Completed

2.6 Check Results

Before implement the countermeasure, average rejection quantity of Nissan Intermediate Shaft (IMS) model for five months (September 2015 to January 2016) was 270 units. Target was set by the project team to reduce rejection rate

up to 90% i.e. from 270 to 27 units in three months from February 2016 to April 2016. But after implement countermeasures the rejection quantity reduces to 0 units by June 2016. The rejection trend was shown graphically in the Fig. 8 which shows before and after applying the countermeasures.



	Sep-15	Oct-15	Nov-15	Dec-15	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16
Rejection Qty.	372	389	154	227	207	63	21	7	3	0

Figure 8: Rejection trend before and after applying countermeasures.

2.7 Conclusion

In order to reduce the rejection rate of Nissan Intermediate shaft of steering column, three main potential causes found by project team responsible for higher rejection rate were to be addressed immediately. The main countermeasures taken were: providing Dowell pins to machine unit, mounting hydraulic pressure gauge in front of the operator of the machine and increase the quantity of grease volume. It was found that due to weak design, the claw position was disturbed during machining of intermediate shaft of steering column. So it was decided to provide the Dowell pins to both side of mounting unit to stop the widening of claw play. To control the tool flow variation hydraulic pressure gauge was provided on both side of the operator and interlinked with machine. To avoid the needle out from bearing case, the quantity of grease was increased from 0.23 gram to 0.35 gram which resulted in less friction between needle bearing and spider. These three corrective actions helped the industry in reducing the rejections of Nissan intermediate shaft of steering column and thus the target of quality improvement by reducing the rejection rate to zero was met successfully.

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