Improvement of Quality in Inner Ball Joint Assembly using Signal to Noise Ratio Analysis

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Abstract

The quality department faces the problem of "Grease Missing in Inner Ball Joint Assembly" of manual steering gear. The objective of this system is to improve the overall productivity and to eliminate the defects without compromising the quality, optimizing the cost and time of the defective components. The problem is identified by Pareto Analysis which is one of the techniques of six sigma. The problem is analysed by various quality control tools such as Affinity diagram, Relationship diagram, Multi-vari chart, Why-Why analysis, signal-to-noise ratio analysis. The signal-to-noise ratio analysis (Taguchi Method) helps to find the most significant factors for the problem. They are re-designed to overcome the problem and gives the counter measures for the problem. This counter measure is suggested to the company which has forwarded to the quality department. The suggestions are given to the company and the expected results are achieved.

Keywords - *Affinity diagram, Relationship diagram, Multi-vari chart, Why-Why analysis, signal-to-noise ratio analysis*

I. INTRODUCTION

Quality Improvement is a challenge to every industry. There has to be continuous efforts for quality improvement so as to sustain and grow in the competing business world.

Indian automobile industry is undergoing tremendous growth. The need for quality improvement in the automotive industry, and therefore within the suppliers of the motor vehicle industry arises due to the high level of worldwide competition within this sector. The Indian automotive component manufacturing industries have gained significant stride due to growing domestic demands and the outsourcing of components.

The Indian automobile industry is one of its most vibrant industries. The industry accounts for 22 per cent of the country's manufacturing gross domestic product (GDP).

It is presently the seventh-largest in the world with annual production of 17.5 million automobiles of which 2.3 million are exported.

The collective foreign direct investment (FDI) inflows into the Indian auto manufacturing industry during the period April 2000 -May 2014 was recorded at US$ 9,885.21 million, according to data published by Department of Industrial Policy and Promotion (DIPP).

The next few years are projected to show solid but cautious development due to improved affordability, increasing incomes and untouched markets. In addition, with the government's backing and a special focus on exports of small cars, multi-utility vehicles (MUVs), two wheelers and auto components, the automotive sector's contribution to the GDP is expected to double, reaching a income of US$ 145 billion in 2016, according to the Automotive Mission Plan (AMP) 2006-2016. This paper presents to improve the quality of a large- scale auto component manufacturing company.

II. PROBLEM IDENTIFICATION

The quality department is involved in every stage of the production activity. So, the problems faced by the quality department at every stage of the production process are studied. From the study, it is found that the company is facing a major problem in the process quality division. This will affect the productivity and consumes the cost and time of production. If exceptionally they pass through the inspection process, it will lead to serious consequence in the customer quality division. So from the study, the major problem faced by the company is "Grease Missing" Problem. So the objective is to improve the overall productivity by eliminating the grease missing problem and defects of necessary components manufactured in the company.

A. Pareto Analysis

Pareto analysis is a numerical technique in decision making that is used for selection of a limited number of tasks that produce significant overall effect. In terms of quality improvement as per Pareto principle a large majority of problems (80%) are produced by a few key causes (20%). This is also known as the vital few and the trivial many.

Pareto analysis is a formal technique useful where many potential courses of action are competing for attention. In essence, the problem-solver estimates the benefit delivered by each action and then selects a number of the most effective actions that deliver a total benefit rationally close to the maximal possible one. The factor responsible for rejection and the corresponding Number of rejection in Parts per Million are shown in Table 1.

Table I Factor Responsible For Rejection

S.NO	FACTORS	REJECTION IN PPM
1	GREASE MISSING	700
2	HIGH TORQUE	250
3	LOW TORQUE	230
4	BALL HEAD NOT OK	110
5	PEENING NOT OK	80
6	OTHER	70

The Pareto chart for the data shown in the Table 1. is shown in Fig.1

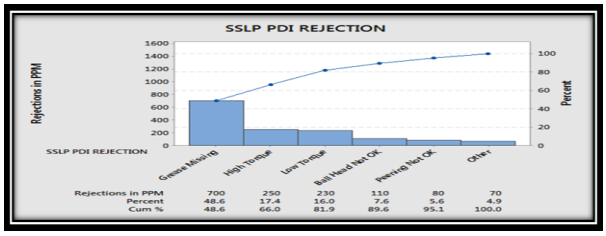

Fig 1 Pareto Chart Based on Problems

Based on the values taken from the rejection in PPM, the highest rejection in PPM "Grease Missing" has been narrowed as an important one and taken for further analysis. Next, customer Pareto analysis for customer wise analysis is shown in Fig 2.

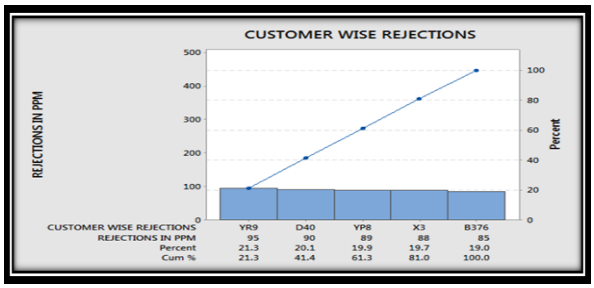

Fig 2 Pareto Analysis for Customers

From the Fig 2.it is clear that YR9 product is affected majorly from a lot of rejections which makes B376 negligible. As all the products undergoing "Equal amount of rejections", it is considered to be an important customer for further analysis to avoid the Grease Missing

B. Effects of Grease Missing

- Customer Dissatisfaction
- Warranty claim
- Affects reputation of the company
- Loss of new product contracts to company
- Debit the customer
- Lowers the rating of the company

C. Objectives

The following are the objectives of the project

- To improve the overall productivity by eliminating the grease missing problem and defects of necessary components manufactured in the company.
- To eliminate the defects without compromising the quality and optimizing the cost and time of the defective components.

The defective components are planned to be reduced by the following objectives

To explore the causes for the "Grease Missing".

To identify the causes which has a significant relationship with the effect.

To analyze those significant cause using quality control tools

To develop a feasible solution using Signal to Noise Ratio Analysis (Taguchi Method) by optimizing the resources.

III. CAUSE ANALYSIS

A. Data Collection

The data is collected during the operation to ensure the probability of occurrence of the grease missing and it is found that grease missing occur at least 10% in every lot. In order to ensure that the grease missing are formed either because of men (operator) or machine or shifts. The data are collected and analysed individually.

It is done by two methods such as

Method 1 (Operator vs. Machine)

- Every operator is asked to work with all the machines i.e. there are 2 machines for machining socket and each operator has to machine the socket in both the machines.

Method 2 (Operator vs. Shift)

- Each operator is asked to work in all shifts on each separate day i.e. there are three shifts in the company so for day 1, Operator 1 will work in 1st shift and the next day, the same operator will work in 2nd shift likewise it goes. The shifts of the operators are interchanged as per schedule without collating any problem.

From the above two methods, the data are collected. These data are analysed using Multi-vari chart to identify the causes behind grease missing

B. Multi-Vari Chart

Multi-vari chart is a type of Shainin technique which visualizes the variability (difference) between factors through a series of charts. Multi–Vari chart is a graphical representation of ANOVA (Analysis of Variance).

Multi-vari chart has been used to describe a visual way to display analysis of variance data. It is a two-dimensional representation of multiple dimensions (one for each factor in the ANOVA), the multi-vari chart is useful for comparing the variability among at most four factors.

1) Method 1

The data for this method is taken for a week. The input to this analysis is the average of 3 months' shift wise rejection of each operator.

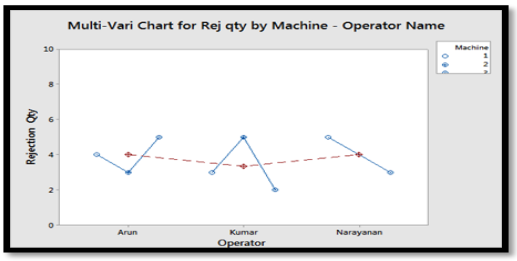

Fig.3 Multi-vari chart for Machine vs. Operator

2) Method 2

The data for this method is taken for a week. The input to this analysis is the average of 3 months' shift wise rejection of each operator.

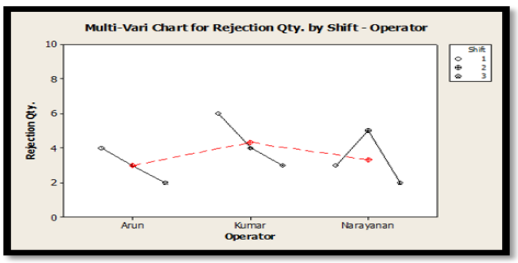

Fig.4 Multi-vari chart for Shift vs. Operator

C. Brainstorming

Brainstorming is a group or individual innovative technique by which efforts are made to find a conclusion for a specific problem by gathering and generating a list of ideas spontaneously contributed by its member(s).

As the above analysis didn't show any significant conclusion, it is taken for further analysis. To solve this issue, the causes behind the Grease Missing are brainstormed. The brainstormed ideas (causes) for Grease Missing are listed below

1. Wrong Setting
2. Socket Collection
3. Pressure Variation
4. Uneven drum Setting
5. Grease Properties
6. Grease Timer
7. Grease Pressure
8. Rotation in PPM
9. Uneven Sequence
10. Torque Setting
11. Handling
12. Grease Seconds

D. Affinity Diagram

The affinity diagram is a business tool used to organize ideas and data. It is one of the Seven Management and Development Tools. The tool is normally used within project management and allows large numbers of ideas stemming from brainstorming to be sorted into groups, based on their natural relationships, for review and analysis

The affinity diagram organizes ideas with following steps:

- Record each idea on cards or notes.
- Sort cards into groups until all cards have been used.

Its simplicity makes it easy to combine it with other tools and put it to a wide variety of applications. For instance, it can be combined with a cause-and-effect diagram to identify and regroup causes for a problem. Thus it can assist in problem solving.

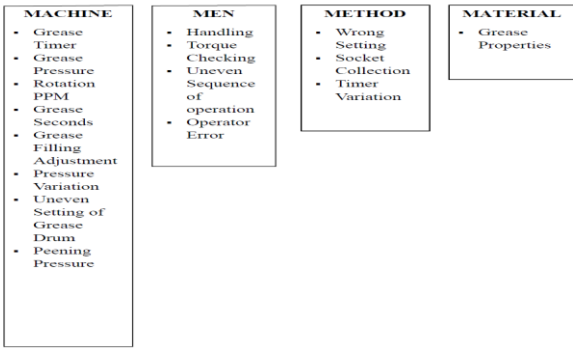

Fig.5 Affinity Diagram for Grease Missing

E. Relationship Diagram

A relationship model is a systematic way of describing and defining a business process. The process is modelled as components (entities) that are linked with each other by *relationships* that express the dependencies and requirements between them. The purpose of relations diagram is to generate a visual representation of the relations between an effect and its causes as well as the interrelationship between the causes in complex problems.

As the causes organized above are just based on the ideas gathered, it needs some facts to narrow down to those which have a significant relationship

on "Grease Missing". Relationship diagram explores the relationship between the causes and also identifies the root cause for the effect. Root cause is the one which has a significant relationship to the effect.
Thus to find the root cause, a relationship diagram is drawn for the grouped causes.

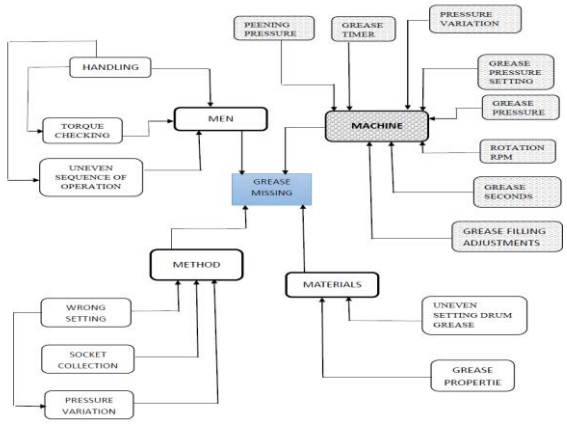

Fig.6 Relationship Diagram for Grease Missing

F. Signal – To -- Noise Ratio Analysis (Taguchi Method)

Signal-to-noise analysis is also used to understand the importance to verify whether the factors and their interaction have effect on variance also. The **signal-to-noise-ratio** (SNR) is the ratio of the strength of the signal and noise. The higher the ratio the easier it is to extract information and the more reliable are the results. In analytical chemistry the SNR is one of the facts of merit that describes the quality of a specific analysis technique.

In statistics, signal-to-noise analysis is a statistics process for estimating the relationships among variables. The variables which are affecting the quality may be classified into controllable variables and Uncontrollable (Noise) Variables. In signal-to-noise Analysis the factors are classified into control factors and noise factors .The control factors are placed in the inner array and the noise factors are placed in the outer array. The best settings of the control factors will improve the measure of performance.

Fig 7 Effects Plot For SN Ratio

Level	Peening Pressure	Grease Seconds	Socket Rotation	Pressure Variation	Main Air Pressure	Grease Filling Adjustment	Grease Setting	Grease Timer
1	20.92	20.00	20.92	20.92	19.78	20.92	20.92	24.25
2	20.92	20.54	20.92	20.92	20.09	20.92	20.92	19.82
3	20.92	22.23	20.92	20.92	22.91	20.92	20.92	18.70
Delta	0.00	2.23	0.00	0.00	3.13	0.00	0.00	5.56
Rank	7	3	7	7	2	4.5	4.5	1

1) Signal -To - Noise Analysis Inference

According to Minitab (DOE Tool), when the value of the rank is obtained, then the results are achieved.
From Taguchi Method, it is found that the following independent variables shows a significant relationship with "Grease Missing"

- ✓Grease Timer Setting
- ✓Grease Dispense Level

As the above independent variable shows a significant relationship with the primary Cause, a change in their values will impact a change in the dependent variable.
The result obtained from the signal-to-noise analysis is used to the rank in which it has the
Highest significant factors

- The Rank in which has the top two are taken as the significant factor for the countermeasure.
- The grease timer and main air pressure is taken for the analysis. These two parameter setting met the specifications.

IV. COUNTER MEASURE TO RE DUCE DEFECTS DUE TO GREASE MISSING

A. Main Air Pressure

The first action was taken against the Main air pressure .The main air pressure is used to regulate the passage of grease from the grease drum. During the process of the grease filling the main air pressure due to some malfunctioning the process is unable to get the grease filled.

1) Why-Why Analysis

The Why - Why Analysis is a great simple technique for involving a team in getting to the Root Causes of a problem, issue or opportunity. The technique can be used at any time a group or individual is trying to get below the surface of indications that appear to have lots of causes all interacting at the same time. The technique uses the Tree Diagram as its main presentation tool and utilizes other techniques such as **Brainstorming** to bring out ideas from the team.

Simple to use and easy to set up the technique can be really valuable when opening out on root

cause identification. There are some **'watch outs'** for this technique and they revolve around the subjectivity of ideas created on the fly, lack of data and team members having a controlled perspective on Root Causes based on their experience. Having said that the technique is a powerful one for engaging a team and beginning the thought processes on solving a problem or seizing an opportunity .The outcome of the Signal to Noise Analysis has projected the "Main Air Pressure" and Grease Timer "to the significant causes for grease missing

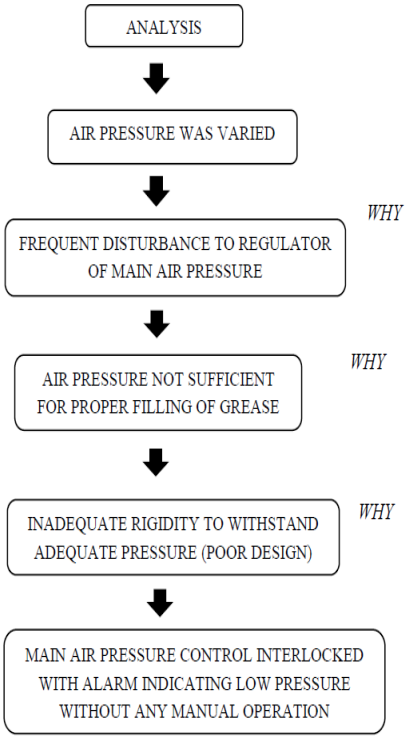

Fig 8 Why-Why Analysis for Main Air Pressure

This solution neither involve an extra activity nor increase the time of production nor increases the cost of manufacturing. Also, this solution doesn't compromises the quality. There are no limitations to this measure

2) Result

The modified main air pressure control interlocked with alarm indicating low air pressure without any manual operations. This measure resulted in 700 PPM to 500 PPM in the rejection of grease missing

B. Grease Timer

The Grease timer was used to regulate the timing of filling up of grease in the socket and based on the specific rotation of rpm of the socket it is used to fill the grease inside the socket. Due to the continuous changes in the timer manually by the workers it leads to the malfunctioning of the process and grease is not applied inside the socket which leading to the grease missing problem.

1) Why-Why Analysis

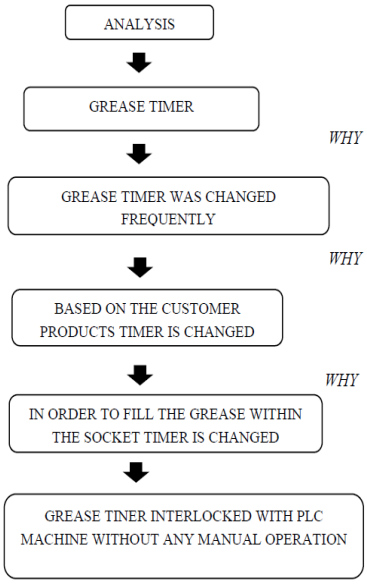

Fig 9 Why-Why Analysis for Grease Timer

2) Result

The modified grease timer interlocked with plc machine without any manual operation .This measure resulted in 500 PPM to 400 PPM in the rejection of grease missing. This solution neither involve an extra activity nor increase the time of production nor increases the cost of manufacturing. Also, this solution doesn't compromises the quality. There are no limitations to this measure.

C. Operator Carelessness

From the affinity chart the possible causes for the grease missing is validated and it is found that the operator error makes a significant cause for the problem. Due to this the operator forgets to keep the socket without grease in the peening machine which leads to grease missing in IBJ Assembly.

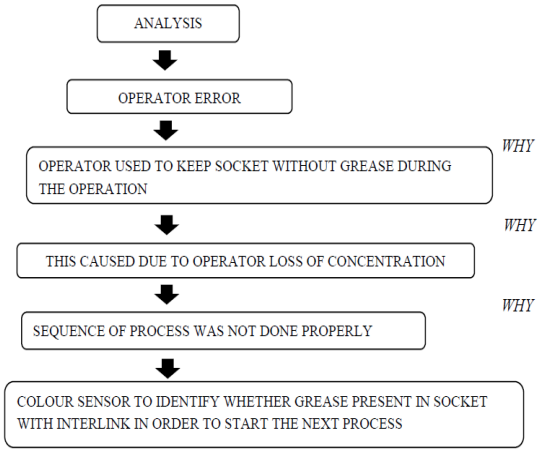

Fig 10 Why-Why Analysis for Operator Carelessness

1) Two Counter Measure For Operator Carelessness

a) Colour Sensor

The colour sensor to identify whether grease is present in the socket with interlink in order to start the next process .which is used to monitor the filling up of the grease and the sensor are interconnected through the machine, so that if there is no filling of the grease which is given by the negative response and vice versa.

b) Change In Plc Program

The PLC Program which is used to control the entire process of operations. Instead of selecting the socket and cup in the grease filling unit the operator directly keep the IBJ Assembly without grease in the peening machine. The process for the grease filling is not done by the operator instead they going for next process .So, we found that the possibility of grease missing is very high in this process.

So, we decided to go for another countermeasure by changing the PLC program and inter linked to start the next process only after the cup and socket collection passing through sensor.

The rejections' data with respect to Grease Missing are taken for 3 months after implementing the solution and then converted them to ppm.The rejection part per million (ppm) is totally eliminated from 700 ppm to zero ppm.

2) Result

This Colour Sensor and Change in PLC Program resulted in reduction of rejection due to grease missing from 400 PPM to 0 PPM.

The result shows that the intervention by the above programs does not involve any extra activity to oversee grease missing phenomenon and does not increase the time of production.

PLC Program Modified

The productivity of IBJ Assembly per day is increased from 2100 units to 2400 units because of Grease Missing Problem is eliminated. When the IBJ undergoes grease missing, it will be taken for the final checking such as the grease present or not.

V. CONCLUSION

The overall productivity of the company could be increased by eliminating the defective components. In this paper, the company has faced a large number of rejections in a component. The rejections behind that component have been studied, analysed and a feasible solution has been recommended.

A major problem faced by the company is Grease Missing in Inner Ball Joint Assembly of Manual Steering gear. The causes for this problem has been analysed using Pareto Analysis and the important cause for Grease Missing "Machine" is identified. The causes for Grease Missing are further analysed using advanced quality control tools such as affinity and relationship diagram and identified the root cause "Main air pressure and Grease Timer" for the overall problem faced.

Signal-to-noise ratio analysis is done to analyse the factors that has a significant relationship with the Machine Parameter settings. Thus Signal-to-noise analysis narrowed down two significant factors and they are re-designed to overcome the Grease Missing. But that measure has increased the time of manufacturing and decreased the productivity. So, a counter measure has been suggested which increased the productivity by optimizing the cost and time of manufacturing.

This counter measure (solution) is suggested to the company which has forwarded to the Quality Department. After this recommended solution has been approved by the Quality Assurance Manager, it is implemented in the company and the expected results are achieved.

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