Study of Application of Six Sigma of DMAIC in Dent Minimization in Gear Manufacturing

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Abstract

DMAIC is a Data-driven quality strategy used to improve processes. It is an integral part of a Six Sigma initiative, but in general can be implemented as a standalone quality improvement procedure or as part of other process improvement initiatives such as lean Technology. The present paper deals with application of six sigma for gear box system for dent minimization purpose. The various problems which lead to Gear box rejections such as Noise, Leakage, Damages, Assembly jam were studied in details for period of 2013-2016. All the parameter of DMAIC technology such as Define, Measure, Analyze, improve & Control were applied to above stated problem. The given study found that the Dent Minimization has been successfully carried out and has a satisfactory effect and can be a promising factor to improve future quality issues.
Keywords- Six Sigma, DMAIC, Gear Box, Dent, Quality Improvement

I. INTRODUCTION

Modern gearboxes are characterized by high torque, low torque, low running noise and compact design. In order to fulfill these requirements, gear specifications have to be accurately controlled. Many issues have occurred and still do occur during the manufacturing process of gears, especially in the areas of Hobbing, Shaving, Heat Treatment processes, etc. and attempts have been made to address them. Fulfilling the customer's requirements is one of the key performance indicators for any organization. The major challenges faced in the areas of quality and productivity, can be addressed by using Quality control tools, Statistical approaches, etc. which help in achieving the desired targets. Accordingly, we have worked on the Quality control strategy for minimizing the Dents by DMAIC control strategy.

II. LITERATURE REVIEW

From the paper "Application of root cause analysis in improvement of product quality and productivity" we understood the root-cause identification methodology has been adopted to eliminate the dimensional defects in cutting operation in CNC oxy flame cutting machine and a rejection has been reduced from 11.87% to 1.92% on an average. A detailed experimental study has illustrated the effectiveness of proposed methodology. [1]

From the paper "Gear Hobbing Cutting Process Simulation and Tool Wear Prediction Models" we understood the paper models to predict the wear development in gear Hobbing which are introduced, whereas the chip generation in full cut and in the transient work piece cutting regions is considered. The wear laws in the individual generating positions investigated in are exhibited with the aid of the developed algorithm FRSWEAR and procedures to determine the optimum tangential shift amount are proposed. In order to enable the monitoring of the wear progress in the individual generating positions and the determination of the included in the wear describing equations constants, the fly Hobbing with continuous axial feed was applied. [2]

From the paper "Gear Finishing by Shaving, Rolling & Honing - Part I" we saw, there are several methods available for improving the quality of spur and helical gears following tile standard roughing operations of Hobbing or shaping. Rotary gear shaving and roll-finishing are done in the green or soft state prior to heat treating. These processes have the ability to modify the gear geometry to compensate for the distortions that occur during heat treatment. Gear honing is a particularly effective [3]

From the paper "Six Sigma Implementation Practice in Manufacturing Industries" we studied and reviewed and examine the advancement and encounters of six sigma practices in Global Manufacturing Industries and identify the key tools for each step in successful Six Sigma Project execution. The paper also integrates the lessons learned from successful six sigma project ant their

prospective application in various manufacturing industries. In today's scenario, many global manufacturing industries operate their process at two to four sigma quality levels. [4]

From the paper "Implementing lean six sigma: a case study in concrete panel production" which draws the attention to the adoption of Lean Six Sigma in the construction industry with a case study. Lean tools combining along with Six Sigma methodology is used on projects by improving the process and removing the variations and creating workflow in a process. Despite its relatively new introduction to construction industry, it has been popularized by several organization and adopted as the primary improvement process. [5]

From the paper "A Review on Six Sigma (DMAIC) Methodology" we studied the detailed analysis regarding application of six sigma Methodologies in Organizations and Institutions. This paper provides an overview to the literature into various categories and considers various methods/techniques suggested in the literature. Based on the review, avenues for further research are also discussed. [6]

From the paper "Six Sigma – A New Direction to Quality and Productivity Management" which discusses the quality and productivity improvement in a manufacturing enterprise through a case study. This paper shows the application of DMAIC used in an industry to eliminate various operational questions to optimize the operation variables, improve and sustain performance viz. process yield with well execute control plans. Six sigma improves the process performance (process yield) of the critical operational process. [7]

III. CASE STUDY

We are analyzing all the defects caused at the final inspection, apart from which we will be focusing on Dents specially. After this according to DMAIC which is a part of Six Sigma we will be implementing the necessary remedies. We will be checking each process that is taking place on the gear manufacturing. Accordingly, we will be applying the preventive measures for the cause and observing the results. We are following the process of DMAIC Quality Control Strategy. [4]

1) Define: The problem is defined as dents minimization on gear flanks occurring.
2) Measure: Inspection of rejected gearbox is done. The gears are again checked in roll testing and noise testing machines Dents encountered were repaired by filing with a grinding stick.
3) Analyze: Dents encountered in the gear were repaired and checking on the dent marks it highlights the root cause of various Dents.
4) Improve: The goal of the improve stage is to find and implement solutions that will eliminate the causes of problems
5) Control: Once the improvement has been made and results documented, continue to measure the performance of the process routinely, adjusting its operation.

A. DMAIC

Define: According to the data we came across various problems which lead to Gear box rejections, those are:-

1) Noise: Due to improper meshing of gears, noises such as Picking/knocking, Rattling or Grinding noises occur which hampers the efficiency of Gear box.
2) Leakage: Due to improper fitting in the assembly, leakages occur at the testing.
3) Damages: Due to some mishandlings of operator, damages occur to various components of Gear box
4) Assembly jam: Due to improper assembly Gears do not mesh in proper manner causing the whole assembly to jam.

Table 1: Various Types of defects

	2013	*2014*	*2015*	*2016*
Noise	*458*	*443*	*535*	*695*
Assembly Jam	*67*	*125*	*210*	*220*
Others	*7*	*14*	*16*	*10*
Total	*532*	*582*	*761*	*925*

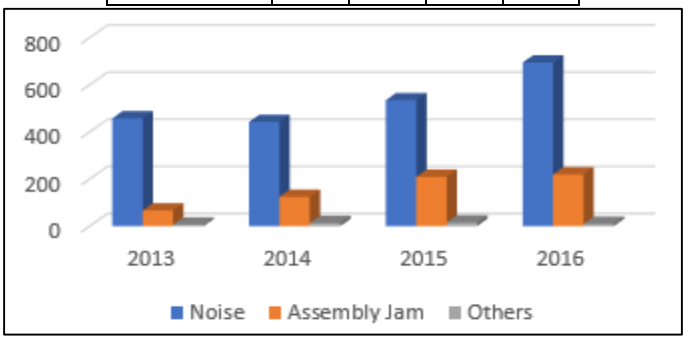

Fig. 1: Graphical representation for the various defects occurring

As noise has been a major contributor in the rejections we decided to select the rejections due to noise and work on it. Similarly, we collected the Data on rejection of various noises and tabulated it below: -

Table 2: various rejections due to noise

	2013	*2014*	*2015*	*2016*
Dents	*186*	*338*	*314*	*375*
Grinding Noise	*236*	*69*	*123*	*210*
Whistling noise	*35*	*25*	*46*	*62*
Rattling Noise	*1*	*11*	*52*	*48*
Total	*458*	*443*	*535*	*695*

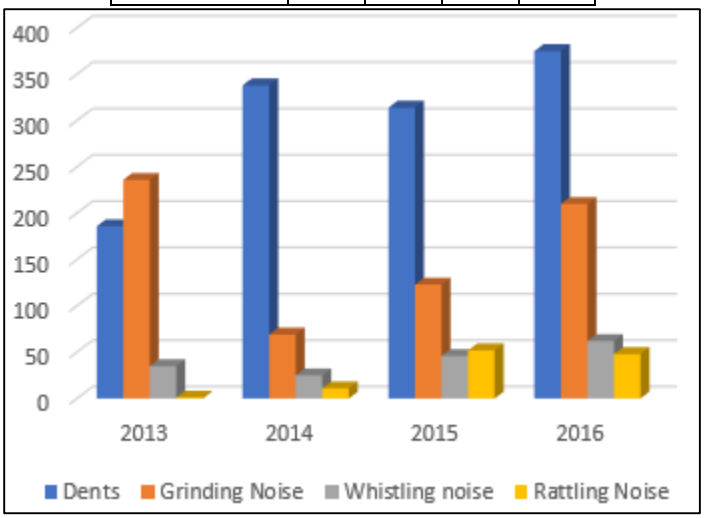

Fig. 2: Graphical representing various rejects due to noise

Considering the data collected of the rejections, Dent Noise has a major contribution in the total noise rejections. Thus, we selected Dent Noise Rejections to be reduced and ultimately selected this as our problem statement.

– What is Dent?

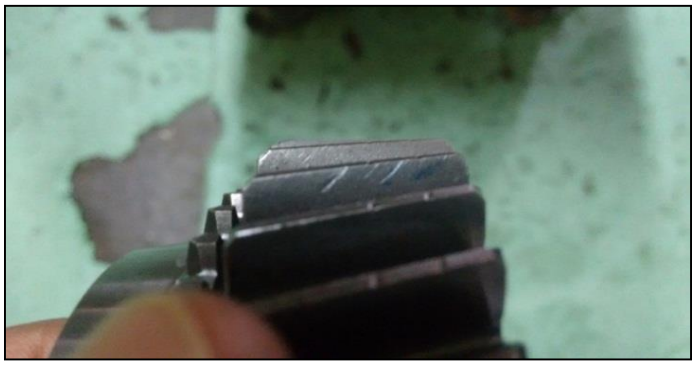

Fig. 3(a): Dent scratches inside the gear box

Fig. 3(b): Red circle indicates the procuring part of dent

The Marks present on the flank of gear as shown in above fig.3 (a) are termed as Dents. While manufacturing, if tool dressing is not carried out properly it promotes to dent formation. Above fig 3(b) shows (red circle) dent formed due to lack of attention at manufacturing stage. Also, fig 3(b) represents the dent formation due to improper finishing process on Sampotensli Machine and finishing processes such as Shaving, Deburring etc.

B. Measure

1) Data collection: Contact of 3rd gear on Layshaft with the structural member of trolley

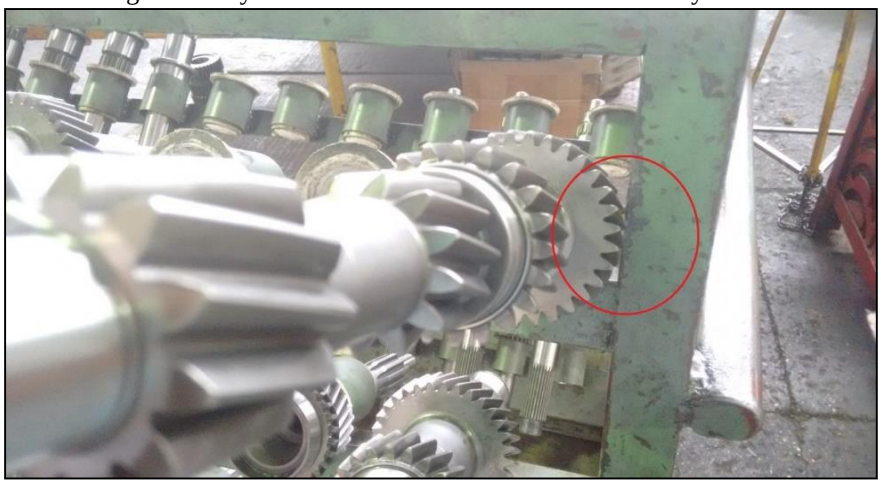

Fig. 4: Contact of Layshaft gear with the Trolley structure

After coming across some problems such as trolley structure contact with Gears. We found that the 3rd Gear on Layshaft if mostly affected due to the trolley design.

2) Absence of Chuckle Plates between Synchromesh gears:

After some research, we found that there is absence of chuckle Plates between the synchromesh Gears. This Synchromesh Gears get in contact with each other due to which Dent marks are generated on them which at the testing creates a problem to the Shifting mechanism of gear box.

Some more issues we detected, which were:

- There is supervision problem while transferring the gears from soft condition to Heat treatment plant
- Loading Problem at Heat treatment plant
- Improper Deburring and chamfering may lead remaining of burr on the Gear flanks in soft condition which may get hardened in Heat treatment process
- Improper loading of synchromesh gears

We also went through the testing and tested some Gear box by ourselves. One of the Gear box tested by us is shown below:

Fig. 5: Tested gear Box

From the above tested Gear box, we found out that there were Dent Problems on Reverse Gear as well as on 2nd gear.

Process done to remove dents on above gear box:

- We first disassembled the Rejected gear box
- We took each gear to the washing process were all the gears were washed.

- Later on, we took all the gears and performed the roll testing process on Parkinson's Roll testing setup. Here Reverse gear and 2nd Gear were found to be having dents. By the use of filling stick we removes the dents present on them
- Then we went to the Noise testing room. Here all the gears were tested on noise testing setup. The results obtained from noise testing concluded that the dents were eliminated and then all the gears were again send back to assembly
- All the gears were assembly in the gear box, and finally the testing results concluded the gear box was ok to be accepted.

C. Analyze

1) Mentality of the operator

During the production, the Gear box quality also depends on the mentality which may get disturbed due to continues repetition of his work. Also, due to his personal problems, pressure from the higher authorities due to mass production. This all things hamper the mentality causing some or the other mistakes from operator while production.

2) Awareness regarding the importance of his work

Operator should be made aware regarding the contribution and importance of the work, and significance of the work he is contributing to the company. This may boost up his determination towards his work.

3) Material handling

This is most important factor for maintaining the quality, if a component is not handled properly from one place to another there are possibilities of quality of the component getting compromised

4) Due to Trolley problems 3rd layshaft gear is been evidence of the dent problems appearing.

D. Improve

1) Layshaft Trolleys

There should be independent trolleys for layshaft with proper bushes and design to minimize the contact between Gear teeth's and Trolley structure.

2) Handling Problems

This is most important factor for maintaining the quality, if a component is not handled properly from one place to another there are possibilities of quality of the component getting compromised, so taking the importance of work the handling of components should be carefully done.

3) Operator Mentality

Environment should be friendly and comfortable for the operator to perform his operations.

4) Authority

Giving every successive machine operator the authority to discard the previous lot if not properly machined or if any quality standard is bypassed.

5) Proper Machining Tools

There should be a full set of machine tools, which should be near by the operator so that he can use them without wasting time in searching them in storeroom.

6) Noise Testing Sensor Implement

As the noise testing machine is old factory version and is solely dependent on the skill of operator which might not be always reliable, hence a noise sensor should be implemented in the noise testing machine.

7) At heat treatment tray of loaded gears should have proper spacing between them so as to keep them equidistant from each other.

E. Control

1) Implement Set of Precautions

Each and every operator should be given the list of quality standards and process information which should be followed and not be bypassed.

2) Checklist on Quality Checkups for Major Processes

Every major process such as Hobbing, shaping, roll testing etc. should hold a checklist at the end of their respective process. This will help in improving the quality of the product and quality checkups, & at the final operation the quality checkups will be reduced resulting in time saving.

3) Giving every successive machine operator the authority to discard the previous lot if not properly machined

4) Proper mounting of work piece should be done on sampotansli cutter machine.

IV. CONCLUSION

The purpose of this review is to study the DMAIC six Sigma procedure by implementing it on Gear Manufacturing and finishing processes. As we can see that in the upcoming projects there is a huge demand and a necessity for using such processes to identify problems, defects and accordingly implementing preventive measures on them.

Also from this paper the Dent Minimization which has been successfully carried out is done and has a satisfactory effect and can be a promising factor to improve future quality issues.

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