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Reduction of Gear Dent and Damage in Gear Manufacturing Industry to Improve Quality Through Kaizen

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ABSTRACT- Kaizen is considered as the main concern and prerequisite for competitiveness in today's manufacturing. One form of the continuous improvement is in the field of quality product.A case study was carried out in a gear manufacturing industry. If the problem of gear dents & damage are eliminated then most of the other problems like noise, rejection, profile problem also get decreased. For improving the gear quality, the main focus was on the minimization of dent and damage.For this, a process flow diagram is constructed from material movement to the final inspection. Then a Gemba audit is conducted on the shop floor. During Gemba audit, the various causes of gear dents & damage are identified in the shop floor. After conducted Gemba audit on the shop floor, the root cause of the dent & damage are identified by applying various QC tools like Ishikawa diagram, Brainstorming, Pareto Analysis. Then, Kaizens were applied to those root causes of dents and various new ideas was implemented on the shop floor. After the implementations of Kaizens, the results were outstanding with a decrease in**46.31%** of dent ppmin just one month.It was found that the reduction in gear dent & damage has been successfully carried out and has a satisfactory effect and be a promising factor to improve future quality issues.

KEYWORDS- Gemba audit, Ishikawa diagram, Brainstorming, Pareto Analysis, Kaizens

I. INTROUCTION

Kaizen is a Japanese word which means change for better. The word refers to any improvement, one time or continuous, large or small, in the same sense as the English word "improvement"**.** Kaizen is an approach to creating continuous improvement based on the idea that small, ongoing positive changes can reap major improvements. **In gear industry,** KAIZEN plays an important role as to achieve the desired quality as well as to reduce the rejection. In gear industry 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. Modern gearboxes are characterized by high torque, low torque, low running noise and compact design. In order to fulfill these requirements gears specifications have to be accurately controlled. The major challenges faced in the areas of quality and productivity, can be addressed by using Kaizens. By the use of various quality control tools, Statistical approaches etc we can achieve the desired targets. Accordingly, we are working on the Quality control strategy for minimizing the dent and damage problem of the gears.

Continuous improvement is the process of constantly making things better than they were before. Kaizen can be defined as the philosophy and practice of continuous improvement. It refers to the practice of looking for ways to improve work processes on a regular basis. The practice involves small, incremental changes rather that large changes. With Kaizen, all people within the organization look for possible improvement opportunities, not just managers or executives.

II. PROBLEM FORMULATION

The research problem is a case study of a gear manufacturing industry. Various gears, crown wheel pinions, shafts are manufactured in this plant. But the most common defect occurs in those gears, shafts and crown wheel pinion are of dents and damage. The manufacturing of gears take place through various machining operations. Dents may take place during any machining operation. So for

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this research, the case study of each and every operation is required. For this, Genba observation is required. After daily genba audit observations, the root cause of the dents may be easily verified and then kaizens can be implemented. The root cause of the dents and damage are the main causes of rejection and production loss.

Figure- 1 Dent & damage on a gear shaft

III. OBJECTIVE

The major objective of this research is to reduce the rejection due to dents in gears. In this, we can reduce the gear dents by applying different Kaizens. The main objective of this project is to reduce the gear dent ppm, reduce the rejection rate of gears due to gear dents and increasingthequality keeping in view reducing production cost. So, these are the main objectives of this research.

IV. METHODOLOGY

For this research, a process flow diagram from material movement, intermediate processes to final inspection is constructed. After this, Gemba audit in shop floor is performed and then the possible causes of dent and damage in shop floor are analyzed with the help of Ishikawa Diagram, Pareto Analysis and Brainstorming. After identifying the root cause of dent & damage, Kaizens are implemented for reducing the dent & damage ppm and new ideas at shop floor are implemented.

PROCESS FLOW DIAGRAM

OPERATION NO.	SYMBOLS	ACTIVITY	OUTSOURCING/ IN HOUSE	MACHINE/ WORKSTATION
1		Normalized forging	OUT- SOURCING	Mat. Lab GS- 1
2		Blank turning	OUT- SOURCING	Q C GS- 1
3		Spline hobbing	IN HOUSE	H-400 (with Bottom Clamping)
4		Gear hobbing	IN HOUSE	H-400 (with bottom clamping)
5		Tooth rounding	IN HOUSE	Romanian Rounding
6		Gear shaving	IN HOUSE	Russian Shaving

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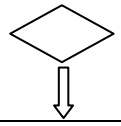
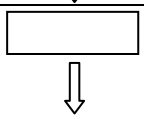
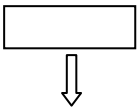
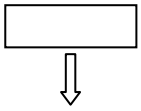
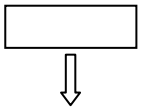
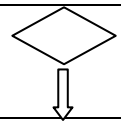
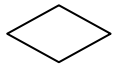
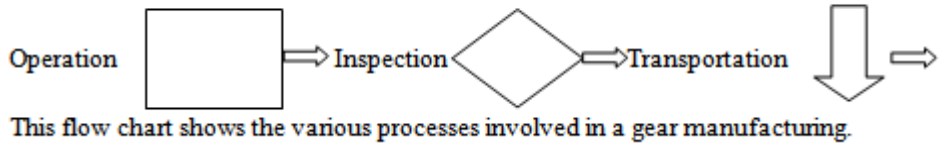
7		Soft stage inspection	IN HOUSE	Soft finish Q.C GS-1
8		Heat treatment	IN HOUSE	Gas carburising furnace
9		Shot blasting	IN HOUSE	Shot blasting Machine GS- 1
10		Straightning (in case of shafts)	IN HOUSE	Bemco press
11		OD/ID grinding (if any)	IN HOUSE	O D Grinder K130
12		Gear rolling	IN HOUSE	Rolling tester
13		Final inspection	IN HOUSE	QC GS- 1

Table 1 Process flow diagram of a gear shaft in a gear manufacturing plant



This flow chart shows the various processes involved in a gear manufacturing.

GEMBA AUDIT OBSERVATION
Gear shop observations in Soft stage

SECTION	DATE	PART/MODEL	OBSERVATION	M/C NO.	REMARK
Production	1 May 2020	Axle shaft	Overloading of parts in tray at m/c	Hurth shaving-2	Teeth contacting with each other in shaved parts
Quality	3 May 2020	FDP Shaft 1768 Z-13	Parts keeping in damaged trolley	Soft QC (Offered for passing)	Damaged trolleys Should not be used in shop
Production	7 May 2020	Sliding $3^{rd}/4^{th}$ Reliability	Wrong material handling at LC 200-1^{st}	LC – 200	Stacking of parts at base of rotating table with tools [possibilty of dent is more]

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Production	3 May 2020	Primary SC	Overloading of parts in trolley	H-400-10th	Possibility of fallen is more, dent may occur on dog teeth
Blank store	8 May 2020	Axle shaft	Old trolley design used at soft stage	----------	Possibility of part fallen is more in case of trolley movement.
Production	12 May 2020	H/L Sliding	Wrong part handling at machine	TRJ- 1	Teeth contacting with each other in shaved parts.
Production	19 May 2020	Primary DC / FDP	Parts resting not proper in racks	----------	Fallen cases may happen
Robot line	23 May 2020	3rd Reliability	Parts fallen from Robo gripper	Robo line	Dent may occur on the parts

Table 2 Genba observation in soft stage

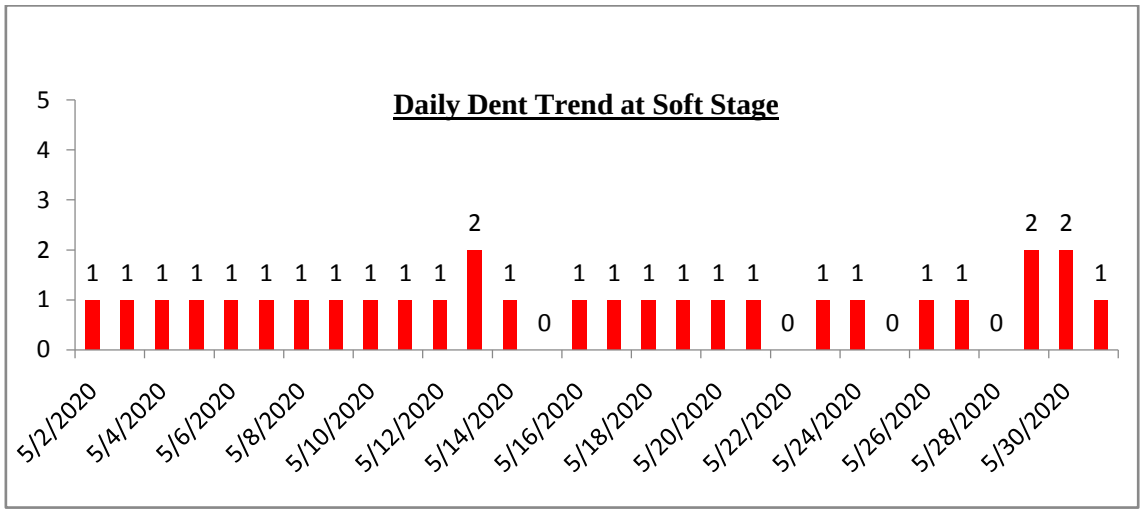

Figure 2 Graphical representation of daily dent trend at Soft Stage after Gemba audit

Gear shop observations in Hard stage

SECTION	DATE	PART/MODEL	OBSERVATION	M/C NO.	REMARK
Heat Treatment	4 May 2020	Primary DC	Wrong method of keeping parts in tray	Rack stand (H.T-1)	Only gears should be hang in rods, not suitable for shafts
Heat Treatment	13 May 2020	Axle shaft	Parts overloaded in trolley at H.T	----------	Dog teeth may damage in case of fallen
Heat Treatment	15 May 2020	Primary SC	Overloading of parts at HT area	Straightening area	Chipp off will be happen in case of fallen

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Heat Treatment	16 May 2020	FDP 1768 Z- 13	Overloading of parts in trolley after passing from QC inspection area	Quality control inspection area	Sometimes quality dept. helpers overload the trolley due to shortage of trolleys
Heat Treatment	23 May 2020	½ Sliding Gear	Old trolley design used in hard stage	----------	Possible chances of dent due to falling of parts from trolley

Table 3 Gemba observations in hard stage

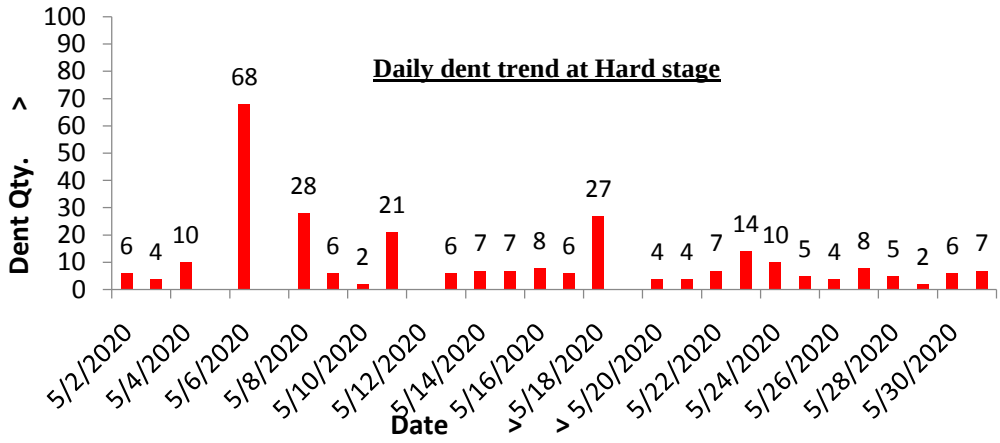

Figure 3 Graphical representation of daily dent trend at Hard stage

In Gemba audit, day to day data of the dents occurred in the shop is recorded so that we can find out the main cause of the dents in the gear shop. It is observed every day so that the monthly ppm of the gear dents can be calculated. This data is shown in two stages i.e. Soft stage and hard stage as shown in figure 1 & 2.From this, the monthly data is collected and calculated as 308 dented & damaged components. The total production of May month is 64342 components. From this data, the ppm of dented components is calculated as

$$\text{Ppm of May} = \frac{\text{Total no. of dented components}}{\text{Total production of the month}} \times 10^6 = \frac{307}{64342} \times 10^6 = 4772$$

This is the ppm of dents in the month of May 2020.

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ISHIKAWA DIAGRAM

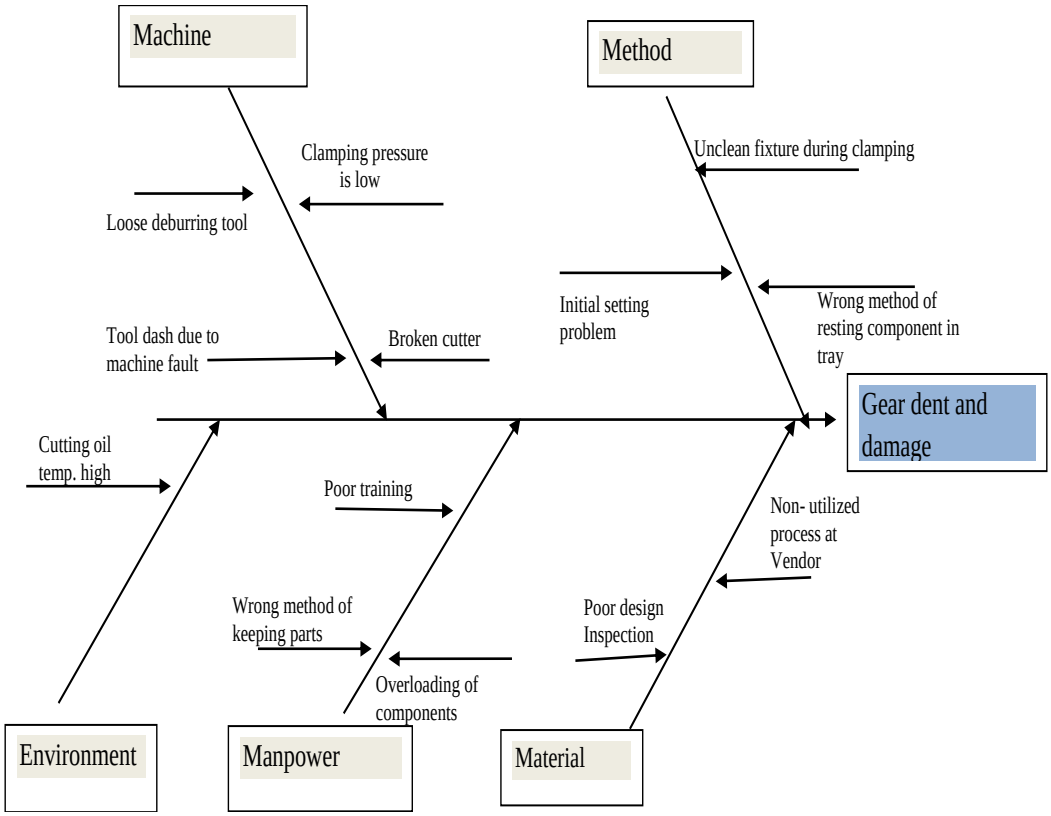

Figure4 Ishikawa diagram for dent & damage

Ishikawa diagram examines the possible causes of the gear dent & damage in a gear shop. From this diagram various causes are identified as shown above. The possible causes for gear dent & damage are Wrong method of keeping parts, Overloading of components in trolleys, poor design inspection, wrong method of resting component in tray , poor training etc. So, these are the reasons for gear dent and damage in a gear shop.

PARETO ANALYSIS- Pareto Analysis is a statistical technique in decision-making used for the selection of a limited number of tasks that produce significant overall effect. It uses the Pareto Principle [also known as the 80/20 rule] the idea that by doing 20% of the work you can generate 80% of the benefit of doing the entire job.

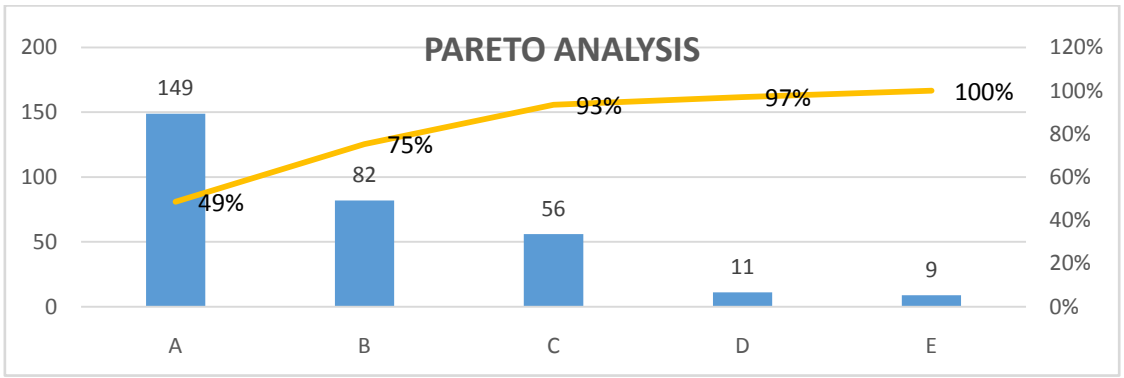

Figure 5 Pareto analysis for the dent & damage in a gear shop

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ISSUES	NAME OF ISSUE	QTY
A	Dent due to falling on floor	149
B	Dents due to overloading in trolleys	82
C	Overloading in m/c trays	56
D	Dents due to machine fault	11
E	Dents due to operator mistake	9

Table 4 Dent issues for Pareto analysis

This Pareto analysis shows that the main reason of the dent is due to the falling of the components on the floor and overloading of components in the trolleys . So, to minimize the dent ppm the organization has to work on that specific area i.e. to reduce the falling of components and overloading of trolleys. As, the dent ppm decreased the quality of the gears will increase.

IMPLEMENTATION OF KAIZENS

From the Gemba audit, Ishikawa diagram and Pareto analysis, it is clear that most of the dents occurred due to falling on the floor. So, first of all we need to reduce the dents & damage by minimizing the falling rate of the component on the floor. In Gemba audit, it is clearly shown that most of the dents are of shafts like Primary shafts, Axle shafts, Final drive pinion shafts. So, the first focus is on the shaft line for reducing the dent rate on the shaft gears. Various Kaizens are given to reduce the gear dent & damage in gear shop.

1. A tray should be fixed to the machine so that the operator can get extra space for placing the component after the trolley gets fully loaded. Before new trolley is given to the operator, the operator can place the components on the machine tray. This Kaizen helped in reducing the dent rate on the gears.
2. In soft stage, most of the trolleys were of old design. In these trolleys, the possibility of part fallen is more in case of trolley movement. So, a Kaizen is given for repairing and replacing these old trolleys with the new trolleys.
3. In old design trolley, the component may not rest properly so new design is introduced through Kaizen. In new trolleys, the component rests properly and therefore chances of falling of component during trolley movement was reduced.
4. A Kaizen was given that training should be given every month to the operator and the helper to eliminate the problem of improper material handling.
5. Nylon bushes are employed in the trolleys so that the component may not strike with each other.
6. A Kaizen was given that the quality inspection table area should be covered with proper rubber sheet to eliminate the dent and damage due to falling of components while inspection.

So, those are the Kaizens that are implemented to reduce the gear dent & damage in a gear manufacturing industry.

V. RESULTS

In the month of July 2020, it is observed that there are only174 dented components. The total production of that month is 67914 components. From this data, the ppm of dented components is calculated as

Now ppm of gear dents

$$= \frac{\text{Total dented components}}{\text{Total production}} \times 10^6$$

$$= \frac{\mathbf{174}}{\mathbf{67914}} \times \mathbf{10^6}$$

$$= \mathbf{2562}$$

So, **2562** is the ppm of dented components in the month of July.

By comparing the ppm of May and Julymonth ,it was found that the dented ppm of July month was very low as compared to the month of May. In the month of July, Kaizens were implemented which decreased around **46.31%** of ppm from the month of May.

VI. CONCLUSION

Dent problem is the most common problem that occurred during the manufacturing of the gears and gear shafts. There is a huge competition in the market and now everyone is more concerned about the quality rather thenquantiy. For improving the quality of the gears, the dents should be eliminated. The main objective of this research is to improve the gear quality by reducing the gear dents. The main reasons responsible for the gear dents and damaged are discussed and analysed. It was found that most of the dent are due to falling of component on the

shop floor. Various 7 QC tools are implemented to find out the root cause of the dent & damage problem. Kaizens are implemented to decrease the dent ppm and increase the overall quality of gears.

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