Problem Solving Approach in Manufacturing Process Using Quality Tools

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Abstract

Assembly shop is almost the last shop in the manufacturing industry. When problem occurs in this stage will lead to waste (time, money, manpower, delay production, etc.). Gear fitment problem on the layshaft during assembly of the engine is one of the major problem. Through this paper one can able to reduce this kind of problem by knowing the root causes with the help of quality tools like Flow Chart, Cause-Effect Diagram, Hypothesis and why-why analysis.

Keywords: *Flow Chart, CAD Model, Cause-Effect Diagram, Hypothesis Testing, why-why analysis.*

1. Introduction

On the assembly station, in about 10% cases, the gears and the Layshaft do not conform to each other specification which leads to the material wastage due to rejection[1,2]. Therefore, causes intermittence and inconvenience in production. The lay shaft- gear sub-assembly includes the following [3]:

1) A Lay shaft(Φ(60.73-60.795), 17 splines)
2) Four gears with internal 17 splines(bore Φ(54.41,54.48))
   a) Helical common mesh(C.M.) gear (z=43)
   b) Gear 1(z=24)
   c) Gear 2(z=28)
   d) Gear 3(z=35)

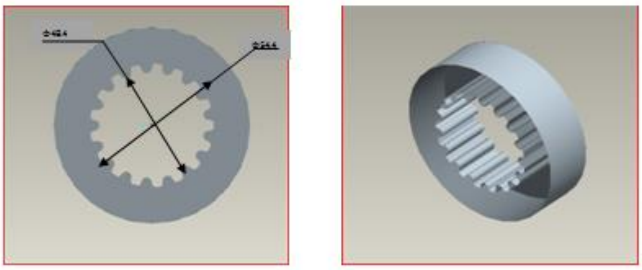
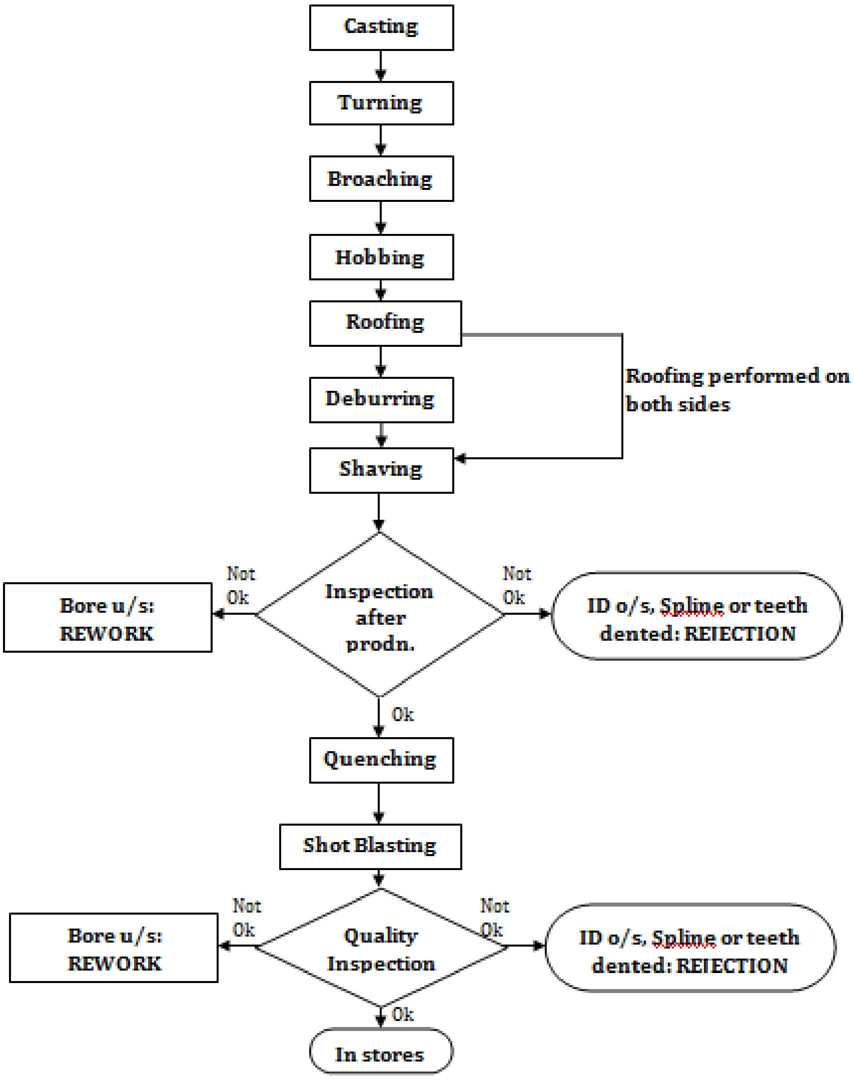


Figure 1. CAD model of section of Gear hub (Z=17)

2. Process Flow Chart for Gears

According to the provision in the plant, besides the two inspection stages every operator is liable to 'Self Inspect' every workpiece he prepares[4,5]. The following process flow chart represents the various processes involved during the manufacturing of gear[6].



3. Chart depicting the percentage rejections of Gears in a month

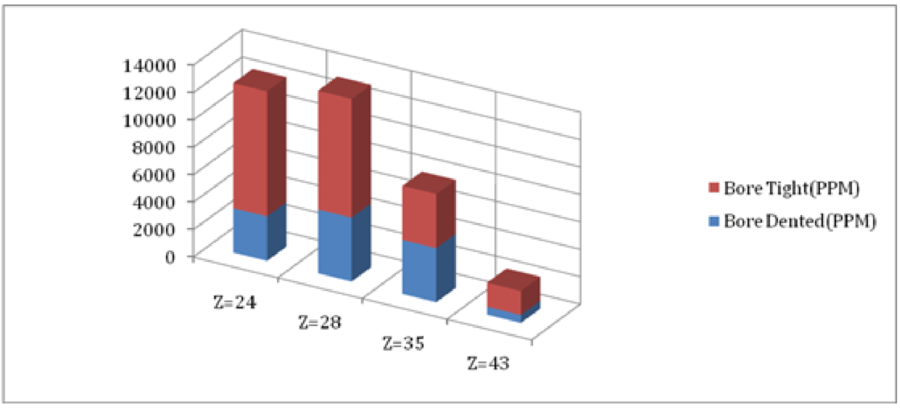


Figure 2. Percentage Rejections

4. Measurement Tools used

Measurement is required to be done after every process so as to meet the required specification of workpiece[7]. The following types of measuring tools are used to measure the specification of gears.

4.1. Dagger Master

A replica of the required portion of the Layshaft with dimensions as the lower permissible limit of the gear hub i.e. major bore diameter = 54.48mm with 17 splines.

4.2. Dial Gauge Indicator

To check the hub for ovality and taper a standard indicator with zero fixed at 54.48mm.

5. Cause –Effect Diagram

The cause-effect diagram is basically used to find out the root causes of problem. It is also known as fish-bone diagram because of its fish-bone like structure[8]. The following figure shows the cause-effect diagram of line fitment problem on layshaft.

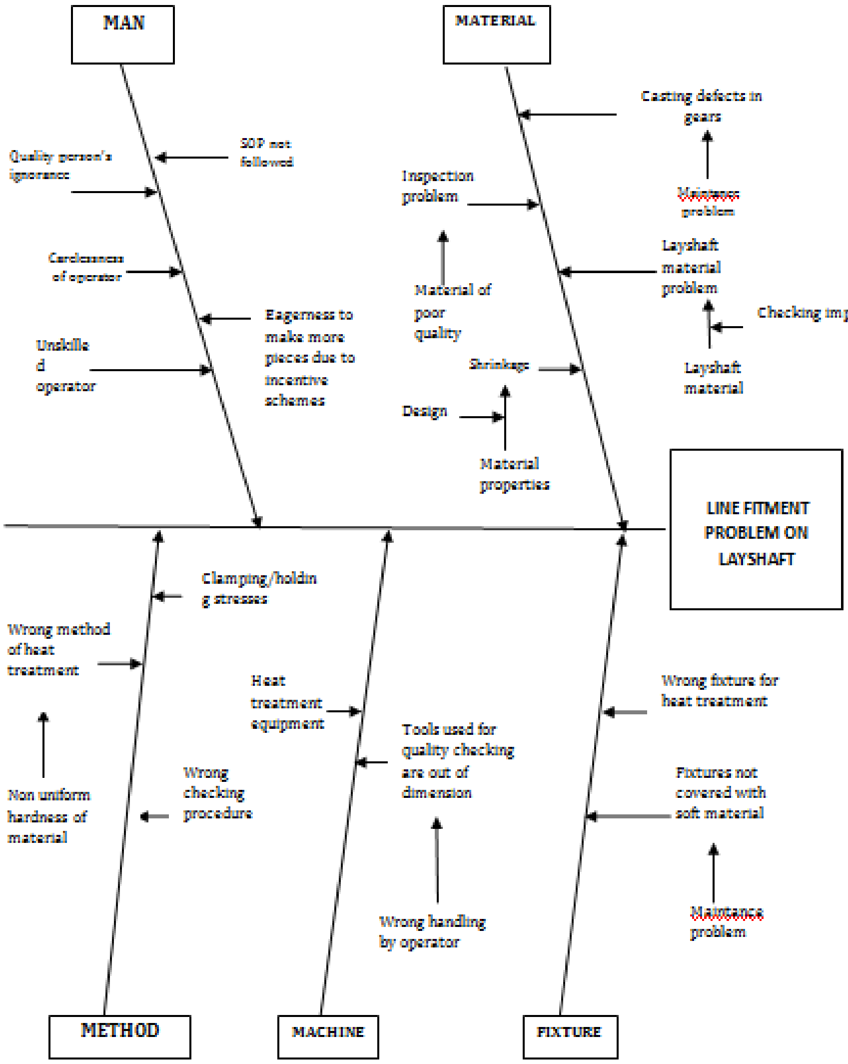


Figure 2. Cause-Effect Diagram

6. Hypothesis Testing

In hypothesis testing, a list of probable causes is made. After making the list of probable cause, it is decided to select the correct testing method for the probable cause. With the help of testing method it should be decided that the probable cause is valid or invalid[9]. The following table shows the hypothesis testing of probable causes of gear fitment problem on layshaft.

Table 1. Hypothesis Testing

Sr. No.	Probable causes	Testing method	Hypothesis
1.	**Poor Maintance of fixtures** Most of fixtures carrying the soft gears were not covered with any soft material.	On visual inspection, the coating of soft material was found worn out or found absent from the fixtures.	Valid
2.	**Distortion during heat treatment due to-** **a) Varied cooling rates at different sections**	In gears, shrinkage takes place due to the non uniform cooling of the thin and thick sections of the gears. The checking before and after the Heat Treatment process confirmed this cause.	Invalid
	b) Material properties	The Gears were found to be made of Low Carbon Steel(0.2%) due to which differential stresses arise on quenching leading to distortions.	Invalid
3.	**Faulty working method implemented for using inspection tools** causes gears to pass on to assembly which should have been rejected	Occasionally untrained operator was found testing the Gears for dimensional errors whose method of using the inspection tool (Dagger Master) was found faulty.	Valid
4.	**Uncalibrated inspection tools** namely Dagger Master not checked regularly with standards	Visual inspection revealed poor maintenance of inspection tools. Inspection tools such as Dagger Master were found to be Uncalibrated for long time.	Valid
5.	**Careless parts handling**	The soft workpieces while being transported between workstations were found to be handled carelessly while loading and unloading from the fixtures.	Valid
	Gear mixing during Heat treatment	The gears of one type were found to be mixed in the lot	Invalid

6.		of some other gears while being taken to the SQF. But due to long soaking period of furnace the size difference between the mixed gears was not found appreciable to have any impact on their hardness.	
7.	**Overloading of Furnaces** Furnaces charged beyond the prescribed load.	On the basis of information taken from heat treatment person sometimes furnace is overloaded with charge which causes non uniform hardness of the pieces.	Invalid
8.	**Distortion during Post Broaching processes** namely during Hobbing	An inspection of 50 CM gears (z-43) revealed some distortion in the splines while the gear underwent hobbing operation.	Valid

7. Root Causes

From the hypothesis testing, the following are the main root cause need to be analyzed:

- Poor Maintenance of fixtures
- Faulty working method for using inspection tools followed.
- Uncalibrated inspection tools used.
- Careless parts handling.
- Distortion in post Broaching processes.

8. Why-Why Analysis

In this analysis, a number of times ask the question (why?) till the solution of the problem not find[10]. The following table shows the why-why analysis of the root causes that were find during the hypothesis testing.

Table 2. Why-Why Analysis

Sr. no.	Root Cause	Why?	Why?	Why?	Why?
1.	**Poor Maintance of fixtures.**	No regular maintenance checking of the fixtures done.	No standard Procedure followed for maintenance.		
2.	**Faulty working method implemented for using inspection tools**	No standard method being followed	No SOP	Lack of knowledge	
3.	**Uncalibrated inspection tools**	not matched regularly	No standard available		

		with standards	for calibration		
4.	**Careless loading and unloading of fixtures**	Worker trying to work fast	Tendency to finish job early	Tendency to increase free time	Ineffective supervision
5.	**Distortion in post broaching machining processes**	High work holding stresses in Hobbing causing distortion in spline teeth	The work holding done on a circular shaft without splines		

9. Remedies for Root Cause

The following table shows the suggested remedies for the root cause.

Table 3. Remedies for Root Cause

Sr. no.	Root Cause	Suggested Remedy
1.	Poor Maintenance of fixtures	Coating of **All** the fixtures with soft material such as **Polyurethane** and Scheduled and timely checking of the fixtures for maintaining soft coating intact to ensure safety of the gear hub from dents.
2.	Faulty working method implemented for using inspection tools	Proper training regarding the method and importance of correct use of the quality inspection tools should be provided and SOP should be provided at the station where checking is carried out.
3.	Uncalibrated inspection tools	The Inspection tools such as the Dagger Master should be revised and calibrated against some standard in order to maintain their correct working.
4.	Careless loading and unloading of fixtures	Proper supervision by the appropriate quality inspector should be carried out at the time of loading and unloading of the workpieces from their fixtures.
5.	Clamping/Holding stresses	While working on a process like hobbing, the tool holding must be facilitated on a splined shaft to reduce the deformations caused in the spline teeth due to holding stresses generated during operation.

10. Conclusion

Any dimension on pattern cannot be ignored. Timely maintenance of equipment is required. Standard quality tool is required to avoid large variation and also process adherence is must. Any allowance taken can never turn the chances of distortions due to Heat Treatment to zero because of the transient nature of the process itself but choice of an appropriate material and work design can increase the efficiency of the process manifold. Quality circle story is the right way to analyze and resolve the problem.

11. References

[1] Narayan and K. Lalit, Author Computer Aided Design and Manufacturing, “Prentice Hall India Learning Private Limited". New Delhi, India. (2008).

[2] David A. Madsen and David P. Madsen, Author of Engineering Drawing & Design, “ADDA a Legacy of Excellence Approved Publication”, Clifton Park, NY (2012).

[3] D.B. Potter, Chairman, “American Society of Mechanical Engineers (ASME) standard”, Operation and Flow Process charts. New York, (1947).

[4] Ishikawa Kaoru, Author of Guide to Quality Control, “Asian Productivity Organization”, Japan (1976).

[5] Theodore Schick and Lewis Vaughn, Author of *How to think about weird things: critical thinking for a New Age*, “McGraw-Hill Higher Education”, Boston (2002).

[6] Ivan Fantin, Author of Applied Problem Solving, Applications, Root Causes, Countermeasures, Poka-Yoke and A3. How to make things happen to solve problems. Milan, “APS ”, Italy(2014).

[7] Gregory Vlastos and Myles Burnyeat, Author of *Socratic studies*, “Cambridge University Press”, Cambridge (1994).

[8] S.K. Khatkar, N.M. Suri, S. Kant and Pankaj, “A review on mechanical and tribological properties of graphite reinforced self lubricating hybrid metal matrix composites”, Vol. 56(2018), pp. 1-20.

[9] S.K. Khatkar, R. Verma, S. Kant, N.M. Suri, “ Optimization of Wear Behavior of AZ91D-SiC-Gr Hybrid Composites Using Taguchi Experimental Design. In: Pant M., Sharma T., Verma O., Singla R., Sikander A. (eds) Soft Computing: Theories and Applications. Advances in Intelligent Systems and Computing, vol 1053. Springer, Singapore.

[10] Taiichi Ohno and Norman Bodek, Author of *Toyota production system: beyond large-scale production*, “Productivity Press”, Portland(1988).