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Optimization and Analysisfor Reduction in Process Rejection of Sway Bar

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ABSTRACT

This paper has been considered as a systematic and collective optimal approach to reduce threading rejection during manufacturing of Sway Bar. This paper covers the manufacturing process of Sway Barand data analysis done by root cause method.We have collected allthe data from M/s NHK Springs India Ltd, manufacturer of Sway Bar, and M/s Gayatri Auto Industries, Gwalior and analyzed it with the help of Juran Quality Tools to reduce rejection.

Keywords: Juran Quality Tools, Manufacturing Process,Optimal Approach, Root Cause Method Threading Rejection.

I INTRODUCTION

An anti-roll bar (roll bar, anti-sway bar, sway bar, stabilizer bar) is a part of many automobile suspensions that helps reduce the body roll of a vehicle during fast cornering or over road irregularities. It connects opposite (left/right) wheels together through short lever arms linked by a torsion spring [Fig.1,2]. A sway bar increases the suspension's roll stiffness—its resistance to roll in turns, independent of its spring rate in the vertical direction [1].When both the wheels deflect up or down by the same amount, the stabilizer bar simply turns in the bearings. When only one wheel deflects, then only one end of the stabilizer moves, thus twisting the stabilizer bar that acts as a spring between the two sides of the independent suspension. In this way, the stabilizer reduces the heeling or tipping of the vehicle on curves [Fig. 3].

This paper presents systematic and collective approach to reduce the process rejection due to incorrect threading of Stabilizer Bar. We have done the work at M/s NHK Springs India Ltd, Malanpur (Manufacturer of Stabilizer Bar) and M/s Gayatri Auto Industries, Gwalior (Vendor of M/s NHK).M/s NHK Springs India Ltd manufactures stabilizer bar for the Maruti 800 CC, Zen, ALTO, Esteem, Versa, Honda City, Santro, Toyota Qualis, Mahindra Bolero, Scorpio Marshal, Armada.

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II METHODOLOGY

We have analyzed the rejection at each and every stage of manufacturing process of Stabilizer bar with the Juran Quality Tools. After analyzing the data with the help of Pareto analysis, we have found that the major rejection is due to incorrect threading. The root cause analysis has been done with the help of Cause and Effect Diagram to find the root cause.

III MANUFACTURING PROCESS

According to fastening methods, Stabilizer bar is classified in two types.

- Both ends are threaded and fastened with the help of nuts.
- Both ends are forged and fastened with the help of bolts & nuts.

The manufacturing method of sway bar whose both ends are threaded is shown in Table 1.

IV INSPECTION

According to Kimball, *"Inspection is the art of comparing materials, products or performance, with established standards" [20].* Whenever products are manufactured, some will be in the limits of errors and some will be outside the allowances provided.

4.1. Objects of Inspection

- To collect the information regarding the performance of the product with established standards for the use of engineering, production purchasing, and quality control etc.
- To sort out poor quality manufactured products and thus to maintain the standard.
- To establish and increase the reputation by protecting customers from receiving poor quality products.

4.2. Inspection Standards

- Inspection Standards for raw materials.
- Inspection Standards for work in process.
- Working inspection standards.
- Inspection Standards for finished products.

4.2.1. Inspection Standards for Raw Materials

The inspection standards for raw materials are based upon purchase specification. Raw materials which are used by this company are:

Spring Steel i.e. Sup 9A, EN 45AWasher

This company has own inspection standards to inspect raw material.

4.2.2. Inspection Standards for work in process

Inspection standards for work in process may be classified in five heads:

- Relating to physical condition or properties of materials.
- Relating to size & shape.
- Relating to degree of finish.
- Chemical Functional or performance.

4.2.3. Working inspection standards

The work is simply inspected by the use of "GO" & "NO-GO". The following dimensions have been inspected by this method.

- Length of bar
- Turning Dimensions
- Drilling Dimensions
- Bending Dimensions

4.2.4. Inspection Standards for finished products

Every dimensions of each piece have been inspected at this concern according to given standard.

4.3. Methods of Inspection

- Screening or 100 % Inspection
- Lot by Lot Inspection
- Process Inspection

4.3.1. Screening or 100 % Inspection

In this method, each & every unit manufactured is inspected to meet the desired specifications.Final inspection of Stabilizer bar is being done by this method.

4.3.2. Lot by Lot Inspection

This method is also known as sampling inspection. This method was developed to eliminate the high cost of Screening Inspection.This method of Inspection is being used at each process at the end of a shift.

4.3.3. Process Inspection

The purpose of this method of inspection is to search out defective products where and when they occur, so that an immediate corrective action can be taken.This method of Inspection is being used on each process of a sway bar (stabilizer bar).

V PROCESS WISE REJECTION OF SWAY BAR

Process wise rejections of sway bar are shown in Table no. 2 & 3.

VI DATA ANALYSIS

6.1. Pareto Analysis

By analyzing the data, we found that the major rejection of the stabilizer bar in March 2005 is due to incorrect threading. Thus, I have worked on this area (Table 4).

There are following problems in threading.

- Threads Undersize
- Threads Oversize
- Gap More
- Taper Threads
- Damaged Thread

Various analyses have been done to reduce to reduce the rejection due to incorrect threading (Fig. 4).

6.2. Cause and Effect/ Ishikawa Diagram

A cause and effect diagram is a tool that shows systematic relationship between a result or a symptom or an effect and its possible causes. This tool was devised by Dr. K. Ishikawa and is also known as Ishikawa diagram (Fig.5 & Fig.6).

The factors that influence threading are:

- Man i.e. Operator
- Machine i.e Thread Rolling Machine
- Material i.e. Finish Turned Bar
- Tools & Instruments i.e. Circular Dies, Measuring tools (Ring Gauges, Pitch Micrometer, External MicrometerEnvironmentDrawings).

There are apparent and root causes for any defects. Apparent causes represent the immediate or obvious reasons for a problem. Of course, the apparent cause may turn out to be the root cause, but until this is confirmed by analysis, this assumption should not be made.

The apparent causes for incorrect threading may be:

- Variation in hydraulic pressure
- Incorrect Thread Rolls
- Damaged Thread Rolls
- Too much Gap in Slides
- The indirect factors that indirectly affect the threading are:

- Variation in finish turning size
- Ovality on turning size
- Surface Finish of turning

The indirect factors that affect the final turning are:

- Eccentric Rough Turning
- Variation in Rough turning diameter

6.2.1. Reasons for Rejection

By detailed analysis, we have reached on conclusion that the problem in threading may be due to (Table 5 & 6):

- Out of Roundness
- Variation in Surface Finish

6.2.2. Reasons for Out of Roundness on finish Turning

Eccentric Rough Turning

Fine turning of Φ16 mm &Φ 11.16 mm has been done simultaneously on CNC Turning Machine. The process chart is shown in figure. If Φ17 mm &Φ 12.2 mm are not concentric w.r.t. Φ 20mm, it will produce out of Roundness due to variation in depth of cut in each revolution.

At present, there is no control on eccentricity during rough turning operation. They perform rough turning outside the factory by various vendors.

6.2.3. Reasons of variation on surface Roughness of finish Turning

6.2.3.1. Variation in Depth of Cut

Variation in depth of cut affects the surface finish of the job. If depth of cut increases, surface finish will be decreases and vice – versa. So that if maintain the rough turning diameter in close tolerances, we can also maintain surface finish in close tolerance.

6.2.3.2. Incorrect Cutting Tool

Cutting tool Material also affects the surface finish of turning. The cutting tool materials that are suitable for turning alloy steels are:

High Speed Steel (HSS)

Tungsten carbide Inserts

Ceramics

VII MODIFICATIONS TO REDUCE REJECTION

The following suggestions may be/ have been implemented to reduce rejection due to threading:

7.1. Correction in drawing

Following corrections in drawing have been done.

- Surface finish has been specified
- Concentricity has been mentioned

7.2. Design of Gauge to Check Eccentricity

There must be a gauge to check eccentricity of rough turning w. r. t. outside diameter. Now we have reached on conclusion that if control the dimension during rough turning, we have/can reduced/reduce too much rejection. This unit have got done rough turning outside the factory.

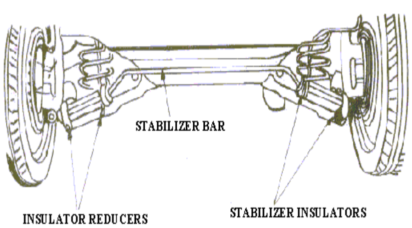
7.3. Modification to Reduce Eccentricity during Rough Turning

To reduce the eccentricity between diameter 20 and 12.2mm, we have done following modification:19.7 mm diameter collet is purchased instead of ϕ20 mm and after installation; this collet is bored to 20mm diameter. So that the collet axis coincide with spindle axis. Therefore no chance of eccentricity due to any misalignment of spindle.

VIII RESULT

Various analyses have been done to reduce the out of roundness as well as variation in surface roughness by controlling the machining parameters as well as by adopting new method of inspection. The rejection rate after modification is mentioned in (Table 7).

IX LIST OF FIGURES /TABLES



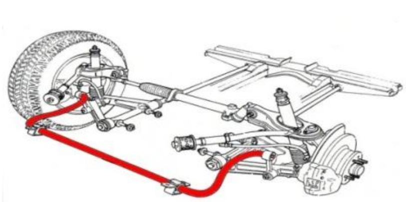
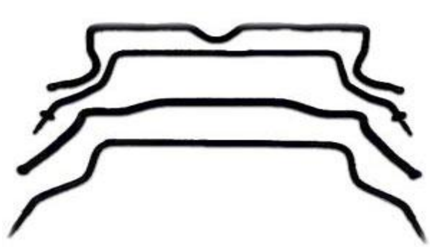


Fig.1: Front Suspension of Automobile **Fig.2: Front Suspension of light vehicle**



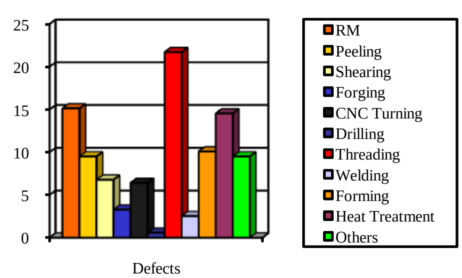


Fig.3: Stabilizer Bar **Fig 4: Process wise Rejection Rate**

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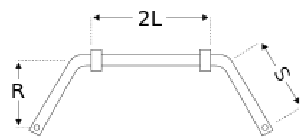

$$Q = \frac{10^4 \times T^2 \times K^2 \times d^4}{R^2 \times L}$$

Fig.5: One way of estimating antiroll bar stiffness

T=Vehicle track width (inches)
K=Fractional lever arm ration (movement at roll bar / movement at wheel)
d=Bar diameter (inches)
R=Effective arm length (inches)
L=Half length of bar (inches)
S=Length of lever arm (inches)
Q=Stiffness (lb*in per degree)

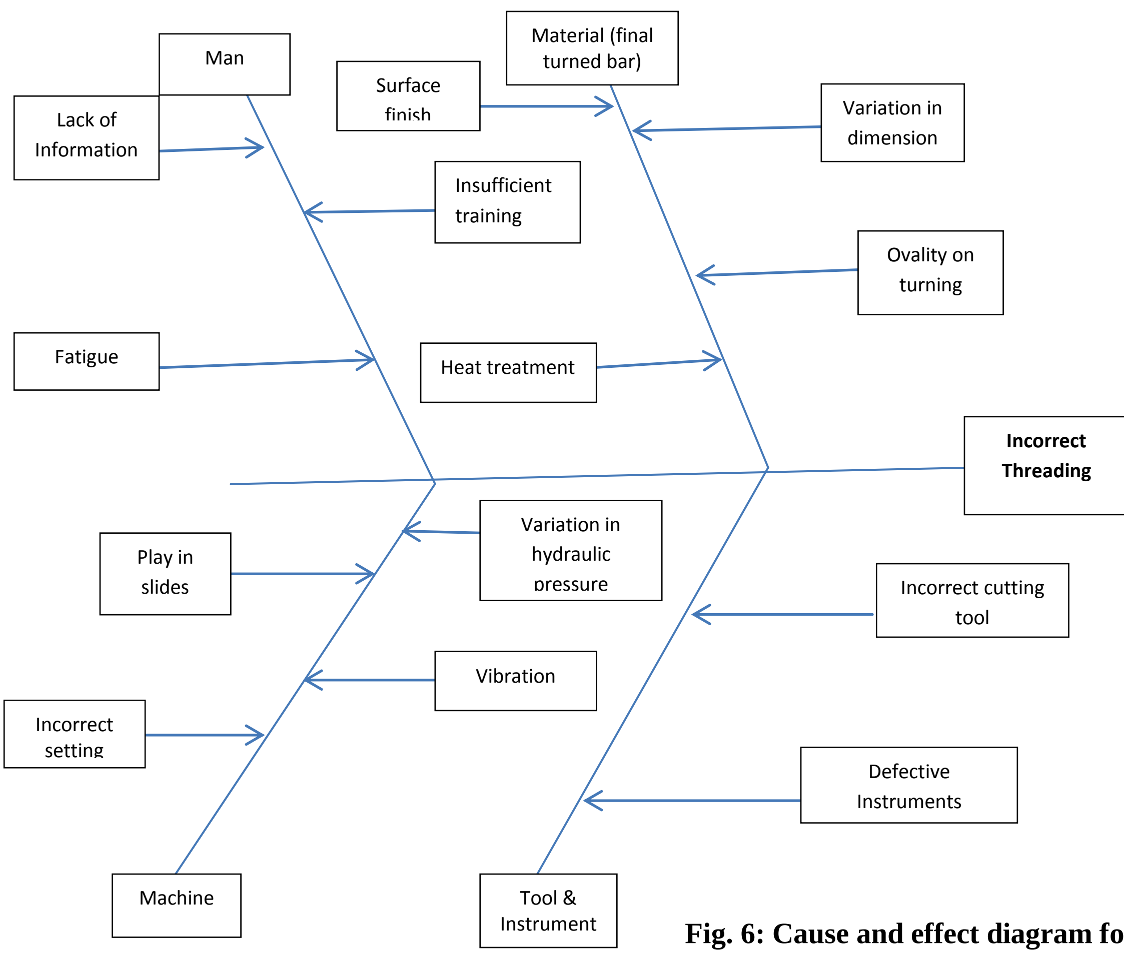

Fig. 6: Cause and effect diagram for defected threads

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Operation Process Chart	
Sequence of Operation	**Name of Operation**
01	Shearing at Desired Length
02	Both Ends are Annealed
03	Rough Turning (Out Side Factory)
04	Fine Turning
05	Drilling & Chamfering for Split Pin
06	Threading from Circular Rolling Dies
07	Welding of Washer on Both Ends
08	Heat Treatment of Bar
09	Hot Bending as per Drawing
10	Correction in Bending
11	Shot Blasting
12	Phosphate
13	Powder Coating
14	Cleaning of Threads
15	Final Inspection
16	Packaging

Table 1: Manufacturing Process of Stabilizer Bar

Name of Process	**Reasons of Rejection**
Shearing	• Length Short
Annealing	• Not Proper
Turning	• Undersize • Oversize • Chamfer not correct • Deep Mark • Geometry not circular • Step at ends
Drilling and Chamfering	• Hole undersize • Hole Oversize • Hole Offset
Thread Rolling	• Threading Undersize • Threading Oversize • Gap More • Thread Taper • Damage Thread
MIG Welding	• Bar Damage • Washer Damage • Poor
Heat Treatment	• Over Heating • Incomplete Forming • Quenching Delay • Eye Twist

Table 2: Process wise Reasons of Rejection

Table 3: Process Wise Rejection Rate

S.N.	Name of Process	Rejection in Percentage	
		March	April
01	Shearing	0.050	0.06
02	Turning	0.050	0.080
03	Drilling and Chamfering	0.005	0.014
04	Thread Rolling	0.187	0.220
05	MIG Welding	0.020	0.056

Table 4: % Rejection Out of Total Defect

Defect	Rejection in March 2016		
	No of Rejected Parts	% Out of Total Defects	Cumulative %
Raw –Material	78	15.12	15.12
Peeling	49	09.50	24.62
Shearing	35	06.78	31.40
Forging	17	03.29	34.69
CNC Turning	33	06.40	41.09
Drilling	03	00.58	41.67
Threading	112	21.70	63.37
Welding	13	02.52	65.89
Income. Forming	52	10.08	75.97
Heat Treatment	75	14.53	90.50
Others	49	09.50	100.00
Total	516	100	

Table 5: Effect of Out of Roundness on PCD

Ovality	Finish Dia.	Pitch circle diameter in mm			
40 μ	11.16	11.06 ~ 11.08	11.07 ~ 11.09	11.07 ~ 11.09	11.07 ~ 11.09
30 μ	11.16	11.08 ~ 11.10	11.08 ~ 11.10	11.09 ~ 11.11	11.08 ~ 11.10
20 μ	11.16	11.10 ~ 11.11	11.10 ~ 11.11	11.11 ~ 11.12	11.10 ~ 11.11
10 μ	11.16	11.13 ~ 11.14	11.13 ~ 11.14	11.13 ~ 11.14	11.14 ~ 11.15

Table 6: Effect of Surface Roughness on PCD

Surface Roughness	Finish Dia.	Pitch circle diameter in mm			
5 μRa	11.16	11.07 ~ 11.08	11.08 ~ 11.09	11.08 ~ 11.09	11.08 ~ 11.09
4 μRa	11.16	11.09 ~ 11.10	11.09 ~ 11.10	11.09 ~ 11.10	11.08 ~ 11.09
3 μRa	11.16	11.12 ~ 11.13	11.12 ~ 11.13	11.12 ~ 11.13	11.12 ~ 11.13
2 μRa	11.16	11.15 ~ 11.16	11.14 ~ 11.15	11.15 ~ 11.16	11.14 ~ 11.15

Table 7: Rejection Rate after Modification

S.N	Name of Process	Rejection in Percentage				
		Marc.	April	May	June	July
1	Shearing	0.050	0.06	0.13	0.060	0.040
2	Turning	0.050	0.080	0.070	0.047	0.08
3	Drilling and Chamfg.	0.005	0.014	0.018	0.003	Nil
4	Thread Rolling	0.187	0.220	0.100	0.070	0.060
5	MIG Welding	0.020	0.056	0.023	0.050	0.004

X CONCLUSION

As we know, nowadays competition is very high & also increasing day by day. Thus to survive in the market the quality of the product must be high standard with minimum cost.

In present work an effort has been done to reduce rejection rate because ultimately rejection plays an important role to decide cost & quality. We have found the total rejection rate is too much i.e. 1.26% in April or in terms of money Rs.3 lacs/ month, at M/s NHK Springs India Ltd. The major rejection i.e. 21.7 % of total rejection is due to incorrect threading. We have reduced this rejection up to 8.8 % of total rejection and total rejection up to 0.69% by controlling the parameters of rough turning.

The rejection may also be reduced at minimum level by implementing the suggestion mentioned in this paper because still rejection is at very higher side i.e. 0.69%. There are so many operations such as heat treatment, powder coating etc in which improvements can be done.

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