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Analysis of Hard Chrome Plating Process to Reduce Rejections using PDCA Cycle

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Abstract - *This paper concentrates on Hard Chrome Plating process of piston rod and the defects arising. This defects lead to rejections of piston rods. Being an expensive process, rejections up to 11% are unacceptable. This leads to rise in production time and reduction in overall equipment effectiveness which leads to delay in achieving target. This leads to bigger consequences like gap between customer supplier bonds. We used proper systematic approach namely PDCA cycle to analyze the process and find the gaps in process. We used certain quality control tools and six sigma tools to analyze these flaws. After implementation of results obtained from analysis, we got reduction in rejection quantity by 50%. This resulted in increase in production, cost saving and most importantly increase in product quality.*

Key Words: **Quality control tools, CT matrix, Pareto Chart, XY Matrix, Hard Chrome Plating**

1. INTRODUCTION

In today's world everyone wants product with high quality. But when production is considered, there are always some flaws and gaps which lead to decrease in quality of product and efficiency of process. These flaws can be tackled by use of proper and systematic approach. In this paper we are going to use PDCA cycle to analyze and reduce the process related problems.

In a piston rod manufacturing industry, hard chrome plating is carried out on piston rods to increase their corrosive resistance property and increase their life. But due to some unknown flaws and problems in process, approximately 10 to 11% rods are facing rejections. To analyze and find the root cause of the problem we have to take help of some quality control tools and six sigma tools.

2. THEORY

Chrome plating is also known as chrome. It is a process of electroplating a thin layer of chromium on a metal body. The chrome plating is carried out for decorative purpose for example car fronts. It also acts as corrosion resistance, ease cleaning procedures. Sometime it is also used to increase surface hardness.

There are mainly two types of chrome plating, decorative and hard. In this paper we will be focusing on hard chrome plating (also known as industrial plating) on piston rods of dampers and the defects arising on rods during process.

2.1 Types:

(i) Decorative:

Decorative chrome is used for aesthetical purpose. The chrome layer thickness varies from 0.05 to 0.5 μm, however to be more precise they are generally between 0.13 and 0.25 μm. Typically base materials used includes steel, copper alloys, aluminium, plastic and zinc alloys. Decorative chrome plating is also corrosion resistant and is generally applied on kitchen utensils car parts, and tools.

(ii) Hard:

Hard chrome is also called as industrial chrome or engineered chrome. It is hard enough, having hardness between 65 and 69 HRC. Hard chrome is thicker than decorative chrome, with standard thicknesses in general applications varying between 20 to 40 μm, but it can be thicker in case of applications requiring extreme wear resistance (about 100 μm or thicker). But due to higher thickness of chrome some extra chrome has to be removed using super finishing processes like buffing, grinding or lapping. Increase in thickness of plating results in surface defects.

3. GENERAL PROCEDURE OF HARD CHROME PLATING:

(i) Loading Station:

Generally jigs with slots are provided to carry piston rods. These piston rods are threaded at one side and jig has slots with internal threading. Hence the rods have threaded joint with jig.

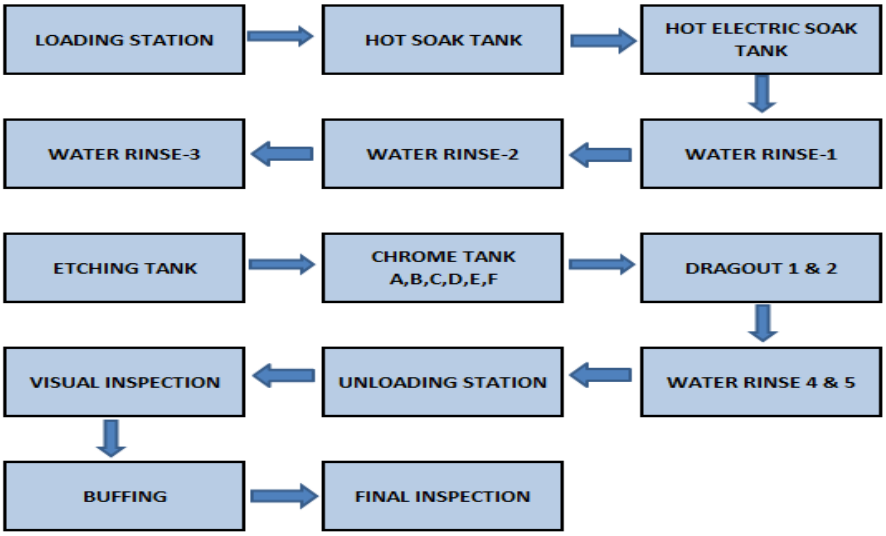

Fig-1: General process of Hard Chrome Plating

(ii) Hot Soak Tank:

Jigs are dipped in hot soak tank in order to remove rust and oil from surface. Generally temperature maintained is 65-80 degree Celsius. Dipping time varies from 4-6 minutes.

(iii) Hot Electric Soak Tank:

Purpose and characteristics of this tank is same as above tank. Just current of 30-40 Ampere is supplied to tank.

(iv) Water Rinse Tanks:

These tanks contain RO water. Purpose of this tank is to remove alkali from surface due to dipping of rods in previous tank. There are three water rinse tanks having pH from 7-12.

(v) Etching Tanks:

This tank has chrome salt with concentration of 130-175 gm/lit. Rods are dipped for generally 1-1.5 minutes. Current varies from 1-1.2 Ampere.

(vi) Hard Chrome Plating Tanks:

Main plating operation is done in this tank. Temperature is generally between 50-61 degree Celsius. Chromic acid concentration varies from 225-275 gm/lit and sulphate content from 2.25-2.75 gm/lit. Time and current varies according to size of piston rod.

(vii) Drag out 1 & 2:

Purpose of this tank is to remove excess chemical from the component.

(viii) Chrome Water Rinse 4 & 5:

These tanks consist of RO water. It is used to remove final traces of chemical from the rod.

(ix) Unloading:

Unload the rods and inspect the rods visually. Inspect for defects like scratches, dents etc.

(x) Super finishing:

Buffing is used to remove small amount of material from rod. Also gives high finish hence lower the roughness.

(xi) Final inspection:

Final inspection is done by passing the rods through air gauge and visual inspection. Also plating thickness is checked by Dry Film Thickness (DFT) meter.

4. METHEDOLOGY:

We will be following Plan-Do-Check-Act Cycle (PDCA) which is a model used for continuous improvement. Demings cycle is also used to increase effectiveness and efficiency of processes. In this paper we will be using PDCA model to improve efficiency of Hard Chrome Plating Process by analyzing the defects or reasons for reworks and eliminating this defects.

(i) PLAN: Define problem and find root cause

(ii) DO: Do analysis on defect and find remedies

(iii) CHECK: Implement the remedies & compare results.

(iv) ACT: Standardize the process.

5. PLAN PHASE:

This phase is initial phase of Plan-Do-Check-Act. In this we will define our problem and identify the root causes and plan for improvements in process. In this phase we have to analyze the current situation. To analyze the process certain sample length was decided i.e. 100000 piston rods for July month. Following data shows rejection data for given month. As we can see about 10.79% rods were rejected due to certain defects.

Table 1: Details of rejection of rods in July 2019

Details	July 2019
Rods Produced	100000
Line Rejection	10796
Rejection %	10.79%
Rejection PPM	107960

These rejections are due to some of the defects in rods. Following data shows types of defects and their respective counts:

Table 2: Defects with occurrence count

Defects	Count	Cumulative count	Cumulative %
OD Undersize	7971	7971	73.83
OD Oversize	1230	9201	85.22
Dent on Piston Rod OD	877	10078	93.34
Peel Off	403	10481	97.08
Metal Defects	97	10578	97.98
Plating Uncover	94	10672	98.85
Rough Finish	80	10752	99.59
White Patches	44	10796	100
Ring Mark on OD	0	10796	100

As you can see in above table we have listed out all defects and their occurrence. To know on which defect we have to focus, we have to plot Pareto chart. A Pareto chart is used to break down each of the parameters. Pareto chart has many benefits. It tells us which parameter is most important and which has to be looked on.

A Pareto chart gives emphasis on problems so that the major problems can be found out. Pareto chart is one of the seven quality control tools. It helps us to narrow our focus on a major parameter or topic. It is also known as 20-80% chart. It means if we work on 20% defect we will get our problems reduced to certain extent. According to Pareto chart, we have to work on defect OD undersize. Reducing occurrence of this defect will result in significant decrease in rejection quantity.

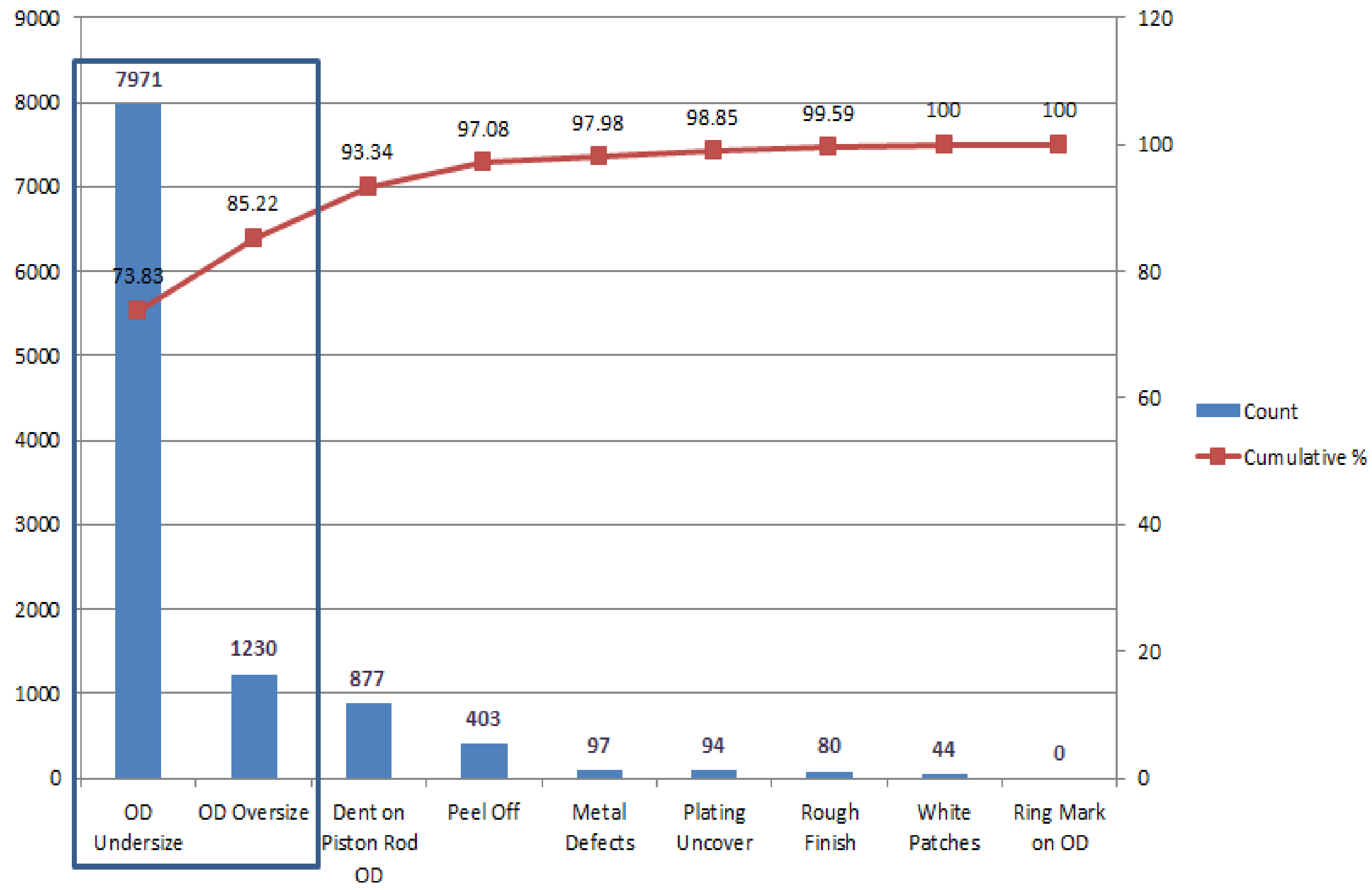

Chart-1: Pareto Chart for defects

6. DO PHASE:

After Plan-phase comes Do-phase. After analyzing the process we understood that working on defect named OD Undersize we can reduce the rejection. So we needed to analyze this defect and find the appropriate reasons for this defect. This can be done with help of CT Matrix. In CT matrix we note all critical to process parameters. Then the experienced people of organization like managers, assistant managers from different departments give ratings to these parameters according to their impact on process. Rating is given on scale of 1, 3 and 9 which indicates low impact, medium impact and high impact respectively. After this we add up the ratings and select top 10 highest rated parameters and plot them on XY tree or matrix.

CT MATRIX

CTX- Key Process Input Variable

		Ass. Manager Production	Manager Production	Ass. Manager	Manager Process	Ass. Manager R & D,E	Manager R & D,E	Ass. Manager Maintenance	Manager Maintenance	Manager Quality	Total
1	Process Validation as per standard Data	9	9	3	9	9	9	9	9	3	69
2	Dipping time variation in chrome tank	3	3	9	9	9	9	9	3	9	63
3	Chrome concentration reduction	3	3	9	3	3	3	3	3	9	39
4	Temperature variation in chrome tank more than 60 degree	9	9	9	3	9	9	9	9	9	75
5	Current variation in chrome tank	9	9	9	3	9	9	9	9	9	75
6	Eccentric positioning of anode and cathode	3	3	9	3	3	3	3	3	1	31
7	Bus bar contact failure due to uneven placement of jig	3	3	3	3	3	3	3	3	3	27
8	Chrome circulation is not as per requirement	9	3	3	1	3	3	9	9	9	49
9	Jig condition worn out	9	9	9	3	9	9	3	9	9	69
10	Rod tightening in collet (loose)	9	9	9	9	9	9	9	9	9	81
11	Anode fixture worn out due to lead and tin concentration	3	3	9	3	1	1	3	3	3	29
12	Incoming material undersized, straightness, taper etc	9	9	9	9	9	9	9	9	9	81
13	Operator dependency-auto programming	9	3	9	9	9	9	9	9	9	75
14	Current feedback system error due to current leakage	9	3	3	1	9	9	9	9	3	55
15	Electrolyte copper quality in jig	3	3	9	3	3	3	3	3	3	33
16	Jig positioning is not designed as per regular rod	3	3	9	3	3	3	3	3	1	31
17	Lack of operator competency about monitoring	1	3	9	3	3	3	3	1	3	29
18	Bodyshort in anode cathode	9	9	9	1	1	1	3	9	9	51
19	Collet tapping are worn out	9	9	3	1	9	9	9	9	9	67
20	Power fluctuation or tripping	9	9	3	3	9	9	9	9	3	63
21	Machine reliability(rectifier)	9	3	1	1	3	3	9	9	3	41
22	Bus bar and contact oxidation	3	3	9	1	1	1	3	3	3	27
23	Monitoring instrument not available(current, jig conductivity, plating	3	1	9	9	3	3	3	3	3	37
24	Piston rod finish is rough after grinding	3	3	9	3	3	3	1	3	9	37
25	Operator sets current manually (not controlled)	9	9	3	9	9	9	9	9	9	75
26	Distance between etching tank to E & F tank is more	3	3	1	1	3	3	1	3	1	19
27	Plating rod material consumption variation	1	1	3	1	1	1	1	1	1	11

Chart-2: CT Matrix

Y		X	
Y	Undersize	X1	Process validation as per standard data
		X2	Temperature variation in chrome tank more than 60
		X3	Current variation in chrome tank
		X4	Jig condition worn out
		X5	Rod tightning in collet(loose)
		X6	Incoming material undersized, straightness, taper etc
		X7	Operator dependency – auto programming
		X8	Collet tappings are worn out
		X9	Power fluctuation or tripping
		X10	Operator sets current manually (Not controlled)

Chart-3: XY Matrix

Action taken or Remedies:

Following actions were taken on top 10 parameters with highest ratings. After this, trial was taken on another 100000 piston rods.

Table-3: Critical to process parameters and remedies

	X	Validation Method	Remarks
X1	Process Validation as per standard Data	Process audit has to be conducted and check the parameters	OK
X2	Temperature variation in chrome tank more than 60 degree	Temperature to be monitored continuously and output should br checked	OK
X3	Current variation in chrome tank	Current to be monitored and output to be checked	OK
X4	Jig condition worn out	New coated jigs to be used and parts should be checked	OK
X5	Rod tightening in collet (loose)	use of rod tightening torque wrench	OK
X6	Incoming material undersized, straightness, taper etc	100% checking of incoming lot	OK
X7	Operator dependency-auto programming	Auto Programing to be started	OK
X8	Collet tapping are worn out	Preventive maintenance plan to be made and tool repairing frequency to be defined	OK
X9	Power fluctuation or tripping	circuit to be modified	OK
X10	Operator sets current manually (not controlled)	as per surface area of job current should be decided	OK

7. CHECK PHASE:

After applying all above remedies, we analyzed the process on another 100000 piston rods. We got following results after applying the remedies in month of August:

Table-4: Details of rejection data in August

Details	August 2019
Rods Produced	100000
Line Rejection	5568
Rejection %	5.57%
Rejection PPM	55680

Table-5: Details of defects and their counts

Defects	Count	Cumulative count	Cumulative %
OD Undersize	3423	3423	61.47
OD Oversize	852	4275	76.77
Dent on Piston Rod OD	745	5020	90.15
Peel Off	425	5445	97.79
Metal Defects	45	5490	98.59
Plating Uncover	30	5520	99.13
Rough Finish	27	5547	99.59
White Patches	21	5568	100
Ring Mark on OD	0	5568	100

After the trial, we observed significant drop in rejection quantity. The line rework quantity fell from 10796 to 5568. This resulted in drop in rework ppm from 107960 to 55680 ppm. So we can see that approximately 50% reduction in rejection quantity was absorbed. In all the defects, OD undersize defect was reduced by more than 50 %. Following Pareto chart shows the defect quantities for month of august.

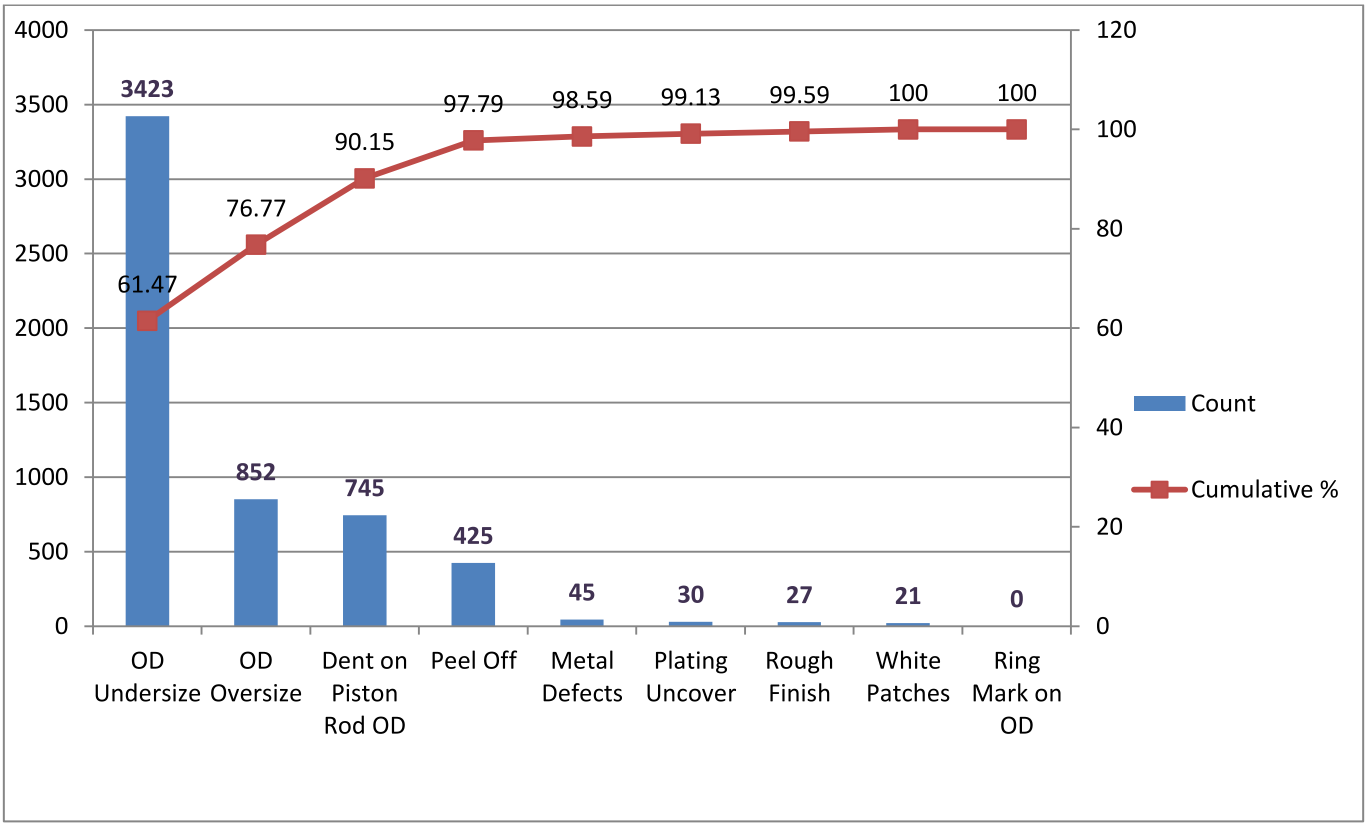

Chart-4: Pareto Chart for defects after implementing remedies

8. ACT PHASE:

Final and last phase of PDCA cycle is act phase. As we have seen significant decrease in rejection quantity, we should implement these changes. In addition to this sustaining this new process is important to achieve higher outputs .This process and method should be standardized. On Regular basis on job trainings should be given to operator about method. This will increase the productivity of company and hence increase the profit with high quality products. In return customer supplier bond also gets stronger.

9. RESULTS:

Piston rods after undergoing process change results in lesser rejections. Before this the rework was 10.47% which was too large. After analysis and implementation of remedies we got significant decrease in rejection quantity. In addition to this significant reduction were observed in all the defects. Following table shows the rejection data comparison of July and August.

Table-6: Comparison of Rejection Data

Details	July 2019	August 2019
Rods Produced	100000	100000
Line Rework	10796	5568
Rework %	10.79%	5.57%
Rework PPM	107960	55680

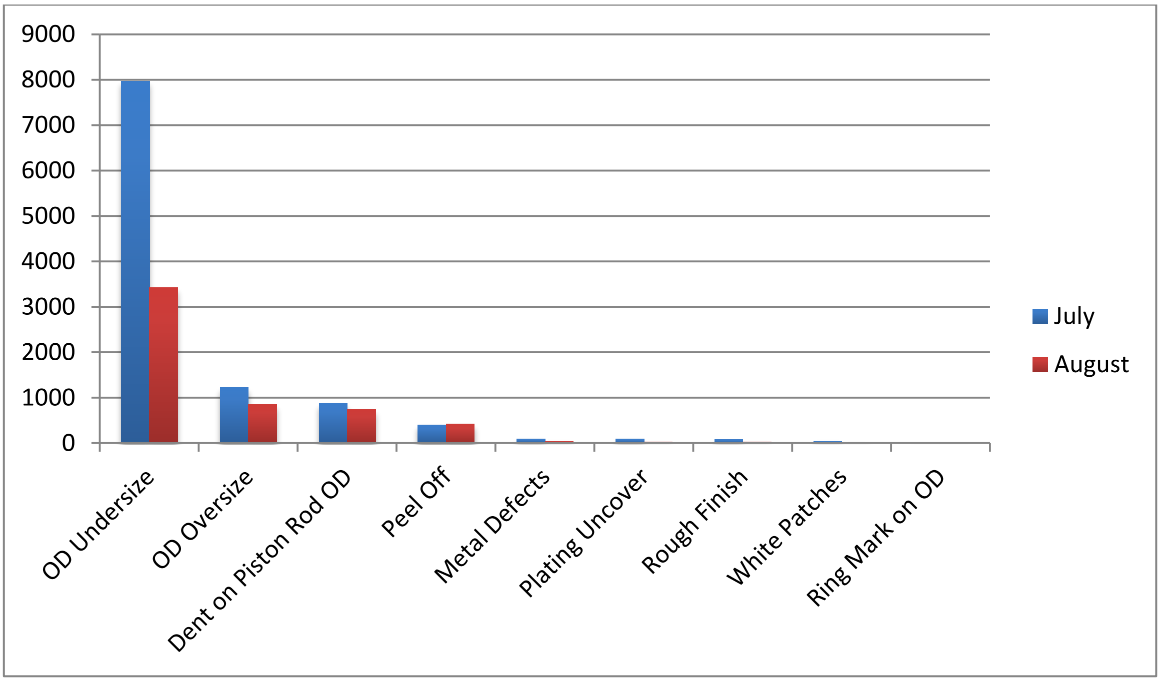

Chart-4: Comparison of defects count in July versus August

10. CONCLUSION:

This study was carried out to improve the production by reducing defects. To do this we required proper systematic approach, hence use of PDCA cycle, quality control and six sigma tools was beneficiary. The process of hard chrome plating is critical and important for piston rod and also expensive. So decreasing the rejection quantity also eliminated the rework cost to certain extent. This can only be implemented by adopting the process as a culture of company. In future doing further in depth analysis can further improve the process and production.

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