APPLICATION OF GD&T IN ALLOY WHEEL TO ANALZYE THE PCD CORRECTION ERROR

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Abstract: Mistake proofing also known as Poke Yoke in which fool proofing is done so that the workpiece cannot wrongly loaded on the machine table. The most important part in an automobile is wheels, without it is not possible to move the automobile from one place to another. In the automotive industry, Alloy wheels are made from an alloy of Aluminium or Magnesium. Alloys are mixtures of a metal and other elements. Aluminium or Magnesium Alloys are typically lighter for the same strength, provide better heat conduction, and often produce improved cosmetic appearance over steel wheels. They generally provide greater strength over pure metals, which are usually much softer and more ductile. A wheel is a round-shaped block of a high-strength and toughest material. Its centre is bored of a circular hole through which an axle bearing is tightened about which the wheel rotates when a moment generated by engine is applied to the vehicle axle about its axis, wheel and axle. The most important part is the Pcd of wheel which is a critical part where the assembly takes place. So, in this project we found out what are different causes which are influencing on pcd error in order to get fit and interchangeability of mating parts and assembly by using tolerance analysis. Thereby, use of quality tools, statistical process control we found out what are the causes and their effects. So, that we would eliminate or control so that we can reduce rejection of alloy wheel due to pcd error. In correction of pcd error we work on the dimension and tolerances of alloy wheel. In the design, there are critical dimensions and geometries in the light of geometric dimensioning and tolerancing (GD&T) for e.g., concentricity, positional tolerance, etc. The condition here used in context to GD&T is the RFS condition which is known as Regardless of feature size. It is used when there is a need of very close tolerances and the eccentricity of wheel is so important so it used. Rotating parts requires eccentricity otherwise there will be imbalance in the wheel and axle connected to it. With the help of statistical quality control study and process capability indices, we are finding out the machine capability and process capability to identify the possible variation in the system. Data would be collected in the consecutive 50 sample size and 125 sample sizes to find out the Cm, Cmk, Cp and Cpk value. So, after further investigating cause and effect diagram and eliminating the root cause we have stopped the wrong loading of the wheel. And the rejection rate of pcd is reduced due to various implementation.

***Index Terms* – Fool proofing, PCD VMC M/c, Alloy wheel, Process capability, concentricity.**

I. INTRODUCTION

Alloy wheels are automobile (car, motorcycle and truck) wheels which are made from an alloy of aluminium or magnesium metals (or sometimes a mixture of both). Alloy wheels differ from steel wheels in a number of ways: Typically, lighter weight for the same strength (1) Better conductors of heat (2) Improved cosmetic appearance. Lighter wheels can improve handling by reducing unsprung mass, allowing suspension to follow the terrain more closely and thus provide more grip, however it's not always true that alloy wheels are lighter than the equivalent size steel wheel. Reduction in overall vehicle mass can also help to reduce fuel consumption. Better heat conduction can help dissipate heat from the brakes, which improves braking performance in more demanding driving conditions and reduces the chance of brake failure due to overheating.

Aluminium Alloy Wheel Alloy Wheels Are Not Only for Improved Driving Performance, They Are Also for Cosmetic Purposes. The Alloys Used Are Largely Corrosion-Resistant, Permitting an Attractive Bare-Metal Finish, With No Need for Paint or Wheel Covers, And the Manufacturing Processes Allow Intricate, Bold Designs. In Contrast, Steel Wheels Are Usually Pressed from Sheet Metal, And Then Welded Together (Often Leaving Unsightly Bumps) And Must Be Painted (As They Corrode Otherwise) And / Or Hidden with Wheel Covers / Hub Caps. Alloy Wheels Are Prone to Galvanic Corrosion If Appropriate Preventative Measures Are Not Taken, Which Can in Turn Cause the Tires to Leak Air.

The world realised long ago that plus and minus system of dimensioning and tolerance parts was insufficient to consistently convey design intent. It was a language capable of transferring the creative inventions of mankind to paper in such a way as to be unambiguous when interpreted by other. Geometric dimension and tolerance through the American national standards institutes Y14.5 Standards (ANSI Y 14.5) is the result of many years of student and collaboration obey dedicated individual in the U.S.A. to find a more complete language of design. It composed of many symbols and concept. It is a language of symbol that allows us in, perhaps for first time, to convey those ideas in a way that is precise and logical. Not only its geometric definition of parts size, shape, orientation and location made more under stable and precise using GD&T methods. If parts are produced as per ANSI Y 14.5 drawing specification, they will mate with mating part of the assembly. Use of GD&T can give 57% of more tolerance than plus minus tolerance system.

Then the potential causes are identified which have the maximum impact on the operational wastages. From the data, maximum rework occurs by the problem of size variation. Cause and effect diagram, often called a fishbone diagram, can help in brainstorming to identify possible causes of a problem and in sorting ideas into useful categories. A fishbone diagram is a visual way to look at cause and effect. It is a more structured approach than some other tools available for brainstorming causes of a problem (e.g., the Five Whys tool). The problem or effect is displayed at the head or mouth of the fish. Possible contributing causes are listed on the smaller ―bones‖ under various cause categories. A fishbone diagram can be helpful in identifying possible causes for a problem that might not otherwise be considered by directing the team to look at the categories and think of alternative causes. "Why-Why" analysis an analytical method that is designed to help you identify all factors contributing to a problem one by one in an orderly fashion, rather than a hit-and-miss attempt to work out the factors and finally, we will have the root cause for the failure.

Process capability is the range over which the natural variation of the process occurs as determined by the system of common causes. Process capability is also the ability of the combination of people, machine, methods, material, and measurements to produce a product that will consistently meet the design requirements or customer expectation. Process-capability study to assess the ability of a process to meet specifications. Finding out Cp and Cpk (Process capability index). Process capability study is a method of combining the statistical tools developed from the normal curve and control charts with good engineering judgment to interpret and analyse the data representing a process. The purpose of the process capability study is to determine the variation spread and to find the effect of time on both the average and the spread. Process capability indices are intended to provide single number assessment of the ability of a process to meet specification limits on quality characteristics of interest.

II. LITERATURE SURVEY

X Jiang , R Lyu ,Y Fukushima ,M Otake and D Y Ju did Process capability improvement through DMAIC for aluminum alloy wheel machining. The generic problems of alloy wheel machining and subsequently details on the process improvement of the identified critical-to-quality machining characteristic of A356 aluminum alloy wheel machining process. The causal factors are traced using the Ishikawa diagram and prioritization of corrective actions is done through process failure modes and effects analysis. Process monitoring charts are employed for improving the process capability index of the process, at the industrial benchmark of four sigma level, which is equal to the value of 1.33. The procedure adopted for improving the process capability levels is the DMAIC approach. By following the DMAIC approach, the Cp, Cpk and Cpm showed signs of improvement from an initial value of 0.66, -0.24 and 0.27, to a final value of 4.19, 3.24 and 1.41, respectively. **Daniel Kern et al** describe a new method of representing characteristics of a manufactured component using the attributes of feature, geometry, material, and process. This representation enables better storage and retrieval of process capability data. In addition, they describe a method for rapidly and robustly indexing components' characteristics for entry into a process capability database. William H. Woodall was discussed about the tools and techniques of statistical quality control (SPC) in a very effective way to improve the communication between practitioners and researchers. **Yerriswamy Wooluru, Swamy D.R. P. Nagesh** this paper shows that Process Capability can be evaluated through the computations of various process capability ratios and indices. The basic three capability indices commonly used in manufacturing industries are Cp, Cpk,Cpm and Cpmk .Process capability indices are intended to provide single number assessment of the ability of a process to meet specification limits on quality characteristics of interest. Thus, it identifies the opportunities for improving quality and productivity. The objective of this paper is to conduct process capability analysis for boring operation by understanding the concepts, methodologies and making critical assumptions. **M. Mostaqur Rahmana , M.A. Alima , M.A. Khairula , Z. Abdinb** and **I.M. Mahbubu** has shown measurement of manufacturing process capability: a case study. The purpose of this study was to discuss and illustrate how the capability of a process can be measured. The study has been conducted using a case study. It is seen from the analysis that the capability of the process is very low (Cp = 0.448, Cpk = 0.447, Ckm= 0.447) that means the process (machine) is not capable to fabricate the product with respect to the specification limits, and a relatively large number of nonconforming products will be produced. **Funda Kahraman, Ugur Esme, Mustafa Kemal Kulekci, Tarsus Mersin,** and **Yigit Kazancoglu, Balcova-Izmir, Turkey** this paper shows in recent years, process capability analysis has become an important integrated part in the applications of SPC for the continuous improvement of quality and productivity. Process capability indices are the most commonly used indices in managerial decisions. In this study, the parts manufactured out of tolerance were determined during the machining. For the elimination of the observed quality problems, some suggestions were proposed. Quality characteristics such as inner diameter and flange height were improved. Faults, regarding manufacturing out of tolerance limits were eliminated, variability in the process and the cost due to production of less quality was reduced in the choosen company. **Jabir Z. Ansari, Akash R. Tekade, Swapnil C. Dandekar** this paper shows that they have invented instrument that can accurately measure the concentricity, circularity, circular runout and total runout of job. Precise measurement can be achieved quickly for outer circle and inner circle of shaft of work piece. Standard accuracy of 0.01 mm can be achieved by using lever dial gauge, even higher precision can be achieved by using more precise lever dial gauge. Human error can be eliminated and precise accuracy of up to 0.001mm can be achieved. Since the instrument is highly portable it can be taken anywhere, the instrument is also simple to maintain, operating environment should be free of vibration. **Won-Pyo Hong** evaluated machine capability of machining center by using the process precision evaluation of the ISO KS test condition for machining center, the processing, measuring and analysis of specimen were carried out and the machine capability indices were evaluated based on 3 items: linear machining, circular machining and positioning capability relevant to straightness, roundness and positioning accuracy. **Ali Rıza Motorcu, Abdulkadir Gullu** has done an experimental study of some statistical calculations to eliminate quality problems such as undesirable tolerance limits and out of circularity of spheroidal cast iron parts during machining. X–R control charts have been constructed on the data obtained from this manufacturing to discover and correct assignable causes, so that the machine capability (Cp) and the process capability (Cpk) is determined. **Jhy-cherng tsai** and **Mark r. Cutkosky** this paper reviews work in geometric tolerance representation and reasoning and presents a generic and uniform graph-based representation scheme, called the tolerance network, to represent gd&t specifications across a part or assembly. The network can accommodate gd&t specifications related to the function, behavior, manufacturing, and inspection requirements embedded in design specifications and supports the use of different types of tolerances. The network also accommodates common design practices such as the specification of over constrained features and parts. The necessary properties of such a network are discussed that allow under- and over constrained design specifications to be detected and analyzed. **Saurin Sheth et al** demonstrates how GD&T can improve the quality of product and reduce the cost of manufacturing by reducing the rework. Here an attempt is made to use the concepts of DFMA and GD&T on dual plate check valve. Applying proper tolerance to the mating parts plays a vital role in inspection and assembly of the product. So, by using GD&T standards, one can apply zero tolerancing and maximum material virtual conditions (VC) which will lead to proper assembly of the part. The conventional drawing should be revised to GD&T drawing, so that the rework in assembly of the valve can be eliminated or minimized. **PM Tadvi, PM George and RG Jivani** this research discuss about the turning process and its parameters which is optimized by the design of experiments and by the application of GD&T. The machine component used to achieve both the geometrical and dimensional tolerances requirements Conformity of geometry is one of the most significant requirements of turned components to perform its intended functions. The geometrical requirements, apart from dimensional requirements are: Circularity, Cylindricity, Perpendicularity etc. Since they have direct influence on the functioning of the components, the effect of the cutting parameters on them has greater significance. **Indrajit Mukherjee** and **Pradip Kumar Ray** this paper discusses the application potential of several modelling and optimization techniques in metal cutting processes, classified under several criteria and a generic framework for parameter optimization in metal cutting processes is suggested for the benefits of selection of an appropriate approach. In any multi-stage metal cutting operation, the manufacturer seeks to set the process-related controllable variables at their optimal operating conditions with minimum effect of uncontrollable or noise variables on the levels and variability in the output(s). author had classified the modeling and optimization techniques in metal cutting process. Moreover, it attempts to provide the user with flexibility to adopt suitable techniques based on their inherent potential as discussed and on-hand problem complexity highlighting the importance of problem criticality, data collection and analysis. **Miss Myela A. Paige, (Georgia Institute of Technology)** the purpose of this paper is to share a set of learning tools used to teach GD&T to first year engineering students. To assist students in developing spatial understanding, GD&T at a basic level has been developed for a first-year undergraduate engineering CAD, sketching, and visualization course, including a set of hands-on demonstration tools and an interactive activity. This paper describes those tools and how to make your own set, along with some suggested activities to help students engage with and retain the concepts. The tools can be made with inexpensive materials, requiring only clear plastic sheets (PVC, acrylic, etc.), clear tape, permanent marker

III. PROCESS SEQUENCE

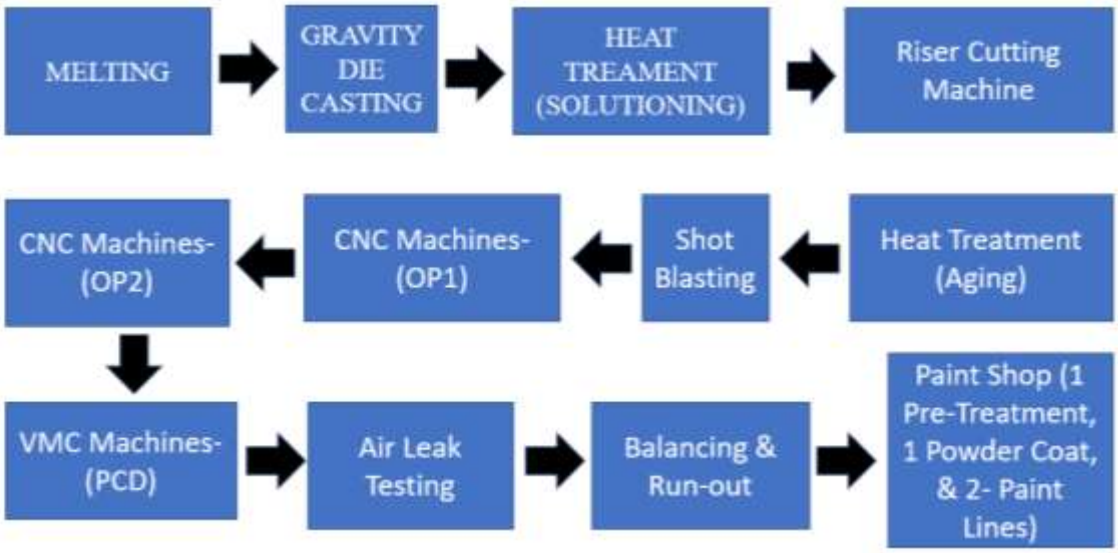


Figure 1 PROCESS SEQUENCE

Primary stage: Design phase

As per the customer requirement, drawing of the wheel in which, the mold design is prepared according to the required dimensions and tolerances. Design should be prepared to fulfill the requirement of manufacturing, assembly and the customer needs.

Secondary stage: Manufacturing phase

Manufacturing phase in which casting and machining would be come about according to the drawing. As per the design intent, pattern making process would be done. Casting will be prepared after the completion of pattern and mold making. Casting product will transfer to the heat treatment purpose to increase the strength of the alloy. Further after that it will go to machining of hub bore, bolt holes, valve hole would be done according to dimensions and related tolerances provided in the design.

Tertiary phase: assembly phase

Assembly of the alloy wheel is done in this phase which very most critical phase because assembly accuracy will directly affect to the running accuracy of the car if the given eccentricity of the wheel is not proper and it will affect on the job.

3.1 OP3: PCD (PITCH CIRCLE DIAMETER)

In this operation first clamping of wheel is done the bolt hole are drilled in a sequence of one after another total four are drilled. After the bolt hole are drilled the bed is tilted at 20^0 with the wheel so that the valve hole is drilled. After valve hole is drilled the bed comes to its initial position with the wheel and the operation is completed by unclamping of wheel.

Figure 2 PCD VMC MACHINE

3.2 PCD VMC MACHINE SPECIFICATION

SR.NO	CONTENTS	
1.	Travel length (mm)	X= -1000 Y= -500 Z= 730
2.	Spindle speed (rpm)	1200 - 2400
3.	Rapid feed rate (m/min)	50 m/min
4.	Cutting feed rate (m/min)	250 mm/min
5.	Repeatability	20 microns
6.	Controller	Brother
7.	Max. loading weight (kg)	300 kg
8.	Accuracy	1.06 – 0.020 mm

IV. ROOT CAUSE ANALYSIS

Root cause analysis (RCA) is a systematic process for identifying "root causes" of problems or events and an approach for responding to them. RCA is based on the basic idea that effective management requires more than merely "putting out fires" for problems that develop, but finding a way to prevent them. We are trying to identified root causes and their effect on the performance of the machine as well as on the product and rectify or eliminate by the study the effect of process parameter on spindle housing and by the study of system of machine. WHY-WHY Analysis can be carried out to find out the possible root causes and to take appropriate actions to control them.

4.1 Causes and Effect Diagram (Fishbone diagram)

Four main causes (men, material, method, environment) and causes which affect on the fit and function of the spindle housing by affecting the process capability. In this diagram, we are trying to find out the root causes which will affect on our process and precision of machine and control or eliminate them by the study on process parameters and machine and that effect on product parameter.

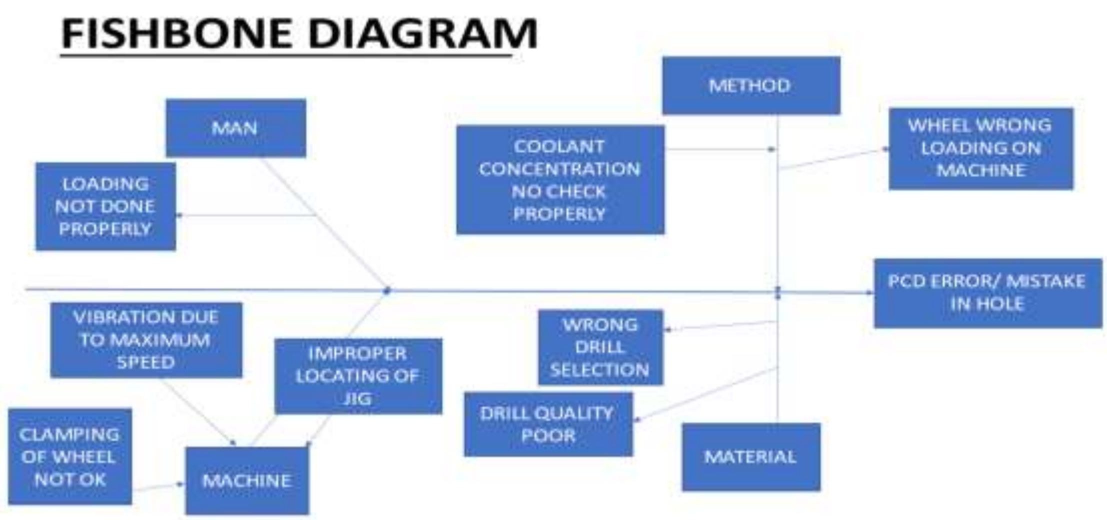


Figure 3 FISHBONE DIAGRAM

4.2 4M USED FOR FINDING OUT THE ROUTE

1. MAN: Loading not done properly due to lack of knowledge and skill.
2. MATERIAL: Here there are two parameters affected (a) Wrong drill selection and (b) Drill quality poor.
3. METHOD: Coolant concentration not check properly and wheel wrong loading on machine.
4. MACHINE: Here they are three factors affecting the most (a) Vibration due to maximum speed, (b) Clamping of wheel not ok (c) Improper locating of jig.

4.3 WHY- WHY ANALYSIS:

"Why-Why" analysis an analytical method that is designed to help you identify all factors contributing to a problem one by one in an orderly fashion, rather than a hit-and-miss attempt to work out the factors and finally, we will have the root cause for the failure.

SR.NO	CAUSE	WHY?	WHY?
1.	LOADING NOT DONE PROPERLY	WRONG LOADING OF WHEEL BY OPERATOR MISHANDLING	WRONG LOADING OF WHEEL DUE TO LACK OF TRAINING AND CONCENTRATION
2.	COOLANT CONCENTRATION	NOT CHECKED PROPERLY SHOULD BE GREATER THEN >5 AS PER REFRACTO METER	ONE DIRECTION HOSE IS USED INSTEAD OF TWO DIRECTION HOSE
3.	CLAMPING OF WHEEL NOT OK	DUE TO CHIP FORMATION ON THE REST PAD	UNCLEANED CHIPS
4.	VIBRATION DUE TO MAXIMUM SPEED	VIBRATION DUE TO MAXIMUM SPEED	SPEED NEEDED TO BE LOWER
5.	WRONG DRILL SELECTION	WRONG USE OF DRILL	DRILL USED OF 15 INCHES INSTEAD OF 16 INCHES
6.	DRILL QUALITY POOR	DEFECTIVE PIECE	WEAR OUT DUE TO CONTINOUS USAGE
7.	IMPROPER LOCATING OF JIG	3 PIN NOT LOCATING AND CENTERING THE HUB BORE	3 PIN NOT OPENING AT SAME TIME

V. EXPERIMENTATION AND RESULTS

5.1 Process Capability of PCD ALLOY WHEEL

Process capability is the repeatability and consistency of a manufacturing process relative to the customer requirements in terms of specification limits of a product parameter. This measure is used to objectively measure the degree to which your process is or is not meeting the requirements. Process capability data for PCD diameter of Alloy wheel can be measured with 125 sample size in 5 sample subgroups as shown from table 5. Average, Range and Standard deviation can be calculated from equations shown in table 7.

	Sub Group no.												
Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13
X1	100	100.02	100.01	100.01	100.03	100	100.01	100.05	100	100.04	100.03	100.05	100.02
X2	100.01	100	100.03	100.01	100.03	100.03	100.01	100.05	100	100.04	100.03	100.05	100.02
X3	99.96	100.01	100	100.02	100.02	100.02	99.97	99.97	100.01	100.01	100.04	100.02	100.04
X4	100.04	100	100.03	100.01	100.04	100.02	100.04	100.02	100	100.03	100.03	100.04	100.02
X5	100.03	100.01	100.02	100	100	100.05	100.04	100.02	100.03	99.97	100.03	100	100.02
Average	100.01	100.01	100.02	100.01	100.02	100.02	100.01	100.02	100.01	100.02	100.03	100.03	100.02
Range	0.05	0.02	0.03	0.02	0.04	0.05	0.07	0.08	0.03	0.07	0.01	0.06	0.02
UCLxbar	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04
LCLxbar	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99
UCLr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
LCLr	0	0	0	0	0	0	0	0	0	0	0	0	0

	Sub Group no.												Calculations		
Sample No.	14	15	16	17	18	19	20	21	22	23	24	25	Xdouble bar	Rbar	Std Dev
X1	100.05	100	100	100.04	100.02	100.03	100.01	100.03	100	100.02	100.03	100			
X2	99.93	100	100.02	99.97	100.02	100.03	100.01	100.03	100	100.02	100.03	100			
X3	100.01	100.04	99.97	100.03	100	100.02	100.04	100.01	100.05	100.04	99.98	100.02			
X4	100.01	100.03	100.01	100	100.01	100.01	100.03	100.05	100.01	100.05	100	100.04			
X5	100.03	100	100.03	100.03	100.02	100.05	100.03	100.02	100	100.03	100	100.02	100.018	0.046	0.02
Average	100.01	100.01	100.01	100.01	100.01	100.03	100.02	100.03	100.01	100.03	100.01	100.02	Cp		Cpk
Range	0.12	0.04	0.06	0.07	0.02	0.04	0.03	0.04	0.05	0.03	0.05	0.04			
UCLxbar	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04	100.04			
LCLxbar	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99	99.99			
UCLr	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1			
LCLr	0	0	0	0	0	0	0	0	0	0	0	0	2.21		1.91

Figure 4 PROCESS CAPABILTY OF PCD

Here,

USL = 100.13 mm

LSL = 99.87 mm

Cp and Cpk value is 2.21 & 1.91

Table 1 Sigma Calculations

Xd BAR	100.018	
R BAR	0.046	
SIGMA(S)	R BAR/D2	0.02
6S	**0.12**	
3S	**0.06**	

Table 2 Constants

SAMPLE	D2	A2	D4	D3
2	1.128	1.88	3.267	0
3	1.693	1.023	2.574	0
4	2.059	0.729	2.282	0
5	2.326	0.577	2.114	0

5.2 FORMULA FOR CP AND CPK

(1) $C_p \;=\; \frac{USL - LSL}{6\sigma}$,

(2) $C_{pk} \;= min\,\{\frac{USL - \mu}{3\sigma}, \frac{\mu - LSL}{3\sigma}\}$,

(3) $\sigma \;=\; \frac{R}{d2}$,

(4) $UCL_{\underline{R}} = D_4$ x $\underline{R}$,

(5) $UCL_{\underline{X}} = \underline{X} + A_2$ x $\underline{R}$,

(6) $LCL_{\underline{X}} = \underline{X} - A_2$ x $\underline{R}$

Where,

USL = Upper specification limit

LSL = Lower specification limit

σ = Standard deviation

μ = Process means ($\underline{X}$)

$UCL_{\underline{R}}$ = Upper control limit in Range

$UCL_{\underline{X}}$ = Upper control limit in Average

$LCL_{\underline{X}}$ = Lower control limit in Average

5.3 Concentricity

Concentricity is a geometric control of the median points of all diametrically opposed elements of the figure of revolution. It is also a control of all correspondingly located elements of two or more radially disposed features. If perfectly concentric, these median points/elements coincide exactly in all their aspects with the datum axis (or canter point). Actual concentricity < 0.15 mm. below in table 50 samples were collected in which 10 samples were out of concentricity range.

Table 3 Concentricity Data

SR.NO	DEVIATION mm	SR.NO	DEVIATION mm	SR.NO	DEVIATION mm
1.	0.062	19.	0.076	34.	0.069
2.	0.061	20.	0.054	35.	0.045
3.	0.184	21.	0.049	36.	0.012
4.	0.076	22.	0.049	37.	0.171
5.	0.011	22.	0.081	38.	0.045
6.	0.112	23.	0.171	39.	0.112
7.	0.014	24.	0.063	40.	0.050
8.	0.154	25.	0.079	41.	0.012
9.	0.131	26.	0.119	42.	0.017
10.	0.042	27.	0.186	43.	0.014
11.	0.064	28.	0.018	44.	0.154
12.	0.035	29.	0.165	45.	0.085
13.	0.035	30.	0.047	46.	0.035
49.	0.158	31.	0.125	47.	0.141
15.	0.075	31.	0.125	48.	0.171
16.	0.050	32.	0.180	49.	0.074
17.					
18.	0.022	33.	0.070	50.	0.105

VI. ELIMINATING CAUSES

6.1 COOLANT CONCENTRATION

Not checked properly should be greater than >5 as per refractometer the time for checking the coolant concentration is now 8 hrs before it was in 24 hrs.one direction hose is used instead of two direction hose. So, we have introduced one more hose.

Before implementation

Figure 5 One direction hose coolant flow

After implementation of two hose by adding one hose of coolant.

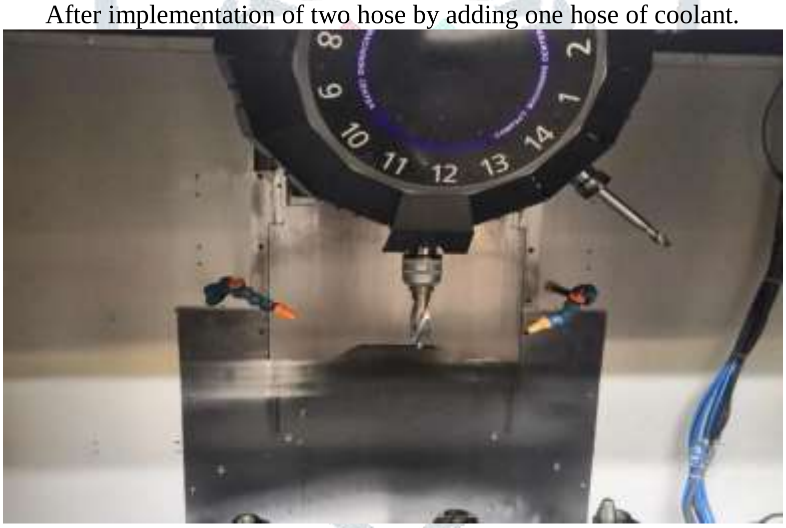


Figure 6 Two direction hose implementation

6.2 CLAMPING OF WHEEL NOT OK

Chip formation on the rest pad due uncleaned chips formation which leads improper levelling of wheel which was found not ok. Which leads to wrong position of drill in bolt hole. So, to eliminate this we have introduced new PATA gun for uniform air flow to clean the chips compared to conventional regular air gun.

Before,

Figure 7 Conventional Air gun

After new gun,

Figure 8 New PATA Gun

This PATA gun is a unique air-gun attachment works more efficiently than a regular air-gun in dewatering, particles removal, cleaning etc. Having this type of arrangement make the chip cleaning process easily for the operator working on it. Capable of 4 times the range of a conventional air-gun. It emits intermittent shock waves in broad angles, achieved by the high-speed rotation of its air spouting nozzle.

6.3 VIBRATION DUE TO MAXIMUM SPEED

There was vibration on the bolt hole due to which there was rejection in it and the tool life was also ending early. The spindle speed was at 2200 rpm there by changing its speed to 1800 rpm we got no vibration at all. And doing it increased the tool life of machine tool.

Before Implementation

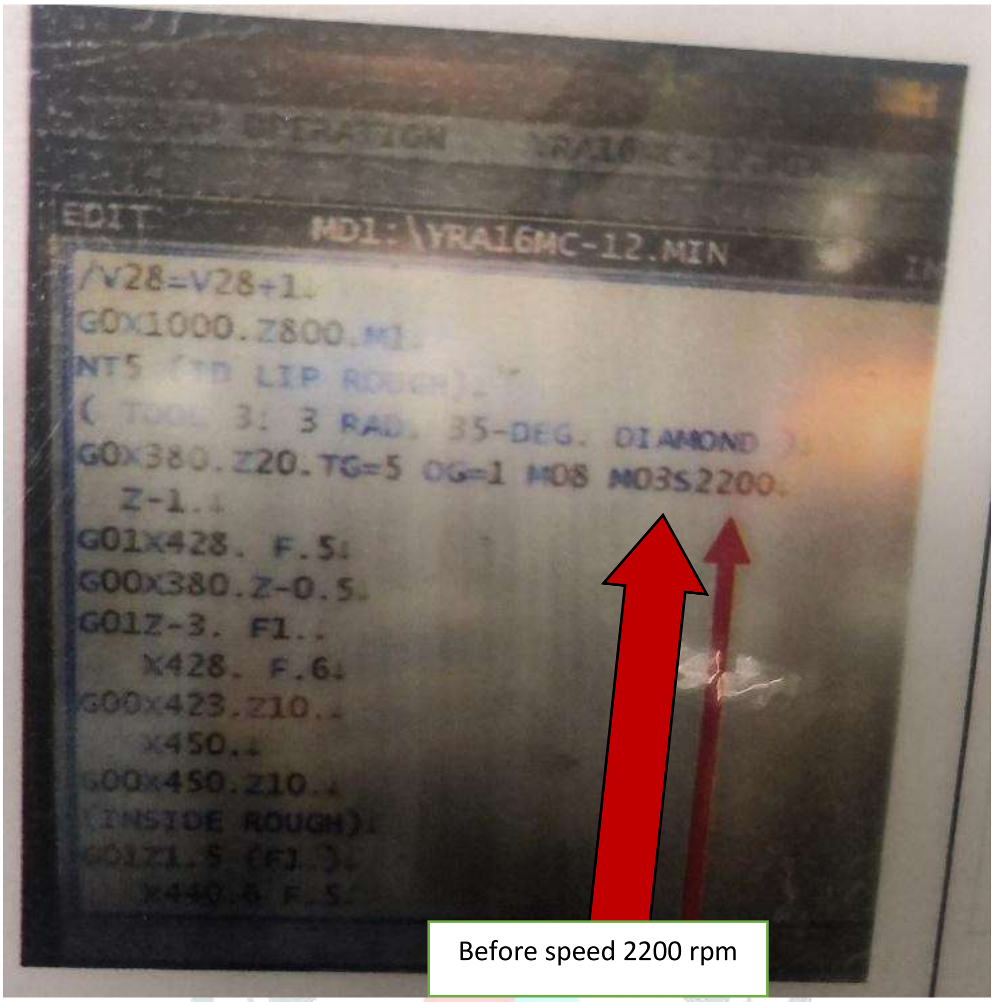


Figure 9 Maximum Machine spindle RPM

After Implementation

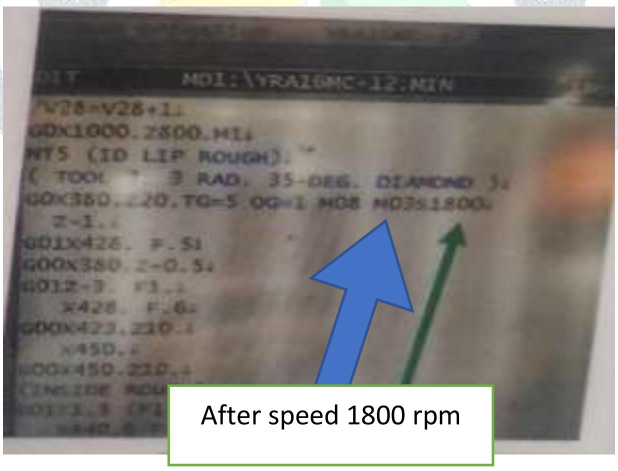


Figure 10 Changed spindle RPM

6.4 WRONG DRILL SELECTION

If the drill not selected as per the standard for the specific wheel which leads to poor quality material finishes. This could be seen as rough edges, cutter marks on the surface, raised marks, or burn marks on the material's edges or corners. Another main cause was the use of 15 inches wheel drill was used instead of 16 inches drill. Proper arrangement of machine tool is done so that any future problems doesn't occur.

6.5 DRILL QUALITY POOR

Some of the drills were found to be defective, improper finishing, improper point angle, blunts too quickly due to less coolant concentration, chips on the lips and cutting edge, continuous usage leads to wear out were the different causes for poor finishing.

6.6 FOOL PROOFING

Fool Proofing is a method by which ensures that the workpiece will fit into the work holder only if the workpiece is placed in the correct position. For fool proofing the design of jig and fixture is incorporated in such a way that it makes it impossible to place the workpiece into incorrect position but it will not interfere with loading and unloading of workpiece. It is achieved by using fool proofing pins and blocks. It ensures the correct loading of components. This concept ensures that the component will fit into work holder only in its correct position. The location devices make it difficult/ impossible to the user to load component incorrectly in a jig and fixture.

6.7 IMPLEMENTING ROD(PIN)

The rod being attached with the 3 – Pin jig. Same type of rod can attach on the opposite side or the adjacent side of the rod. So, that the wrong loading can be stopped because of the restriction in the Degree of freedom. Here, using the trial and implementation method the best suitable position was at the opposite of the rod. This type of arrangement not only stopped the wrong loading but also limited the pcd error occurring in the wheel. The term wrong loading is due to the valve hole not being perpendicular to the tool. If the wheel is wrongly loaded then there are chances of damaging the drill and wheel.

Before implementation,

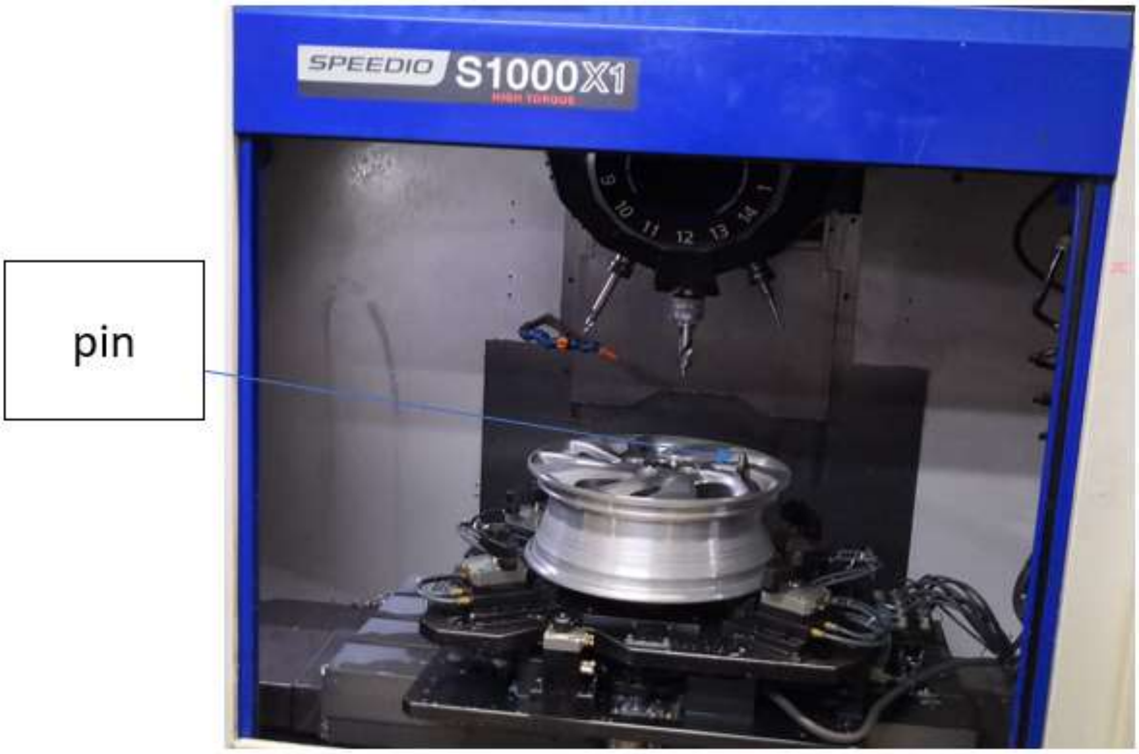


Figure 11 Before setup

After implementation,

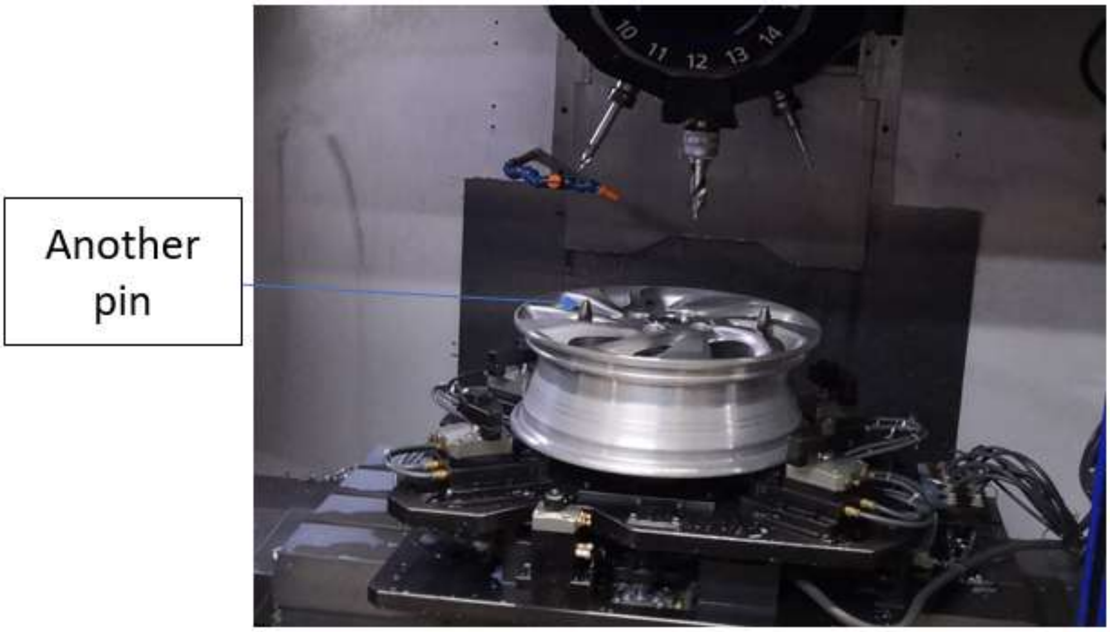


Figure 12 After implementation setup

6.8 IF THE WHEEL IS WRONG LOADED

If the wheel is wrong placed then it will not be able to rest on the jig and on rest pad. This way wrong loading is also stopped due to which pcd error rejection is reduced. Below figure is shown for wrong position placed.

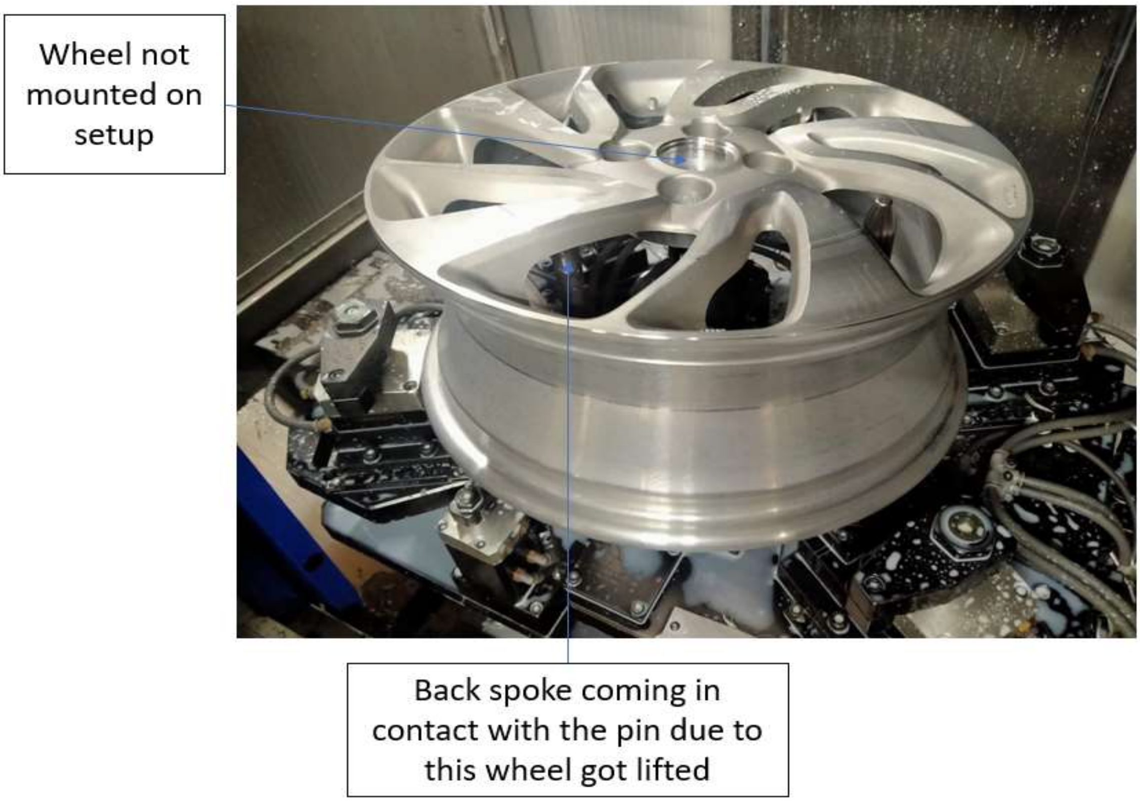
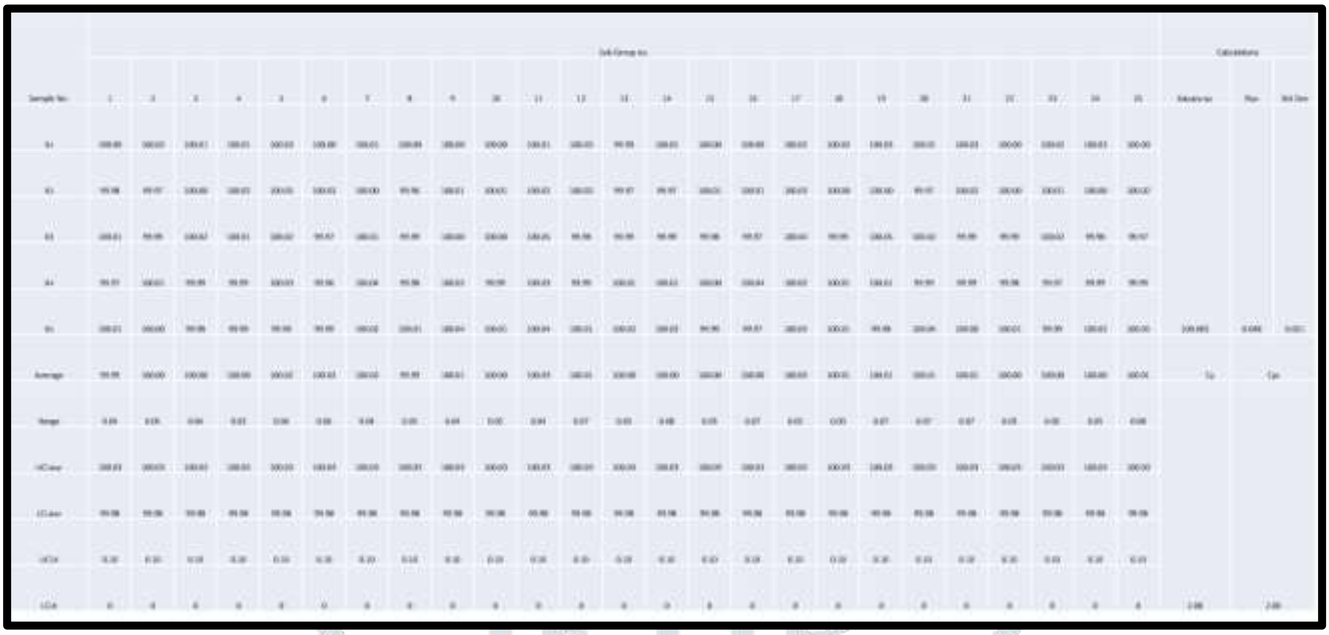


Figure 13 Setup of wheel wrong loading stopped

6.9 PROCESS CAPABILITY OF PCD

After implementation and eliminating various causes if there is an affect we check the process capability again for pcd and concentricity.



Cp and Cpk value are 2.08 & 2.00

6.10 Concentricity Data

SR.NO	DEVIATION mm	SR.NO	DEVIATION mm	SR.NO	DEVIATION mm
1.	0.121	19.	0.074	34.	0.069
2.	0.124	20.	0.057	35.	0.045
3.	0.061	21.	0.071	36.	0.012
4.	0.012	22.	0.055	37.	0.071
5.	0.140	22.	0.081	38.	0.045
6.	0.114	23.	0.171	39.	0.112
7.	0.014	24.	0.047	40.	0.050
8.	0.157	25.	0.079	41.	0.012
9.	0.112	26.	0.119	42.	0.017
10.	0.044	27.	0.158	43.	0.014
11.	0.012	28.	0.018	44.	0.017
12.	0.037	29.	0.045	45.	0.085
13.	0.031	30.	0.047	46.	0.035
49.	0.165	31.	0.125	47.	0.141
15.	0.075	31.	0.125	48.	0.085
16.	0.022	32.	0.040	49.	0.074
17.	0.050	33.	0.070	50.	0.105
18.	0.050				

After implementation, the rejection rate of concentricity is reduced by 75%.

VII. ACTUAL SETUP ASSEMBLY

Figure 14 Assembly of Alloy wheel on machine

VIII. CONCLUSION

In this paper, we have improved the rejection of alloy wheel due to PCD error occurring by various causes and thereby eliminating the causes. Here we have carried out machine capability and process capability of the machine and process and to find out whether what is impacting in the rejection.

By the help of 7 QC tool in which one is the fishbone bone diagram also called as cause and effect diagram in which we have tried to control all the possible factors affecting it.

The following results were obtained from the experimental work:

- From Cause & Effect Diagram in Root Cause was found, in which we have seen that number of system and special causes are effect on product.
- From WHY-WHY Analysis, it is seen that root cause for "wrong loading" in PCD operation. A survey was done in which 80% error was due to wrong loading done by the operator and 20% was machine related.
- From process capability analysis, it is seen that practical data of hub bore dia, Bolt hole, and pcd of alloy wheel, in sample size of 125 each was taken. Because of bilateral tolerances used, Process capability (Cp) and process capability index is considered and calculate the value of Cp, Cpk for hub bore is 2.03,1.952, for bolt hole is 1.88,1.84 and for pcd is 2.21, 1.91 which lead to good process capability.
- From the Coordinate measuring machine (CMM), concentricity of hub bore and pcd has been measured. Concentricity of alloy wheel between hub bore and pcd is 0.15 mm out of 30 sample 10 sample were found out of tolerance zone.
- Implementation of orientation pin has not only reduced rejection but also have reduced wrong loading of wheel.
- After the implementation of orientation pin the process capability of bolt hole, valve hole and pcd was again checked to know whether if it is having any effect because these three things are machined in operation 3.
- Here, we have checked the concentricity and the rejection rate is reduced by 75% due to concentricity. Again 50 samples data were taken and out of 50 only 4 were rejected due to out of tolerance range.

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X. FUTURE SCOPE

To design an alternate design in context for the proper alignment of hub bore so that there will be no error in the pcd because if the alignment of the jig and hub bore is not proper then there is pattern shift in drilling bolt hole which will change the bolt hole position and will result in pcd error.

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