EXPERIMENTAL INVESTIGATION OF COMPUTERISED INSPECTION TECHNIQUES IN CNC MANUFACTURING SYSTEMS

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Abstract - *This paper focuses on deviation in the measurement of profile CDS Circle Diamond Square made of Al 6063 by changing speed, feed and depth of cut. The profile of CDS is drawn by CAD modelling software and shape of the work piece is imported for machining in the CNC vertical milling machine. The actual dimensions provided of the work piece is 150*150*19 mm. The profile is made of about 4 sets. The work piece is tested for the tolerances, dimensions, and positional tolerances in the Coordinate Measuring Machine and on machine measurements. After completing the testing process the results are compared between actual value of the specimen and measured value of the specimen.*

Key Words: CMM, On-machine-measurement, CNC machine, AI 6063, tolerance.

1. INTRODUCTION

Error compensation is the important consideration during design and manufacturing. The goal of a CNC machine is to manufacturing a high-quality product by achieving the dimensional tolerance of the CAD model. The errors due to the process such as tool wear and deflection, work piece deflection, work piece location and clamping errors are not generally considered, although they affect part quality. The importance of rising machine accuracy is well recognized because of the increasing demand to reduce the work piece dimensional tolerance. The accomplishment of the accuracy improved by careful design and manufacturing extensively used to solve machine error issues. A great deal of analysis efforts is dedicated to error compensation on coordinate measuring machines (CMMs), machine tools, and robots. The globally competitive nature of manufacturing combined with the growing expectations of customers for quality assured parts at minimum cost has increased the importance of process control in manufacturing systems. Generally, process control is related to all manufacturing processes where materials undergo chemical or mechanical transformations. In the context of Computer Numerical Control (CNC) manufacturing, the definition of process control is to monitor a process to increase the quality of finished parts by controlling input parameters. Process control has been introduced as an option to increase the quality of manufactured parts in addition to the typical approach of employing more accurate machine tools. Generally, process control is divided into two sub-sections namely monitoring and decision making. Recent developments in computer control and software has made it available to automate the components in CNC manufacturing. However, these components remained as isolated automated islands due to lack of communication.

2. LITERATURE SURVEY

Jingxia Yuan, Jun Nic and el to developed Conducted an experiment for Integrated geometric error compensation of machining processes on CNC machine tool. Kinematic errors due to geometric inaccuracies in machining system cause deviations of tool positions and orientation from being machined point on the work piece, which consequently affect geometric error model of machining system and compensation method on machine tools [1]. A.C.Okafor and el to A Studied on geometric errors of simulated geometry which are measured and compensate in vertical machining centers. There are many errors in CNC machine tools have effect on the accuracy and repeatability of manufacture. Most of these errors are based on specific parameters such as the strength and the stress, the dimensional deviations of the structure of the machine tool, thermal variations, cutting force induced errors and tool wear [2]. Seng Khim, Tan and Chin Keong and el to fabricate locations of the axis average line and centerline of the rotary axes strongly influence the performance of these machines; however, techniques to compensate for eccentric error in the rotary axes remain weak. This paper proposes optical (Non-Bar) techniques capable of calibrating five-axis CNC machine tools and compensating for eccentric error in the rotary axes.[3]. W.T. Lei, Y.Y Hsu A method to reduce the machining errors of a three-axis machine tool by implementing an on-machine measurement with a touch probe. Probing errors of a touch probe and positioning errors of a machine tool, inevitably included in the measurement data, are compensated for to obtain the true machining errors for the repeated machining process [7]. Zhan.G, Veale.R, Reni Shaw ball bar tests can be used in tandem (or in some cases in lieu of) a “Circle diamond square” cutting test check to machine performance. Firstly, it provides summary of the circle diamond square contouring test and the measurement [8].

3. SOFTWARE AND METHOS

3.1 Source of Errors

In any measurement, there is invariably a degree of uncertainty resulting from measurement error. Let all measurements are inaccurate to some extent Measurement error is the difference between the indicated and actual values of the measured. The error may be designated either as an absolute error or on a relative scale, most typically as a percentage of full scale. It is most important to investigate fully the errors in measurement systems that cause these uncertainties, the meaning and interpretations of these errors and methods of decreasing or circumventing of errors. Each element of the measuring device has sources of errors which will contribute to measurement error.

- Static error
  - Environment error
  - Characteristic error
  - Dynamic error

3.2 Master Cam Design X5

Master cam, CNC Software's main product, started as a 2D CAM system with CAD tools that let machinists design virtual parts on a computer screen and also guided computer numerical controlled (CNC) machine tools in the manufacture of parts. The drawing dimensions in 150*150*19 mm.

3.3 Computer Aided Inspection

CAI is a software tool that makes it possible to inspect physical models using computer-aided design (CAD) programs. CAM creates real life versions of components designed within a software package. CAM was first used in 1971 for car body design and tooling. The inspection dimensions in 150*150*19 mm.

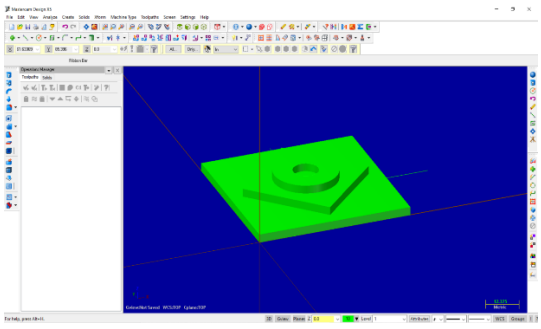

Fig -1: CNC milling 3D drawing using Master Cam Design X5

3.4 Circle diamond square test

Cutting tests have always provided a most popular method of determining machine tool performance. The machine is employed to produce a test piece under controlled conditions. The machine's performance is then evaluated by checking the dimensional accuracy of the test piece on a CMM (Co-ordinate measuring machine). In 1966 the Aerospace Industries Association of America defined a series of standardized cutting tests for CNC milling machines in National Aerospace Standard NAS979 1 (Uniform cutting tests – NAS series - Metal cutting equipment specifications). This customary defines a composite cutting test concerning machining of circular, diamond and square shaped profiles under CNC control. This test called the "circle, diamond, square test. Square-Circle-diamond (SCD) tests have been used by machinists for decades to gauge the precision of their machines. The process is to mill a few of them, measure the dimensions of each feature (the square, the circle, and the diamond) on each one with a micrometer or other precise instrument, compensate in your CAM software system. The strength of the circle-diamond-square artifact lies in its simplicity. Each feature of this artifact tests a specific aspect of the machining center used to produce it. The outside square tests the straightness of the individual axis used to cut the respective side of the square and the squareness between the two axes.

4. EXPERIMENTAL DETAILS

4.1. Materials:

Al 6063 matrix material is used in metal matrix composites. Al 6063 is used in application requiring high strength to weight ratio, good electrical and thermal conductivity, good fatigue resistance, low density.

Table -1: Typical composition of AL 6061

Component	Amount (wt. %)
Aluminum	Balance
Silicon	0.2-0.6%
Iron	0-0.35%
Copper	0-0.10%
Manganese	0-0.10%
Magnesium	0.45-0.9%
Chromium	0-0.10%
Zinc	0-0.10%
Titanium	0-0.1%

4.2 METHODOLOGY:

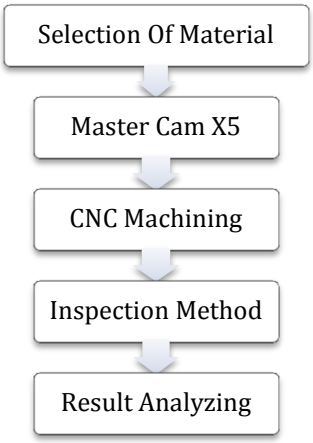

Fig -2: Flow Chart

5. EXPERIMENTAL SET UP AND PROCEDURE

In this process aluminum 6063 material taken and the profile shape is drawn by the CAD modeling software. Circle diamond square test is used to making this process. In this process Aluminum 6063 specimens cut into 4 profile shapes. Each profile has circle, diamond and square shape with different dimensions. The work piece is machined in the CNC machine to change the feed, speed and dimensional parameters of each profile shape.

Table -2: Input parameter in profile

S.NO	PROFILE	SPEED	FEED
1	Profile-A	800	0.1
2	Profile-B	1200	0.2
3	Profile-C	1500	0.3
4	Profile-D	1800	0.4

Fig -3: CNC milling machine

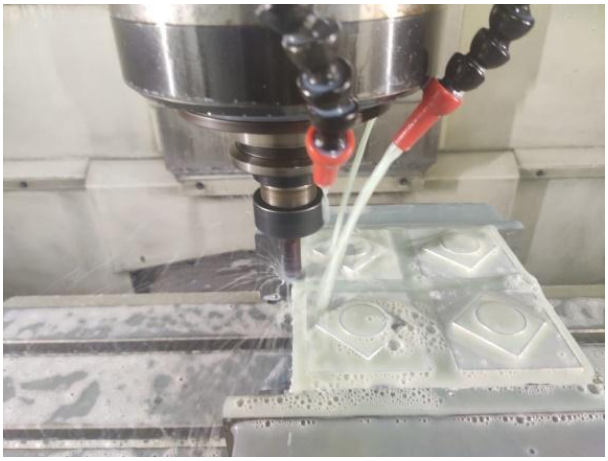

Fig -4: CNC machining process

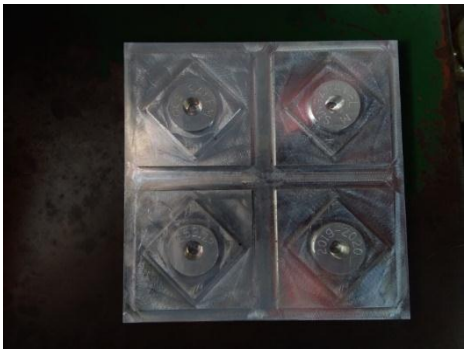

Fig -5: workpiece 6063 alloy

6. INSPECTION METHOD

The measure geometrical output, tolerance parameter and surface roughness of each profiles shape in the Coordinate measuring machine. Finally, compared the results what are the CMM measured value and OMM measured values.

6.1 Co-ordinate measuring machine

A measure the geometrical output, tolerance parameter and surface roughness of each profiles shape in the Coordinate measuring machine. A reading on CMM report.

6.2 On-Machine Measurement (OMM)

a CNC machine for inspection, an inspection probe is mounted in the spindle of CNC machine. A reading on OMM report.

Fig -6: Inspection Probe

The OMM method as an alternative for inspection in CNC manufacturing line. In addition, they noticed the reduction in inspection time as a reason for popularity of the OMM. The OMM is believed as a shop-floor inspection method that does not require unclamping and non-value-added movements from machining to environmentally controlled room for inspection.

6.3 Machined features

S.NO	FEATURES	MEASURING IN ERROR
1	Centre hole	Cylindricity of hole C
2	Square	Straightness of X
		Straightness of Y
		Straightness of Z
3	Diamond	Straightness of W
		Straightness of V
4	Circle	Roundness of P
		Straightness of F

7. RESULT ANALYSIS

The deviation is between OMM measured value and CMM measured value. Measured Cylindricity of hole, Straightness, Roundness. All measuring value in CMM and OMM reports.

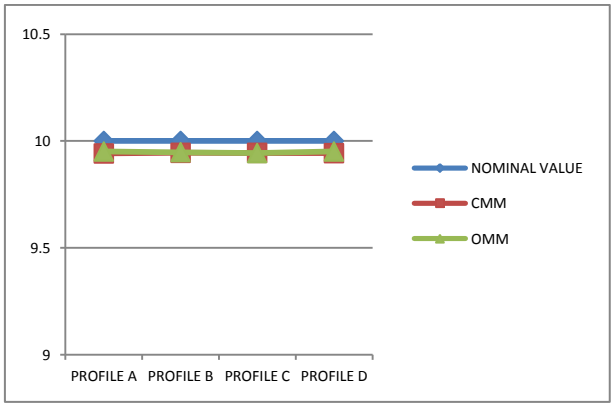

Chart -1: Cylindricity of hole c

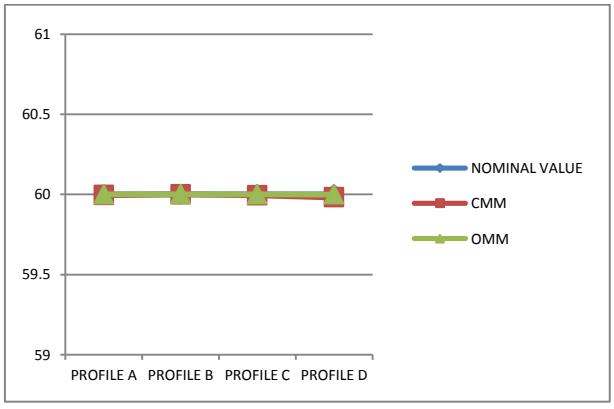

Chart -2: Straightness of X

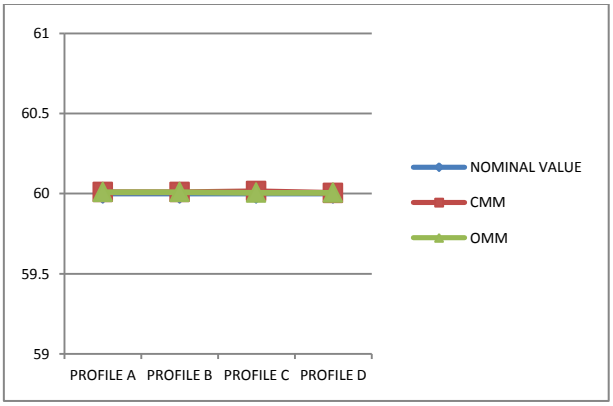

Chart -3: Straightness of Y

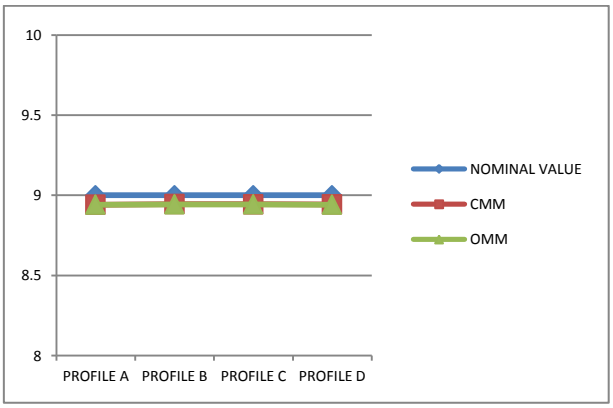

Chart -4: Straightness of Z

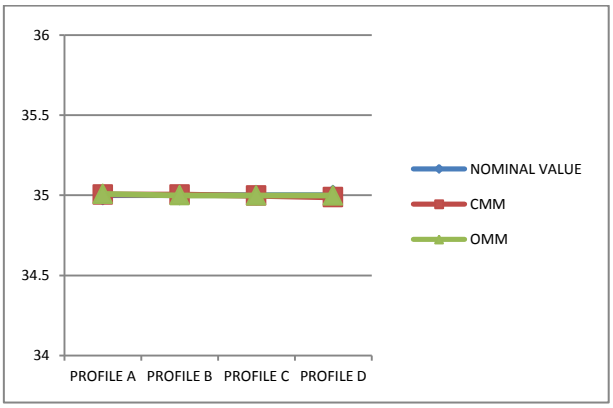

Chart -5: Straightness of W

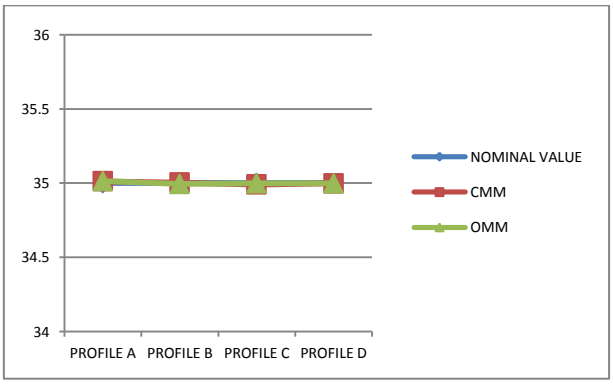

Chart -6: Straightness of V

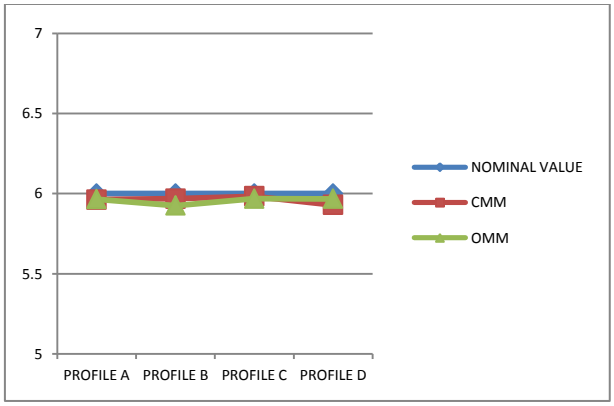

Chart -7: Straightness of R

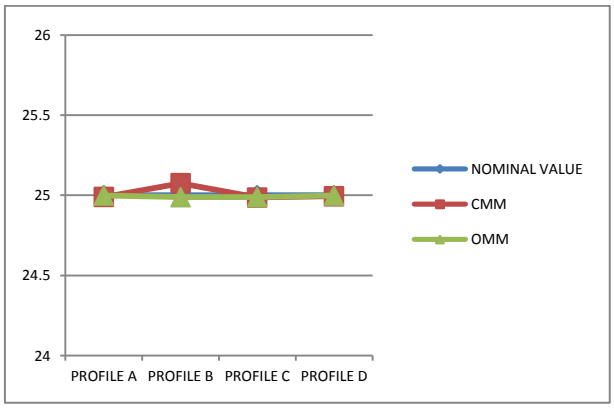

Chart -8: Roundness of P

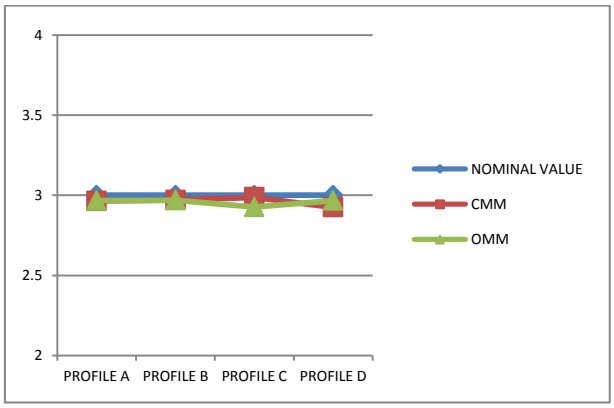

Chart -9: Straightness of F

8. CONCLUSION

CMM has been used effectively to express the errors and the computerized software has been used to check whether the parts are within the tolerance limits or not. The circle diamond square test on another CNC machine is selected for the Al 6063 work piece. The deviation is measured in CMM coordinate measuring machine and OMM on machine measurement. Thus, the deviation is seen between measured value in OMM and measured value in CMM.

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