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TIME SERIES ANALYSIS OF STANDARD SPHERE CMM DATA (SPHERICITY) FOR MACHINE LEARNING

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Abstract

The coordinate measuring machines (CMM's) has given a new impulse in the field of geometrical and dimensional metrology. The CMM's in industrial environments have become an important resource for the quality systems, monitoring manufacturing processes, reduction errors during the manufacturing process, inspection of product specifications and in continuous quality improvement. However, there is a need to evaluate, through practical, fast, effective and low cost methods, the CMM metrological specifications. In this research work, time series analysis of standard sphere CMM data (Sphericity) for machine learning purpose is carried out by a comparative study between the precision (repeatability) obtained with sphericity measurement of three different (in diameter) probe calibration spheres by three different (in diameter) combination of styli, measured on a specific coordinate measuring machine (CMM). Styli used for this study are of ruby material and sizes are 2X30 mm; 3X30 mm & 4X30 mm (Tip Diameter X Shank length mm). Probe calibration spheres used for this study are of ceramic material and diameter sizes are 19.9705mm; 19.9940mm & 29.9971mm.These three types of probes and calibration sphere are most commonly used in CMMs. In order to this time series analysis, three standard ceramic spheres of diameter 19.9705 mm, 19.9940mm and 29.9971 mm were measured for sphericity at 9 distinct locations in the CMM working volume with three different styluses of 2X30 mm; 3X30 mm & 4X30 mm. The above-mentioned sphericity measurements were repeated three times at each location and exercise was conducted for 10 days. All the measurements were taken at a temperature of 20 ºC ± 1 ºC.

Keywords: CMM; Sphericity; Stylus; Precision

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1. Introduction

Generally speaking, coordinate measuring machines (CMM) represent one of the most accurate and flexible measuring instruments used in the metrology field. These are the main reasons why they have become widespread throughout manufacturing companies. Therefore, with this kind of measuring device, it is possible to carry out measurements with a high degree of precision for manufactured parts of practically any type of shape and size [1].

There are several basic CMM configurations such as: moving bridge type, fixed bridge type, column type, cantilever type, horizontal arm type and gantry type, among others [1].This precision study is to be carried out on a moving bridge CMM since it is the most widely used type. CMM performance verification is accomplished through standard tests by ISO or other corresponding standards.

In many cases, when we need to measure parts with over a thousand characteristics and during the measurement process, when we get results very different from those we expected,

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which is the procedure that should be taken? What tests we should do? And which the reference standards that we use to confirm the results obtained?

The need for verification of the accuracy and precision of measurement and control equipment is an important prerequisite for quality departments in the industry, since the quality of its production is based on the target of "zero defects", so the need to have a good knowledge about the state of the equipment is extremely important [2]. In the specific case of the CMM's, in addition to the regular calibration provided in the international standard ISO 10360-2:2009 as a mandatory requirement, the same standard determines the need to make re verification tests, according to the user's specifications, looking for deviations not allowed in their systematic errors[2]. There is a need to evaluate, through practical, fast, effective and low cost methods, the CMM metrological specifications.

So, the main aim of this work is to do time series analysis of standard sphere CMM data (Sphericity) [3] for machine learning (performance evaluation) purpose. In order to do this, three standard ceramic spheres of diameter 19.9705 mm, 29.9971 mm and XXX mm were measured for sphericity at 9 distinct locations in the CMM working volume with three different styluses of 2X30 mm; 3X30 mm & 4X30 mm. The above-mentioned sphericity measurements were repeated three times at each location and exercise was conducted for 10 days. All the measurements were taken at a temperature of 20 ºC ± 1 ºC.

2. Methodology procedure

As was mentioned above, the coordinate measuring machine used in the present study was of the moving bridge type. Fig. 1 shows a picture of the CMM, where it can be observed that this type of CMM has a stationary table, made of granite, which supports the part to be measured.

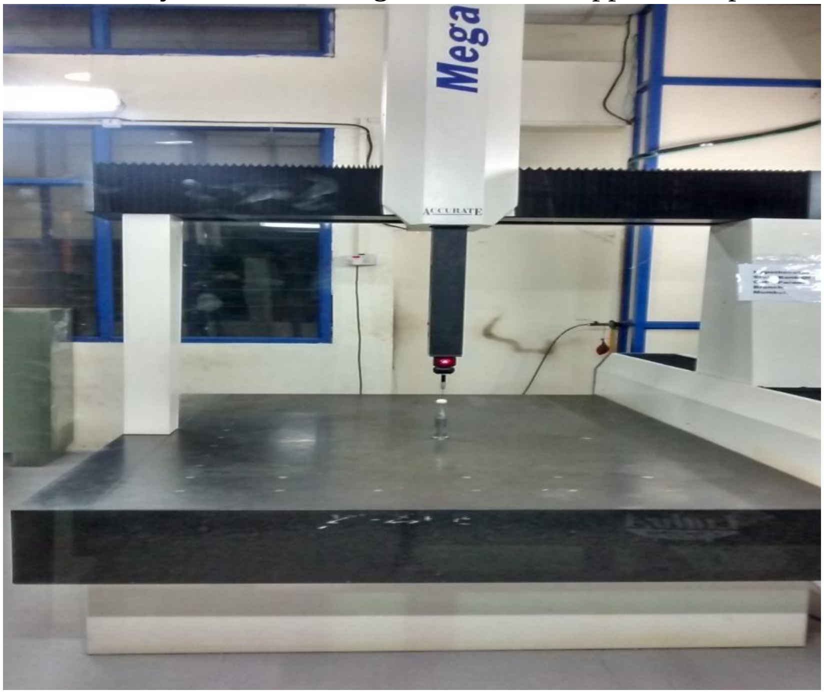

Fig. 1. Moving bridge coordinate measuring machine used in the present study.

Some of the advantages that this CMM configuration presents are as follows: higher natural frequencies (if it is compared to cantilever configuration), small to medium measuring range and relatively small measuring uncertainties [1]. On the other hand, due to the yawing effect, which is caused when the two CMM columns move at different speed values, the bridge can twist, thus affecting both the CMM accuracy and precision.

2.1 Equipment's used for this study

The CMM used in this precision study, which belongs to Accurate gauging and instruments PVT. LTD. It has an articulated probe head of type PH10M and the measuring software is Accusoft. Accuracy of this CMM claimed by manufacturer MPEE (as per ISO 10360- 2 with TP 200 in µm) is (1.9 + L / 350), where L is the length (in mm) being evaluated, and its measuring volume is as follows: 1200 mm (X) x 2000 mm (Y) x 1000 mm (Z).

Styli used for this study are of ruby material for styli tip and Tungsten carbide for shank. Various sizes of Styli used for this study are 1) 2X30 mm 2) 3X30 mm &3) 4X30 mm (Tip Diameter X shank length mm).

Spheres used for this study are of ceramic material. Various diameter sizes of Spheres used for this study are 1) 19.9705 mm 2) 19.9940 mm &3) 29.9971 mm.

2.2 Experimental Procedure

a) CNC programs for sphericity measurement (with 5 points) were prepared on above mentioned coordinate measuring machine (CMM) using different styli and Sphere combinations as shown in below table no1, 2 and 3.

Table 1: Stylus and sphere combination A

Program	Stylus (Tip dia & Shank Length)	Sphere (Diameter)
Program A1	2X30 mm	19.9705mm
Program A2		19.9940mm
Program A3		19.9971mm

Table 2: Stylus and sphere combination B

Program	Stylus (Tip dia & Shank Length)	Sphere (Diameter)
Program B1	3X30 mm	19.9705mm
Program B2		19.9940mm
Program B3		19.9971mm

Table 3: Stylus and sphere combination C

Program	Stylus (Tip dia & Shank Length)	Sphere (Diameter)
Program C1	4X30 mm	19.9705mm
Program C2		19.9940mm
Program C3		19.9971mm

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b) Program A1 to A3, Program B1 to B3 & Program C1 to C3 were run at all 9 locations as shown in the below figure 2. Each program run three times at every location and the results for sphericity are recorded.

Table 4: Locations (identified as “P1” to “P9”) distributed all over the measuring volume of the coordinate measuring machine.

Location	X Coordinate	Y Coordinate
P1	0	0
P2	0	-1000
P3	-600	-1000
P4	-600	0
P5	-600	-1000
P6	0	1000
P7	600	1000
P8	600	0
P9	600	-1000

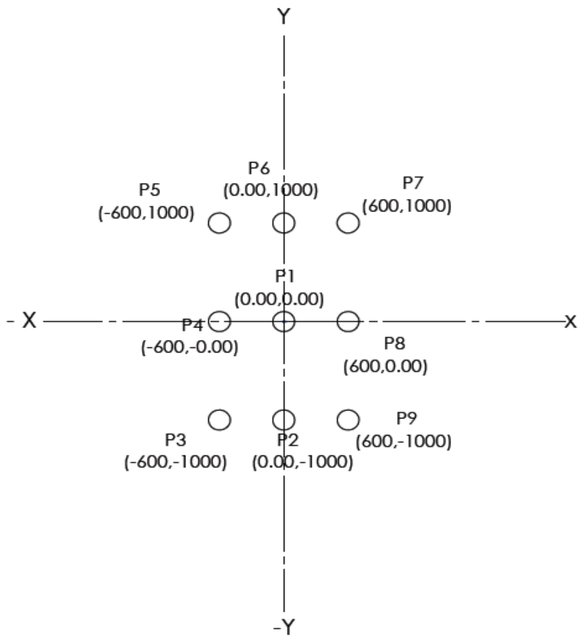

Fig. 2. Locations (identified as “P1” to “P9”) distributed in XY plain all over the measuring volume of the coordinate measuring machine.

c) In order to conduct the time series analysis , above procedure was repeated for 10 days and the results of sphericity was analysed to see the CMM performance.

3. Result Analysis – Performance evaluation of Coordinate measuring machine

3.1 Stylus and sphere combination A :

Table 5: Repeatability data of sphericity measurement with Stylus 2X30 mm (Tip diameter X Shank length) with various Sphere dia combinations

Repeatability data of sphericity measurement with Stylus 2X30 mm (Tip diameter X Shank length) with various Sphere dia combination				
Period of Measurement	Repeatability (in mm)-Stylus 2X30 mm & Sphere dia 19.9705	Repeatability (in mm) -Stylus 2X30 mm & Sphere dia 19.9940	Repeatability (in mm)- -Stylus 2X30 mm & Sphere dia 29.9971	Upper Limit -(Accepted repeatability)
DAY 1	0.0001	0.0003	0.0003	0.002
DAY2	0.0003	0.0004	0.0006	0.002
DAY 3	0.0002	0.0004	0.0004	0.002
DAY 4	0.0003	0.0003	0.0005	0.002
DAY 5	0.0003	0.0005	0.0003	0.002
DAY 6	0.0003	0.0005	0.0003	0.002
DAY 7	0.0002	0.0004	0.0003	0.002
DAY 8	0.0004	0.0003	0.0004	0.002
DAY 9	0.0003	0.0004	0.0003	0.002
DAY 10	0.0004	0.0003	0.0004	0.002

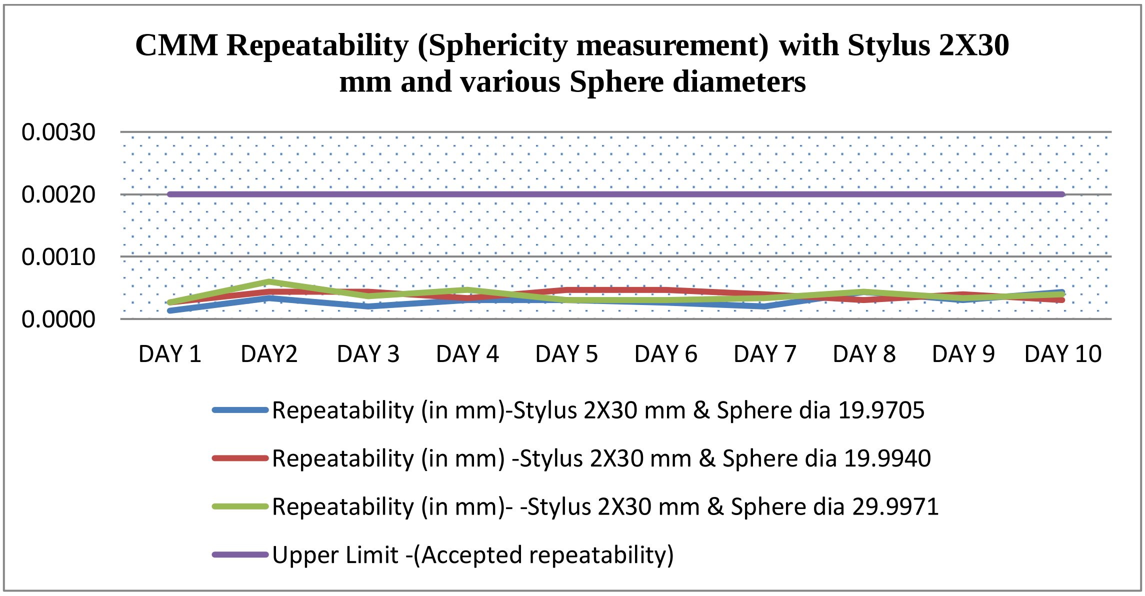

Fig. 3.Graph-Repeatability data of sphericity measurement with Stylus 2X30 mm (Tip diameter X Shank length) with various Sphere dia combination

With the reference of data in table 5 and fig.3, CMM Repeatability (Sphericity measurement) for Stylus and sphere combination A is well within the accepted limit and CMM performance found satisfactory.

3.2 Stylus and sphere combination B :

Table 6: Repeatability data of sphericity measurement with Stylus 3X30 mm (Tip diameter X Shank length) with various Sphere dia combinations.

Repeatability data of sphericity measurement with Stylus 3X30 mm (Tip diameter X Shank length) with various Sphere dia combination				
Period of Measurement	Repeatability (in mm)-Stylus 3X30 mm & Sphere dia 19.9705	Repeatability (in mm) -Stylus 3X30 mm & Sphere dia 19.9940	Repeatability (in mm)-Stylus 3X30 mm & Sphere dia 29.9971	Upper Limit -(Accepted repeatability)
DAY 1	0.0003	0.0007	0.0004	0.002
DAY2	0.0003	0.0004	0.0008	0.002
DAY 3	0.0003	0.0005	0.0003	0.002
DAY 4	0.0005	0.0004	0.0006	0.002
DAY 5	0.0004	0.0004	0.0005	0.002
DAY 6	0.0003	0.0004	0.0003	0.002
DAY 7	0.0004	0.0005	0.0004	0.002
DAY 8	0.0004	0.0004	0.0004	0.002
DAY 9	0.0004	0.0006	0.0003	0.002
DAY 10	0.0006	0.0003	0.0004	0.002

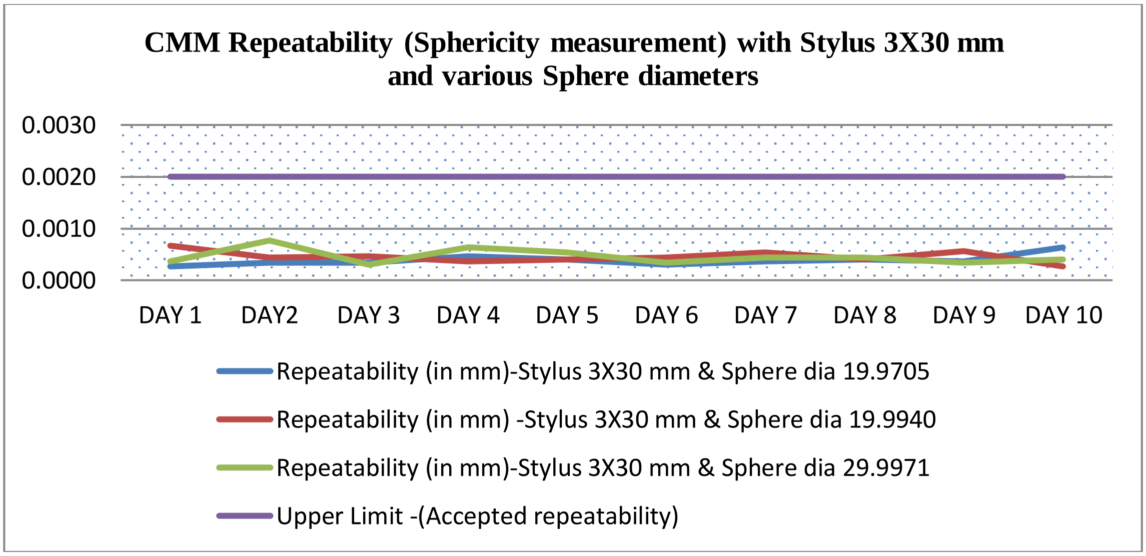

Fig.4.Graph- Repeatability data of sphericity measurement with Stylus 2X30 mm (Tip diameter X Shank length) with various Sphere dia combinations.

With the reference of data in table 5 and fig.4, CMM Repeatability (Sphericity measurement) for Stylus and sphere combination B is well within the accepted limit and CMM performance found satisfactory.

3.3 Stylus and sphere combination C :

Table 6: Repeatability data of sphericity measurement with Stylus 4X30 mm (Tip diameter X Shank length) with various Sphere dia combinations.

Repeatability data of sphericity measurement with Stylus 4X30 mm (Tip diameter X Shank length) with various Sphere dia combination				
Period of Measurement	Repeatability (in mm)-Stylus 4X30 mm & Sphere dia 19.9705	Repeatability (in mm)-Stylus 4X30 mm & Sphere dia 19.9940	Repeatability (in mm)-Stylus 4X30 mm & Sphere dia 29.9971	Upper Limit -(Accepted repeatability)
DAY 1	0.0003	0.0007	0.0004	0.002
DAY2	0.0003	0.0005	0.0004	0.002
DAY 3	0.0003	0.0004	0.0003	0.002
DAY 4	0.0003	0.0004	0.0005	0.002
DAY 5	0.0002	0.0003	0.0006	0.002
DAY 6	0.0007	0.0004	0.0003	0.002
DAY 7	0.0004	0.0007	0.0005	0.002
DAY 8	0.0005	0.0003	0.0004	0.002
DAY 9	0.0004	0.0004	0.0004	0.002
DAY 10	0.0006	0.0004	0.0003	0.002

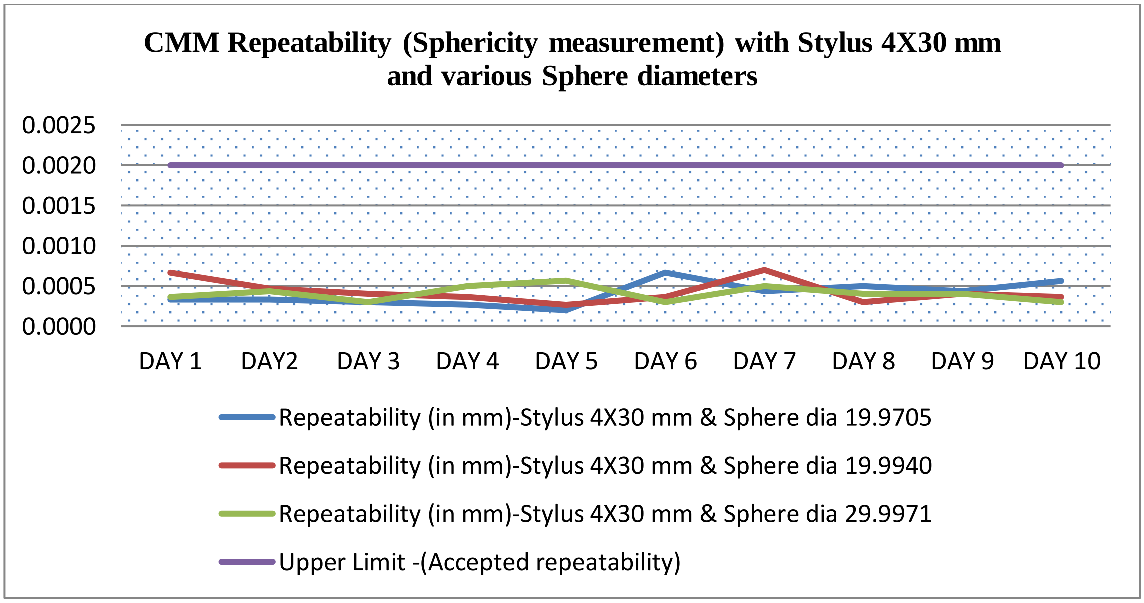

Fig.5.Graph- Repeatability data of sphericity measurement with Stylus 4X30 mm (Tip diameter X Shank length) with variuos Sphere dia combinations.

With the reference of data in table 6 and fig.5, CMM Repeatability (Sphericity measurement) for Stylus and sphere combination C is well within the accepted limit and CMM performance found satisfactory.

4. Conclusions

In this research work, time series analysis of standard sphere CMM data (Sphericity) for machine learning purpose is carried out by a comparative study between the precision (repeatability) obtained with sphericity measurement of three different (in diameter) probe calibration spheres by three different (in diameter) combination of styli, measured on a specific coordinate measuring machine (CMM).

Based on the results we got, it is clear that there is no doubt on the CMMs performance and there is no need of calibrating the CMM till the time we get similar trend of the sphericity repeatability when measured with above procedure.

We can extend the calibration frequency of CMM if we practice to perform this study on regular basis. This would save the calibration cost and CMM breakdown time as well.

References

[1] Puertasa,, C.J. Luis Péreza, D. Salcedoa, J. Leóna, R. Luria, J.P. Fuertes,Precision study of a coordinate measuring machine using several contact probes, The Manufacturing Engineering Society International Conference, MESIC 2013

[2] Fernando A. M. Ferreiraa,, Jesus de Vicente y Olivab, Angel M. Sanchez Perezc, Evaluation of the performance of coordinate measuring machines in the industry, using calibrated artefacts, The Manufacturing Engineering Society International Conference, MESIC 2013.

[3] ASME Y14.5-2009- Dimensioning and Tolerancing.