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Design of Experiment Analysis of Probing Strategy Factor in CMM Measurement

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Abstract: The accuracy of CMM measurement is the crucial factors in determines the size of the part measured. Inaccuracy of measurement will cause the measurement information that obtained also inaccurate. The measurement with inaccurate cause of product rejected.The selection of number and distribution points is the key factors in probing strategy. The inappropriate selection of number and distribution of measurement points may affect to the accuracy of measurement. This paper was purpose to study the effects of number of point and distribution of point selection on the workpiece to the CMM measurements and factor that causing inaccuracy of measurements. The effect of number of point and distribution of point in probing strategy of Coordinate Measuring Machine (CMM) is investigated. The factor such as the low and high number of contact point and point distribution of operator choosing is considered. The measurement is using manual measurement. The DOE analysis method is applied for data analysis.

Keywords: CMM Measurement, Probing Strategy, DOE Analysis

1. Introduction

Coordinate Measuring Machine (CMM) are widely used in manufacturing industries. The accurate measurement, fast, and reliable dimensional measurement of component are make the CMM very useful in industries. CMMs have revolutionized dimensional metrology and become an integral part of industrial quality systems, resulting in lower inspection costs and increased productivity. To ensure that the CMM measurement is always accurate, the error of CMM measurement needs to reduce. The good performance of CMM measurement is expected in manufacturing. Measurement is a process of numerical evaluation of a dimension or the process of comparison with standard measuring instruments**.** In manufacturing, dimensional measurements are needed basically to provide information about some product. The measurement also is very important to knowing the manufactured part that received ismeet to specification.

In this research, the effects of number of point and distribution of point during probing selection in Coordinate Measuring Machine (CMM) measurement investigated. Analyze data expected to show the significant of the two factor selection in CMM measurement. The Design of Experiment (DOE) method is used by Minitab to shows the effect to the measurements.The study has been conducted on the following scopes:

(i) Coordinate Measuring Machine (CMM) Resolution=0.0001 mm
(ii) Circle and length measurement:
Ring gauge with dimension of 70.0060mm
Gauge Block with dimension of 100.00mm is used as workpiece.
(iii) Probing strategy : Number of probing points
: Distribution of measurement points

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2. Experimental

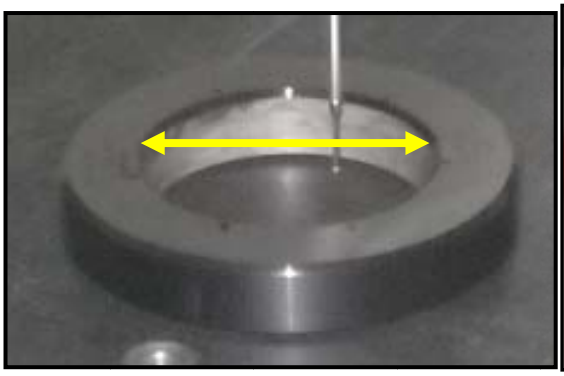


Figure 1.Master ring gauge (Ø 70.0060mm)

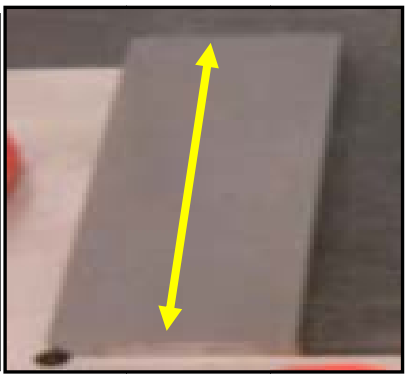
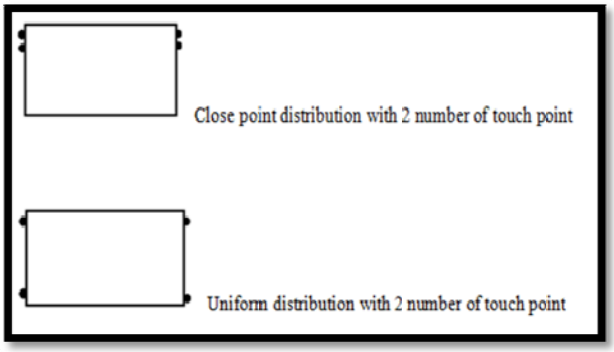


Figure 2. Gauge Block (Length 100.0000mm)

The two specimen is used to in this study. The master ring gauge is used for circle (figure 1) and gauge block (figure 2) is used to measure length measurement. The two different shape of workpieceis used and only one person (1)makes every measurement. For every measurement, the three (3) reading of data is taken. For study the effect of number of point, the two (2) different number of point is used; three (3)and fifteen (15) number of points is selected. For study the effect of distribution point, the close and uniform distribution is selected.

Figure 3. CMM machine



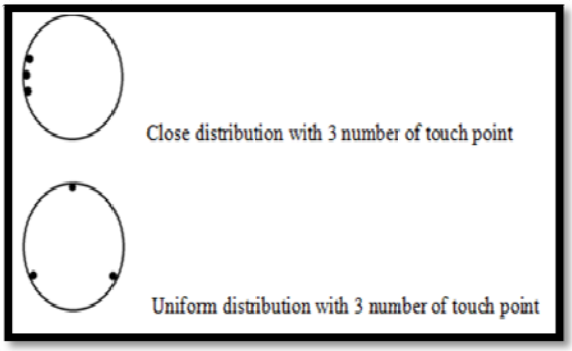


Figure 4.Example of Ring Gauge measurementFigure 5.Example of Gauge Block

3. Analysis and Result

3.1. DOE Analysis

The DOE analysis is conducted to show which factors have more effect to the measurement. It also shows the whether the two effect is significant to CMM measurement.This analysis use full factorial with two factor and two level.

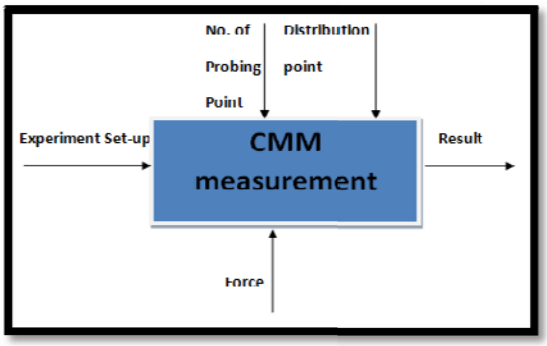
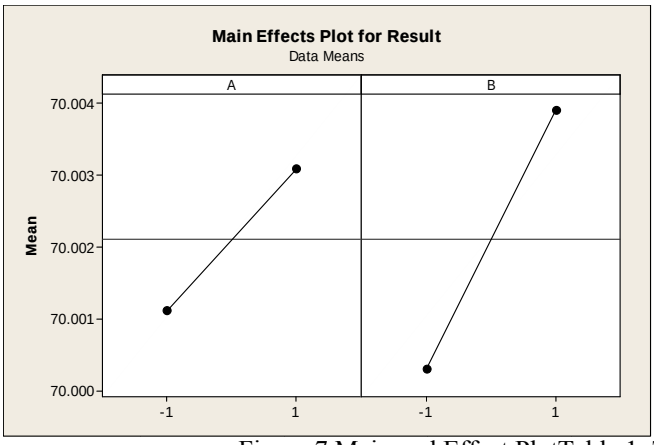


Figure 6. Factor and response measurements

3.2. Experiment 1 : CMM circular measurement using Ring Gauge



Two-way ANOVA: Result versus A, B

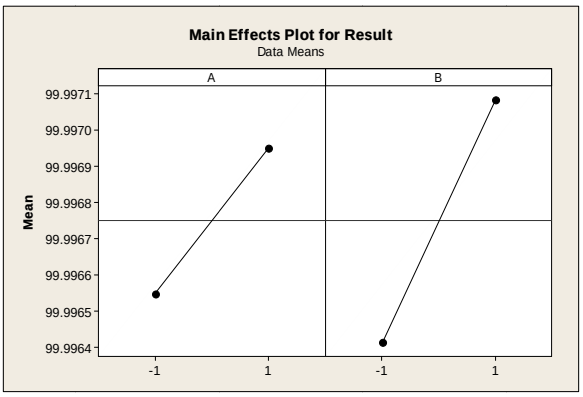
Source	DF	SS	MS	F	P
A	1	0.0000116	0.0000116	17.21	0.003
B	1	0.0000389	0.0000389	57.67	0.000
Interaction	1	0.0000019	0.0000019	2.85	0.130
Error	8	0.0000054	0.0000007		
Total	11	0.0000578			

Figure 7.Main and Effect PlotTable 1. Two-way ANOVA for significant test

The plot in figure 7 shows the B (Distribution point) is giving more effect to measurement by the gradient of line is more than A (Number of point). It shows the distribution of point selection is giving more effect to the measurements. The range result of B also larger than A that shows the inconsistentmeasurement.

Table shows in the table 1 the P value for both A and B is below 0.05. It indicates the two factors, the number of point and point distribution is significant effect to the CMM measurement. But, the interaction of the two factors is not significant. Table show the P value for A (number of point) is less than 0.05 that indicate the number of point significant effect in to this measurement. P value for B (Distribution point) is less than 0.05 that indicate the distribution point is significant effect in this measurement. From the DOE analysis shows that the number of point and distribution point at ring gauge (diameter measurement) is significant effect to the measurement. The distribution point at the workpiece is giving more effect in measurement. The proper strategy in measure diameter of workpiece is by use large number of point and use uniform distribution on the workpiece.

3.3. Experiment 2 : CMM Linear measurement using Gauge Block



Two-way ANOVA: Result versus A, B

Source	DF	SS	MS	F	P
A	1	0.0000005	0.0000005	4.20	0.074
B	1	0.0000013	0.0000013	11.68	0.009
Interaction	1	0.0000000	0.0000000	0.03	0.869
Error	8	0.0000009	0.0000001		
Total	11	0.0000027			

Figure 8.Main Effect PlotTable 2. Two-way ANOVA for significant test

The plot in Figure 8 shows the B (Distribution point) is giving more effect to measurement by the gradient of line is more than A (Number of point). It shows the distribution of point selection is giving more effect to the measurements. The range result of B also larger than A that shows the inconsistentmeasurement.

Table 2 above shows that the P value for A (number of point) is more than 0.05 that indicate the number of point is not significant effect to this measurement. P value for B (Distribution point) is less than 0.05 that indicate the distribution point is significant effect in this measurement. As a result from the DOE analysis shows that the number of point at gauge block (length measurement) did not give significant effect to the measurement. The distribution point at the workpiecein the other hand give more significant effect in measurement. The proper strategy in measure length of workpiece is by use uniform distribution on the workpiece. While ,for the factor of number of point, the result showsthat the effect is less significant if compared to the distribution point factor . Therefore, in this case we no need to use large number of point to save time for measurement.

4. Conclusion and Recommendation

As a conclusion, the analysis shows that two factors in probing strategy in CMM measurement ; the number of probing point and probing point distribution are affecting the result of CMM measurement. The variation of measurement result will cause the inaccuracy of measurement. For the circular measurement in CMM , distribution of probing point factors give the effect to the CMM measurement result. However,For the uniform distribution, the result is not too much difference. The significant difference of measurement result is come from closely point distribution. The closely point distribution is need to avoid during measure circle part because the measurement is worst compare to uniform distribution. It can conclude that the measurement by uniform distribution is suitable in circular measurement. The number of probing point is also effect to this measurement results. The best result is from high number of probing point compare to low. This has proved that number of probing point will influence significantly the circular measurement's results

On the other hand in the measurement of gauge block (linear measurement), both probing strategy factors, distribution point and number of probing give significant effect to the CMM measurement results. From the result, the difference of result is not too much as compared to the measurement of ring gauge (circular measurement). However, the result still shows that the best measurement is from 15 point of probing and uniform distribution point. However, The results shows the number of point factor is less affected in the linear measurement. Therefore,This has been demonstrated that number of probing point factor will not influence significantly the linear measurement's results

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