

# Gage Repeatability and Reproducibility Analysis of Coordinate Measuring Machines for a Coplanarity Measurement

洪子傑、李佳言

E-mail: 9511105@mail.dyu.edu.tw

## ABSTRACT

Today, industrial parts need more accurate dimensions for manufacturing processes than those in the past. These industrial parts with high precision need more reliable and accurate measuring equipments to do the measurement tasks for quality control. Coordinate measuring machines have been predominately used to generate measurement points for a surface. The measurement data are analyzed to yield geometric tolerance information for the surface features such as flatness. With the availability of tolerance information, it is necessary to check if the surface is within the specified limit. In this paper, I compare the effectiveness of Hemmersley sequence sampling, Halton-Zarmba sequence sampling and the Aligned systematic sampling. The mathematical model is used for the measuring points of the workpiece. The experiment is used to find the optimal number of measuring points and an appropriate sampling method to measuring coplanarity with Gage Repeatability and Reproducibility analysis.

Keywords : Coordinate Measuring Machines ; Sampling Method

## Table of Contents

目錄 封面內頁 簽名頁 授權書 iii 中文摘要 iv 英文摘要 v 誌謝 vi 目錄 vii 圖目錄 x 表目錄 xi 第一章 緒論 1 1.1 研究動機 1 1.2 研究目的 2 1.3 研究之重要性 3 1.4 研究方法 3 1.5 研究架構 4 1.6 研究限制 4 第二章 三次元座標測量儀及GR & R介紹 6 2.1 三次元座標量測儀的原理 6 2.2 三次元座標量測儀構成要素 6 2.3 三次元量床的驅動形式及其測長系統 7 2.3.1 三次元量測的導引方式 7 2.3.2 三次元量測儀之驅動方式及其驅動馬達型式 9 2.3.3 三次元量測儀測長系統 10 2.4 三次元座標量測儀的分類 11 2.5 三次元量測儀之探頭 14 2.5.1 機械式探頭 15 2.5.2 觸發式探頭 15 2.5.3 掃描式探頭 16 2.6 三次元量測座標儀量測程序 17 2.7 量具之重複性與再線性介紹 18 2.8 幾何公差 19 第三章 文獻探討 22 3.1 CMM量測能力研究 22 3.2 量測路徑方面 22 3.3 量測點數與量測點位置方面 23 3.4 物件特性 23 3.5 量具之重複性與再線性 24 第四章 研究方法 26 4.1 量測工件介紹 26 4.2 CMM量測能力 27 4.3 Hammersely sequence sampling 29 4.4 Aligned systematic sampling 32 4.5 Halton-Zaremba sequence sampling 32 4.6 GR & R實驗步驟 35 第五章 實驗結果 36 5.1 實驗室設備與環境 36 5.2 CMM量測能力實驗數據分析 38 5.3 Hammersely sequence sampling 42 5.4 Aligned systematic sampling 45 5.5 Halton-Zaremba sequence sampling 46 5.6 抽樣量測結果比較 48 5.7 GR&R實驗 49 第六章 結論 52 6.1 結論 52 6.2 建議 52 參考文獻 54

## REFERENCES

- 參考文獻 [01] Carr K.and Ferreirat P.,Verification of form tolerances Part 1:Basic issues,flatness,and straightness ” ,Precision Engineering, 17,pp.131-143,1995.
- [02] Hansen,H.N. and Chiffre, L.D. “ An industrial comparison of coordinate measuring machines in Scandinavia with focus on uncertainty statements ” , Precision Engineering,23,pp.185-195, 1999.
- [03] Yau,H.T.and Menq, C.H. “ Automated CMM path planning for dimensional inspection of dies and molds having complex surfaces ” ,International Journal of Machine Tools & Manufacture, 35 ( 6 ) ,pp.861-876,1995.
- [04] ASME Y14.5M :Dimensioning and Tolerancing, American Society of Mechanical Engineers, New York, 1994.
- [05] Lee,G., Mou,J.and Shen,Y., ” Sampling strategy design for dimensional measurement of geometric features using coordinate measuring machine ” ,International Journal of Machine Tools and Manufacture,37 ( 7 ) ,pp.917-934,1997.
- [06] Paulo,C.M., King,T.and Davis,J., “ CMM verification :a survey ” , Measurement,17 ( 1 ) ,pp.1-16,1996.
- [07] Weckenmann,A., Knauer,M.and Killmaier,T., “ Uncertainty of coordinate measurements on sheet-metal parts in the automotive industry ” ,Journal of Materials Processing Technology, 115,pp.9 - 13,2001.
- [08] Lee ,M.K., ” A new convex-hull based approach to evaluating flatness tolerance ” ,Computer-Aided Design, 29 (12),pp.861- 868,1997.
- [09] Mandel, J., “ Repeatability and Reproducibility, ” Journal of Quality Technology , Vol.4, No.2, pp.74-85 (1972).
- [10]Tsai, P. “ Variable Gauge Repeatability and Reproducibility Study Using The Analysis Of Variance Method, ” Quality Engineering, 1(1), pp.107-115 (1988-89).
- [11]潘善鵬, ” 三次元座標量測儀量測精度研究 ” , 中華大學機械與航太工程研究所碩士論文, 2001。

[12]范光照、張郭益;“精密量具及機件檢驗“,高立圖書公司,1995.

[13]陳盈宏;“尺寸與幾何公差評估法研究“,國立中央大學,碩士論文,1984.

[14]范光照,“使用三次元做自動化尺寸檢驗“,機械月刊第20卷第二期,83年,pp.150-154.