AIN SHAMS UNIVERSITY
Faculty of Engineering
Design and Production Engineering Department

3D SURFACE PLOT MAPPING FOR FREEFORM USING CNC-CMM

A Thesis submitted in partial fulfilment of the requirements of the degree of
Master of Science in Mechanical Engineering
(Design and Production Engineering)

by

Ahmed Sobhy Mohammady Ibrahim

Bachelor of Science in Mechanical Engineering
Manufacturing Engineering and Production Technology
Modern Academy for Engineering and Technology, 2011

Supervised By

Prof. Dr. Monir M. F. Koura
Design and Production Engineering
Ain Shams University

Prof. Dr. Salah H. R. Ali
Head of Engineering and Surface Metrology
National Institute of Standards

Dr. Ahmed S. M. El-Akkad
Design and Production Engineering, Ain Shams University

Cairo - (2019)

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Dr. Monir M. F. Koura Design and Production , Ain Shams University	…….
Prof. Dr. Magdi Ibrahim Mohammed National Institute for Standards	…….
Prof. Dr. Mohammed Abd Al-Mohsen Mahdi Design and Production , Ain Shams University	…….

Date: Aug. 2019

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Prof. Dr. Salah H.R. Ali Eng. &Surface Metrology, National Institute of Standards	…….
Dr. Ahmed S. M. El-Akkad Design and Production , Ain Shams University	…….

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Statement

This thesis is submitted as partial fulfilment of Master of Science in Mechanical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

Ahmed Sobhy Mohammady Ibrahim

Signature

……...…….

Date: Aug 2019

Researcher Data

Name	: Ahmed Sobhy Mohammady Ibrahim
Date of birth	: 23 May 1989
Place of birth	: Saudi Arabia
Last academic degree	: Bachelor of Mechanical Engineer
Field of specialization	: Manufacturing Engineering and Production Technology
University issued the degree	: Modern Academy for Engineering and Technology
Date of issued degree	: May 2011
Current job	: Researcher Assistant at National Institute of standards (NIS), Egypt

THESIS SUMMARY

The thesis consists of five Chapters, including the introduction, methodological description of the research plan, previous studies on the subject, and the practical studies that included different methods of freeform surface measurement, presenting a proposed method for calculating, and estimating the kinematic errors of three-axis Computer Numerical Control Machine tool (CNC machine tool), this done by analyzing plot mapping of the proposed test-piece, which was machined on CNC machine tool. The proposed test-piece designed and machined using NX 8 Unigraphics CAD/CAM software Package. The three-axis CNC-machine tested by conventional methods (direct and indirect method) in accordance with international standards. The thesis concludes with recommendations and proposed future actions.

The use of freeform surfaces in various industry sectors such as the aircraft industry, automobiles and casting molds for engineering products to serve aesthetic purposes or for a technical function has increased, which increases the need to produce more complex and high-precision freeform surfaces to fulfill customer demands.

CNC machine tools are the main tool used in the manufacture of freeform surfaces because of their ability to manufacture complex parts with high accuracy, high frequency and cost-effective. The accuracy of the CNC machine tool used is one of the most important factors affecting the accuracy of manufactured freeform surfaces. Determining the kinematic errors of the CNC machine tool is a preferred way to improve the accuracy of the manufactured parts.

There are two conventional methods of testing CNC machine tools, indirect and direct method. The indirect method is used to evaluate the performance of CNC machine tools by judging the accuracy of a trial test sample manufactured and measured in accordance with international standards. This method is much easier; however, the kinematic errors are not identified. The direct method in which the Kinematic errors of CNC machine tools are separated and determined using precision instruments such as laser interferometry. The method is more accurate but requires a long time and expensive devices and highly trained operators, which makes it more expensive and unpopular to use.

The aim of this thesis:

Studying plot mapping of the freeform surface because they are used in almost all engineering products and provide a proposed method for calculating and estimating the Kinematic errors of the three-axis CNC-machine tool by analyzing the plot mapping measurement data of the proposed test-piece which machined according to specified steps. To implement this in practice.

First step: Presenting the research plan, a proposed test-piece is designed using NX8 Unigraphics CAD/CAM software, machining was planned according to specific sequences described in detail in the thesis. DMG 360 linear three-axis milling CNC-machine tool was used. The plot mapping of the proposed test-piece was done utilizing BJ 1015 Mitutoyo Coordinate Measuring Machine (CMM) utilizing contact probs, and by analyzing the results, the Kinematic errors of used three-axis CNC machine tool were calculated and estimated as a suggested method.

Second step: Conventional methods for testing a CNC machine tool (direct and indirect method) were applied. The direct method is planned and carried out according to ISO 230-2:2014 guidelines and recommendations using laser interferometry. The Laser interferometry was provided by NIS. The indirect method was done using a medium-sized trail test-piece, which selected according to ISO 10791-7: 2014 guidelines and recommendations.

Eventually: a comparison have been made between the proposed method and the conventional methods of measuring a three-axis CNC machine tool to evaluate the efficiency of the proposed method for calculating and estimating the kinematic errors of the three-axis CNC machine tool with an estimate of the associated uncertainty related to these measurements.

ACKNOWLEDGMENT

It gives me great pleasure to take this opportunity to acknowledge my indebtedness to all those who have helped me in one way or another in completing the present work.

The First and Outmost Appreciation and Thanks to ALLAH.

I would like to express my deepest thanks to my supervisors, **Prof. Dr. Monir M. F. Koura**, **Prof. Dr. Salah H. R. Ali**, and **Dr. Ahmed EL-Akkad** for their helps, scientific support, continuous encouragement and guidance during my research work.

I owe special thanks to ***Arab Organization for Industrialization*** and ***Aircraft Factory (ACF)*** for their help, provid machine tools needed for the study as well as materials, helping, and guiding as a specialist in dealing with CNC machine tools. I hope a new era of integrity between the industry and scientific research to achieve sustainable development. Such integration would hope to benefit both.

My deepest gratitude goes to my parents and my family for their endless love, encouragement and support during my life.
I would like, also, to acknowledge my laboratory (Engineering and Surface Metrology), at National Institute of Standard (NIS), for providing facilities and hi-technology instrumentations to carry out the present work. My thanks go also to my all colleagues' staff for their help and fruitful discussions.

Aug. September 2019

Table Of Contents