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Application Of Coordinate Measuring Machine In Reverse Engineering: A Case Study

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Abstract

In this work, Reverse Engineering technique is used gathering scientific knowledge about a part by physically examining it with the help of Coordinate Measuring Machine (CMM). Taking a case study of a cover plate of gear box of Falcon Rotavator, this report describes the processes of RE, from object digitization to CAD model reconstruction and error analysis. Measurement data are acquired by scanning the physical object using a three-dimensional CMM.

Point cloud data of Cover Plate of gear box of Falcon Rotavator is to be generated using three dimensional Coordinate Measuring Machine. It helped in creation of CAD model using CATIA software. Also with the help of CMM scanning precise dimensions have found which are helped in comparative error analysis which showed that CMM scanning is a better method of dimensional analysis as compared to manual scanning.

1. Introduction

The process of duplicating an existing part, subassembly, or product without the aid of drawings, documentation, or a computer model is known as reverse engineering. Reverse engineering is also defined as the process of obtaining a geometric CAD model from 3D points acquired by scanning/ digitizing the existing products.[1] Reverse Engineering originally emerged as the answer to provide spares for replacing broken or worn out parts for which no technical data was available. This can be the case if the part was originally imported (without drawings) or the drawings being misplaced or lost. Reengineering or reverse engineering such parts can be a less expensive option compared to reimporting, not only for immediate replacement, but also to create additional spares to maintain the product over a longer period. Reverse Engineering has been defined as a process for obtaining the technical data of a critical spare component. Computer-aided reverse engineering relies on the use of computer-aided tools for obtaining the part geometry, identifying its material, improving the design, tooling fabrication, manufacturing planning and physical realization. A solid model of the part is the backbone for computer-aided reverse engineering. The model data can be exported from or imported into CAD/CAE/CAM systems using standard formats such as IGES, STL, VDA and STEP.[2]

The data-collecting unit in a CMM is the probe. Therefore, selection of probe and its positioning is very crucial. Instructions must be given to CMM system for the speed for positioning the probe, the path to be followed by the probe, angle at which the probe approaches etc. Then, the data about the checked part is sent back to the computer, where the original part geometry is stored. The part geometry as designed is compared with the part produced and the resultant deviation could be identified. It helps in identifying problems in manufacturing. [3]

This paper introduced applications of CMM for obtaining point cloud data and cover plate of gear box of rotavator is used. Duplicating the part is done with the help of CMM and CAD/CAM software. CMM is used to digitize the mechanical object. Taking coordinates (scan data) of the various points on the surface of the object and converting it into IGES file and using the same in the CAD/CAM software with required interfacing creates a surface or solid model of the object. Rapid reverse engineering of severe worn cam of textile machinery was realized by contact measuring profile points using CMM. Reconstructing the digital model and locally modifying reconstructing computer model in CAD software.

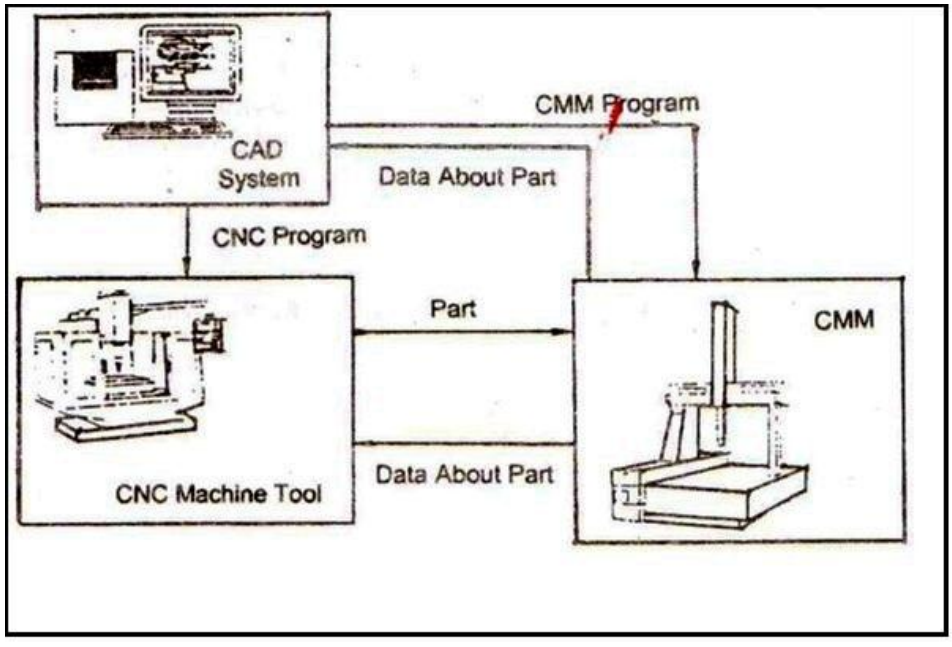

Figure 1.Interrelation among CNC machine tool, CAD system and a CMM

Other applications of Reverse Engineering are seen in various other fields. Such as,

i. Computer Arts: Reverse engineering is used to create realistic digital representations of props or figures that will be transformed and realized on screen.
ii. Medical, Dental
iii. Design / Product Development: The reverse engineering process is a key step for manufacturing companies to create innovative products.
iv. Manufacturing / Product Validation
v. Cultural Heritage.[4].

The RE process can be divided into three steps:

- Digitising;
- Data segmentation;
- Data fitting

The first objective of RE methodology is to generate a conceptual model (example: surface triangulated) from a physical model: a sample (part or tool) or prototype. In this sense the 3D-scanning (digitising) techniques aided by specialised software's for model reconstruction are necessary.

3D-scanning (digitising) is the process of gathering data from an undefined three-dimensional surface. During the scanning process, an analogue-scanning probe is commanded to move back and forth (contact or non-contact) across the unknown surface. During this process, the system records information about the surface in the form of numerical data—generates a point's cloud matrix (3D-coordinates). [5]

2. Methodology

In this project work reverse engineering approach is utilised for preparation of CAD model. A Coordinate Measuring Machine (CMM) is utilised for collection of point cloud data. In this work CMM named Global Classis CMM Hexagon Classic SR is used for the study purpose. This CMM collects the data by mechanical method i.e. using touch probe. The CMM probe collects data by probes touching the surface along the complete profile of that part. It gives the data in the form of point cloud which is then exported to any CAD modelling software for converting it into CAD model.

In this case CATIA software is used for converting the point cloud data into CAD model. In this software first all the points are joined. Then they are padded to form the 3D model of the cover plate.

This CAD model can be use for preparation of inspection program.

3. Use of Coordinate Measuring Machine for Point Cloud Generation:

A **coordinate measuring machine** is a device for measuring the physical geometrical characteristics of an object. This machine may be manually controlled by an operator or it may be computer controlled. In this work, a cover plate of gear box is studied. Any details except its physical model were absent. The main task ahead was to prepare its physical model. The cover plate is shown in Figure 2.

Figure 2 Cover plate of gear box

The job of obtaining CAD model from physical model consists of following steps:

i. Scanning the physical part with the help of CMM.

ii. To obtain point cloud data of a component through CMM scanning.

iii. To export this cloud point data of CMM (PCDMIS software) to the modeling software (preparation of IGES, STET, STL file).

iv. To prepare a CAD model & obtain the various dimensions of the component.

v. Importing the CAD model to the PCDMIS software & preparing inspection program for error analysis.

In this study, first the scanning of physical model of cover plate was done. It gives the point cloud data for the component. This point cloud data was then imported to the modelling software CATIA. Figure 3 shows how this the point cloud data is seen in CATIA.

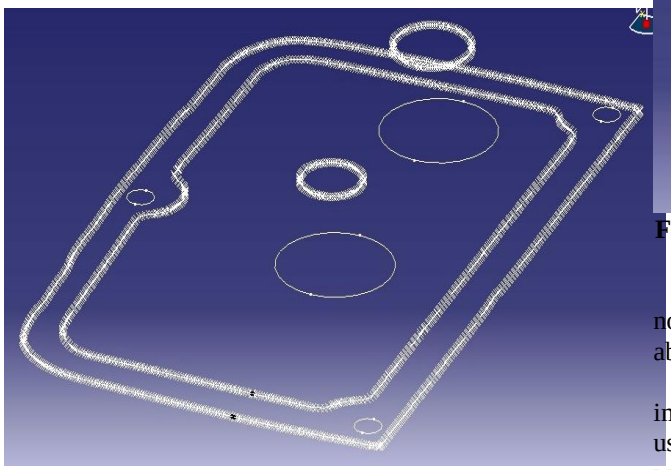

Figure 3 Point cloud data obtained from CMM

Then all the points in the point cloud data are joined for the preparation of CAD model. Figure 4. shows the model when all the points are joined.

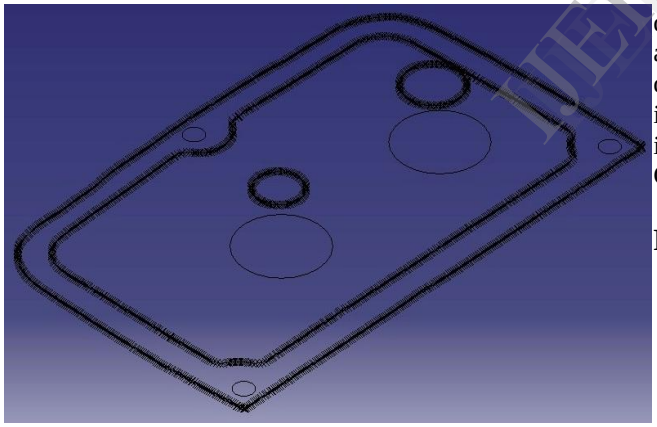

Figure 4 Point cloud data when all the points are jointed in CATIA

After this a CAD model is prepared from the point cloud data using various commands in the CATIA software. Figure 5 shows the CAD model of the cover plate.

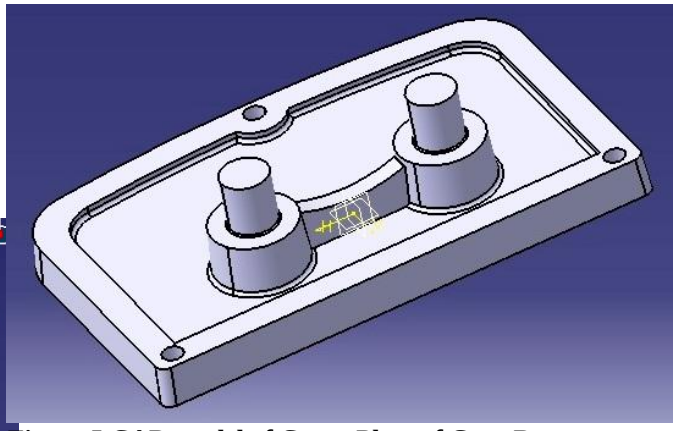

Figure 5 CAD model of Cover Plate of Gear Box

All the dimensions of the parts which are not known can be easily found with the help of above CAD model.

In the next stage, this CAD model was imported to the PCDMIS software where it was used for preparation of inspection program. Also with the help of this inspection program all the components that are manufactured in future can be inspected for error analysis.

Conclusion

The above study shows that using Coordinate Measuring Machine helps to get the unknown details of any component. The intricate dimensions which are not possible to measure by any other method can be measured easily. The design process can also be simplified and cost incurred in designing is also minimises. Also the inspection activity is simplified with the help of CMM machine.

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