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Reverse Engineering using CMM and CAD Tool

Dr. S.B. Thakare
Professor,
Deptt.of Mechanical Engg.
PRMIT & R, Badnera

Mr. Aniket Awate
Final Year Bachelor of Engineering Student
Deptt.of Mechanical Engg.
PRMIT & R, Badnera

Abstract

In this paper, approach for Reverse Engineering (RE) technique using Coordinate Measuring Machine (CMM) and a design software CATIA ispresented.A part is physically examined with the help of CoordinateMeasuring Machine (CMM). Point cloud data of a part is generated through scanning on CMM. Point cloud data is then exported to CAD software CATIA to generate CAD model of a part. Thus, this report describes the processes of RE, from object digitizationto CAD model reconstruction and error analysis.

A case study of RE using CMM and CAD tool is presented considering a part i.e. cover plate of gear box of JADHAO Rotavator is presented and finally important conclusions are drawn.

1. Introduction

Reverse engineering is a process by which the design of a product is analyzed or recreated using a physical part as a starting point. During the design process for a new product, clay models and different types of prototypes are made in order to test, evaluate and validate the conceptual design. This process is usually iterative and requires several modifications to the original design. For that reason, reverse engineering can become a valuable solution for extracting the dimensions of handmade models, clay models and prototypes; especially those with freeform shapes. You could also acquire the 3D geometry of an existing object in order to incorporate some of its features in the new product design. In addition to that, 3D scanning solutions also provide a powerful tool for documenting and archiving the different design iterations.The critical steps in reverse engineering are acquiring, accurately and efficiently, the dimensions of the object and extracting the necessaryinformation from the resulting scan in order to create the new design with the right look and functionality.

Reverse engineering is alsodefined as the process of obtaining a geometric CADmodel from 3D points acquired by scanning/ digitizingthe existing products.[1] Reverse Engineeringoriginally emerged as the answer to provide spares forreplacing broken or worn out parts for which notechnical data was available. This can be the case if thepart was originally imported (without drawings) or thedrawings being misplaced or lost. Reverse Engineering has been defined as a process forobtaining the technical data of a critical sparecomponent.Computer-aidedreverse engineering relieson the use of computer-aided tools for obtaining thepart geometry, identifying its material, improving thedesign, tooling fabrication, manufacturing planning andphysical realization. A solid model of the part is thebackbone for computer-aided reverse engineering. Themodel data can be exported from or imported intoCAD/CAE/CAM systems using standard formats suchas IGES, STL, VDA and STEP. [2]

The data-collecting unit in a CMM is theprobe. Therefore, selection of probe and its positioningis very crucial. Instructions must be given to CMMsystem for the speed for positioning the probe, the pathto be followed by the probe, angle at which the probeapproaches etc. Then, the data about the checked part issent back to the computer, where the original partgeometry is stored. The part geometry as designed iscompared with the part produced and the resultantdeviation could be identified. It helps in identifyingproblems in manufacturing. [3]

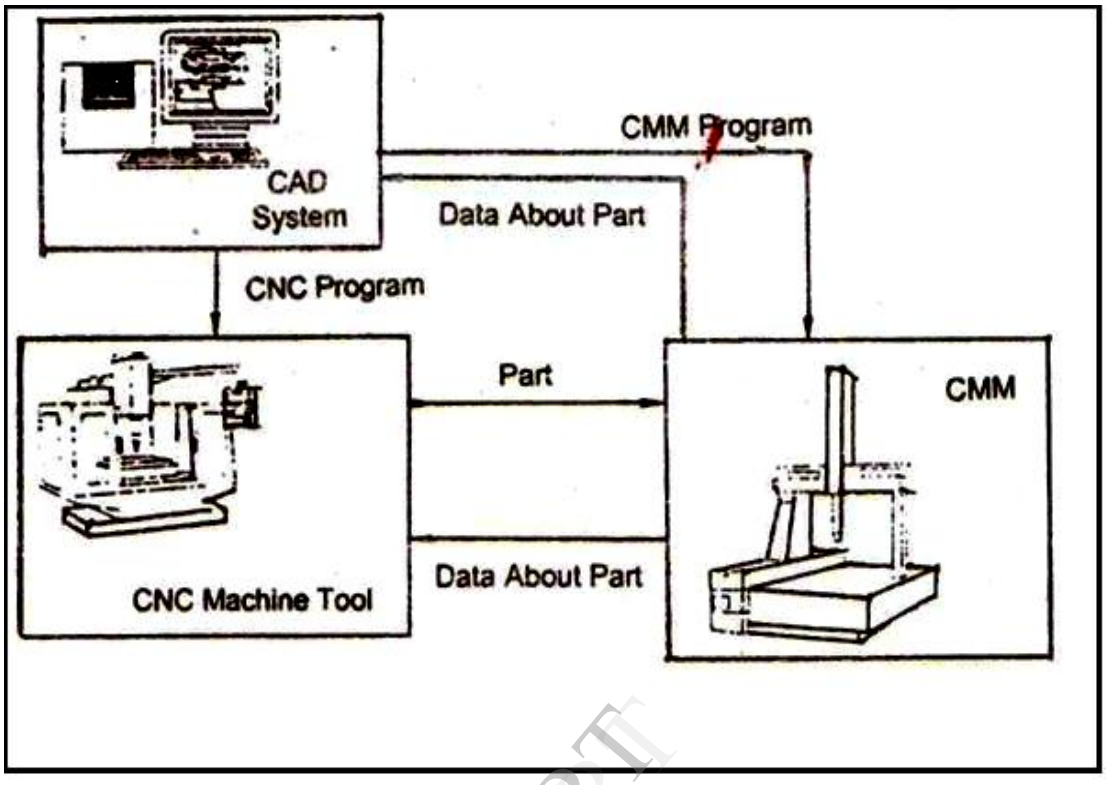

Figure 1.Interrelation among CNC machine tool, CAD system and a CMM

Following are some of the reasons for using reverse engineering:

* The original manufacturer no longer exists, but a customer needs the product, e.g., aircraft spares required typically after an aircraft has been in service for several years.
* The original manufacturer of a product no longer produces the product, e.g., the original product has become obsolete.
* The original product design documentation has been lost or never existed.
* Creating data to refurbish or manufacture a part for which there are no CAD data, or for which the data have become obsolete or lost.
* Inspection and/or Quality Control–Comparing a fabricated part to its CAD description or to a standard item.
* Some bad features of a product need to be eliminated e.g., excessive wear might indicate where a product should be improved.
* Analyzing the good and bad features of competitors' products.
* Exploring new avenues to improve product performance and features.
* Creating 3-D data from a model or sculpture for animation in games and movies.
* Creating 3-D data from an individual, model or sculpture to create, scale, or reproduce artwork.

The RE process can be divided into three steps:

- Digitizing;
- Data segmentation;
- Data fitting

The first objective of RE methodology is togenerate a conceptual model (example: surfacetriangulated) from a physical model: a sample (partor tool) or prototype. In this sense the 3D-scanning(digitising) techniques aided by specialized software's for model reconstruction are necessary.3D-scanning (digitizing) is the process ofgathering data from an undefined threedimensionalsurface. During the scanning process,an analogue-scanning probe is commanded to moveback and forth (contact or non-contact) across theunknown surface. During this process, the systemrecords information about the surface in the form ofnumerical data—generates a point's cloud matrix(3D-coordinates). [5]

2. Methodology

In this project work reverse engineeringapproach is utilized for preparation of CAD model.In thiswork

CMM named Global Classis CMM HexagonClassic SR is used for the collection of point cloud data. It is collected by mechanical method i.e.using touch probe. The CMM probe collects databy touching the surface along the completeprofile of the part. It gives data in the form ofpoint cloud which is then exported to any CADmodeling software for converting it into CAD model.In this case CATIA software is used forconverting the point cloud data into CAD model. Inthis software first all points are joined. They are padded to form the 3D model of the coverplate.This CAD model can also be used forthepreparation of inspection program.

3. Point Cloud Generation using CMM

A coordinate measuring machineis adevice for measuring the physical geometricalcharacteristics of an object. This machine may bemanually controlled by an operator or it may bedirect computer controlled (DCC). In this work, a coverplate of gear box is studied. Any details except itsphysical model were not available. The main task aheadwas to prepare its physical model. The cover plateis shown in Figure 2.

Figure 2 Cover plate of gear box

The job of obtaining CAD model fromphysical model consists of following steps:

i. Scanning the physical part with the help ofCMM.
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 modelingsoftware (preparation of IGES, STET,STL file).
iv. To prepare a CAD model & obtain thevarious dimensions of the component.
v. Importing the CAD model to the PCDMISsoftware& preparing inspection programfor error analysis.

In this study, first the scanning of physicalmodel of cover plate was done. It gives the pointcloud data for the component. This point cloud datawas then imported to the modeling softwareCATIA. Figure 3 shows the point clouddata as seen in CATIA.

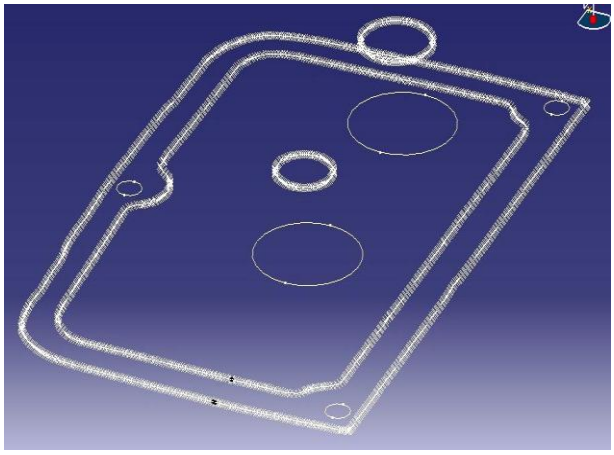

Figure 3 Point cloud data obtained from CMM

All the points in the point cloud dataare joined for the preparation of CAD model.Figure 4.shows the model when all the points arejoined.

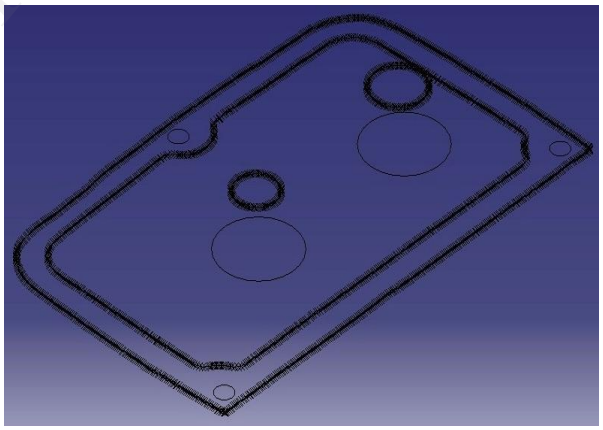

Figure 4 Point cloud data when all the points arejoined in CATIA

ACAD model is prepared fromthe point cloud data using various commands in theCATIA software. Figure 5 shows the CAD modelof the cover plate.

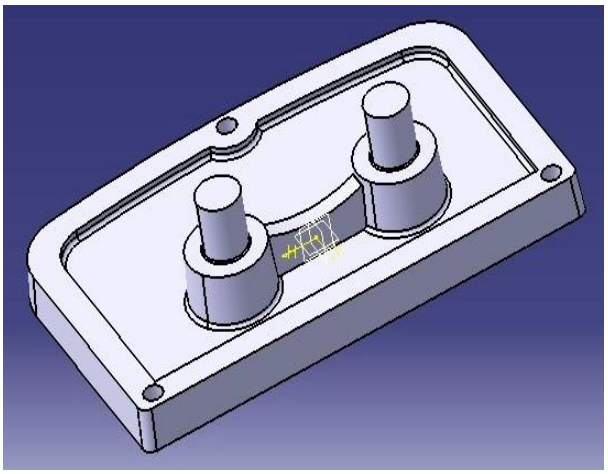

Figure 5 CAD model of Cover Plate of Gear Box

All the dimensions of the parts which arenot known can be easily found with the help ofabove CAD model.In the next stage, this CAD model wasimported to the PCDMIS software where it wasused for preparation of inspection program. Alsowith the help of this inspection program all thecomponents that are manufactured in future can beinspected for error analysis.

Conclusion

The above study shows that usingCoordinate Measuring Machine helps to get theunknown details of any component. The intricatedimensions which are not possible to measure byany other method can be measured easily. Thedesign process can also be simplified and costincurred in designing is also minimum. Also theinspection activity is simplified with the help ofCMM machine.

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