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INTEGRATION OF CAD/CAM AND CAI THROUGH STEP FILE

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Abstract

CAD and CAM play a key role to produce products of high quality in reduced time. However, practically there is lack of smooth flow of information between these systems. Hence these systems are to be integrated for automatic transmission of data. This can be achieved by CAD exchange files. In this work, an attempt is made to integrate CAD, CAM and CAI using STEP file. The part model created is converted to STEP file and the CAD data extracted from the STEP file is used as reference data for inspection. From the CAD model, NC code is generated using the manufacturing module of the CAD/CAM software. The parts are produced by the generated NC code and are subjected to inspection using image processing technique. Then the inspection results and the reference data are compared for detecting error.

1.1 Introduction

In the industrial environment, all the stages of the product lifecycle are performed and controlled manually. This causes increasing manufacturing defects and non value added activities. This can be overcome by automation. To implement automation in an industry, computer systems are used to control manufacturing activities and business related functions and is known as computer integrated manufacturing (CIM). CAD and CAM are the main components of a CIM system [1]. CIM is impossible in the absence of the integration of design and manufacturing [2].

CAD model contains all part definition data which are to be retrieved for various applications such as process planning, NC code generation, assembly planning, inspection and

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so on. However, practically there is a lack of smooth flow of information between these systems. Hence, these systems have to be integrated for automatic transmission of data. This can be achieved by CAD exchange files which are neutral file format to transmit the data in the CAD/CAM systems. STEP files are data exchange files now gaining popularity due to various advantages. These can be used through out the product life cycle for various applications. Inspection is one such application where the data in the STEP files can be used as reference data for computer aided inspection. Hence, the CAD information from the STEP file can be used for CAM, CAI and so on.

1.2 Problem Statement

Computer aided systems such as CAD, CAM and CAI are developed in accordance with the needs of different departments in enterprise during the process. These systems could not realize automatic transmission and exchange of data due to lack of link between programs. Here, designer needs to convert the technical files to proper data format. This in turn causes waste of material and time and produces error during data transmission and conversion and reduces reliability of product data. Hence integration of CAD and CAM becomes essential which enables direct transmission of the data among computers.

CAD contains all part definition data in an integrated design and manufacturing system. The relevant part definition data contained in the CAD database are to be retrieved for various manufacturing applications. Manufacturing applications generally operate on the basis of features. Feature data is essential for integration of CAD and CAM. To achieve this, automatic interpretation of feature data from the CAD model is necessary for further downstream applications.

In the present manufacturing scenario many industries need to produce products of better quality in lesser time and cost. Each industry may use CAD systems of different capabilities and functionalities. However a great deal of data has to be exchanged between them. But all the data are not in a uniform format. Hence, data has to be translated from original system format into a standard neutral file format and then from neutral format into the target system format.

For exchange of data, many neutral file formats are used in industries in which some of them

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are international standards. Of these, STandard for the Exchange of Product model data (STEP) format is emerging as a new standard for CAD/CAM design to provide complete unambiguous, computer readable definition of the physical and functional characteristics of a product through out its lifecycle. This can be used effectively for different applications such as CAPP, NC code generation, CAI, and assembly and so on.

In industries, inspection is performed by human inspectors on a small-sized sample which is generally a time-consuming procedure involving precise, yet monotonous work. Hence, automatic inspection is needed which can be done through computers known as computer aided inspection (CAI) to reduce lead time in manufacturing. For the computer aided inspection, the data extracted from the CAD model can be used as reference data which lead to the integration of CAD, CAM and CAI systems.

1. LITERATURE SURVEY

Computers are used to integrate the islands of automation such as CAD, CAM and CAI by using information from CAD models [3]. In today's global market, quality is an important factor to determine the market of a product. This can be achieved by CAI, which also reduces time, cost and labour. There are two methods to use the CAD information for CAI. In the first method, the extracted data from the CAD model are directly used in CAI. In the other method, an information model is developed from which the data are send to the CAI. Peihua Gu proposed a new feature model as part of a product model to improve design representation in a computer integrated environment [4]. Ismail *et al.*, described a methodology to extract the feature information from STEP file and recognize the features using rule-based technique [5]. Kramer developed a feature based inspection and control system which requires feature based description of part as an input [6]. Newman and Jain used CAD model information for surface classification and inspection of 3D castings in range images [7]. Jose *et al.*, discussed least squares and minimax mathematical models and algorithms to determine the out-of-roundness error in automated roundness inspection [8]. Woods *et al*., described a methodology for reliably locating pre-defined features in constrained images which used a geometric model for knowledge about images and a grey level model capable of identifying specific features in

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grey level profile [9]. Prieto *et al.*, used a cloud of 3D measured points of a part provided by a range sensors and its CAD model for automated inspection of manufactured parts [10].

Perusal of the available literature indicates that many works have been done to integrate CAD, CAM and CAI. Many methods of integration are sighted in which integration through CAD exchange files is one among them. This can be effectively used in downstream applications.

4.0 METHODOLOGY

In this work, it is proposed to integrate the various stages of product life cycle. A part model is created using commercial modeling software and is converted into STEP data. The feature data for inspection are extracted from STEP file using the program written in C++ language. Then NC code for manufacturing the part is generated from the CAD model using CAM module and the part is manufactured using CNC machine. Further the part produced is inspected using image processing technique. Thus the results obtained from image processing technique are compared with reference data for finding the error.

4.1 Generation of CAD model

In this work, a stepped cylindrical part is taken. The part model is created using Pro/ENGINEER software. The stepped part has three length dimensions and are 20, 15 and 10 mm and diameters of 24, 20 and 16 mm respectively. The part model created is shown in figure 1.

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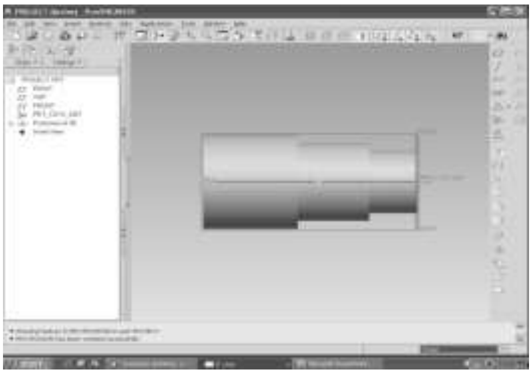

Figure 1 A stepped cylindrical part

4.2 Extraction of data

The part model is converted to STEP file. The STEP file contains all part definition data which are to be retrieved for various applications such as process planning, NC code generation, assembly planning, inspection and so on.

The information for inspection contained in the data section of the STEP file in the form of vertices, coordinates, vectors and so on is to be extracted for inspection. This forms the reference data. An algorithm is developed for extracting the reference data for inspection. A program is written in C++ language based on the algorithm for the extraction of the reference data from the STEP file. The output of the program for reference data extraction is shown in table 1.

Table 1 Reference data from STEP file

Parameter	Step1	Step 2	Step 3
Diameter (mm)	24	20	16
Length (mm)	20	15	10

4.3 NC code generation and machining

To manufacture the part, the NC code is generated from the part model created in Pro/ENGINEER. For generating the NC code CAM module of the Pro/ENGINEER software

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is used. First the raw material part model is created over the finished part model. Then the tool path is defined for the part. After completion of the tool path the simulation is carried out. Of the available post processors, the FANUC post processor is selected. The NC code is automatically generated.

The NC code is given as the input to the machine simulation software to view simulation. Then this NC code is entered in the XLTURN lathe CNC machine. An aluminium rod of 25.4 mm diameter and 75 mm length is used as a raw material and carbide tipped tool is used for machining. Five similar parts are machined.

4.4 Inspection using image processing

In the present industrial environment image processing is considered as an important technology which enables non contact method of inspection and can be easily coupled with computers to achieve accurate and faster inspection of parts. In the image processing technique, the parameter information namely length and diameter are measured from the images of part. The process consists of image acquisition, pre-processing, segmentation and image measurement.

The stepped cylindrical part is placed horizontally and the top view of the part is captured by CCD camera. The image of the slip gauge is also captured in the same position for calibration. Figure 2 shows the image of the part and figure 3 gives the slip gauge image for calibration.

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Figure 2 Image of the part

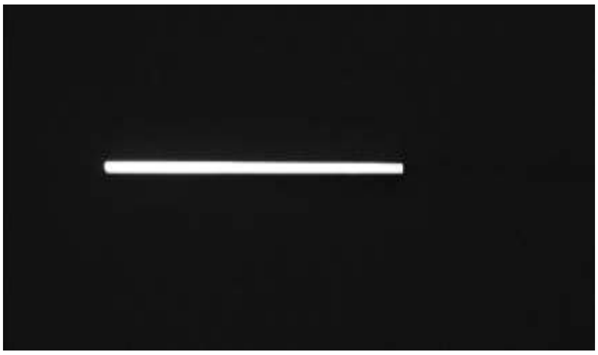

Figure 3 Image of the slip gauge

In image processing three factors namely resolution, distance of object and condition of illumination are to be considered for better accuracy.

The acquired image cannot be used directly for measurement purposes. It has to undergo pre-processing stage. The image of the part is preprocessed in order to improve the quality of the image by removing the noise. The region of interest with in the preprocessed image is then defined and separated which is known as segmentation. This is done by edge detection technique.

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From the preprocessed and segmented images, required dimensions are measured. Since the measurement is carried out directly on the images, the results obtained are in terms of pixel units. Hence, calibration is required to convert the pixel unit to the required dimensional unit. This is carried out using the image of the slip gauge.

Here, the calibration and measurement are carried out using Sherlock software. The length and diameter of all the steps are measured and are shown in figure 4 and 5.

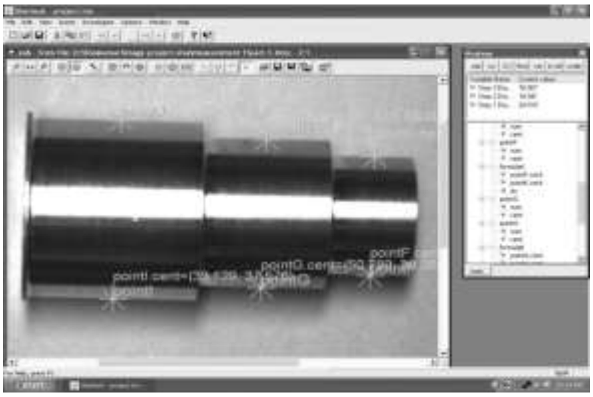

Figure 4 Diameter measurement using Sherlock software

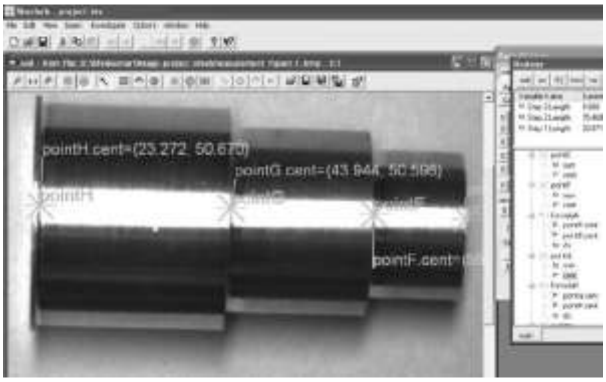

Figure 5 Length measurement using Sherlock software

5.0 RESULTS AND DISCUSSION

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Five similar parts are manufactured in XLTURN lathe. All the parts are inspected using image processing technique. In the inspection process, the dimensions of the parts namely diameter and length of each step are measured and the results are shown in table 2.

Table 2 Results of Inspection using Image processing

Parameter	**Cylindrical step**	**Part 1**	**Part 2**	**Part 3**	**Part 4**	**Part 5**
Diameter (mm)	1	24.010	24.048	24.146	24.036	23.875
	2	19.941	20.077	20.212	20.013	20.077
	3	16.007	16.034	16.143	16.056	15.871
Length (mm)	1	20.671	20.535	20.398	20.535	20.808
	2	15.469	15.606	15.196	15.469	15.332
	3	9.993	9.857	10.267	10.267	10.130

The inspection readings from image processing technique are compared with the reference data. The maximum error of 2.95 % is found in the results of image processing. It is observed that the percentage of error is less in diameter (0.26 to 0.46%) than in the length. However, the percentage of error in length varies from 1.632 to 2.95. The deviation of inspection results from the reference data may be due to machining as well as inspection. The graphs are drawn between diameter/length and the parts for the results of inspection by image processing (IP) and the reference data (RD) and are shown in figure 6 and 7.

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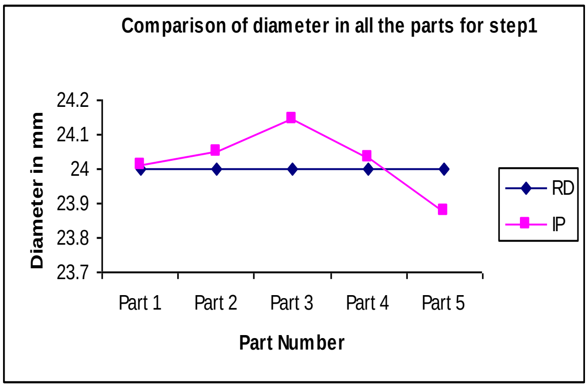

Figure 6 Comparison of diameter in all the parts for step1

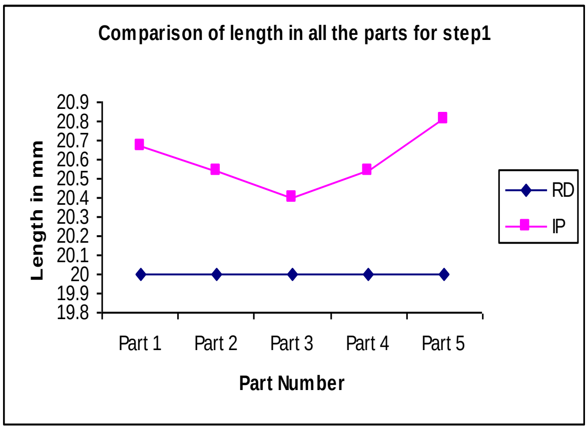

Figure 7 Comparison of length in all the parts for step1

From the above graphs, it is observed that there is an error between the results of inspection and the reference data. This error is due to two reasons namely machining and inspection. It is observed that the machining error may be caused due to error setting up of work piece and tool and machine tool deflection due to static and dynamic loading. In addition, it is found that the inspection error may be due to poor illumination and use of low resolution camera. By incorporating the remedies for the causes, the integration of CAD, CAM and CAI will be fulfilled.

6.0 CONCLUSION

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For integrating the various systems in a CIM environment an adequate product design model is needed. This model should contain technical and other relevant information necessary for integrating down stream applications. However for downstream applications, feature extraction information forms the basis to integrate design model with the application system. Here the CAD, CAM and CAI systems are integrated using the data available from the product model which intern increase the degree of automation. Thus the above investigation shows that integration of CAD/CAM/CAI can be achieved which will go a long way to fulfill the requirements of a global market.

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