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Integration of CAD/ CAM Softwares for Manufacture of Mechanical Components

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Abstract- **The progressions in the field of manufacturing have been increasing massively like the use of AI (Artificial Intelligence) in manufacturing, autonomous machining and so on. Likewise, Numeric control (NC) and Computer numerical control (CNC) machines have also evolved and are boosting the output as well as efficiency metrics increasing competitiveness playing field for small and medium-sized manufacturers. With these advancements, there has been a need to bridge the communication gap between design and manufacturing to minimize errors and maximize production. The growth of CAD and CAM technology has substantially increased productivity in every field. Nevertheless, individual progress has significantly limited the increase in overall efficiency from design to production which can be solved through Integration. Existing integrated CAD/CAM systems can customize the geometry model and allow the user to manually develop machining operations and other parameters for each operation. The objective of this work is to integrate the design with the aid of DNC (Direct Numeric Control) and MasterCAM software. This software provides nearly all the machining capabilities and automates the selection of tool paths with management. In this project, a hose nipple fitting is fabricated on the CNC Lathe with this software.**

Keywords — CAD/CAM (Computer Aided Design/Computer Aided Manufacturing), CNC, DNC, Integration, MasterCAM software.

I. Introduction

CNC (Computer Numeric Control) machining is a subtractive processing technology where parts are produced by using a series of cutting tools to remove material from a solid block. CNC manufactures high-accuracy components with exceptional physical properties directly from a CAD (Computer Aided Design) file. A Lathe machine is capable of producing an object which rotates on a spindle by removing excess material using various cutting tools that are applied to the workpiece. A conventional lathe is operated manually and can perform all the basic operations like turning, facing, threading etc. CNC Lathes have replaced the traditional ones as they possess the benefits of being set up and operated with ease. These lathes are typically designed to use updated versions of carbide tooling and techniques [11]. Components can be customized, and machine tool pathways are often designed utilizing CAD or CAM (Computer Aided Manufacturing) processes. Nonetheless, the programmer can also manually model a component or tool path. The corresponding coded data file is then submitted to the CNC system, and the machine will then simply produce the desired parts with which it has been configured. Due to the incredibly complex geometries involved in the machining process, advanced machines need CAM programming for optimum performance.

CAD is a software which involves the designing of geometric models with necessary parameters. The models are shown on the monitor as a three-dimensional object of the designed component [3]. It also provides the ease of altering the design parameters wherever necessary with the benefit of interfacing with analysis, fabrication and end-user.

CAM is a software which makes use of the drafted CAD models and sends it to a computer-controlled machine for automated manufacturing by generating toolpaths which

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turns the design into physical components with the aid of machine tools. The important segments required for functioning of CAM are Software which allows the machine to establish toolpaths, Machines for converting the raw material to finished parts and Post Processor which helps to convert the toolpaths into a language which is inferred by the machines.

This paper aims to model and fabricate Hose nipple with the help of MasterCAM on a 2-axis CNC lathe.

II. Literature Review

The key benefits of automatic manufacturing for the production phase are comprehended with the effective introduction of automation. The high quality provided by CAD/CAM leads to better output and reduction in lead time improving production process [1]. An integration of computer aided design and computer aided manufacturing is required to bridge the gap between islands of automation. Each computer aided system has its own internal structural and varies from the other. Hence the product data exchange between them is crucial [2]. Apart from generating codes from Step NC and G-codes, programs in C++ are being developed from derived data of the model part [3]. CAD/CAM as a technology facilitates product production and manufacturing with this aspect it has become an invaluable technology empowering time compression in product growth. This is achieved by an integrated approach to carry out diverse tasks in product creation through smooth data transmission [4]. Being an advanced option CAD/ CAM is being used for manufacturing of ceramic components which undergo sintering. The target geometry is collected from the designer in CAD format with the final goal of achieving the product with minimum errors [5]. In most machining operations the selection of tools and determination of parameters are often carried out manually by professional operators with the help of extensive research and going through various catalogues which requires a lot of time hence automation in this aspect has been developed. To accomplish this a database has been created which contain information regarding cutting tools and different parameters for developing fully integrated CAD/CAM system [6]. CNC machines have an outstanding surface finish and increased tool life in a short time period. The machines like 3-axis, 5-axis lathe machines can give form to geometrically complex turbines [7]. CAD/CAM being an advanced technology serves as a best option for various materials. Ceramics such as Corain which are used to reproduce the lighter materials while enhancing their properties can be conveniently be manufactured by CNC machines [8]. Integration is an important aspect in DNC and becomes the heart of contemporary DNC. Integrated DNC (IDNC) links machine related devices (such as numerically operated machine tools) to a superior control panel to enforce unified monitoring and management by simultaneously exchanging the information. It is a method for implementing complete integration which is important for automation which is key in CIMS [9]. Presently, the domestic demand for CAM applications is at the pivotal point in the market. MasterCAM software has integrated 2-D drawing, 3-D solid modelling, curved surface design, NC programming, cutting tool path simulations and so on, it has a lower requirement for the operating system environment. Both of these benefits ensure that users can produce the best potential results in machining operations [10]. DNC includes the control of machine tools by a single mainframe computer via direct and real-time links. The existent DNC has been advanced with a new system called Distributed Numeric Control which enables a specific device to be networked with one or more that use computer numeric control (CNC). This distributed numeric control helps the user to easily install CNC programs to several machines [11].

Shorten the programmers time for CNC programming of complicated parts and also reduce the production while boosting work efficiency [12]. The features of CAD/CAM systems have reduced market time, fair growth in design and ability to be bring rapid innovations into goods. The process of tool path generation is automated, machining features are utilized to define machining geometries and eliminate the necessities of user interventions [13]. The DNC solution is a simple one the text file with the measured values is placed on a path in the network drive in a specific tabular form. To read the measured values, the text file in the network drive selects a network drive which is launched as a software. In the inner tool database, the correct input will be generated for the machine tool. The full tools must be placed into the machine tool physically after this reading process. The transition of the calculated tool values through DNC reduces the potential of error typing [14].

III. DESCRIPTION OF MACHINE

Super Jobber 500 Lathe which is manufactured by Ace Designers, India, is being utilized for the purpose of machining. The lathe can perform operations like turning, roughing, drilling, boring, chamfering etc using CNC programming and Siemens Controller. Being a numerically controlled machine, it can be used for machining parts in any industrial domain featuring high rapid rates, cutting parameters and constant surface speed. The structural elements of the device, including the bed, the headrest, the axis slides and the turret, are designed using CAE analysis technology. Augmented rigidity and good thermal displacement. It allows the operator to provide various shapes to the job by generating G-M code programs. It helps to simulate the programs written before machining t o state compliance with the specification.

Machining a workpiece by NC software requires a coordinat

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e system to be added to the computer tool. Where each plane represents as an axis which acts as a reference to the main spindle and working holding surface.

IV. Description Of Software

The CAD CAM software used in this work is MasterCAM. It provides software tools for a wide range of CNC programming uses, from simple to advanced. It also offers flexible and innovative solutions with great support network. The modeling (CAD) and manufacturing (CAM) process with this software can be categorized into five portions namely sketching, setting up the environment for machining, selection of tools, operation and parameter setting and post-processing.

SKETCHING

Until beginning the development of geometry, the toolbars should be personalized to look at the different options required to construct a component and a geometry making sure that the grid is turned on. This indicates where the origin of the component is. For creating a new model, select the plane after which wireframe option can be opted for the sketch and then it can be extruded, rotated or sweep operations are performed as per requirement. Complex shapes can also be sketched using the wireframe module.

ENVIRONMENT FOR MACHINING

For the setup of machining, machine module can be opted by setting the environment of lathe. The first step in order to produce part program is to define the "Co-ordinate System" of the machine which can be initiated by the gnomon tab.

SELECTION OF TOOLS

Another essential step is to pick the right tool, it's apt shape and size for it to be used. To determine this the "Lathe Tool Manager" is accessed by selecting Tool Manager on the Lathe Turning contextual tab. When comparing the simulated and cut workpiece model along with the model design, the cutting conditions may be defined to adjust the incorrect position data of the device before processing, to ensure that the actual position is achieved. To comply with design specifications while processing components [13].

OPERATION AND PARAMETER SETTING

For this step click the Machine tab to select the Lathe and the contextual toolpath displays different options like rough, drill, contour etc, on selecting an option another window pops up for enquiring the parameters like cutting parameters, depth of cut, speed and feed.

POST-PROCESSING

Many CAM applications now allow users to organize transformation. Using post-processing coordinates, computing coordinates are substituted, which will make computing simpler for users [13]. To create the part program of the desired operation, the Contour Definition Manager in Settings tab is selected which further leads to a window with the option of Post-processor and the installed processor is chosen. This produces a post-processed file for the required machine in G and M codes.

V. Modelling and Manufacturing

The component was first drawn in Catia for a brief overview of the part. After which the drafting was done in the Mastercam ribbon interface which comprises of access options which allow to draw with ease. This was followed by generation of part program by CAM. Finally, it was fabricated on CNC Lathe.

HOSE NIPPLE

To draw the model of the component the wireframe module was used in which ZY plane was selected to draft the sketch. The model chosen is a polygon whose given dimensions are a total length of 80mm and a diameter of 25mm. Apart from the wireframe module, surfaces tab is also used for solid generation and extrusion of the solid.

In order to finish the model, we are supposed to give the blank geometry and dimensions followed by stock and chuck setup. Once this is done the lathe operations can be performed by giving the necessary parameters like tool parameters. In this case the depth of cut given was 0.5mm and the feed rate was maintained in the range of 0.1-0.30mm/rev which can be changed optimally. Similarly, for operations like drilling and boring the depth and positioning distance were provided. For threading, the lead, major diameter and minor diameter were given as an input.

After completion of the modelling, the G and M codes are to be generated for the manufacturing of the component. This is done by selecting all the operations performed on the model which are roughing, drilling, threading, boring and finishing. The entire process is shown in the Fig 5.1. Then the BACKPLOT option is selected for the verification of all the selected operations after which G1 (Generation) option is selected for the code to generate. In the post processing window, the lathe option is selected. As soon as this window is opened the units are changed to METRIC so that the generated part program is in the same units as the model.

This part program is executed by Super Jobber 500 Lathe. First the origin is defined for the job and then the blank is fixed to a 3 jaw chuck, with the length being 80mm and diameter of 25mm.Once the operation is started the excess material is removed and then the extra portion which holds in the chuck is cut off and finishing operation is done.

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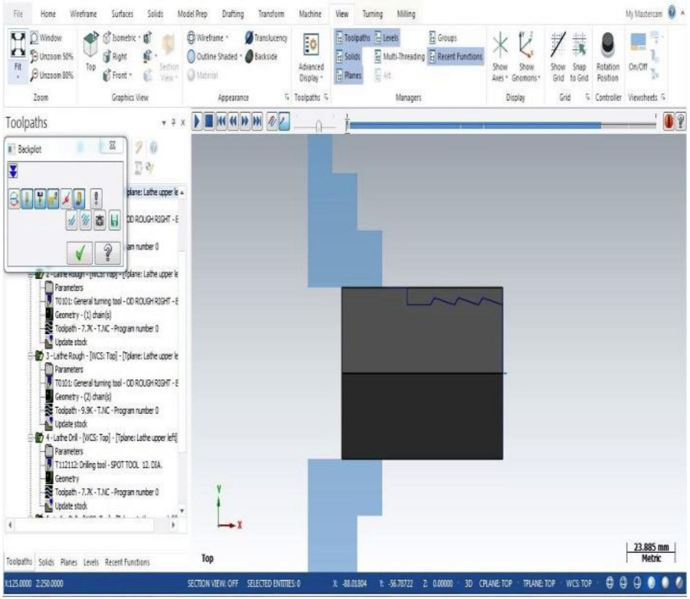

Fig 5.1 Operations Selection

Backplotting indicates the route to cut the piece by the tools. Which facilitates to spot errors with ease in the software before machining the component. As observed in Fig 5.1 the entire operations for the process is selected for achieving the next step which is simulation.

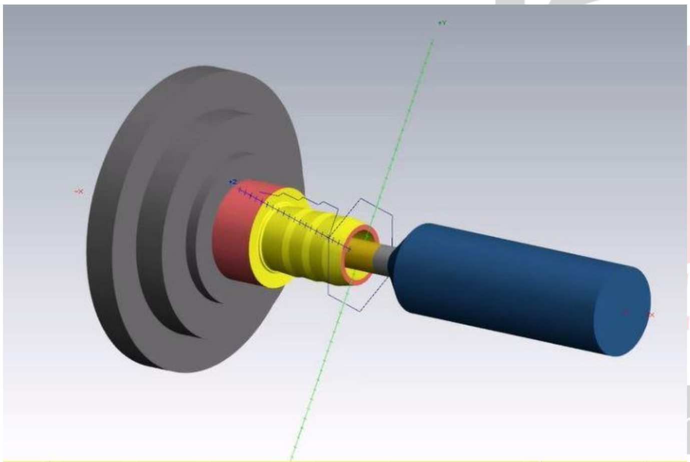

Fig 5.2 Simulation of hose nipple

Toolpath Verification allows the user to simulate machining a part using solid models as depicted in Fig 5.2 The model created by the test shows the surface finish and whether any collisions occur. This step is crucial so that there are no errors while machining on the lathe which is a benefit for the programmer.

VI. RESULTS

The use of integrated approach over non-integrated approach proves to be an optimal solution for complicated geometries. The various problems which have arisen in the production of the component using CAD/ CAM system have been addressed. Suitable process planning such as choice of machining operation, estimation of available tools and operation process have helped in completion of the product in an efficient manner. The system allows direct production of complex parts by designing in the CAD software.

VII. CONCLUSION

The following conclusions were made after the fabrication of the component.

- In this research, an experimental and theoretical study towards the integration of CAD/CAM has been carried out on the existing CNC Super Jobber 500 Lathe machine with the help of MASTERCAM software.
- Selection of components were made such that they could be fabricated on the 2 axis CNC Lathe.
- Hose nipple, a mechanical component used to connect in pipe fittings was chosen and drafted using CATIA with the dimensions.
- The component was then simulated, and part programs have been generated with the help of MasterCAM software.
- It was integrated to the CNC lathe and then fabricated as required.
- The component being a complex one helped in understanding the various difficulties in the Lathe and allowed to find a solution.
- The scope for this fabrication is not limited to integration with DNC, with constant developments in the technologies there are many more options to complete this fabrication and more could be added.

It therefore integrates the different areas of design and production, giving every domain an acknowledgment of its role in the design process. The use of this method has shown significant improvements in reducing time and cost with efficient machining.

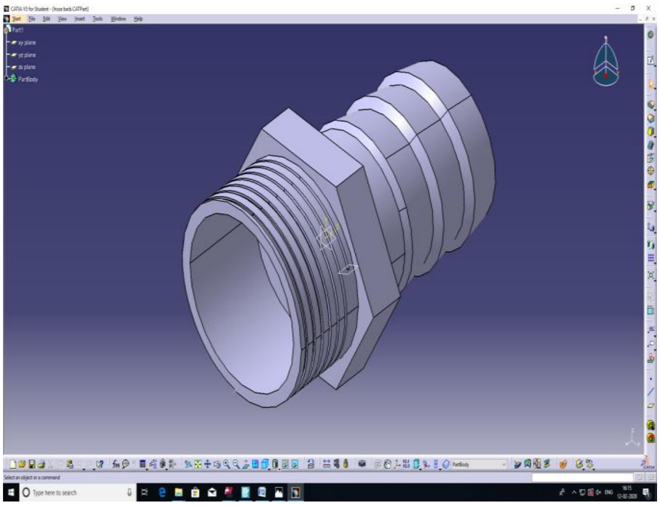

Fig 7.1 CATIA model of hose nipple

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Geometric model of the hexagonal part present in the hose nipple design after machining is achieved is shown in Fig 7.1.

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