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An Investigation into the Compatibility of CAM Tools with CNC Machines to Facilitate Interchangeability and Accessibility

Durvas Naik [#1], Vinayak Chavan[#2], Elamthendral Sengunthar[#3],Sachin Salunkhe[#4], Dr. J. J. Dange[*5]

[#]*U.G. Students Mechanical Engineering Department, Mumbai University, Mumbai, India*

[*]*Professor Mechanical Engineering Department, Mumbai University, Mumbai, India*

[1]durvasnaik@gmail.com
[2]vinayakchavan94@gmail.com
[3]elamaesi@gmail.com
[4]sachin1991.ss@gmail.com
[5]jayesh_dange@rediffmail.com

Abstract: CNC machine tools though capable in providing the required functionalities but lack in adaptability, portability and compatibility. This is due to the fact that a fifty year old language is still employed. This paper reports on a comparative study on the part code generated by two different CAM softwares and a part program manually developed. It shows in particular tool path, length of program and simulation time. The comparison is carried out through a case study: a simple cylindrical machining component was designed using CAD software and CNC part program was generated with two different CAM systems (NX CAM & Mastercam) and the difference in various allied parameters was identified. The above part was produced using the same machine tool, tooling and process parameters; and measurement of simulation time was gathered. The results show differences between the tool paths generated by each approach and the one developed manually. Finally comparison was made taking into consideration the simulation time and approach of Step NC and accessibility (wireless transmission) was also analysed.

***Keywords*— Simulation, Compatibility, Interchangeability**.

I. INTRODUCTION:-

Automated CNC machine tools are the main components in any automated manufacturing system. There are demands and new opportunities to empower the current CNC machines with the much needed features such as interoperability, compatibility and flexibility. There are two major issues that need to be addressed namely product data compatibility/ interoperability and adaptable CNC machines.

Whereas, previously research has been carried out in this field, but due to the developments of the new CNC data model, there has been a surge of research activities in trying to address the above-mentioned issues. This paper reports on these research activities and tries to address the issues of compatibility and adaptability for CNC machine tools [7].

X.W.Xu (2005)addresses that,modern CNC machine tools, though capable in functionalities, lack adaptability, compatibility and flexibility. NC programs following this format are only meant for execution on a specific machine tool. They cannot be reinterpreted by a CAM system or a NC system for a different machine tool.Automatic generation of a 100% optimized NC program is not possible design information and know-how about the machine tools and materials is represented in different formats and on different databases[7].Perhaps, Raphael Laguionie(2011) claimed that,STEP-NC can provide a uniform NC program format for CAM and NC, avoiding post-processing and exchangeable format. Step NC offers a range of new opportunities for programming machine tools and also for monitoring simulating and reduce cycle time in manufacturing process.[9].Whereas, S.P.LeoKumar(2014)suggested that feature extraction from a part model and CNC code generation for machine tool control are the two extreme activities of any CAPP system. The present work discusses new approach for the invention of micro feature for tool based micro machining process. Manycontrol systems such as fanuc, Siemens, Mitsubishi, Heidenhain, etc, are available in the market, but it has compatibility issues for different machine tool. [8]

SCOPE OF PAPER:-

It is the next level of the existing CNC machine control system. Every individual control system has its own merits & demerits. If one firm buy a CNC manufacturing system, the firm only knows about that particular system wisely, even they suggest that CNC system to every other organization. Due to this every organizer known for one kind of system thus the versatility reduced.

Previously efforts were carried out to overcome this obstacle and keeping these efforts in mind a review of that research was carried out.

II. METHODOLOGY :-

- Design a two dimensional drawing
- Establish job setup setting
- Create a feasible lathe tool path
- Check the tool path using Mastercam's verification module and simulation of path.
- Then obtain the program for the given part.
- Execution or simulation of these program on different software system and observation of simulation time keeping input constant and comparative study of the same

SOFTWARES UTILIZED:-

- Pro E
- Mastercam
- Unigraphics

PRO-E

PRO-E is good modeller and most popularly used in industry whereas its manufacturing module has got limitations like lengthy and tedious procedure which consumes time.

UNIGRAPHICS

It's the most advanced software for modelling and simulation at present but the programs obtained using Unigraphics is too advance for the system to be compatible with (i.e. Fanuc CNC 110). It requires a thorough knowledge of software and hence is difficult in case a newcomer is suddenly exposed to it.An example is shown below fig 1 and 2.

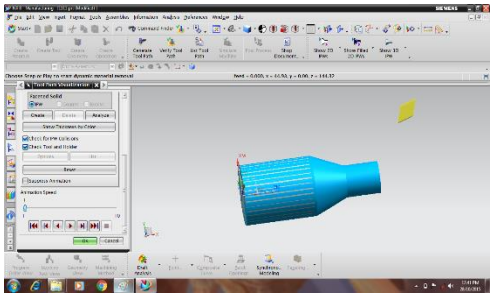

fig 1. 3D model of NX-CAM

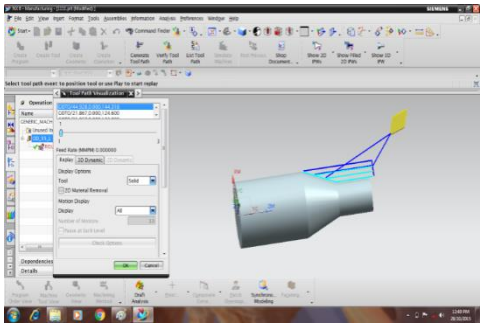

Fig 2. Toolpath of NX CAM

MASTERCAM

The most suitable for the project is Mastercam it is more user friendly as well requires less time for creating the Tool Path. Creation of tool path is less time consuming .Provided it is one of the most user friendly software available and can be easily grasped by a newcomer. An example is shown below in fig 3 and 4.

Mastercam for turning operation

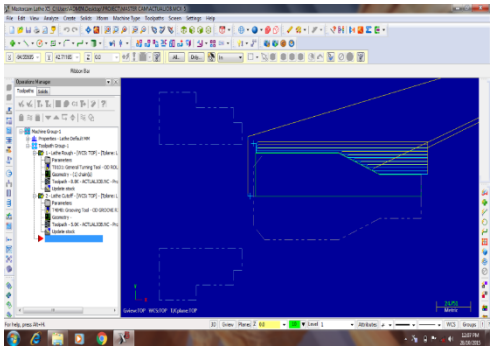

Fig 3.Toolpath of Mastercam

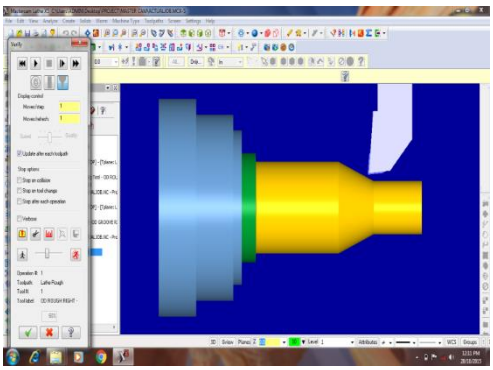

Fig 4.Simulated model of sample

III. COMPARATIVE STUDY OF THE CAM SOFTWARES

The workpiece orientation and the length of the NC code segments influence the reduction of machining time.Some main activities were carried out during this experiment.These are presented below.

Case study part design

A particular part was designed for the experiment. Its general dimensions of cylindrical object are 120 x 60.The case study part's geometry in Fig 5 from Master cam and in Fig 6 from NX CAM. Required step turning operation. The purpose of using this operation was to compare parameters when generating the NC part programs for different CAM tools.The material selected for the part was Mild steel [10].

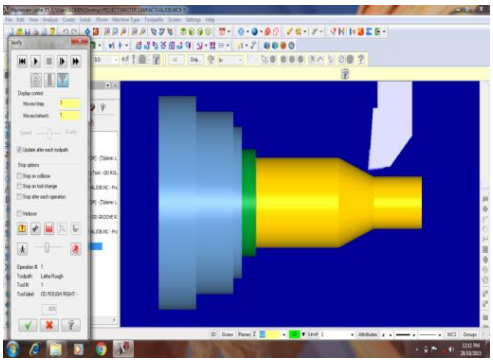

Fig.5. Case study part Mastercam

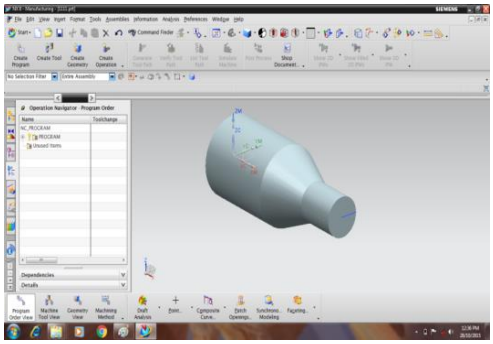

Fig 6: Case study part NX CAM

Machining process design

As mentioned before, two commercial software, i.e. NX CAM and Master CAM X5, were used to generate the NC code for the case study part. A third part program was generated manually and executed on the controller of the machine tool.

Machined case study part

A part sample was machined using similar process strategies and parameters. Sample was measured at the end of the experiment to verify that final dimensions matched the original design. The codes produced by the two software tools and the codes programmed manually were compared taking into account the differences between the cycle time and the number of steps of their corresponding machining processes. Researching these two variables helped in achieving some important time consumption conclusions. As mentioned above, for the turning programs, the same type of cutting tool and machining strategies were used.

The program which was manually generated had the least number of lines as compared to the CAM tools. This program also had the least number of tool path segments. By analysing the code of each one of the part programs, thus we confirmed that the difference in the cycle times is associated with strategies to generate "safe "tool paths that avoid collisions. This approach generates more code lines, and therefore longer cycle times. On the other hand, we did not produced code with a "safe" strategy, when programming directly in the CNC machine controller. This produced a part program with lesser steps and therefore shorter cycle time. This is shown in Table 1. In the same way, the differences on energy consumption are also due to the additional steps produced when using "safe" strategies to generate part programs. The code generated by us is just based on the desired geometry, so tool path did not consider incremental depth of cuts to avoid tool or work piece damage as commercial software did

TABLE 1: Part code generated

MASTERCAM	NX CAM
G0 **T0101** G18 G97 S1559 M03 G0 G54 X56.156 Z4.7 G50 S3600 G96 S275 G99 G1 Z2.7 F.25 **Z-119.8** X60. X62.828 **Z-118.386** G0 Z4.7 X52.311	N0010 G94 G90 G20 N0020 G50 X0.0 Z0.0 :0030 T00 H00 M06 N0040 G97 S0 M03 N0050 G94 G00 X1.7688 Z5.6818 N0060 X.8609 Z4.9055 N0070 G92 S0 N0080 G96 M03 N0090 G95 G01 Z4.874 F.004 N0100 Z2.826 N0110 X1.0157 Z2.4543 N0120 X1.038 Z2.4766 F.0394
G1 Z2.7 **Z-119.8** X56.556 X59.384 **Z-118.386** G0 Z4.7 X48.467 G1 Z2.7 **Z-58.28** X50.246 **Z-60.415** G18 G3 X50.4 **Z-60.8** I-.923 K-.384 G1 **Z-119.8** X52.711 X55.54 **Z-118.386** G0 Z4.7 X44.622 G1 Z2.7 **Z-53.667** X48.867 **Z-58.76** X51.695 **Z-57.346** G0 Z4.7 X40.778 G1 Z2.7 **Z-49.053** X45.022 **Z-54.147** X47.851 **Z-52.733** G0 Z4.7 X36.933 G1 Z2.7 **Z-44.44** X41.178 **Z-49.533** X44.006 **Z-48.119** G0 Z4.7 X33.089 G1 Z2.7 **Z-39.827** X37.333 **Z-44.92** X40.162 **Z-43.506** G0 Z4.7 X29.244 G1 Z2.7 **Z-35.213** X33.489 **Z-40.307** X36.317 **Z-38.892**	N0130 G94 G00 Z4.9055 N0140 X.706 N0150 G95 G01 Z4.874 F.004 N0160 Z3.1976 N0170 X.8609 Z2.826 N0180 X.8832 Z2.8483 F.0394 N0190 G94 G00 Z4.9055 N0200 X.5512 N0210 G95 G01 Z4.874 F.004 N0220 Z3.5693 N0230 X.706 Z3.1976 N0240 X.7283 Z3.2199 F.0394 N0250 G94 G00 X1.7688 Z5.6818 N0260 M02
G0 Z4.7 X25.4 G1 Z2.7 Z0. **Z-30.6** X29.644 **Z-35.693** X32.473 **Z-34.279**	

REMARK: As seen from the above table no.1 it can be said that simulation of NC program generated by Master CAM will require more time for simulation as compared to NX CAM.
Simulation Time: 11.43 sec (NX-CAM)
Simulation Time: 15.11 sec (Mastercam)
If the idle time (setup, etc) which are incurred during the operations are ignored, the simulation time and actual execution time are considered to be the same, then more the time for execution, more energy consumption will occur.

Step-NC approach:

The standard ISO 14649, also known as step NC provides new opportunity to support high level and standardize information from design to NC controller. It allows bidirectional data flow between CAM/CAD and CNC without any information loss this ISO 14649 does not describe the actual tool movement for a specific cnc machine as G – codes does but provides a feature based data model

It shows the Integration of high manufacturing level in the numerical chain CAD-CAM-SIMULATION-CNC allows the implementation of the unique file gathering of all needed information of part that is directly machined without post processing.

Remote Access:-

As discussed that developing a compatible CNC program will reduce the time which is basically required for the purpose of compatibility and further this time can be utilized for the purpose of any other value added activity if possible. As seen in fig 7,Further using a portable connector provision can be made to wirelessly transfer this programme to the CNC machine that will provide a remote controlled access to the machine .

Wireless Serial Adapter with Fanuc Controller (LM058 / LM158 / BTD-433)

Fig 7: Wireless device (LM058 & LM158) on a Fanuc OM control

IV. CONCLUSION

Compatibility of CNC programmes generated from the CAM softwares are not directly compatible with the CNC machine and further efforts needs to be employed in order to make this programmes compatible in particular with the CNC machines. Making this output softwares compatible with the CNC machines will reduce the time which is consumed in making this softwares compatible and further this time can be positively utilized in other value added operation if required . A comparative study of the NC program as shown in the table 1, clearly suggests the time which will be consumed during the execution of the programs. Transmission of the programme through RS-232 port is the approach of transmitting this programme to the CNC machine. Further advancement in the existing approach can be done by making use of a wireless device which will possibly make use of Bluetooth or WiFi connection for wirelessly transmitting this programme to the CNC machine. This will make the remote controlled operation of CNC machine possible.

V. ACKNOWLEDGEMENT

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