DEVELOPMENT OF A WEB-BASED VIRTUAL MANUFACTURING OF CNC TURNING SYSTEM

Rahmatullah, [2]Mohd Razali Muhamad, [2]Zolkarnain Marjom
[1]Faculty of Mechanical Engineering Universiti Sains Malaysia (USM), Penang, Malaysia.
[2] Fakulti Kejuruteraan Pembuatan (FKP), UTeM at Melaka Malaysia.

ABSTRACT: *Virtual technology in the manufacturing, machining industry has shown the role of growing. Virtual manufacturing (VM) is the illustration of processes actual manufacturing simulation on computer with virtual reality technology. The capability to illustrate, visualize, evaluate, and optimize the quality of machining production and processes, without need to build physical prototypes or run production trials, is highly appealing to both machine tool builders and end users. In turning operation have some error or weaknesses at machining in processes. Possible errors or weaknesses usually in predict setting part geometry, feature, shape and efficient tool path generation. The objective of this paper is generally to improve processes of CNC turning operations easily and relatively simple, cheap and to develop method that it able to use to model the virtual CNC machine tool efficiently. The main requirement of a CNC software is to simulate a product 3D design and a program of an accurate tool path generation for a typical CNC machine. Only high-level CNC software supports a large variety of tool paths turning operation. One mistake in software selection is to consider only the existing CNC machines and existing machining methods and practice. The VM is develop by using VRML, Java; Cosmo Player, VRML Pad, Web Browser and CATIA. A workpiece is viewed in simple 3-D model. Effective tool path simulation virtually is discussed in this paper as representation of Virtual Reality system as correction tool to eliminate material waste and faulty design and solve weaknesses and errors evaluation. It provides better understanding of a simulation process without making of physical prototypes.*

Keywords: Virtual Manufacturing, VRML, CNC Turning Operations

I. INTRODUCTION

At present, various 2D and 3D CAD software technologies (such as Master CAM, Solidworks, CATIA, Pro/E, Unigraphics, Abaqus etc.) develop very quickly and are easily accepted by the domestik manufacturer due to their lower cost. Therefore the application of CAD technology in machining enterprise is already widely used and the technology has become the indispensable tools for the size calculation of the turning design and the geometrical modeling, especially for the geometrical modeling of complex parts. CAM technology plays significant effect in turning operation, especially in precise facing, roughing, boring, finishing and other process. The turning cavity geometric data can be directly transformed into the path of tools. Consequently the results are transformed into numerical control (NC) code.

VM applications have been done for a long time. Technology and system development of VM continue to this day. VM has also proven its ability to predict manufacturing design processes well, easily and relatively cheaply. All design processes and manufacturing simulations are carried out with a computer system. In the CNC machining design process such as CNC milling and turning can be done with high flexibility with VM system. Application of VM technology has a significant effect in reducing, time, cost and product design procedures. This has been proven with a lot of research and publications about the application of the VM system and technology. [6] Virtual Manufacturing is defined as a computer system which is capable of generating information about the structure, states, and behavior of a manufacturing system.

VM is an illustration of the manufacturing process that is occur. VM technology is also widely adopted and applied by manufacturing companies. There are no adverse effects that occur in the ongoing manufacturing process because everything has been predicted, anticipated and corrected during the simulation process with the VM system. [4] VM is the reflection of actual manufacturing process on computer, that is adopting the computer simulation and virtual reality technology. [5] Virtual Manufacturing involves the uses of simulation and computer generated modal to design and develop a prototype of a thing which is to be manufactured. All design development, simulation, animation, tests, confirmations, communication, evaluation, data storage can be done with a virtual manufacturing system with the advantages of being easily modified, easily improving the design and easy to publish and transfer to other designers and researchers quickly. VM is also a part of engineering design development and that it supports of industry revolution 4.0., and in the future design improvement and further development of this VM system is carried out according to evolving needs, idea of designers, researchers and can do so relatively easily.

II. MACHINING OPERATIONS

A. Turning Operations

The basic concept of the turning operation process is a cylindrical workpiece and other forms rotating with the turning of the chuck and cutting tool in the tool holder moving towards the x axis and z axis following the planned design such as for facing, roughing and finishing and other turning operations .

Generally, turning is the process in which a tool cuts a rotating workpiece held in the chuck. Turning can be further classified as facing, cutoff, contouring and so on (Fig. 1). In turning operations, the workpiece is held to a rotating spindle. Standard workholding devices called “chucks” are used to locate and support the workpiece [2].

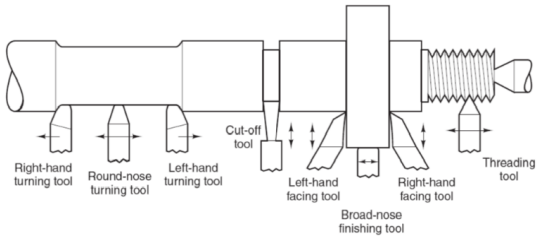


Figure 1 Turning operations [2]

Fig. 2 shows machining the rotational part along with the machining cycles. The first of these cycles is facing, the

next is roughing, groove turning, hole drilling and reaming [14].

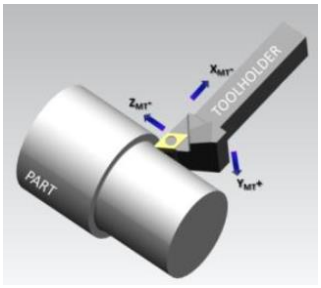


Figure 2 Machining for rotational part [20]

B. CNC Turning

In CNC turning the Z-axis is usually collinear with the axis of turning. Therefore, the turning cut is sketched in the XZ plane. The typical co-ordinate setting is shown in Fig. 3.

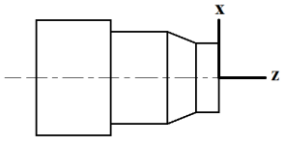


Figure 3 Co-ordinate Setting in NC Turning

Stock boundary and area turning is often convenient to define the stock boundary and then create the NC sequences through the area clearance approach. Fig. 4 (a) (b) (c) shows a component to be machined, area turning and successive cuts for machining [16].

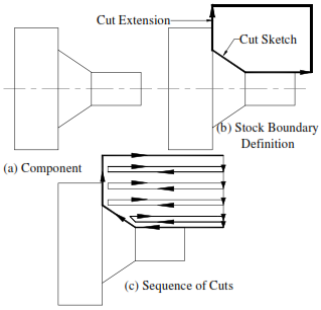


Figure 4 Stock boundary definition and area turning

C. Tool Path Generation

[8] Most CNC programming system require a tool path geometry creation firstly before the actual path of a cutting tool can be generated. The key words here are *tool path geometry*. When it comes to tool path geometry, two scenarios must be faced. One will be work form a paper drawing, the other from a CAD drawing stored in the computer. The tool path geometry and generation can be done with a VM system both conventional and web based VM systems. The tool path generation can be simulated firstly so that the ineffectiveness and inefficiency of the tool path generation are known firstly and the design of the tool path generation can be modified and improved quickly.

III. VIRTUAL MANUFACTURING

The development of VM systems in this paper is to be applied to CNC turning systems. CNC turning systems mean all aspects of the CNC turning process and its main components. All processes of turning, visualizing, G and M Code program operations, tool path generation, 3D models with a virtual environment. Web-based VM systems that are self-developed by adopting freeware and shareware software and combined with commercial ware for integration design such as CATIA V5 which have proven their capabilities and are widely used by researchers and companies around the world. Nevertheless, this system is planned to be able to function independently with or without commercial ware and can be modified easily according to the needs and objectives. The combination of this system with CATIA V5 makes more powerful virtual manufacturing (VM) systems.

The benefits of VM from product point of view, it will improve quality of the product, reduce number of physical prototype models [7]. Virtual manufacturing feature is a result of geometric transformations on manufacturing feature using some operators [14]. Many technologies can be used for developing virtual manufacturing systems. The technology must have the capability of specifications according to its designation. One of the main objectives of the virtual system is to be able to operate with a virtual operational environment, good visualization quality, easy to develop, can be combined and integrated with other software and suitable for the main tools and software that exist and are web-based and internet. A key factor for developing a virtual operating of CNC machine tools system is how to represent the CNC machine tools precisely and effectively in the virtual environment. Virtual manufacturing finds application in aerospace and automotive industries [15] [20] [21].

IV. WEB-BASED VIRTUAL REALITY

Virtual reality (VR) is a set of technology which is used to create a computer-generated virtual environment where the users can experience and interact just as if they would do in real life [12] [13]. In VR machine tool, in order to simulate the machine movement during the operation, both the Virtual and/or Real CNC Controllers can be employed to read the NC code [3]. [18] Adopted virtual reality in the simulation and animation of a web-based interactive manufacturing engineering module.

Many references, publications about technology, systems and Web-Based virtual manufacturing applications. Many researchers and companies develop virtual manufacturing systems with a variety of abilities and special specifications. There are also many technologies and software that can support the development of the VM system. The main key of developing this VM system is how the system has the same capabilities or exceeds the current system, reducing dependence on commercial software products, inexpensive, easy to operate, easy to develop, simple and up to date.

In this paper web-based virtual manufacturing is developed to be applied to the CNC turning system operation. The web based VM development will be done by combining existing software based on VRML code, VRML world browser, www and commercial design software and will produce a 3D model, virtual prototype, virtual environment and able to simulate CNC turning machining.

VRML, Cosmo Player, web browser, VRML worlds browser, VRML Client, WWW, Cartona, Web3D, 3D viewer and others with extension *wrl* is parts of web-based virtual reality. The history of VRML version 1.0 to X3D is VRML 1.0, VRML 2.0, VRML97 and X3D. The next

generation of VRML is the XML-based Extensible 3D or X3D. [17] Cosmo Player, at least the completely rewritten 2.x version.

[1][9] Web applications in product design and manufacture are unique in that geometric information is usually involved. [19] Almost all standard CAD software expose their API (Application Programming Interface) to extend their core functionality so that end-users can develop plugins or addins to increase their productivity. [10] [11] Java is the foundation for virtually every type of networked application and is the global standard for developing and delivering embedded applications.

V. WEB-BASED IN CNC TURNING

A. Method

Research method in this paper is by developing virtual manufacturing system in visualization of turning operations virtually. The tools of virtual manufacturing system are integrating of software design CATIA V5, VRML and Java, and has the following capabilities:

- Technology visualization of turning design
- Ability to create heterogeneous virtual prototypes
- Internet enabled and offers a Web user interface
- System for detail design
- Enables fast development and relatively easy in modifications, and simulation.
- Relatively cheaper than other system/software and the designer's can develop design with freeware and shareware and source code.
- VRML and Java able to import CATIA V5 Geometry.

Many system/software with average capability in field of web-based virtual reality but the system/software usually is commercial ware. Many software's with same function as Cosmo Player in vizualition of integrated VRML and Java but Cosmo Player is one of famous and friendly relatively.

The VM method is as shown in 'Fig. 5'.

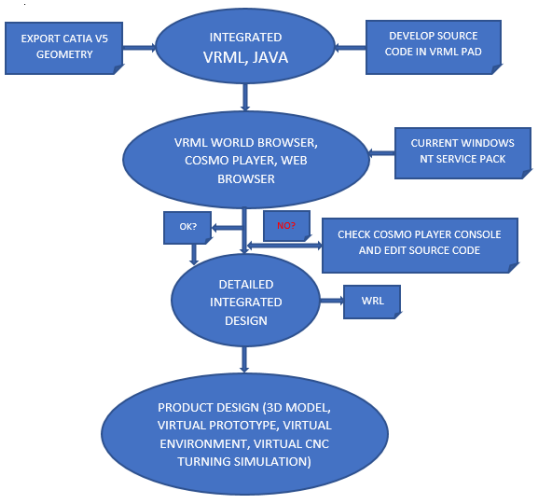


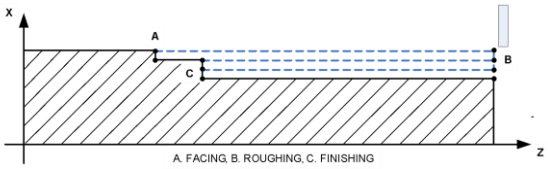
Figure 5 VM in Virtual CNC Turning method

B. Implementation

The implementation objective is to evaluate the degree of workability and limitations of the method as well as its software implementation. Shortcomings will be identified for further improvement. One typical product, namely a cylindrical part with diameter Ø 32 mm and length 120 mm are randomly selected for the case study. Using the case study, most performance of virtual design was developed will knowable easily. The figure of case study is shown in 'Fig. 6'.

C. Analyze

During the machining of turning process such roghing, facing and finishing, the workpiece is permanently rotating around its axis while the cutting tool is permanently moving along the X-axis and Z-axis. The workpiece material is removed step by step follow design of tool pat geometry and tool path generation, and a desired shape design is developed. For the case study, the workpiece geometry is diameter Ø 32 mm and length is 100 mm. This work piece has machined in three phases. The first one was a facing operation in the diameter Ø 32 mm, and the second one is roughing operation consisting in preparing the initial bases for setting and clamping. The roughing is on the diameter Ø 25 mm and diameter Ø 21 mm. The third one is finishing (re-cutting) of work piece on the diameter Ø 21 mm, Ø 25 mm and Ø 32 mm.



Representation of cutting direction and tool path simulation of rotation of cylindrical part is available in '

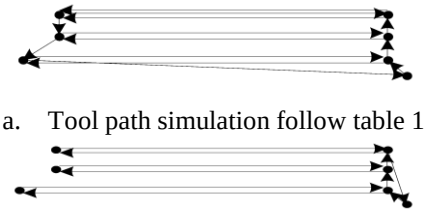
Figure 6'. Half display along center of rotation in the view on the left.

Figure 6 Half representation with rotational symmetry view left of profile recognition and necessary tool paths

The part machined with CNC as Table 1 and Table 2.

Table 1 CNC turning 1 Table 2 CNC turning 2

Table 1 and Table 2 are showed of different tool path of cutting tool in turning operation. Tool path of Table 1 and Table 2 is follow as shown in 'Figure 7'.



a. Tool path simulation follow table 1

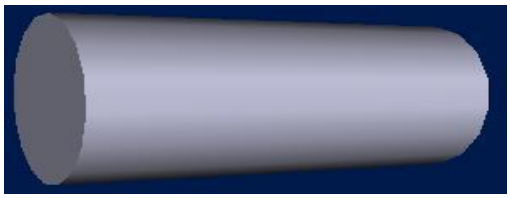
b. Tool path simulation follow table 2

Figure 7 Tool path simulation of actual machining

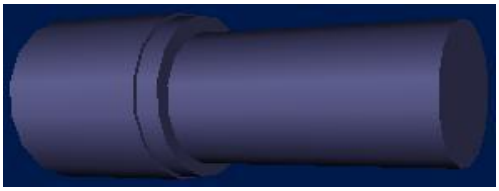
Comparison of tool path simulation "a" and tool path simulation "b" in Figure 6 shows that tool path "b" more effective than tool path "a". 'Figure 8 "a"' showed of many processes (13 cycles) of tool path than in 'Figure 6 "b"' (10 cycles) of tool path. Reduce of process able to reduce time and reduce working of tool in cutting material and that mean able to increase cutting tool efficiency and generally able to reduce cost.

Table 1 shows of G code of turning operations (facing, roughing and finishing) and Table 2 shows of G code of turning operation (roughing). The quality of product machining is relatively same and time machining of the product is relatively different. Virtual manufacturing able

to know machining performs before actual machining. The weaknesses of machining knowable firstly and improve treatment of the weaknesses. Tool path of turning processes able to improve easily without decrease quality of workpiece product and able to correction with high flexible capability. That it because all processes of machining operation are display like real but not real "virtual". Weaknesses or error of machining processes can improve without waste physical material. 'Figure 9 "a" and 9 "b"' showed of virtual machining activities. Spindle and workpiece are rotation and tool will move to modify shape in X and Z direction. 'Figure 8' is tool path simulation in virtual manufacturing processes.



a.Before machining



b. After machining

Figure 8 Virtual turning operation

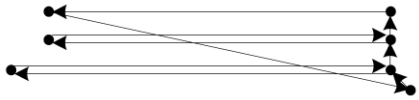


Figure 9 Tool path illustrations in virtual turning

Comparison of tool path simulation 5 "b" and tool path simulation in 'Figure 7' showed that tool path 'Figure 9' more effective than tool path 5 "b". 'Figure 7 "b"' showed of many processes (10 cycles) of tool path than in 'Figure 9' (9 cycles) of tool path.

D. DISCUSSION

Virtual manufacturing able to improve turning operation easily, flexible, increase cuts efficient and cheaper (see 'Figure 9' and its discussion). Modification of machining processes virtually is more effective than modification in actual machining. In virtual machining no physical and waste workpiece, all of activities are virtually. Development of virtual manufacturing system is relatively easy, simple and cheaper. To modification of object only by improve VRML and Java code and re-run. Software and code to develop virtual manufacturing system is freeware and shareware.

VI. CONCLUSION

Virtual manufacturing in this paper adopted in turning operation before actual turning is was applied. Virtual manufacturing is a software relatively simple, cheaper (main software component is shareware). The VM software able to monitor work in process and increase cutting efficiency easily (correction activities are virtually before actual turning). VM can simulate of effective tool paths in 3-D model and knowable predict turning operation such as roughing, finishing simulation virtually in the computer. All correction in turning operation by virtually and it high flexible activities with virtual environment visualization. Virtual Manufacturing system as correction tool to eliminates material waste and faulty design and solve weaknesses and errors evaluation.

.

REFERENCES

1. G.Q. Huang, K.L. Mak, "*Internet Applications in Product Design and Manufacturing*", ISBN 3-540-43465-8 Springer-Verlag Berlin Heidelberg New York, 2003, www.springer.de
2. Tien-Chien Chang, Richard A. Wysk, Hsu-Pin Wang, "*Computer-Aided Manufacturing*", Third Edition, Prentice Hall,International Series in Industrial and Systems Engineering, New Jersey, 2006, ISBN 0-13-142919-1
3. *Yung-Chou* Kao, *Chung-Shuo* Lee, *Zhi-Ren* Liu, and *Yu-Fu* Lin, "*Case study of virtual reality in CNC machine tool exhibition*", MATEC Web of Conferences 123 , 00004 2017, *ICPMMT 2017*, DOI: 10.1051/matecconf/201712300004
4. Bharath V G, Rajashekar Patil, "*Virtual Manufacturing: A Review*", International Journal of Engineering Research & Technology (IJERT), NCERAME - 2015 Conference Proceedings, Volume 3, Issue 17, ISSN: 2278-0181, www.ijert.org
5. Shailendra Kumar Bohidar, Prakash Kumar Sen,Vivek Modi, "*Virtual Manufacturing and Their Application*", International Journal for Research in Applied Science & Engineering Technology (IJRASET) ©IJRASET 2015: Volume 3 Issue V, May 2015, ISSN: 2321-9653, www.ijraset.com
6. Pankaj Sharma, "*Concept of Virtual Manufacturing*", GRD Journals- Global Research and Development Journal for Engineering | Volume 2 | Issue 6 | May 2017, ISSN: 2455-5703, Department of Mechanical Engineering B. S. Dr. B. R. A. College of Agril Engg & Tech Etawah, INDIA
7. R. Bakerjian, "*Design for Manufacturability*", Hand book of Tool and Manufacturing Engineers Handbook. Society of Manufacturing Engineers, vol 6, 1992.
8. Peter Smid, "*CNC Programming Handbook*", Second Edition, Industrial Press, Inc., New York, ISBN 0-8311-3158-6, 2003, www.industrialpress.com
9. http://www.sdrc.com/ideas/vrml_help/vrml_help.html, (accessed on 13 July 2019)
10. *The Virtual Reality Modeling Language, Appendix C. Java Scripting Reference*, Version 2.0, ISO/IEC CD 14772, 1996, Available online: http://gun.teipir.gr/VRML-amgem/spec/part1/java.html, (accessed on 13 July 2019)
11. Java Technologies |Oracle, Develop with the Global Standard, Available online: https://www.oracle.com/java/technologies/ (accessed on 13 July 2019)
12. Emspak, J., "*What Is Virtual Reality*?", Available online:https://www.livescience.com/54116-virtual-reality.html (accessed on 13 July 2019).

13. Minh Nguyen, Huy Tran, and Huy Le, "*Exploration of the 3D World on the Internet Using Commodity Virtual Reality Devices*", School of Engineering, MDPI, Computer & Mathematical Sciences, Auckland University of Technology, New Zealand, 2017, quanghuy1993@gmail.com
14. Janusz Pobozniak, " *The Use of Virtual Manufacturing Features in forward Manufacturing Process Planning*", MATEC Web of Conferences 167, 02008 (2018) IC4M ICDES 2018, https://doi.org/10.1051/matecconf/201816702008
15. He Hanwu, Wu Yueming, "*Web-based virtual operating of CNC milling machine tools*", Computers in Industry 60 (2009) 686–697, 2009, www.elsevier.com/locate/compind, Faculty of Electromechanical Engineering, Guangdong University of Technology, China
16. P. Radhakrishnan, S. Subramanyan, V. Raju, "*CAD/CAM/CIM*", Third Edition, New Age Internasional (P) Limited, Publishers, www.newagepublishers.com
17. Chapter 6. *Applications: VRML Browsers and Other 3D Apps*, http://www.libpng.org/pub/png/book/chapter06.html, (accessed on 13 July 2019)
18. Y. C. Kao, H. Y. Cheng, Y. C. Chen, "*Development of a Virtual Controller Integrating Virtual and Physical CNC*", Materials Science Forum Vols. 505-507 (2006) pp 631-636, http://www.scientific.net, (2006) Trans Tech Publications, Switzerland
19. Praveen R. Nair, Harshit Khokhawat, Rajeevlochana G. Chittawadigi, Praveen R. Nair, Harshit Khokhawat, Rajeevlochana G. Chittawadigi, "*ACAM: A CNC Simulation Software for Effective Learning*", International Conference on Robotics and Smart Manufacturing (RoSMa2018), International Conference on Robotics and Smart Manufacturing (RoSMa2018), Procedia Computer Science 133 (2018) 823–830, www.sciencedirect.com
20. Gorka Urbikain, Alvaro Alvarez, Luis Norberto López de Lacalle, Mikel Arsuaga, Miguel A. Alonso and Fernando Veiga, "*A Reliable Turning Process by the Early Use of a Deep Simulation Model at Several Manufacturing Stages*", Machines **2017**, 5, 15; doi:10.3390/machines5020015m. www.mdpi.com/journal/machines
21. Musa Alhaji Ibrahim, Auwalu Yusuf Gidado, Abdulrahman Shuaibu Ahmad, Saidu Bello Abubakar, Huang Kai, "*Modelling and Virtual Manufacturing of a Flange Tube Using CAD/CAM Tools*", Journal of Advanced Research in Applied Mechanics 43, Issue 1 (2018) 1-7, www.akademiabaru.com/aram.html ISSN: 2289-7895