

Prediction of surface roughness for smart machining process in manufacturing production

Agus Sudianto^{1,2}, Zamberi Jamaludin^{1,*}, Azrul Azwan Abdul Rahman¹

¹Smart Factory System - Centre of Smart System and Innovative Design, Fakulti Kejuruteraan Pembuatan, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

²Teaching Factory, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

³Mechanical Engineering Department, STT YBS Internasional, Jln. Pasar Wetan, Kompleks Mayasari Plasa, 46123 Kota Tasikmalaya, West Java, Indonesia

*Corresponding e-mail: zamberi@utem.edu.my

Keywords: Surface roughness; smart machining; special purpose machine

ABSTRACT – Machinery and machining are important subjects to collaborate resulting products with focusing against to the quality products. This paper offers a comprehensive literature survey of the machinery processes along with surface roughness prediction used in aluminum alloy to determine whether a product is being the best quality. For the above reason, the machinery can work in the smart process such as computer numerical control (CNC) machining, nonconventional machining, special purpose machines (SPM) and cinematic robot mechanisms. In this paper, the author surveys the smart machining process by cutting speed, feeding speed and cutting depth in predicting surface roughness of the product in the manufacturing production.

1. INTRODUCTION

The conventional machines in manufacturing industry have undergone massive transformation into computer numerical control machine, nonconventional machine, special purpose machines, robotic and automation as mechanism to work smart [1]. These machinery conduct smart processes and contribute important roles in producing quality components or parts to meet the demands for equipment and devices such as transportation, machinery, handling, jigs, fixture and others [2], [3]. In machining, the quality of the machined parts are primarily determined based on dimensional integrity that is the accuracy and surface finish quality [4]. The author surveys the literatures of the machining parameters such as cutting speed, feed rate and cutting depth in predicting the surface roughness on aluminum material in the smart milling process as elucidated at table 1.

Table1 Beneficial of process parameters in predicting the surface roughness

Surveys	Topics
[5]	To minimize surface roughness used effectively model by optimum parameters in machining operation.
[6]	Improving machining efficiency and reducing production cost can effectively control and accurate prediction for surface roughness.
[7]	Accurate models are needed in predicting

	surface finish to determine the quality products in manufacturing.
[8]	Minimizing surface roughness and maximizing microhardness simultaneously due to be affected optimum machining parameters.
[9]	Avoiding the costly trial and error operation in machining process determine the surface roughness value.

2. PREDICTING SURFACE ROUGHNESS FOR SMART MILLING PROCESS

Monitoring and control of machining processes are becoming increasingly important for maintaining consistency in quality of machined parts [10]. Table 1 explains the influence of cutting parameters to predict the surface roughness in the smart milling operation.

Currently, in producing the products by benefit of cycle time reduction with involving the high-speed machining process, high precision and complex shapes have been using by CNC machines [11], [12].

Nonconventional machines are used also to process inconvenient and irregular shapes such as electrochemical machining (ECM) [13], electro discharge machining (EDM) [14] and others.

Also special purpose machine in particularly designed tooling, fixtures and material handling system, being dedicated to mass-production [4], [15] that reduces the cost of manufacturing production [3], [16], [17]. And cinematic robotic mechanism which are the restricted working area and produced shape limitations, machining robots symbolize flexible alternatives in a cost-saving [18].

3. CONCLUSION

The main objective in any machining process is to adhere the stringent requirements imposed on the quality of the final parts produced. Machining parameters such as spindle speed, feed rate and depth of cut have been categorically identified as main parameters influencing surface finish quality of machined parts. In order to realise smart machining process, a mathematical model is to be developed, analysed and validated utilizing design of the experiment through response surface methodology and

analyzed using regression method. Smart machining process parameters prediction can be utilized for CNC machining, conventional machines, SPM and cinematic robot mechanisms thus ensuring efficient process planning and high product quality.

For future work, further critical survey regarding surface roughness in smart machining process of aluminum alloys can be carried out.

ACKNOWLEDGEMENT

The authors would like to thank the Faculty of Manufacturing Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for the facilities provided and Sekolah Tinggi Teknologi YBS Internasional for the support given.

REFERENCES

- [1] B. Wang, Z. Liu, Q. Song, Y. Wan, and Z. Shi, "Proper selection of cutting parameters and cutting tool angle to lower the specific cutting energy during high speed machining of 7050-T7451 aluminum alloy," *J. Clean. Prod.*, pp. 1–13, 2016.
- [2] W. Zebala and M. Plaza, "Comparative study of 3- and 5-axis CNC centers for free-form machining of difficult to cut material." pp. 345–358, 2014.
- [3] S. Saffar, F. A. Jafar, and Z. Jamaludin, "Methodology on Investigating the Influences of Automated Material Handling System in Automotive Assembly Process," *Mater. Sci. Eng. Pap.*, 2016.
- [4] R. Bhattacharjee, A. Ashfaq, S. U. Shaikh, and V. Karveer, "Development and Analysis of Special Purpose Machine (Peck drilling machine)," *Int. Res. J. Eng. Technol.*, vol. 06, no. 06 June, pp. 175–178, 2019.
- [5] J. Yi, L. Jiao, X. Wang, J. Xiang, M. Yuan, and S. Gao, "Surface Roughness Models and Their Experimental Validation in Micro Milling of 6061-T6 Al Alloy by Response Surface Methodology," *Math. Probl. Eng.*, vol. 2015, 2015.
- [6] N. Liu, S. B. Wang, Y. F. Zhang, and W. F. Lu, "A novel approach to predicting surface roughness based on specific cutting energy consumption when slot milling Al-7075," *Int. J. Mech. Sci.*, 2016.
- [7] I. Abu-mahfouz, O. El Ariss, A. H. M. E. Rahman, and A. Banerjee, "Surface roughness prediction as a classification problem using support vector machine," *Int J Adv Manuf Technol*, 2017.
- [8] P. Raghunayagan and A. Murugarajan, "Experimental investigation of the microhardness and surface roughness of a pressure-die-casted a413 alloy on milling using the desirability approach," *Mater. Technol.*, vol. 53, no. 4, pp. 473–479, 2019.
- [9] G. Zhang, J. Li, Y. Chen, Y. Huang, X. Shao, and M. Li, "Prediction of surface roughness in end face milling based on Gaussian process regression and cause analysis considering tool vibration," *Int J Adv Manuf Technol*, no. 75, pp. 1357–1370, 2014.
- [10] H. Park and N. Tran, "Development of a smart machining system using self-optimizing control," *Int J Adv Manuf Technol*, vol. 74, pp. 1365–1380, 2014.
- [11] R. Lmalghan, K. R. M. C, S. Arunkumar, S. S. Rao, and M. A. Herbert, "Machining Parameters Optimization of AA6061 Using Response Surface Methodology and Particle Swarm Optimization," vol. 19, no. 5, pp. 695–704, 2018.
- [12] K. Zhu and Y. Zhang, "A Cyber-Physical Production System Framework of Smart CNC Machining Monitoring System," *Trans. Mechatronics*, vol. 4435, no. c, 2018.
- [13] A. F. Ibrahim, "Prediction of Surface Roughness and Material Removal Rate in Electrochemical Machining Using Taguchi Method," *Al-Khwarizmi Eng. J.*, vol. 12, no. 4, pp. 72–80, 2016.
- [14] A. Razeghiyadaki, C. Molardi, D. Talamona, and A. Perveen, "Modeling of Material Removal Rate and Surface Roughness Generated during Electro-Discharge Machining," *Mach. Artic.*, pp. 1–17, 2019.
- [15] A. Azizi, P. G. Yazdi, A. Al Humairi, M. Alsalmi, A. Rashdi, and Z. Al Zakwani, "Design and fabrication of intelligent material handling system in modern manufacturing with industry 4.0 approaches," *Int. Robot. Autom. J.*, vol. 4, no. 3, pp. 186–195, 2018.
- [16] C. Wang, "An Improved Dispatching Method (a-HPDB) for Automated Material Handling System with Active Rolling Belt for 450 mm Wafer Fabrication," *Appl. Sci.*, 2017.
- [17] C. Pop and G. Mailat, "Automated Material Handling Systems (AMHS) in libraries and archives Automated Storage / retrieval and Return / sorting Systems," *Recent Res. Neural Networks, Fuzzy Syst. Evol. Comput. Autom.*, pp. 189–194.
- [18] S. K. Chaubey and N. K. Jain, "Analysis and multi-response optimization of gear quality and surface finish of meso-sized helical and bevel gears manufactured by WSEM process," *Precis. Eng.*, 2018.