

# Comparative Study of Tool Path Strategies in CNC Machining for Part with B-spline Surfaces

Zainal Fahmi Zainol Abidin and Muhammed Nafis Osman Zahid

Faculty of Manufacturing, Universiti Malaysia Pahang, Malaysia.  
nafis@ump.edu.my

**Abstract.** CNC machines are widely used in production of various machinery components including turbine blades, impellers, rotors, propellers etc. Most of these components are built-up from free form surfaces which considered complex shapes and required proper set up for machining. This paper presents optimization of toolpath pattern for cutting parts with B spline surfaces in 4 axis machining. Generally the operation is carried out by using 4 axis machining methods which employs variable streamline operations in the finishing process. The appropriate selection of a toolpath pattern can significantly improve productivity and lead to lower production times. Different toolpath scenarios are simulated in CAD/CAM prior to real cutting process. In order to execute the comparative study of tool path strategies, all common cutting parameters (spindle speed, feed rate, tool diameter, plunge-rate, and depth of cut) are set to be constant. The toolpath strategies employed in this study includes helical or spiral, zig, zigzag and zigzag with lift. Cutting operation built-up and validation are performed through NX10, VERICUT and CNC machining. The objective is to optimize the machining process for B-spline model by selecting the shortest toolpath with maximum volume removal based on using variable streamline operation. The result indicates different tool path strategies based on the level of B spline curvature exhibit in the component.

**Keywords:** Toolpath pattern, B-Spline, Free-form surface.

## 6 Acknowledgement

We acknowledge with gratitude to Ministry of Higher Education Malaysia for providing a financial support under Research Acculturation Grant Scheme (RDU160130), which realize this research project.

## References

1. A. Lasemi, D. Xue, and P. Gu.: Computer-Aided Design Recent development in CNC machining of freeform surfaces : A state-of-the-art review. *Comput. Des.*, 7(42), 641–654 (2010).
2. X. F. Zhang, J. Xie, H. F. Xie, and L. H. Li. : Experimental investigation on various tool path strategies influencing surface quality and form accuracy of CNC milled complex freeform surface. *The International Journal of Advanced Manufacturing Technology* 59(5-8), 647–654 (2012).
3. Li H, Dong Z., and Vickers G.W.: Optimal Tool Path Generation for 2½D Milling of Dies and Molds. In: *International IFIP TC5/WG5.3 Conference SSM '98 Sculptured Surface Machining Conference*. 9-11, (1998).
4. T. T. EL-Midany, A. Elkeran and H. Tawfik.: Toolpath Pattern Comparison: Contour-Parallel with Direction-Parallel. In: *Geometric Modeling and Imaging*. *New Trends (GMAT'06)*, vol. 9098902, 77-82, IEEE, (2006).
5. Rakesh Prajapati, Avadhoot Rajurkar, Vijay Kumar Chaudhary.: Tool Path Optimization of Contouring Operation and Machining Strategies for Turbo Machinery Blades. *International Journal of Engineering Trends and Technology (IJETT)*. 4(5) 1731-1737. (2013).
6. P. R. Panchal, S. J. Makwana, S. J. Makwana.: Comparative Study of Tool Path Strategies in NX for Pocket Machining. In: *International Journal of Engineering Technology Science and Research (IJETSR)*. 4(10), 41-48 (2017).
7. K. K. Yana Mundra, Dr. R Karthikeyan, Dr. Vishal Naranjo.: Finite element simulation and Experimental verification of Incremental Sheet metal Forming. In: *IOP Conference Series: Materials Science and Engineering*. 346 (1), 1-12, (2018).
8. [http://www2.me.rochester.edu/courses/ME204/nx\\_help/index.html#uid:drive\\_area\\_milling\\_dialog](http://www2.me.rochester.edu/courses/ME204/nx_help/index.html#uid:drive_area_milling_dialog), last accessed 2019/05/21