Evaluation of Machining Strategies for Production of Free Form Surfaces Using 3-Axle Milling

Peter Ižol[1)], Michal Fabian[1)], Melichar Kopas[1)], Gabriel Fedorko[2)]
[1)]Faculty of Mechanical Engineering, Technical University of Košice, Letná 9, Košice, 040 01, Slovakia.
peter.izol@tuke.sk, michal.fabian@tuke.sk, melichar.kopas@tuke.sk
[2)]Logistic institute of industry and transport, Faculty BERG, Technical University of Košice, Park Komenského 14, Košice, 040 01, Slovakia. gabriel.fedorko@tuke.sk

The components with formed surfaces are being an important category of the machine parts. They are applied in the most of industrial branches. In order to produce such type of machine parts it is necessary to harmonise the contradictory requirements, e.g. the minimal production time, the required precision of dimensions and the surface quality. A relevant role is playing the chosen machining strategy specified for the above-mentioned demands, namely during the finishing operations. The most important evaluation criteria for selection of the concrete CAM-system are: the disposable machining strategies, visualisation level of the proposed process and recognition of the virtually machined surface. The term "machining strategy" represents the pre-defined (and in the CAM-system also the available) tool trajectories that are optimised for machining of the variable formed surfaces so that the work-piece could be machined most effectively. A projection and evaluation of the cutting trajectories is not a simple process. There are at disposal many professional articles, which started to be published after occurrence of the first software solutions created as a support of the NC-software development. A development of the new strategies, i.e. the projection and optimisation of the new methods for control of the tool movement on the machined surface, is a multidisciplinary area, which requires knowledge from the theory of machining, descriptive geometry, informatics and also mathematics. The standard machining applications are such strategies, for example, that are able to optimise the cutting conditions in order to achieve a constant loading of the tool and in this way they enable prolongation of the tool durability as well as improving of the manufactured surface quality. Another important area is also evaluation and comparison of the existing strategies because the proper choice of them can help to reduce the machining times and the tool wear-out due to a shortened length of the tool operational path. This fact has a relevant impact on the production efficiency. The main topic of this paper is a description of the quality analysis focused on a surface area, which was machined by means of the various milling strategies and at the same time there were monitored deviations of the machined surface in comparison to the original 3D-model of the free-form surface area. This matters is analysed in [1], [2], [3], [4].

Keywords: free-form surface, three-axis CNC milling, CAD/CAM/CNC, cutter path strategies, scallop height

Acknowledgements

This paper was elaborated with support of the grant project VEGA 1/0500/12, VEGA 1/0356/11, 1/0922/12 and 1/0036/12.

References

[1] IŽOL, P. (2011). Porovnanie frézovacích stratégií pre tvarové plochy. In: *Transfer inovácií*, Vol. 2011, No. 20, pp. 18–21, ISSN: 1337-7094.

[2] IŽOL, P., ĎURÍČEK, M. (2010). CAM systémy a hodnocení strategií obrábění. In: *itCAD*, Vol. 20, No. 6, pp. 32–33, ISSN: 1802-0011.

[3] FABIAN, M., SPIŠÁK, E., ŠEMINSKÝ, J., DOVICA, M., IŽOL, P. (2010). CAM parameters setup and milled concave and covex surface quality. In: *Metalurgija*, No. 2, pp. 181–185, ISSN 0543- 5846.

[4] MÁDL, J. (2012). Surface Properties in Precise and Hard Machining. In: *Manufacturing Technology*, Vol. 12, No. 13, pp. 158–166, ISSN 1213-2489.

[5] GROOVER, M. P. (2010). *Fundamentals of Modern Manufacturing: Materials, Processes and Systems*. John Wiley & Sons, New York.

[6] GROOVER, M. P. (1980). *Automation, production systems, and computer-aided manufacturing*. Prentice-Hall, New York.

[7] CHANG C. H., MELKANOFF, M. A. (1989). *NC machine programming and software design*. Prentice Hall, New York.

[8] KRÁĽ, J., ŘEHOŘ, J., SPIŠÁK, E., KRÁĽ, J. (2009). *Technologické a informačné činitele obrábania*, s. 506. SjF TU Košice.

[9] DOVICA, M., GMITERKO, A., MOLNÁR, V. (1995). Gauge for straightness and perpendicularity measurement. *Proceedings* of the International Computer Science Conference MicroCAD '95, Miskolc, pp. 1–4.

[10] FABIANOVÁ, J. (2006). CAD/CAM systémy pri návrhu tvaru a výrobe plastových výliskov. In: *Transfer inovácií*, No. 9, pp. 88–90, ISSN: 1337-7094.

[11] ANDREJČÁK, I., MOLNÁR, V. (2001). *Technológie tlakového liatia*, s. 71. FVT TU Košice.

[12] YAO, Z., GUPTA, S. K. (2004). Cutter path generation for 2.5D milling by combining multiple different cutter path patterns. In: *International Journal of Production Research*, Vol. 42, No. 11, pp. 2141–2161 ISSN: 0020-7543.

[13] MICHALIK, P., ZAJAC, J., DUPLÁK, J., PIVOVARNÍK, A. (2012). CAM Software Products for Creation of Program for CNC Machining. In: *Future Communication, Computing, Control and Management*, Vol. 141, pp. 421–425, ISBN: 978-3-642-27310-0.

[14] MICHALIK, P., ZAJAC, J. (2010). Intelligently programming of holes machining. In: *Výrobné inžinierstvo*, Vol. 9, No. 4, pp. 63–65, ISSN: 1335-7972.

[15] WEI, E. J., LIN, M. C. (2005). Study on general analytical method for CNC machining the free-form surfaces. In: *Journal of Materials Processing Technology*, Vol. 168, No. 3, pp. 408–413, ISSN: 0924-0136.

[16] CHEN, Z. C., SONG, D. (2006). A Practical Approach to Generating Accurate Iso-Cusped Tool Paths for Three-Axis CNC Milling of Sculptured Surface Parts. In: *Journal of Manufacturing Processes*, Vol. 8, No. 1, pp. 29–38, ISSN: 1526-6125.

[17] MACUROVÁ, A., VASILKO, K. (2012). Two local extremes of cutting speed. In: *Manufacturing Technology*, Vol. 12, pp. 86–89, ISSN 1213-2489.

[18] QIAN, L., YANG, B., LEI, S. (2008). Comparing and combining off-line feedrate rescheduling strategies in free-form surface machining with feedrate acceleration and deceleration. In: *Robotics and Computer-Integrated Manufacturing*, Vol. 24, No. 6, pp. 796–803, ISSN: 0736-5845.

[19] ERDIM, H., LAZOGLU, I., OZTURK, B. (2006). Feedrate scheduling strategies for free-form surfaces. In: *International Journal of Machine Tools and Manufacture*, Vol. 46, No. 7–8, pp. 747–757, ISSN: 0890-6955.

[20] RAMOS, A. M. RELVAS, C. SIMOES, J. A. (2003). The influence of finishing milling strategies on texture, roughness and dimensional deviations on the machining of complex surfaces. In: *Journal of Materials Processing Technology*, Vol. 136, No. 1–3, pp. 209–216, ISSN: 0924-0136.

[21] TOH, C. K. (2005). Design, evaluation and optimisation of cutter path strategies when high speed machining hardened mould and die materials. In: *Materials & Design*, Vol. 26, No. 6, pp. 517–533, ISSN: 0261-3069.

[22] SELIMOVIC, I. (2006). Improved algorithms for the projection of points on NURBS curves and surfaces. In: *Computer Aided Geometric Design*, Vol. 23, No. 5, pp. 439–445, ISSN: 0167-8396.

[23] VAN DEN BERG, E., BRONSVOORT, F., VERGEEST, J. S. M. (2002). Freeform feature modelling: concepts and prospects. In: *Computers in Industry*, Vol. 49, No. 2, pp. 217–233, ISSN: 0166-3615.

[24] ČUBOŇOVÁ, N. (2013). Postprocessing of CL Data in CAD/CAM system Edgecam using the Constructor of postprocessors. In: *Manufacturing Technology*, Vol. 13, pp. 158–164, ISSN 1213-2489.

 Paper number: M201386

Manuscript of the paper received in 2013-07-17. The reviewer of this paper: *Martin Novak.*