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SOFTWARE REALISATION OF PROPOSAL FOR COMPUTER AIDED SELECTION OF SUITABLE MILLING STRATEGY

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ABSTRACT
The goal of this paper is to describe solution of computer aided selection of manufacturing strategy used for milling using specific software application. Paper also describes selection procedure and criteria determining propriety of choice executed by computer program. From the user's view it features expected functional principles of the program while in the scope of programming environment it deals with factors affecting program creation and solution realization itself.
Keywords: CAD/CAM systems, manufacturing strategies, computer aid, software application

1. INTRODUCTION
In the field of machine industry there is need of improving the production's efficiency, of production time shortening, simplification of production and saving of energies and materials. These goals can be achieved by better exploitation of production devices and lesser tools consumption. Request of productivity improving concerns all the participants from the field of tool, automobile and aero-industry, producers of moulds and different parts of variable shapes in various usage areas.
One possibility of production's efficiency improvement is innovation attitude in milling. It is technology of miscellaneous exploitation for machining of planar, 3D shaped and rotary surfaces, slots, threads and gearing. One of attributes related to better use of milling is milling strategy, which means the way of tool motion down the machined surface. Wrong strategy selection can negatively affect production time and costs in roughing as well as in finishing strategies. Question of suitable strategy choice is therefore still actual even in new vintage CAM systems.
Optimization of manufacturing strategy selection is important matter mainly for new and inexperienced users of CNC technics, as acquirement of knowledge in this area could present barrier from economical and time aspect. Simple but helpful software product should assist in faster decision about strategy fitness and produce positive impacts of this decision correctness. Paper concerns briefing of computer aid of manufacturing strategies and creation method of software used for milling strategy selection.

2. COMPUTER AIDED MANUFACTURING STRATEGIES
Nowadays there is a lot of products offering computer aid in different production spheres including manufacturing strategies area. These systems are intended to simplify the work of NC programmer and to ensure the correctness of his decisions or even to substitute his own decision by software process and by that to secure best possible milling efficiency. To most common CAD/CAM systems

solving the problems of manufacturing strategies currently belong (lat versions of software are listed in brackets): EdgeCAM (version 12), ProENGINEER (Wildfire 4), ProTOOLMAKER, CADDS (version 5), CAM-TOOL (V3), Catia (V5R18), FeatureCAM (2008), SurfCAM (Velocity), Unigraphics (NX5), MasterCAM (X^2), PowerMILL (version 8), ESPRIT (SolidMILL), VX CAD/CAM (version 13)

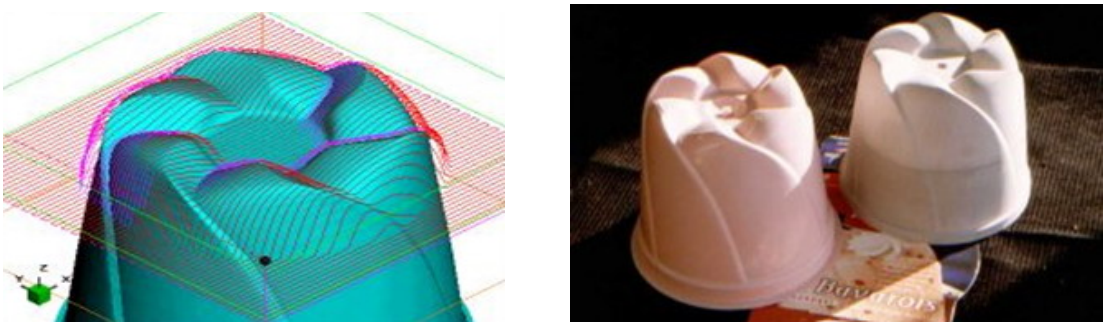

Figure 1. Final product manufactured by using the milling strategy designed in SurfCAM system – raster toolpath copying the shape

These systems providing CAM concern machining up to 5 axis. They contains sections for roughing, which is machining with goal of cutting the most material volume possible considering additional material for further operations and finishing, which means the process of removing residual material left on workpiece after some previous technology.
To main roughing strategies supported in CAD/CAM systems belongs:

- raster milling – tool path is parallel with coordinate system axis, tool is moving upright with minimal steps
- contour milling – tool path copies the contour of machined element
- profiling – tool path copies the contour of machined element while keeps moving with defined steps
- raster and profiling – combination of two previous strategies

Finishing strategies often offered in CAD/CAM systems are:

- projection milling – means projection of 2D predefined motion to the model
- constant Z-hight milling – mill moves in certain hight while copying model's contours
- corner milling – for removing the residual material after previous tool or in between two intersected surfaces
- nib milling – mill moves down the model continuously like a pen
- rotary milling – tool moves linear, workpiece rotates around its axis

In most software concerning manufacturing strategies NC programmer has an option to choose suitable strategy, which would allow surface machining in shortest possible time while preserving requested quality. However only few programs select optimal strategy without choice process of its user.

3. PARAMETERS DETERMINING THE SUITABILITY OF MILLING STRATEGY

When determining the suitability of strategy for certain shape, element or surface, it is necessary to come out with concrete criteria, based on which the decision will be made. These criteria should be usable for various elements, usable and available in different CAM software and utilizable either for man and computer.

To most considered criteria for optimal milling strategy selection belongs:

- **Machining time**

Production efficiency relates to productivity, which is determined by number of parts manufactured in time unit, for example a shift. Manufacturing time of each part is subject to the length of trajectory that the tool absolves during machining process. This length is defined by machining strategy.

Machining time parameter therefore presents important criteria in efficiency judging process since machining time value affects duration of production.

- **Tool wear**

Tool wear parameter is observed especially for tendency of optimal use of cutting tools (mills), which belongs to technical-material resources directly affecting production costs. Mill wear arises from interaction between tool and workpiece material and depends mostly on cutting conditions. Often it's about combination of these four factors:

- Mechanical factor – static and dynamic loads resulting from chip creation process.
- Thermal factor – heat coming from machining strains material of cutting tool.
- Chemical factor – comes out from very metallic surface inclined to chemical reactions.
- Abrasive factor – most machined material contains hard grains causing abrasive effect.

Combination of these four factors negatively affects cutting material and interrupts it. Troubles related to discontinuous cutting can be avoided also by suitable strategy choice.

- **Acquired quality**

This parameter reflects surface condition obtained at the end of milling by used strategy. It is about extent of roughness on surface, overall stresses under the surface, etc. Higher need of further technological actions results in more time needed for manufacturing and higher production costs. Therefore the extent of residual material should be concerning as another criteria for optimal strategy selection.

Of course in all three cases desirable result gives the strategy with minimal criteria value.

4. CREATION OF SOFTWARE APPLICATION SELECTION OF SUITABLE MILLING STRATEGY

Application should terminate optimal strategy after considering decision criteria. To do so it will compare the output values of computations for each strategy (length of absolved trajectory, number of contours, etc). To perform these computations program needs input data given by user corresponding with cutting conditions. That concern tool diameter, feed rate, side motion and machined surface dimensions.

First proposal (test version) of application should be able to evaluate milling strategies shown in figure 3.

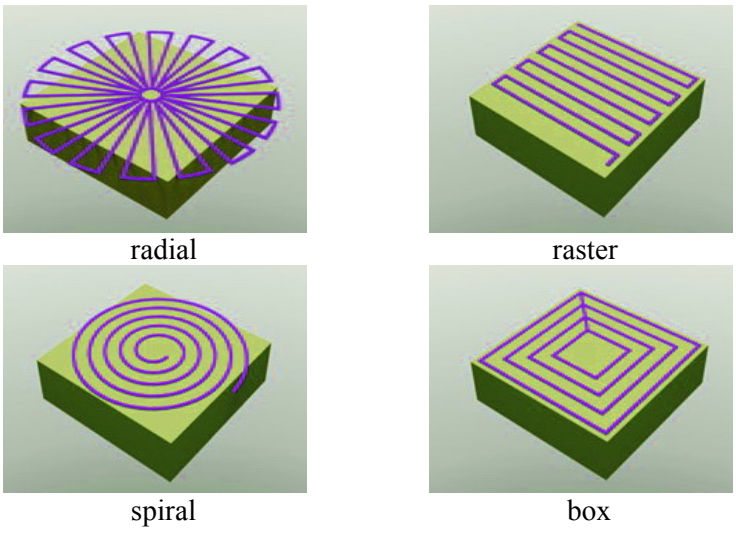

Figure 2. Milling strategies in first proposal of new software application

Computations in first version of program will use mathematical operations summarizing length of tool trajectory. When entering input data into the editable labels, it assigns them to relevant variables. Numerical dimensions of machined surface and tool diameter serves as limit borders decisive about stopping of tool motion. After pressing the COMPUTATION button program starts the procedures that calculate the length of tool path for each strategy according to input data received from user. Optimal solution presents the variant with lowest value of machining time criteria.

As programming environment, Delphi software was chosen. From programmer point of view, application will use events control of particular visual components – panels, edit fields, labeled edit fields, buttons, images. From the aspect of computation, main part of program code will consist of cycles, that ensure computing determination in case of reaching the borders of machined surface. Final border contouring of machined element needs to be added to result in order to make the final faces and edges smooth.

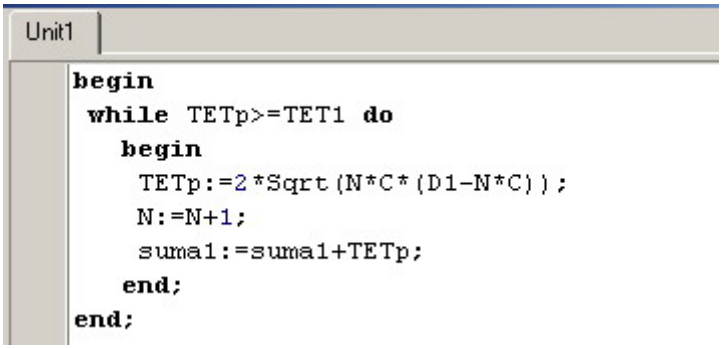

Figure 3. Sample of source code from prepared application – cycle determining computation of trajectory accumulating lengths of strings inside the diameter of machined surface

5. CONCLUSION

Computer aid of optimal manufacturing strategy selection and proposition has important role in improvement process of production efficiency and productivity. This fact is confirmed by experiences of many companies operating in different industrial spheres. Therefore it is mission of software creators to provide users with better and more accessible possibilities of usage of computer aided selection process related to manufacturing strategies.

Current CAD/CAM systems dispose with great tools in the field of suitable strategy selection and proposition. Many users though would appreciate simple program that would not be fixed to any other software able to pre-select optimal manufacturing strategy.

Paper describes the way of such program's creation, briefly describes programmer environment and methods used for determining of suitable strategy. In future the program should be enriched of computations concerning third dimension, what would make it applicable for non-planar surfaces. Huge addition would be the possibility of working with surfaces imported from other software and combination of mathematical computing methods with 3D graphical robot. This software tool of Delphi environment uses vector-declared commands for fictive graphic pen motion in the area with predefined borders.

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6. REFERENCES

[1] Kuric, I. – Novák-Marcinčin, J. – Cotetiu, R. – Ungureanu, N.: Development of Progressive Technologies – Computer Support for Progressive Technologies. Vienna, 2007, 253 s., ISBN 3-901509-28-3.

[2] Vasilko, K. – Hrubý, J. – Lipták, J.: Technology of Cutting and Assembly. Alfa Bratislava, 1991, 480 s., ISBN 80-05-00807-4 (in Slovak).

[3] Kuric, I. – Košturiak, J. – Janáč, A. – Peterka, J. – Marcinčin, J.: Computer Aided systems in Mechanical Engineering. EDIS – ŽU, Žilina, 2002, ISBN 80-7100-948-2 (in Slovak).

[4] Delcam: Education Course PowerMILL v5.5, Delcam Brno, 2005 (in Czech).

[5] Písek, S.: Introduction to DELPHI Programming. Grada Publishing, 2000, 303s., ISBN 80-247-9008-4 (in Czech).

[6] Kalpakjian, S., Schmid, S. R.: "Manufacturing Engineering and Technology". Prentice-Hall, New Yersey, 2001, 1148 p.