ANALYSIS OF SHAPES FOR THE DEVELOPMENT OF ALGORITHMS FOR STRATEGIES OF MACHINING PROCESS IN THE CAM SYSTEM

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Abstract. The article deals with application of geometric features and algorithms for optimization of manufacturing processes. Algorithms allow to create strategies based on a properties of geometric features. These strategies can be used to remove repetitive tasks and shorting of time for creation a machining process. Article describes the use of a Feature Based Machining (FBM) and a recognition of geometric features**.**

KEY WORDS: algorithms, optimization, geometric features, machining process, CAD/CAM systems

1 INTRODUCTION

At present the CAD/CAM systems are essential for almost every company that produces machined parts. These systems allow companies to quickly adapt to customer requirements and respond flexibly to changing production of parts. Their main advantages include speed of creation of NC program for parts with complex shapes as well as the simulation of whole machining process. However, programmer is forced to perform repetitive tasks in the creation of NC programs for new plants, such as a face milling or pocket milling. For that reason, some CAD/CAM systems offer ways to eliminate repetitive tasks and thus automates and streamlines the entire process of creation of NC programs. One such possibility is for example, developing of strategies or macros. The process of creation of strategy is different in every CAD/CAM system. One of the basic functions of these CAD/CAM systems is to identify the features of workpiece [1]

The CAD/CAM systems which allow creation of strategies are for example CAD/CAM system Edgecam 2016 and PLM system NX10 (NX CAM) and others. Name of modules are Strategy Manger (Edgecam 2016) and Machine Knowledge Editor (NX 10).

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2 FEATURE BASE MACHINING IN CAD/CAM SYSTEMS

Feature Base Machining (i.e. FBM), allows the programmer to automate process of creation of NC programs. FBM possibilities can be different in every system. Basically can be said, that FBM evaluates the component's features and automatically creates an effective machining strategy. This task is completed in seconds, and the program is generated in a matter of minutes [6, 7]. FBM combine automatic feature recognition and database with strategies. CAD/CAM systems with FBM can be divided as:

a. add-on module for milling, turning, drilling holes or wire EDM, an example NX 10. It means, company can buy CAD/CAM system without FBM module.

b. as an integral part of CAM software (integrated directly in the system), example is Edgecam 2016, with Feature Finder function. In Figure 1 A dialog is shown with a choice of various features required by the programmer and the component on which will be recognized all shapes. In Figure 1 B are shown all detected features and tree structure of recognized elements in the tab Features

Feature base machining is used with database modules supporting development of strategies, in CAD/CAM system Edgecam 2016 is module named Strategy Manager and in NX 10 module Machining Knowledge Editor.

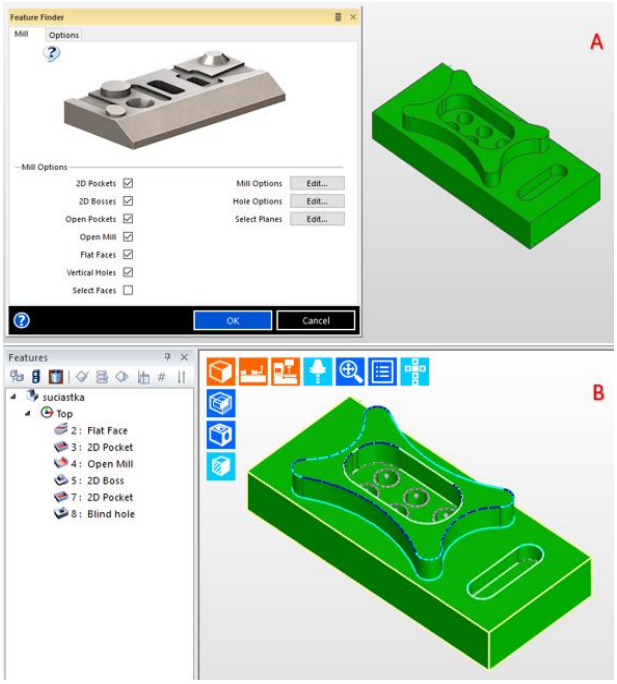

Fig. 1. Feature Finder and recognition of geometric features in Edgecam 2016.

2.1 Recognition of geometric features in CAD/CAM systems

Recognition of geometric features is done after creation of model in CAD system. Recognition can be made in CAD/CAM systems or in another system used for recognition of features. For recognition are necessary two types of data, i.e. geometrical and topological. This data is stored in database of system. The recognition of features is done by searching and comparing information stored in the database and the model itself [2].

Recognition includes three major tasks:

a) definition of the features - for definition are use rules stored in database,

b) sorting and extracting features from model (solid model),

c) storage for further use - e.g. in feature tree.

At recognizing geometric features from CAD models are used two methods. The first method is named as Internal. This method allows to read data directly from a CAD file of system in which was the model created and saved. The second method is named as External and allows read data from files which have been exported to neutral formats ASCII file [2, 3].

CAD/CAM system Edgecam 2016 uses first method, i.e. features are recognized directly from the output CAD file system. Features recognized in Edgecam 2016 can be divided into four basic groups - 2D and 3D features, surfaces and holes.

3 COMPARISON BETWEEN CAD/CAM SYSTEMS WITH RECOGNITION OF GEOMETRIC FEATURES AND WITHOUT

In the next chapter is shown comparison of the time required to create machining process for simple parts (Figure 2) in CAD/CAM systems. The comparison was made between a pair of CAD/CAM systems. First was CAD/CAM system Edgecam 2016 which contains feature recognition and second was CAD/CAM system Creo 2.0 which does not contain feature recognition. Comparison does not take into consideration the time needed to properly set a zero point, choice of a fixture or creation of a tool database [4, 5, 6].

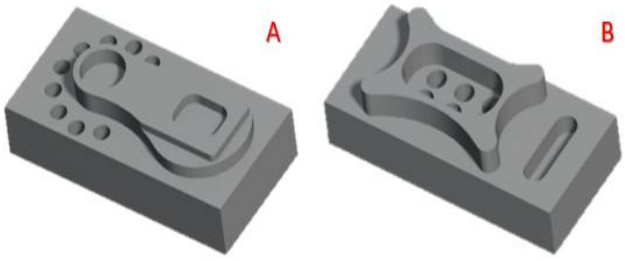

Figure 2. Parts for analysis of time in Edgecam 2016 and Creo 2.

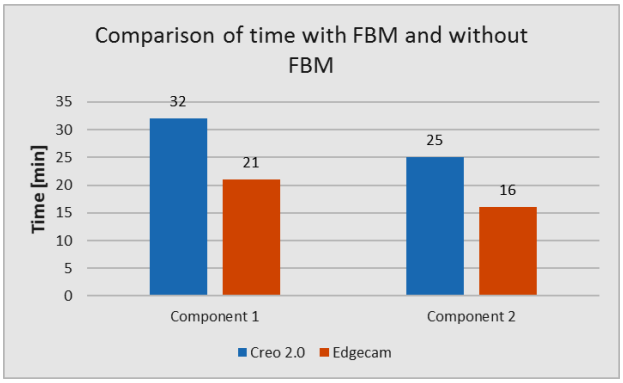

Figure 3. Comparison of time needed for creation of machining process with FBM and without FBM.

The comparison, shown in Figure 3 demonstrated the effectiveness of preparing machining process using Feature base machining. The time needed to creation of the machining process in a CAD/CAM system Edgecam is shorter than the time needed to build the same machining process in the Creo system 2 without the use of feature recognition.

4 SPECIFICITIES AND DIFFERENCES IN CREATION OF STRATEGIES IN CAD/CAM SYSTEMS

The strategies are essentially algorithms, which may include a number of machining processes for a variety of geometric features. Machine cycles and geometric shapes can be combined within a single strategy. For example, roughing and finishing operations or countersinking, drilling and threading.

Input data for strategies can be divided into three basic groups:

a) Geometric data - contain information about the features, dimensions or other information as surface quality and tolerance,

b) Technological data - Contain information about cutting data or chosen strategy of roughing,

c) Additional data - orders for the tool change or move to reference

The main difference in the development of strategy for CAD/CAM system Edgecam 2016 and CAD/CAM/CAE system NX10 is process of creating of strategy.

In CAD/CAM system Edgecam 2016 is strategy created by using an algorithm (Figure 4). Algorithm has form of flowchart. Each part of strategy such as information about geometry and the technological operations are copied from existing machining processes and they are edited so that they may be used for machining of similar geometric features.

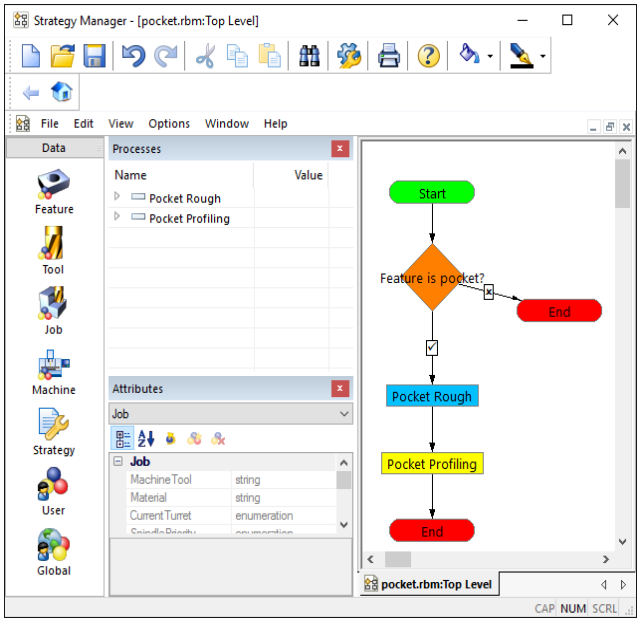

Figure 4. Strategy Manager in CAD/CAM system Edgecam.

In CAD/CAM/CAE system NX10 is a strategy created in the module Machining Knowledge Editor (Figure 5) and requires knowledge of Visual Basic programming language. For creation of strategy is necessary to define the six basic parameters. These parameters are name of strategy, type of operation, priority of rule, input and output geometric features. The next step is to define Conditions. This is a set of rules that determine when will be strategy applied.

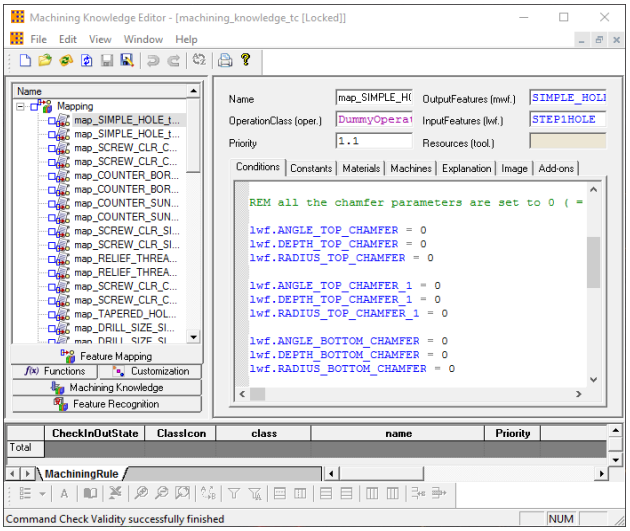

Figure 5. Machining Knowledge Editor in CAD/CAM/CAE system NX10.

5 ANALYZE OF FEATURES FOR CREATION OF EXPERIMENTAL STRATEGIES

As mentioned in chapter 4, geometric data are necessary to creation of strategy. Before creation of strategy was made analyze of features. Feature analysis contained basic types of features and additional attributes of features. Choice of features is based on possibilities of CAD/CAM system Edgecam. Complete analysis is listed Table 1. For all of these types of features was created the sample parts (Figure 6 A - Complex Step B in Figure 6 - Contured Pocket). These parts were used for creation of experimental strategies. The analysis contains only features that are part of milled parts.

Table 1. Analyze of features for experimental strategies

Feature	Attributes			
	Base Shape	Depth	Open/closed	Additional attributes
Surface	Regular	N/A	N/A	N/A
	Complex			
Step	Regular	N/A	N/A	N/A
	Irregular			
	Contured			
	Complex			
Pocket	Regular	Blind	Open	N/A
	Irregular			
	Contured	Through	Closed	
	Complex			
Slot	Regular	N/A	Open	Straight
	Irregular		Closed	Curved
	Contured			Complex
Boss	Regular	N/A	N/A	Thread
	Irregular			
	Non-Uniform			
Hole	Regular	Blind	N/A	Thread
	Irregular	Through	N/A	
Rib	Rectangular	N/A	N/A	N/A
	Trapezoidal			
Chamfer	External	N/A	N/A	N/A
	Internal			
Fillet	External	N/A	N/A	N/A
	Internal			

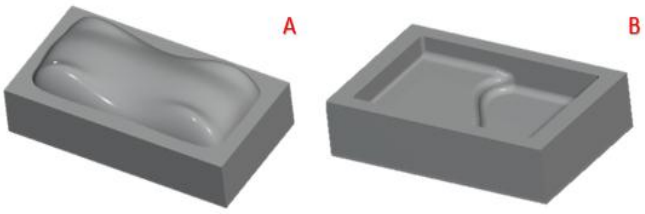

Figure 6. Sample parts A - Complex Step, B - Contured Pocket.

At the verification was found that the features as a boss, rib, chamfer, fillet in Edgecam 2016 do not have assigned their own rules for recognition. For example, chamfer is recognized as 2D step. The analysis also includes only basic features and for further use will be necessary to create additional analysis for complex shapes such as 3D surfaces.

6 PROPOSAL OF EXPERIMENTAL STRATEGIES BASED ON ANALYSIS OF SELECTED FEATURES IN CAD/CAM SYSTEM EDGECAM 2016

Proposal of experimental strategies was based on the analysis shown in chapter 5. After creating a sample parts were created experimental strategy. Strategies have been proposed in the Strategy Manager of CAD/CAM software Edgecam 2016.

The experimental strategies are designed to contain these steps:

1. conditions for use strategy - defined features for which will be the strategy used,
2. choice of Tool - the conditions for the selection of the right tool based on characteristics of features,

3. machine cycles - roughing and finishing cycles,
4. tool change - a position for change of tools,
5. function for update stock.

After creating all experimental strategies have been these strategies applied on experimental component. The experimental part contains several features. As can be seen in Figure 7, features have different characteristics as basic shape or depth. To verify the functionality of experimental strategies was chosen component manufactured.

Figure 8 is shows the comparison of time necessary to create machining process using strategies and without strategies. Implementing of custom experimental strategies, it is possible to reduce time necessary to prepare machining process in CAD/CAM system Edgecam 2016.

By verifying the correctness and functionality of created experimental strategies will be developed more complex strategies for complex features in future. Strategies will be designed to be able to clearly demonstrate the benefits of their use or identifying their weaknesses. They will also study other systems that have the ability to developed strategies as mentioned CAD/CAM/CAE NX 10.

Figure 7. Experimental component produced with experimental strategies.

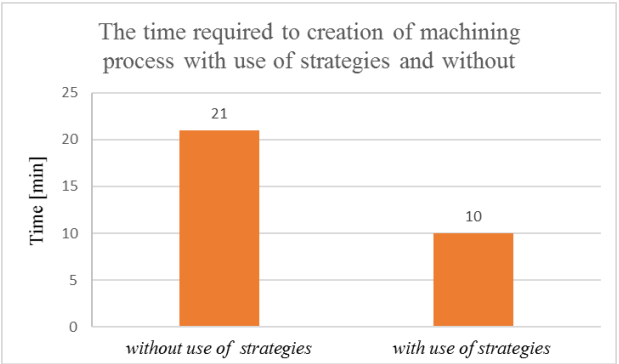

Figure 8. Time necessary to prepare machining process with and without implementation of strategies.

7 CONCLUDING REMARKS

The main advantages of creating strategies belong speed of creation of NC program and also the versatility of use. Strategies can be used for number of components based on similarity of geometric features. Also can be created comprehensive strategies for specific components. This type of strategy contains several machining cycles and several types of features.

Analysis of geometric features and development of strategies highlighted a several problems in CAD/CAM system Edgecam 2016. The most significant problem is recognition of fillet or chamfer. CAD/CAM system Edgecam 2016 recognizes these features as 2D Step. The problem is caused by the absence of rules for recognition these geometric features.

After analyzing the basic geometric features will be processed analysis of complex geometric features such as 3D surfaces and another 3D geometric features. This analysis will also use for creation of complex strategies and it will point out on possible limitations and weaknesses of strategies. These analyzes of geometric features will be used for creation of strategies in another CAD/CAM system e.g. in CAD/CAM/CAE system NX 10.

Analysis of geometric features and design of experimental strategies give the possibility for solution of problems connected with utilization of strategy as well as solving of research projects focusing on the use of the CAD/CAM systems on Department of automation and production systems. Research projects will focus on effectiveness of milling strategies, CAD/CAM system with support of feature base machining, optimization modules and so on.

8 ACKNOWLEDGEMENTS

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9 REFERENCES

►N. Čuboňová, N. Náprstková, (2004). "*NC Verification, Machine Simulation and NC Optimization in CAM Systems.",* pp 57-62,

► N. Čuboňová, M. Císar, (2015) "*Design of camera mount and its application for monitoring machining process*."

►B. Babic, N. Nesic, Z. Miljkovic, (2008). "*A review of automated feature recongnition with rule-based pattern recognition.",* pp 321–337

►V. Bulej., A. Sapietová, I. Kuric, M. Krajčovič, (2013) *"Intelligent Manufacturing Systems in concept of digital factory.",* pp 77-87,

►M. Drbúl, D. Stančeková, O. Babík, J. Holubjak, I. Görögová, (2016) *Simulation possibilities of 3D measuring in progressive control of production,*