A knowledge base model of integral impeller milling process based on Teamcenter platform

Jiangyi Yan1,a, Wenwang Qiu2, Shujie Liu3, Tong Zhao4*

1Beijing Key Lab of Precision/Ultra-precision Manufacturing Equipment and Control Department of Mechanical Engineering Tsinghua University Beijing, China
2Beijing Power Machinery Research Institute Beijing, China
3Beijing Key Lab of Precision/Ultra-precision Manufacturing Equipment and Control Department of Mechanical Engineering Tsinghua University Beijing, China
4Beijing Key Lab of Precision/Ultra-precision Manufacturing Equipment and Control Department of Mechanical Engineering Tsinghua University Beijing, China

aEmail: yanjy18@mails.tsinghua.edu.cn
*Corresponding Author Email: zhaotong@mail.tsinghua.edu.cn

Abstract—As an important foundation of integral impeller milling manufacturing, integral impeller milling process knowledge plays a significant role in design and production. With the rapid development of aerospace industry and intelligent manufacturing technology, it is very urgent to construct knowledge base of milling process for typical integral impeller structure. Based on the analysis of typical milling process knowledge of integral impeller, the study proposes a model of knowledge base of milling process of integral impeller based on Teamcenter platform, which can effectively realize the sharing and reuse of knowledge of integral impeller milling process.

1. INTRODUCTION

Integral impeller is an important part of aero-engine, its manufacturing level will directly affect the overall performance of aero-engine. At present, with the rapid development of intelligent manufacturing technology and big data technology, intelligent manufacturing and rapid manufacturing of integral impeller have become the focus of intelligent manufacturing research[1-3].

Due to the diversity and complexity of the whole impeller process knowledge, the traditional empirical knowledge management method could not effectively describe and apply the whole impeller milling process knowledge[4-5]. How to use effective methods to manage and utilize the knowledge of the whole impeller milling process, so as to improve the design level and core competitiveness of the intelligent manufacturing of the whole impeller[6], is the core problem to be solved in the intelligent manufacturing of the whole impeller.

In this study, a knowledge base model of integral impeller process based on Teamcenter product life cycle management platform is proposed, which can collect a large number of the previous process documents of the whole impeller milling, realize the storage and management of the whole impeller process knowledge and data, automatically generate the milling template process and intelligently determine the relevant process parameters.
2. FUNCTIONAL COMPOSITION
The function modules of integral impeller process knowledge base include Parts information base, Manufacturing resource base, Process rule base, Process template library of typical parts, Process parameter decision base, Cutting knowledge base and Process knowledge base management system[7]. Part information base is used to store the basic information of different integral impeller, mainly including the type and characteristic information of integral impeller. Manufacturing resource bank is used to store the related equipment information needed in the whole impeller milling process, including the machine tool information, tool information, fixture information and other auxiliary equipment information. Process rule base is mainly used to store the process plan information of integral impeller milling, which is mainly the experience and knowledge of process experts expressed in the form of production rules, including process information base, process information base, work step information base and the associated information base between them.

Process template library of typical parts is to establish a relatively complete and mature process template for some commonly used typical and important integral impeller parts, so as to efficiently generate new process route files of typical parts. It mainly includes the following three aspects: Typical 3D template library, Typical process template library and Typical process route reuse rule library[8]. The typical 3D template library is a copy of the 3D template library at the process end, which is mainly used as a reference template for automatic labeling of feature information, so as to facilitate automatic identification and relevant information labeling of process model features of typical parts with the same feature. The typical process template database of structured process compilation system is to classify and store the typical processing scheme and process structure of target parts in the form of template according to the process practice and knowledge of target parts, so as to facilitate the later reference and reuse. The typical process route reuse rule library is in order to facilitate the automatic retrieval and reuse of typical process templates, a matching rule base is proposed for each template to facilitate the post-structured process compilation system to realize intelligent adaptive filtering of corresponding process templates according to the relevant attribute names and attribute values of parts.

Process parameter decision base is mainly used to manage, store and intelligently decide the core process parameters needed in the whole impeller milling stage, and finally output them to CAM. Cutting knowledge base is mainly used to store a large number of mature cutting knowledge and experience, and finally a common cutting comprehensive knowledge manual is formed in the knowledge base system to facilitate the query and management of some basic cutting knowledge, mainly including cutting basic knowledge, tool basic knowledge and some other process experience knowledge.

Process knowledge base management system is the overall framework of the whole impeller process knowledge base[9-10], which is mainly responsible for the communication and information exchange between the knowledge base and the outside world, as well as the modification, expansion, testing and refining of the knowledge base, so as to maintain the consistency and integrity of the knowledge base.
To sum up, the function composition of the knowledge base of the integral impeller milling process based on Teamcenter platform is shown in the Fig. 1.

3. Overall Development Layout
Among the functional modules of the whole impeller milling process knowledge base, Part information base, Manufacturing resource base, Process template library of typical parts, Cutting knowledge base and Process knowledge base management system can be directly established and developed on Teamcenter.

Process rule base is the core and key of process knowledge base. It mainly includes two parts: process framework knowledge and process reasoning rules. Process framework knowledge mainly refers to some process dictionary knowledge in process reasoning rules, which is directly used for query, so it can be directly deployed and developed on team center. Process reasoning rule is the core of process intelligence of the whole impeller milling process knowledge base, which refers to the knowledge reuse and reasoning rules based on the part feature recognition. It needs to recognize the new part features, and then establish a reasoning rule model based on the part feature information and the required generation process. Therefore, it needs to use CAM/CAD software and Eclipse Plug-in to carry out team center Secondary development[11].

Process parameter decision base is mainly used for the intelligent decision-making of overall impeller milling process parameters. It uses Pycharm integrated development environment to carry out data mining and intelligent decision-making algorithm modeling, which needs data interaction with Teamcenter.

The development layout of each functional module in the knowledge base of integral impeller milling process is shown as Fig. 2.

4. Key Information Composition
The key information of the knowledge base of integral impeller milling process mainly refers to some important information contained in each component, the specific contents are as follows:

(1) Machine tool information: machine type and precision, spindle power, cutting force and feed force, maximum feed speed and maximum spindle speed.
(2) Tool information: brand manufacturers, tool types, tool characteristics parameters (ball head radius, working length, tool rod diameter, life and tooth number), and tool price.

(3) Workpiece information: workpiece name, workpiece size, material, structural feature, surface roughness, shape and position accuracy and size accuracy.

(4) Process information: process parameters, processing stage (rough milling, semi finish milling, finish milling, root cleaning and bottom sweeping), processing mode, processing strategy, coolant, etc. Among them, the process parameters include spindle speed, feed speed, axial cutting depth and radial cutting depth, machining allowance and tool parameters (tool ball head diameter, tool taper and tool rod diameter).

5. PROCESS PARAMETERS INTELLIGENT DECISION DATA INTERACTION
The intelligent decision-making of process parameters is the core of the intelligent parameters of the whole impeller milling process knowledge base. It is necessary to build an intelligent decision-making model of the whole impeller milling process parameters based on machine learning and data mining algorithm by using Pycharm platform, to intelligently decide the combination of process parameters needed for the whole impeller milling process, output to CAM, and finally reduce the milling processing time and improve production efficiency.

The specific implementation process and data interaction process are as follows: Firstly, all the collected process data are sorted out and collected in the process parameter database established by Teamcenter platform to form process parameter big data. Then, it is the input to Pycharm integrated development environment platform for data mining and analysis, and an intelligent decision algorithm model of process parameter based on machine learning and data mining algorithm is established. After that, for new parts, the combination of process parameters can be obtained by using the intelligent decision-making model of process parameters, and output to the process parameter database of Teamcenter platform. Finally, it is exported by Teamcenter platform for the input of process parameters of CAM milling process programming of new parts.

Fig. 3 shows the intelligent decision-making process of process parameters and data interaction process as a whole.

6. OVERALL OPERATION PROCESS.
Based on the design of the above integral impeller milling process knowledge base model, the final automatic process generation process of integral impeller milling template based on Teamcenter platform is shown in Fig. 4.

The core of the whole model is to realize the intelligent decision of the whole impeller milling process parameters

7. CONCLUSIONS
Aiming at the milling process of aero-engine, a knowledge base model of integral impeller milling process based on Teamcenter platform is proposed in this paper, which can effectively manage and reuse the previous process knowledge of integral impeller, and realize the automatic generation of integral impeller milling process and intelligent decision-making of process parameters.

Finally, it can reduce the whole impeller milling cycle, improve the machining efficiency and reduce the production cost.
ACKNOWLEDGMENT
1. This work was supported by the National Natural Science Foundation of China (51875312).
2. This work is supported by Research Room of Intelligent CNC System of Department of mechanical engineering in Tsinghua university of China.

REFERENCES
[1] S J, Monies F and Redonnet J M. Improved positioning for side milling of ruled surfaces: Analysis of the rotation axis's influence on machining error [J]. International Journal of Machine Tools and Manufacture, 2007, 47: 934-945.
[2] Wu P and Xu Z 2005. Silanation of nanostructured mesoporous magnetic particles for heavy metal recovery Industry and Engineering Chemistry Research. 44(2005)816-825.

[3] S Assarzadeh and M Ghoreishi. Neural-network-based modeling and optimization of the electro-discharge machining process[J]. The International Journal of Advanced Manufacturing Technology, 2008,39:488-500.

[4] Ali R and Yildiz. Hybrid Taguchi-differential evolution algorithm for optimization of multi-pass turning operations[J]. Applied Soft Computing, 2013,13(3):1433-1439.

[5] Srinivas J, Giri R and Yang SH. Optimization of multi-pass turning using particle swarm intelligence[J]. International Journal of Advanced Manufacturing Technology, 2009,40(1/2):56-66.of Advanced Manufacturing Technology, 2008,39:488-500.

[6] Qiang Li and Ling jiang Ouyang. Process Optimization of CNC End Milling of Integral Impeller Channels. Applied Mechanics and Materials. 2012, 268-270. 1469-1473.

[7] Bonczek R H, Holsapple C W and Whinston A B. A generalized decision support system using predicate calculus and network data base management[J]. Operations Research, 1981,29(2):263-281.

[8] Zhang X H, Deng Z H and Liu W. Combining rough set and case based reasoning for process conditions selection in camshaft grinding[J].Journal of Intelligent Manufacturing, 2013,24(2):211-224.

[9] Feng H Y and Mend C H. The Prediction of Cutting Forces in the Ball-End Milling Process-I, Model Formulation and Model Building Procedure[J].International Journal of Machine Tools & Manufacture, 1994,34(5):697-710.

[10] Lee P and Altintas Y. Prediction of Ball-End Milling Forces from Orthogonal Cutting Data[J]. International Journal of Machine Tools & Manufacture, 1996, 36(9): 1059-1072.

[11] Monica Shekhar and RAK Saravanaguru. A case study on semantic web search using ontology modeling[J]. International journal of engineering and technology, 2013.5(3):2342-2348.