Design and Development of the Intelligent Process System for Marine Shafting

Yiheng Qiao[a], Ning Mei[b], Lina Song[c], Ji Zhang[d], Ance Shang[e]

Laoshan Campus, Ocean University of China
No. 238, Songling Road, Laoshan District, Qingdao, Shandong, China

*Corresponding author e-mail: 1997015@ouc.edu.cn, [a]yihengqiao@126.com, [b]nmei@ouc.edu.cn, [c]1997015@ouc.edu.cn, [d]348389755@qq.com, [e]1771600211@qq.com

Abstract. In order to realize the automation of shipbuilding industry and the integration of products, this paper develops an intelligent process system for the marine shafting based on modular design to obtain the automatic generation of process documents and the construction of enterprise's database. The intelligent process system is established by VB programming language, which based on the object-oriented visual programming language. The structure of the intelligent process system is modeled by design philosophy, which is easy to combine object-oriented programming with modular design philosophy. The structure of the intelligent process system is divided into knowledge base/database module, automatic drawing module and process planning module. The marine shafting of a large container ship is adopted to verify the rationality of the intelligent process system. Design parameters is input in the user interface, then the technical files of the marine shafting are generated that can be used for guiding the process of manufacture. Technical files are unified and managed by database of the intelligent process system. The intelligent process system realizes the automatic management of product files. The example shows the system increases the enterprise's degree of information and automation and also improve the competitiveness of enterprise in the market.

1. Introduction

Modular design has become a widespread theme in product manufacturing. Modular design has unique advantages in the intelligent process system. Modularity facilitates managing large number of interfaces, which is important for structuring design knowledge, complexity management, upgrading, evolvability, parallel working of teams and replacement of parts of the system [1], [2], [3]. Although integral design could be advantageous from high performance, spatial and material efficiency point of views [4], the flexibility provided with modular design remains an advantage from the technology development, product variations, large scale and multi-scope management point of views. The characteristic of a modular product is identification of separate groups of components within the system in such a way that intra-group relations within the components are maximized and the inter-group relations are minimized [5]. Minimizing the component and subsystem dependencies is also in accordance with the famous axiomatic design approach [6]. The modular design and application of the

system is not only indispensable needs in this age, but also is the best choice for enterprise's response to the rapidly changing market [7]. The modular design of this intelligent process system includes knowledge base/database module, automatic drawing regeneration module and process planning module. The knowledge base/database is equivalent to the information collection in the entire system, knowledge base and database work together to control the operation of the entire system. Automatic drawing module manages the generation of AutoCAD drawings, which includes parts drawings and process drawings. The output of the process files is done by the process planning module, the process files guide the manufacture of the intermediate shaft. The machinery industry is becoming increasingly competitive, in order to stand out in the market's fierce competition, enterprise must improve the ability to innovate, shorten the manufacture cycle, reduce production costs, ensure product quality and great after-sales service. In the era of personalized and large-scale customization of the product, the traditional manufacturing method has not been able to complete the manufacture task, modular design method will play an increasingly important role [8].

Although modular design has achieved great progress, there are still several problems remaining to be solved. All the methods have very different criteria on what basis to modularize. All are important, of course, but one cannot optimize perfectly according to all criteria. Technical performance is one important criterion in many industries and the above methods do not handle this aspect particularly well. In addition, the above methods do not rely on the software platform, some functional modules cannot run uniformly on the software platform based on the modular design. An active research direction in modular design is to build a software platform realizing the concept of ''intelligent manufacturing'', the software platform can also be considered as a marketplace, in which the stakeholders trade [9], [10], [11]. To solve these problems and make modular design more accessible, in this paper we present a smart software platform for intermediate shaft of a ship based on modular design.

The proposed software platform takes three modules to generate the technical documents about marine shafting, in the intelligent system we added the simulation analysis in the module to solve the problems about the technical performance. After the simulation, the results are post-processed for visualization. The proposed software platform based on the modular design has four unique features different from other existing software platform:

1. Our practical software platform based on the modular design includes automatic drawing module, process planning module and knowledge base/database module, combining with specific industrial applications about the intermediate shaft of ship.

2. The software platform based on the modular design supports different output data (2D drawings, 3D drawings, technical documents, simulation analysis).

3. The software platform uses the genetic algorithm to calculate the minimum working hours of the turning.

The layout of the paper is as follows. Section2 overviews the overall framework of the software platform. Section3 introduces the knowledge base/database module. Section4 presents the automatic drawing module. Section5 presents the craft automatic planning module. Finally, Section6 draws the conclusion.

2. Overall Framework

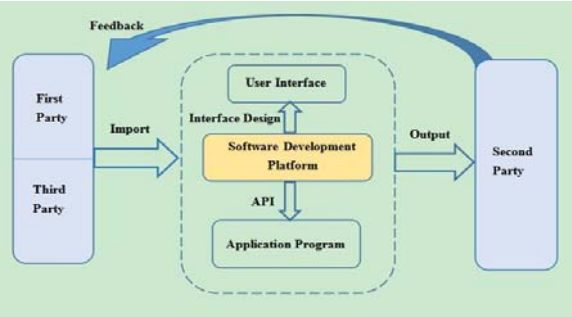

Fig. 1. The overall framework of the system

As shown in Fig.1, this paper takes the marine shaft as an example, expounding the principle of overall framework of the system. Party A represents customer, Party B represents enterprise, the third party on behalf of the enterprise's Party B. Due to the lack of enterprise's capacity of production, part of customers' matching orders will be outsourced to the third party. Party A and the third party should provide the design parameters as an input side. The side will send enterprise files they needed by the software development platform. What's more, the side will solve the enterprise technical problems in production process. In a sense, the software development platform is a medium that has its own hierarchical structure. The middle layer is the core of this platform which is used for interface design and forming the top user interface ultimately. System and users will have a good interaction and information exchange with user interface, and it is also the user interface to receive product design parameters of party A and the third party. After obtaining the API interface access with coding design, some lowest level Windows applications such as AutoCAD, SolidWorks, Ansys can have a secondary development. According to the intermediate shaft design parameters of input terminal, AutoCAD drawings, process files and visual simulated diagram will serve enterprise. So far, the software platform has completed three modules, which are drawing regeneration module, process automatic planning module and enterprise knowledge base/database module.

3. Knowledge Base/Database Module

3.1. The theory of knowledge base/database module

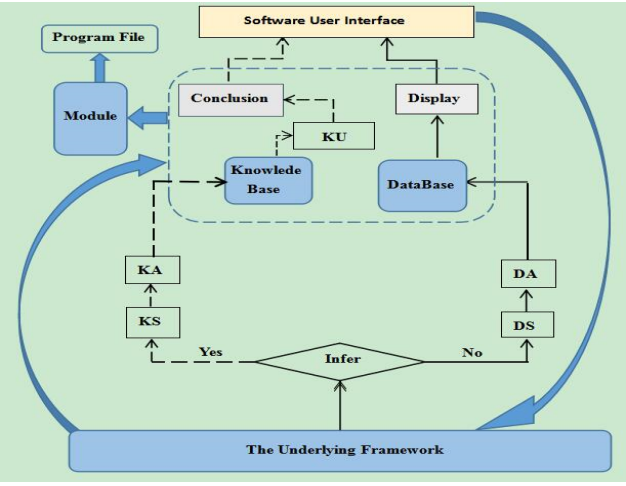

Fig 2. The theory of knowledge base/database module

As shown in Fig. 2, the basic level of the system's user interface is covered with huge knowledge, so that it must have a knowledge base and database module to support software development platform. As it is the underlying framework that supports database and knowledge base, and its main function is to realize the triage of knowledge and data, without the ability to dominate data and knowledge. Considering this situation, the upper software user interface will have rich functions and give users excellent experience only when knowledge base/database is powerful enough to support the intermediate shaft software development. The difference between the knowledge/database is that the database stores a variety of obvious facts which do not need to be reasoned, while the knowledge base refers to a set of rules used by experts, including the connected facts and evidences. The source of the knowledge base contains rules which are logical. So, we can divide data and knowledge by whether it needs inference. When the parameters are entered in the text box of software interface, the system can detect the response signal automatically, and the underlying framework will divide parameters to knowledge and data flow. They will go into the enterprise knowledge base system and the database system separately, completing the different work tasks.

3.2. Example demonstrate

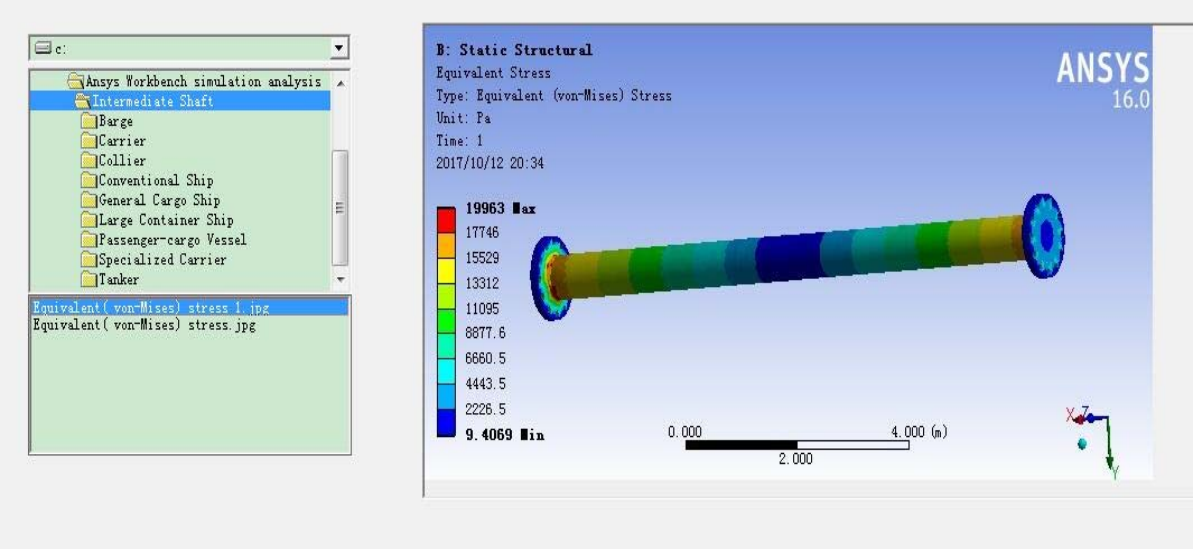

Fig. 3. Intermediate shaft 1/4 arc transition simulation

About example running of database, as shown in Fig. 3, for the shaft, the most urgent technical problems to be solved is how to predict performance of intermediate shaft under the condition of actual operation before production manufacture. Thus, it requires simulation analysis to provide a visual experience for the users, and database should response automatically to obtain a simulated diagram which highly similar when the products with similar design parameters appear. It is worth noting that the so-called similarity is not only the body size but also the stress and strain values. The final process scheme can be determined referring to the previous scheme. The time of simulation of model will be saved and possibility of repetitive labor will decline to maximum extent because of database.

4. Automatic Drawing Module

4.1. The theory of automatic drawing module

The reason why automatic drawing module is required in system is that drawings sent by designing institute are not perfect enough to guide enterprise's process and manufacture. The module adopts AutoCAD ActiveX which enables users to operate the outside or inside of AutoCAD by programming.

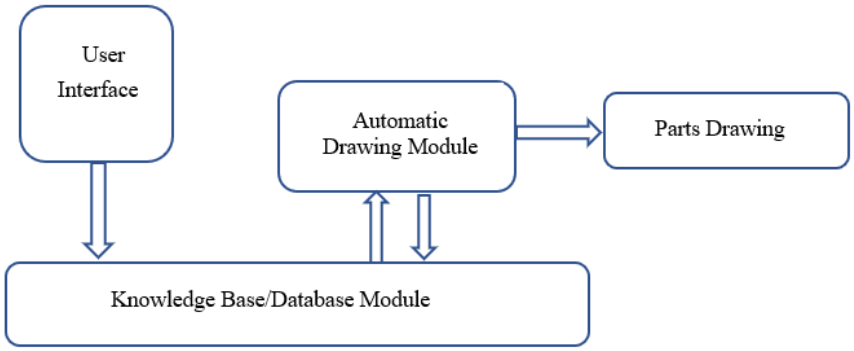

Fig. 4 The theory of automatic drawing module

As is shown in Fig. 4, design parameters of the marine shaft are entered in the user interface, and the design parameters will be stored firstly in enterprise's knowledge base. In the automatic drawing module, design parameters that are stored in enterprise's knowledge base support from AutoCAD ActiveX to operate drawings, completing part drawings and process drawings. Part drawings are important technical documents for the production of parts, part drawings are the basis for making parts. Process drawings are designed on the basis of elected technological plan. A process drawing shows and emphasizes the process content of a modular machine tool. Part drawings and process drawings generated will be stored in enterprise's database in order to consult conveniently.

4.2. Example demonstrate

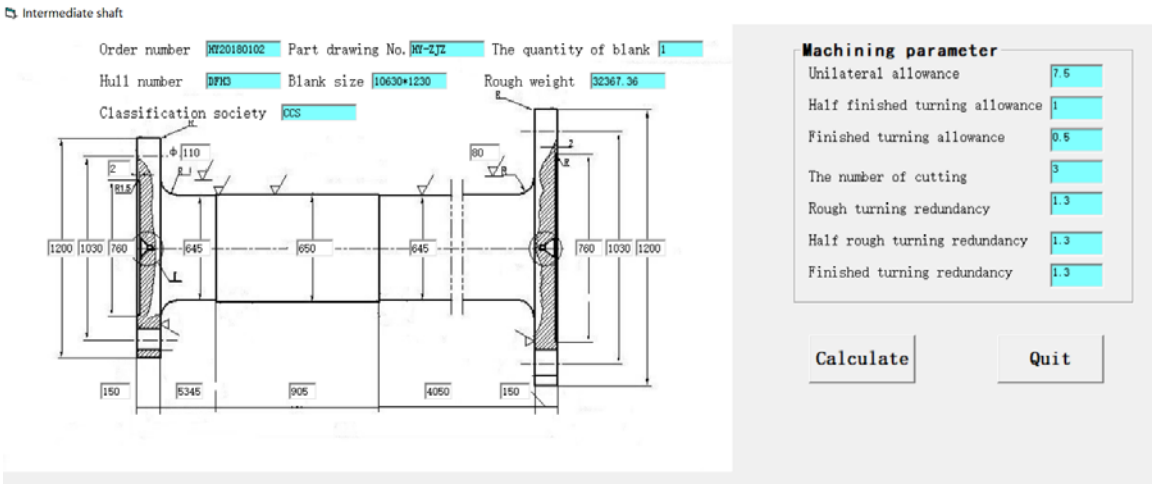

Fig. 5 The main interface of the system

Fig 5 shows the main interface of the system, inputting the design parameters into the text box of the interface, and the system will automatically draw the part diagram of the shafting. Fig. 6 shows part drawings of the intermediate shaft of a large container ship. The whole details of drawings are generated according to the design parameters provided by designing institute. After checking by the technical staff in the enterprise, the part drawings will be stored in the database which contains the electronic technical documents of the enterprise.

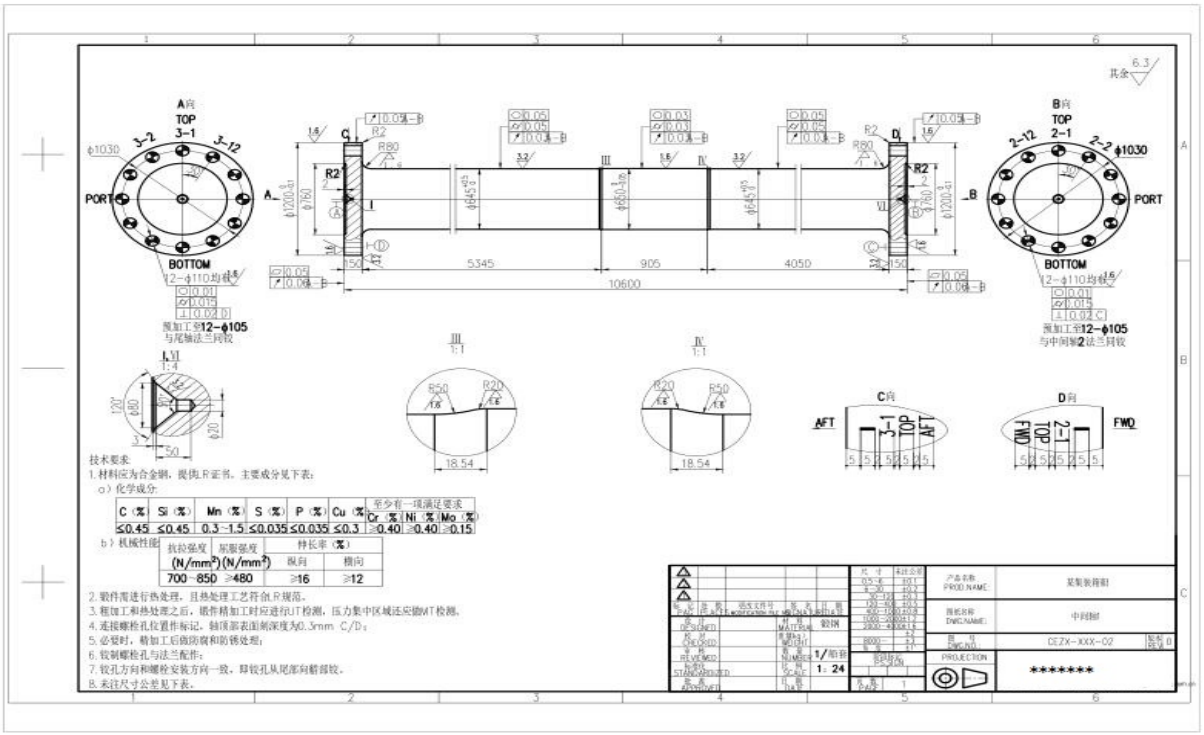

Fig. 6 The part drawing of intermediate shaft of a large container ship

5. Craft Automatic Planning Module

5.1. The theory of craft automatic planning module

Craft is a method and a process that the workers use various different kinds of tools to handle raw materials or process semi-finished products then produce the final goods. The principle of making craft is advanced technology and economical rationality. Different enterprises have different equipment production capacity, accuracy and proficiency of workers.

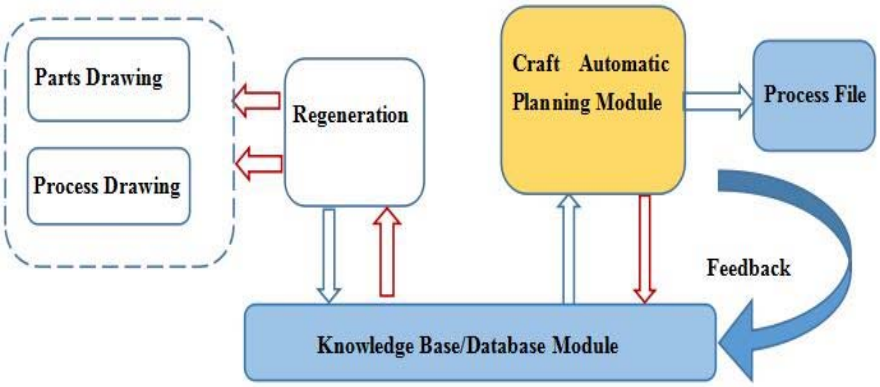

Fig 7. The theory of process planning module

As shown in the Fig.7, craft automatic planning module can be divided into two parts, the first part is the generation of craft files, the second part is the feedback regulation of craft files. Enterprise uses

Excel files, so they need to operate Excel by API interface. Geometric parameters and craft parameters of drawings regeneration module are stored in knowledge base. Crafts automatic planning module calls these parameters to generate planning craft files through knowledge base or database. Crafts automatic planning module put the time and cost back to knowledge base. The knowledge base will use ant colony algorithm to compare the optimizations of cost and time in existing conditions to the feedback value. If it is close to a certain range (this range should be planed according to the actual situation), the work will stop, if the output craft files do not meet the requirements, the drawings regeneration module will plan the drawings then store the geometric parameters and craft parameters in the base. Crafts automatic plan module calls these parameters to output the craft cards then gets the time and cost until the result meets the requirements. This process generates the craft files of intermediate shaft under the condition that the cooperative response of three modules (drawings regeneration module, Crafts automatic plan module, knowledge base or database module) works effectively.

5.2. Example demonstrate

The process route of the marine shaft is the acceptance of the work blank, the first rough machining, the second rough machining, stress relief treatment, semi-finish turning, bench marking, flange drilled, the finish turning (once), reaming. Because the marine shaft has many process files, the reason for the length of paper, this paper takes the step of the finish turning as an example to introduce, as is shown in Fig.8. Fig.8 shows the process document of acceptance of the blank. Fig.9 shows the finished product of intermediate shaft.

<table>
<tr><td colspan="3" rowspan="2">The order number: HY20180102
Hull number: DFH3
Classification society: CCS</td><td rowspan="2">Process card</td><td>Card number</td><td>01</td><td>Equipment type</td><td colspan="2"></td><td>Part dwg No.</td><td>HY-ZJZ-01</td></tr>
<tr><td>Process name</td><td>Acceptance of the blank</td><td>Manufacturing Numbers</td><td>Number</td><td>1</td><td>Name of parts</td><td>Intermediate shaft</td></tr>
<tr><td>Material</td><td>Forge piece</td><td>Size
10630*1230</td><td>Number
1</td><td>Rough weight
32367.36kg</td><td>Net weight
28230.81kg</td><td colspan="2">Utilization:
87.22%</td><td colspan="2">Man-hour:</td><td>Page:
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<tr><td rowspan="2">The serial number</td><td rowspan="2">Craft</td><td colspan="3" rowspan="2">Process content</td><td colspan="3">Fixture</td><td colspan="2">Tool</td><td></td></tr>
<tr><td colspan="3">Name
Specification</td><td colspan="2">Name
Specification</td><td>Machining parameter</td></tr>
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<tr><td></td><td>1.1</td><td colspan="3">According to technical agreement, drawing acceptance.</td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
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<tr><td></td><td>1.3</td><td colspan="3">Factory acceptance：Inspecting certificate, blank mechanical properties, blank size, shape tolerance and so on and archived.</td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>2</td><td>Dispatching</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td></td><td>2.1</td><td colspan="3">Protect the oil with anti-rust oil and transfer it to the suitable location in the workshop.</td><td colspan="3"></td><td colspan="2"></td><td></td></tr>
<tr><td>3</td><td>Sign in</td><td>Responsible person/date</td><td colspan="2"></td><td colspan="3">Inspector/date</td><td colspan="2"></td><td></td></tr>
</table>

Fig 8. The process document of acceptance of the blank

Fig. 9 The finished product of intermediate shaft

6. Conclusions

In this work, the intelligent process system establishes a relationship between object-oriented programming and modular design philosophy. This approach makes the process system for marine shafting more stable and convenient for the development of the later module. After the example verification, some conclusions can be draw as follows:

The automatic generation of drawing saves the time of technicians and reduces the error rate, the drawings are uniformly stored in the drawings unit of the enterprise's database which is used to browse for customers and technicians.

(2) Generation of process files saves the time for technical personnel to compile process documents, process files are stored in the process file unit of database, the workshop director can view process files in the software to determine specific production plan.

(3) Technical documents are stored in the classification unit of the software platform database. The company's internal technical personnel can check the information in the software platform after obtaining the permission.

Acknowledgments

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Nomenclature

KS Knowledge source
DS Data source
KA Knowledge acquisition
DA Data acquisition
KU Knowledge use

References

[1] Whitfield RI, Smith JS, Duffy AHB. Identifying component modules. In: Seventh international conference on artificial intelligence in design, AID'02, Cambridge, United Kingdom; 2002.
[2] Bald win CY, Clark KB. Modularity in the design of complex engineering systems. Understanding complex systems. Berlin, Heidelberg: Springer; 2006. P. 175-205.
[3] Holmqvist TKP, Persson ML. Analysis and improvement of product modularization methods: their ability to deal with complex products. Syst Eng 2003; 6 (3): 195-209.

[4] Holtta K, Suh ES, de Weck O. Tradeoff between modularity and performance for engineered systems and products. In: Proceedings of the 15th international conference on engineering design; 2005.p.15-8.
[5] Zamirowski E. J. & Otto K. N., “Identifying Product Family Architecture Modularity Using Function and Variety Heuristics”, Proceedings of the ASME Design Engineering Technical Conferences, Las Vegas, NV, 1999.
[6] Suh NP. Axiomatic design: advances and applications. USA: Oxford University Press; 2001.
[7] Mingzhong Xia, Yixuan Xia, Bingyuan Li. "Software modularize design and modularize management." Journal of China Information Times, 2012.
[8] Qiang Chen."The development of Visual Basic from primary to advanced." Posts and Telecom Press, p.2, 2016.
[9] K. Kim, J. Altmann, Evolution of the software-as-a-service innovation system through collective intelligence, Int. J. Coop. Inf. Syst. 22 (3), 2013.
[10] D.G. Messerschmitt, C. Szyperski, Software Ecosystem: Understanding an Indispensable Technology and Industry, MIT Press, Cambridge, MA, USA, 2003.
[11] S. Jansen, S. Brinkkemper, A. Finkelstein, Business network management as a survival strategy: A tale of two software ecosystems, in: Proceedings of the First International Workshop on Software Ecosystems, 2009.