

Design and Improvement of the Material Coding Standardization for Power Group Enterprise

Gang XIONG¹, Lei HU², Tao QIN¹, Timo R. NYBERG³, Fei-yue WANG¹, Qing-song SHI²

¹ the Key Laboratory of Complex System and Intelligent Science,
Institute of Automation, Chinese Academy of Sciences, Beijing, 100190, China

² China Guodian Corporations, Beijing, 100034, China

³ BIT Research Centre, Aalto University, FI-00076 Aalto, Finland

Abstract— This paper describes the definition and functions of materials classification and coding firstly, and several prevalent coding approaches are introduced. Next, the materials coding problems existing in power industry are analyzed and relevant research achievements are summarized. Typically, one giant power enterprise group, named as “G” power group, is used as a study case to specify its problems and the existing solution from the perspectives of materials coding management, and the application of its corresponding IT system. Based on current situation of the power enterprise group and its existing problems in materials coding field, some improvement suggestions and effective approaches are put forward for the performance improvement of materials classification and coding system, to reduce the material management costs and make more profits for whole power group.

Key words—Materials Coding Management; Materials Classification and Coding; Coding Standardization; Power System

I. INTRODUCTION

1.1 Summary of Materials Classification and Coding

Materials coding is the process to convert the symbol system that can represent various materials naturally, into another standard and uniform symbol system that computers and human can identify and utilize more easily and efficiently [1]. It is a technical means to unify human's recognition, exchange real-time information, and keep the high accuracy of various and complicated information for communication among all kinds of activities.

To improve the efficiency of materials management, a standard and scientific Materials Classification and Coding (MC&C) system should be established to meet the collaboration and communication needs among enterprises. Typically, MC&C is one of indispensable pre-conditions for sharing all kinds of resources and achieving efficient

Project Supporting:

This work is mainly supported by the project 2F09E05, and in part by NSFC 70890084, 60921061, 90920305; MOST 2006CB7055 06, 2006AA010106; and CAS 2F09N05, 2F09N06.

Introduction of Authors:

Gang, Xiong (1969-) Research Professor of institute of automation, Chinese Academy of Science. Until now, more than 90 papers have been published and his major researches include intelligent control of complex system, parallel management system, the infomationization of enterprise, etc.

Feiyue, Wang (1961-) is the deputy-director of institute of automation, CAS. The major researches include intelligent control of complex system, parallel system management, social network computation, etc.

E-mail: gang.xiong@ia.ac.cn

materials management. Each material code represents concrete equipment or material uniquely, which can be saved, extracted, modified and retrieved by using computer database, for the application purpose of classification and statistics.

In particular, MC&C system plays an important role in materials management and the major functions are shown as follows [2]:

- ✧ It could provide the unified and standard identifications for the collaboration of materials management.
- ✧ Code is the unique “Identification number” of material and can avoid redundant storage of the same material.
- ✧ It could avoid information errors of manual input and output, and improve the quality and efficiency of materials management.
- ✧ Once the fixed codes are inputted into an information system, they can help prevent the fraud activities on materials management.

Relevant researches have been done earlier in western developed countries. The United States has invested a number of manpower resources to the study on MC&C as early as 1910s. Germany established the Defense Material Agency in 1956 for military supplies classification and coding. Japan completed "Standard Commodity Classification and Coding" with its fourth amendment in 1975. The Soviet Union established an unified coding management system with 19 categories for MC&C in 1979 [3]. Chinese military started researches on MC&C from 1986 and the General Logistics Department completed the standard system of "Logistics Materials Classification and Coding" for Chinese armies in 1990 [4].

The western developed countries started researches on MC&C in the field of power industry from 1960s, accumulated and formed complete MC&C standard system with a whole life cycle management of power materials gradually. China was aware of the importance of MC&C from 1970s. Simultaneously, Chinese government established an independent organization in charge of the study on MC&C standardization and dozens of MC&C standards for many fields have been published. Typically, "MC&C National Standard in Power Industry" with the name of "DL/T700.1~3-1999" was promulgated in 2000. However, it was not accepted and implemented widely in the Chinese power industry due to the complex regulations. Until now, almost all power enterprises have their unique MC&C systems, and the management of MC&C is quite chaotic and

out of order. Hence, to keep the healthy, fast and efficient development of China's industrial economy, it is really necessary and meaningful to unify and standard MC&C for all fields through the country.

1.2 Introduction of Coding Methods

In particular, all coding methods can be classified into two categories according to the coding rule: meaningful coding methods, meaningless coding methods. Meaningful coding methods mainly include the classification method, the combined features method and the combined coding method. In contrast, meaningless coding methods mainly include the sequence coding method and the structure coding method, etc. In China, the location coding method, the property coding method and the sequence coding method are commonly used in the MC&C management which can be described as follows:

- ❖ Location coding method: Generate materials codes according to physical locations. It is good at retrieving the stored materials but hard for obtaining the detailed information.
- ❖ Property coding method: Generate materials codes according to the properties and features. It is easy to get the information of materials properties but hard to apply for computer management due to different lengths of codes.
- ❖ Sequence coding method: Generate materials codes according to the natural sequence. It is simple to use but difficult for management due to lack of hierarchy and systematicity.

Furthermore, Kraftwerk - Kennzeichen System (KKS) which focuses on the materials identification of power plants has become one of complete and mature identification systems for the materials management of power plants. It consists of technical identifier, installation location identifier and position identifier [6]-[7]. After the long-term practice and improvement, KKS has become mature and systemic. However, it is difficult to understand because of the limitation of professional knowledge.

Currently, the most popular MC&C method is the combination of the property coding method and the sequence coding method to identify the materials' properties for the management convenience [1]. According to the hierarchical design of MC&C system, the upper catalogs are formed by the principles of the property coding method and the lower catalogs are designed by the sequence coding method to refine the classification of materials and improve the utilization percentage of coding space. In this paper, the MC&C system of "G" power group used the combined method for its design and application.

1.3 Literature review

Many Chinese researchers focused on the study of MC&C in power industry. He et al. analyzed the establishment and implementation of a MC&C system in enterprises and highlighted the issues in the process of carrying out MC&C system [2]. Yao et al. interpreted the major issues in MC&C

system basically but there is lack of further analysis and argumentation for resolving existing problems [8]. Jiang et al. finished the research on the design and application of MC&C in enterprise resource planning (ERP) but the solution was preliminary [9]. Han et al. proposed a multi-layers MC&C system, which is based on struts framework to improve materials management work. However, there were still some limitations on the method [10]. Hu analyzed the MC&C methods in the integrated business information system of power plants and summarized the major problems about materials coding. Unfortunately, there is still no comprehensive solution to resolve these issues [11].

For foreign researchers on MC&C, Mok established a Structured Product Coding System (SPCS) to integrate the materials information in order to reduce the materials management costs [12]. Wolin proposed an automated classification algorithm for product catalog [13]. Bergamaschi et al. made researches on the integrated framework of MC&C management and a semi-automatic classification method was proposed [14]. Beneventano et al. studied on the MC&C framework based on a web application layer and carried out the framework in the materials management of e-business activities [15].

In summary, there are plenty of researches on the analysis and argument of MC&C. However, few effective methods can be used to improve the performance of materials management in practice. This paper will focus on an efficient and effective methods and suggestions to improve MC&C being used in "G" power group, and a feasible solution is proposed to ensure the full support on MC&C management in power plants.

II. DESIGN ON MC&C SYSTEM OF "G" POWER GROUP

Material management system of "G" power group is a comprehensive information system including the headquarters, the distribution centers and the power plants. Through the long-term development and continuous improvement of the information system, those unreasonable designs have been modified gradually, system stability has been enhanced greatly, as well as the cost and the time for system promotion has been saved. Furthermore, some intractable technical bottlenecks are resolved successfully. Finally, the remarkable breakthroughs about MC&C design and implementation have been made in the material management of "G" power group.

2.1 Analysis on the design of current MC&C system

2.1.1 Introduction of current MC&C system

The standard on MC&C system of "G" power group is named as "MC&C Handbook of "G" power group" and its contents mainly includes two parts. The first part is the category of power materials and the other part is the codes of power materials. Especially, the first part consists of three sections: the general MC&C section, the spare parts MC&C section, and services product MC&C section. Figure 1 shows the overall structure of MC&C system of "G" power group.

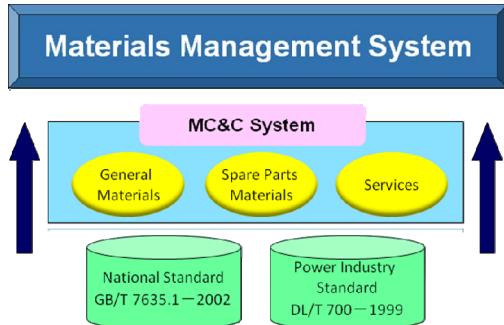


Figure 1 Generation Rules on MC&C

The generation rules on MC&C are explained as follows:

- ❖ **0-2 category:** It means the general materials category. The 1st position of code can be 0, 1, or 2. The code from 2nd to 8th positions can represent the materials classifying structure according to the 7 layers framework of the national standard coding law (GB/T 7635.1 - 2002). And the last 6 positions consist of sequence number decided on the combination of materials attributes.
- ❖ **3 category:** It means spare parts materials category. The 1st position of code is the fixed number 3. The code from 2nd to 9th positions can represent the materials classifying structure according to the 5 layers framework of the power industry standard (DL/T 700—1999). And the last 5 positions consist of sequence number decided on the combination of materials attributes.
- ❖ **4-6 category:** It means the servicing products category. The 1st position of code can be 4, 5, or 6. The code from 2nd to end is formed according to the national coding standard (GB/T 7635.3—2002).

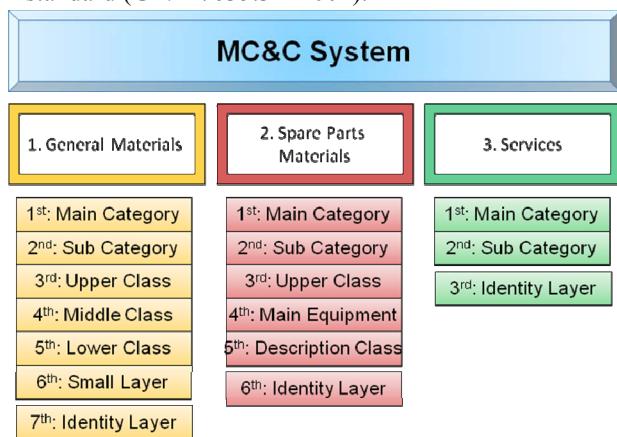


Figure 2 MC&C Structure of “G” Power Group

Currently, the MC&C system for general power materials and spare parts materials in “G” power group are established according to the national coding standards and the power industry coding standards, respectively. The structure of an entire code can be represented as: category codes + sequence codes, where the category codes are generated by classification, and the sequence codes are given by computer.

The detailed structure on MC&C system of “G” power group is shown in Figure 2. It follows the major principles for establishing a scientific and practical coding system through the rigorous and rational analysis, as well as effective implementation. The system satisfies the main principles, such as the unique principle, ease to use principle, classifying principle and open framework principle etc. Specially, it abides by the national coding standards and power industry coding standards, and can be used to unify and communicate with other similar enterprises easily and effectively. Currently, this MC&C system has become the benchmark of Chinese power industry and can be a successful case to improve the materials management of Chinese enterprises in power industry.

2.1.2 Analysis on the problems of current MC&C system

Even though there are remarkable successes on the implementation of MC&C system in “G” power group and the materials management level has been raised gradually, an evident gap is still existing between the current status and the final target that achieves “an Unique Power Material Matching an Unique Code” for all materials, and executes the power materials management strategy of “Centralized Purchasing and Decentralized Management”. The main problems existing in the application and implementation process are listed as follows:

- ❖ The information about material name, specification, and parameters, is chaotic without specific standards. This information is hard to be used effectively for materials management due to its low quality.
- ❖ The verification procedure of materials codes cannot operate successfully because there is too much information with low quality to handle.
- ❖ The formal codes and temporary codes coexist in the MC&C system simultaneously. Due to the failure of materials codes verification. There are lots of inaccurate codes and redundant codes.

In order to resolve the aforementioned problems, a comprehensive and scientific solution of MC&C system should be proposed to achieve the targets to improve data quality, to restart codes verification process, as well as to provide intelligent decision support services on materials management in “G” power group.

2.2 Analysis on MC&C information management system

The MC&C Information Management System (MC&C-IMS) of “G” power group has been integrated into the materials management information system and is running well in more than 50 power plants until now. The basic framework of the MC&C-IMS and its interpretations are shown and detailed in Figure 3 as follows:

- ❖ **Standard codes management module (Core):** The module consists of 10 functional sub modules for materials codes verification, maintenance etc. The detailed functions are listed in Table 1.
- ❖ **User category management module:** The module is made up of 4 functional sub modules and mainly responsible for the management of user rights. The detailed functions are

listed in Table 2.

- ❖ *User coding management module:* The module includes 3 functional sub modules for the maintenance of MC&C-IMS. The detailed functions are listed in Table 3.

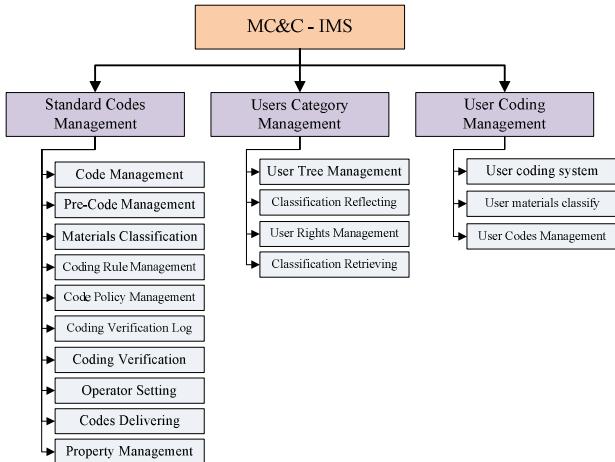


Figure 3 the basic framework of MC&C-IMS

Table 1 Functions description on standard codes module

Name	Functions Description
Code Management	The management of temporary codes and the utilization of standard codes.
Pre-Code Management	The pre-coding process management for generating temporary codes.
Materials Classification	Unify the classification management of whole power materials.
Coding Rule Management	Draw up the coding generation rules.
Coding Policy Management	Provide the visibility management of materials codes.
Coding Verification Log	Retrieve the statue of codes verification process.
Coding Verification	Carry out the verification process of the temporary codes on the side of power plant.
Verification Operator Setting	Assign codes verification work to suitable person based on his knowledge.
Verification Codes Delivering	Delivery the codes verification result to the relative power plants.
Property Management	The management on the properties of power materials.

Table 2 Functions description on user category module

Name	Functions Description
User Classification Tree Management	Establish user classifying category and generate the classification tree.
Classification Reflecting	Build up user custom category and reflect with the standard codes.
User Rights Management	Control the user rights according to different levels.
Classification Retrieving	Implementing the fuzzy query of materials based on user category.

Table 3 Functions description on user coding module

User coding system management	Mainly establish the user coding system.
User materials classification	Built up the user classification tree based on user coding system.
User Materials Codes Management	Establish the relationship between user materials codes and the standard codes.

Currently, The MC&C – IMS of “G” power group is playing an important role in the materials management to achieve the strategic target of “Centralized Purchasing and Decentralized Management”, and improve the performance of materials management. However, there are still some bottlenecks in the MC&C – IMS and they are described as follows:

- ❖ Functions definition is vague without specific criterion for the different demands from different layers.
- ❖ The quality of data input is low and the mechanism for data input is unreasonable and unscientific. Current system is not simple for user in power plants.
- ❖ The different education background and personal habits of different users result in the inaccurate recognition on all kinds of materials and operation errors.

In summary, an effective solution should be proposed to resolve these problems to improve the performance of materials management.

III. IMPROVEMENT ON MC&C SYSTEM OF “G” POWER GROUP

To resolve the problems existing in MC&C system and the corresponding MC&C – IMS of “G” power group, some solutions and suggestions are proposed from the perspectives of “Management Process”, “Management Element”, “System Design” and “Improvement of IMS”, to achieve the final strategy of materials management in power plants.

3.1 Improvement on MC&C management process

The MC&C management process of “G” power group mainly refers to two parts: the headquarters, and the power plants. Firstly the users of power plants generate temporary codes in the MC&C – IMS of the power plants side, and then upload it to the headquarters side. Then experts in headquarters side will verify the temporary codes according to related rules. Finally, the verified results are delivered to IMS of power plants. The overall process is described in Figure 4.

To optimize the generation of materials codes in “G” power group, a new generating process is proposed and shown in Figure 5.

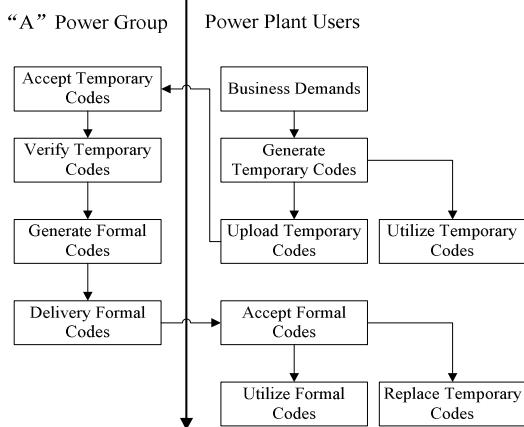


Figure 4 The verification process of materials codes

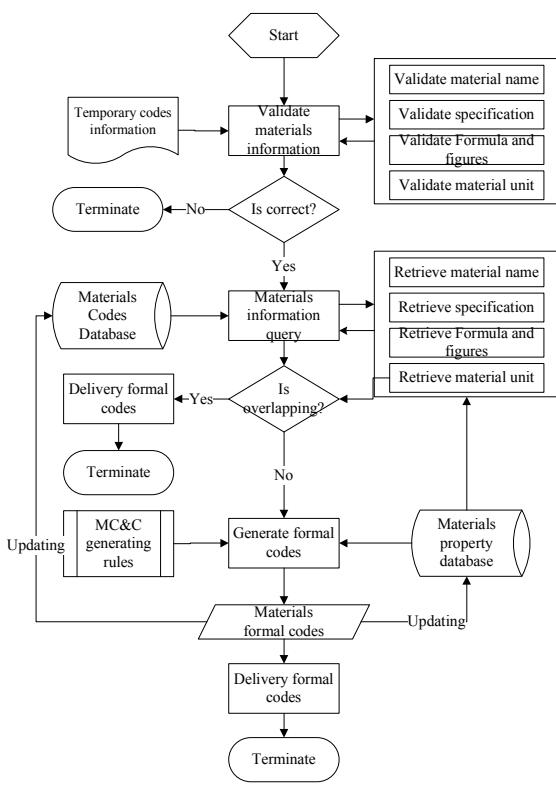


Figure 5 The improved process generating materials codes

3.2 Improvement on MC&C management elements

The MC&C management improvement in “G” power industry is done from the perspectives of personnel management, basic data management and regulation management.

❖ **Personnel management:** Establish a dedicated MC&C organization and train professional managers. Especially, train new employees of power plants and improve the system operation quality, as well as keep key-managers stable to ensure the accuracy and standardization of materials coding information. Assign some experts of MC&C to execute the normal interactive work of materials coding verification and the management of

whole material classification framework.

❖ **Basic data management:** The implementation of advanced query and intelligent decision-making is based on a complete standard coding base and materials properties base, as well as the support of materials coding experts. It is necessary to keep an interactive and real-time communication mode among MC&C system, users, and experts. Through the continuous efforts on the improvement of MC&C system, the users and experts can enhance the system performance and reduce its bottlenecks.

❖ **Regulation management:** The fine level and the precise positing of materials coding management are closely decided by a specific and scientific regulation, which can ensure the establishment and implementation of MC&C system successfully. To make suitable regulations of the materials management, it must decide the importance of each role easily, such as different kinds of materials, the responsibility of managers and the application of system between the headquarters and the power plants.

3.3 Improvement on designing MC&C system

For optimizing the MC&C framework of “G” power group, an optimized procedure of controlling the information of materials coding verification is proposed to help enhance the performance of MC&C system. The procedure is shown in Figure 6.

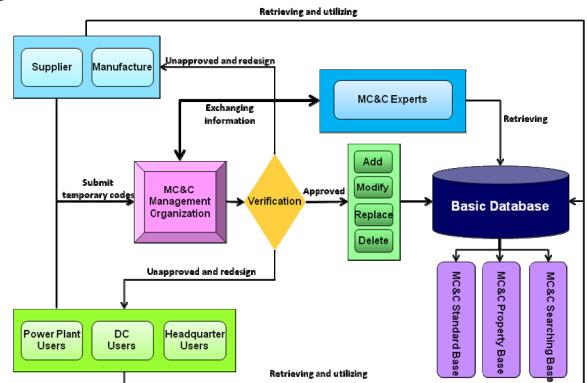


Figure 6 The optimized procedure of controlling the information of materials coding verification

In addition, some suggestions are given from the perspectives of classification structure, classification rules, the fine level of classification and materials codes length setting.

- ❖ Specify and unify the materials classification criteria to reduce/prevent the overlap codes in MC&C system. Generate the codes according to materials properties and standard coding rules.
- ❖ Establish reasonable MC&C framework to material cluster for the convenience of management and operation, as well as the materials codes query.
- ❖ Adjust the relationships of materials category and specify the whole structure, such as the key features of materials.
- ❖ Reduce the utilization of vague words, especially in the

process of generating upper category.

- ✧ According to the particular habits of users in each power plant, temporary codes are verified to accumulate and enrich the standard coding system of “G” power group.
- ✧ Based on the frequency of utilization and importance of materials, the major category is divided further to enhance the practicability of MC&C system.

3.4 Improvement on MC&C – IMS of “G” Power Group

The main problems existing in current MC&C – IMS of “G” power group includes the difficulty to use, the subjective errors of input, etc. It should change manual input approach to system guiding approach to raise the automation level and to reduce the participation of user in order to improve the accuracy of inputting in MC&C system.

- ✧ Add intelligent search engine into MC&C – IMS. On one hand, unify the current search engine and provide advanced fuzzy query to retrieve the materials codes and related information effectively and easily. On the other hand, insert intelligent search engine to support the materials coding management and display the similar output result automatically in order to improve the accuracy of coding searching.
- ✧ Establish mapping knowledge base. For resolving the chaotic recognition of one material with different name, some semi-automated collecting methods are developed to enhance the practicability of MC&C system. Especially, the materials codes mapping database and user habits mapping database are established to keep the personality of each power plant according to commonness of “G” power group.

Simultaneously, two mapping databases can be integrated with the intelligent search engine to improve the ability on identification and rectification of searching results and to achieve the unification of materials coding management.

IV. CONCLUSIONS

Materials codes are the base and the key for enterprise information system and it plays an important role for improving the materials management. This paper introduces the basic functions, approaches and latest researches of materials coding management. Through the case study of “G” power group, the overall status and major problems in MC&C system and MC&C – IMS are analyzed, and their corresponding solutions and suggestions are proposed to resolve these problems and enhance the materials management performance.

After the further improvements on the MC&C system of “G” power group, an optimized MC&C system and MC&C – IMS can manage and control all materials information more specifically and precisely, as well as provide a clearer and more reasonable materials classification framework, keep the utilization convenience for materials management information system, improve the fine level and the performance of materials management. Based on the MC&C system, a new Key Performance Indicator (KPI) system on

materials performance management can be established to help enhance the operation and management of “G” power group to achieve the final targets of the whole group. In addition, new technologies and theories, such as Radio Frequency Identification (RFID), Wireless Communication Technology (WCT) can influence the materials coding management evidently, to help managers to control and achieve the enterprise strategy successfully.

REFERENCES

- [1] J. Y. Dong, Z. D. Lin. Material's coding system design and implementation of database [J]. Mechanical and Electrical Information, 2004, Vol.19:15-18.
- [2] X. D. He, F. Xie, X. M. Zhong, Ping Mao. Promotion on the establishment of materials coding management system in enterprise [J]. Light Metals, 2004, Vol.5:3-5.
- [3] W. Liu, X. Y. Wang, Y. L. Ji. The thinking about the materials coding management system of Chinese military [J]. Logistics Technology, 2005, Vol.4:46-47.
- [4] G. A. Zhang, S. Liang. The analysis on the future of materials coding management in military [J]. Reporting of Standardization, 1995, Vol.16 (1):11-14.
- [5] W. H. Ni, H. L. Li. Research and design on the ERP materials coding system [J]. Electrical Technology and Automation, 2003, Vol.6:134-136.
- [6] X. L. Li, J. C. Zhan, L. Lao. Identification system design and application on power plants [M]. Beijing, China Electric Power Press, 2007.
- [7] L. M. Yang, J. J. Li, Y. Wang. The unified identification solution on power plants based on KKS method [J]. Computer Engineering and Science, 2008, Vol.30 (7):148-154.
- [8] S. T. Yao. Discussion on the materials coding in power industry [J]. Logistics Technology, 2007, Vol.26 (4):107-108,126.
- [9] W. J. Jiang, H. F. Xu, X. D. Kou. Application of materials coding system in the implementation of ERP system [J]. Metallurgical Equipment, 2005, Vol.152(4): 54-57.
- [10] X. W. Han, Q. Zhao. Design and implementation on multi-layers materials coding system [J]. Computer Engineering and Design, 2006, Vol.27 (15): 2846-2850.
- [11] Y. H. Hu. Discussion on the materials coding method for the integrated business information system of power plants [J]. Power Utilization, 2008, Vol.25 (2):12-15.
- [12] S. M. Mok. A structured product coding system for intelligent product data management [D], Northwestern University, Illinois, United States, 2003.
- [13] B. Wolin. Automatic Classification in Product Catalogs [C], in the annual ACM conference on research and development in information retrieval, 2002:351-352.
- [14] S. Bergamaschi, F. Guerra and M. Vincini. A Data Integration Framework for e-Commerce Product Classification [J], in the lecture notes of computer science, 2002, Vol.2342:379-393.
- [15] D. Beneventano, F. Guerra, S. Magnani and M. Vincini. A web service based framework for the semantic mapping amongst product classification schemas [J], in the Journal of Electronic Commerce Research, 2004, Vol.5 (2):114-127.