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Research on materials classification model building and procurement strategy of coal enterprises

Materials are the prerequisite for the production of coal enterprises. They belong to consumables and do not constitute product entity. With various types and numerous suppliers, it is more difficult to manage. Therefore, the science of materials management relates to economic benefit of the whole enterprise. To reduce the cost and promote efficiency of materials management, ABCD classification method is proposed by combining with the current problems existed in materials classification of coal industry, algorithm model is built by adopting fuzzy comprehensive evaluation method, with specific description of application process of a specific example provided. Then, the supplier management strategy based on this classification form is proposed on basis of the materials classification, and the test results are favourable, which further reflects the important role of the materials classification in materials procurement.

Keywords: Coal enterprises, fuzzy comprehensive, materials classification.

1. Introduction

Raw materials of coal enterprises are consumed articles, which have higher requirements for materials quality and inventory safety, so materials procurement is always concerned by enterprises[1-2]. How to manage raw materials reasonably and scientifically is always in the research scope of coal economic circle. Materials procurement is the primary link in enterprise supply chain, and materials classification is the first step in materials management, which is also the direct basis for procurement and inventory decision making of the materials department [3-4], thus it is the most critical step too. Rationality of classification not only concerns materials management efficiency of enterprise, but also affects economic benefit of enterprise directly. Materials procurement strategy of enterprise has great significance to reduction of total cost of enterprise, assurance of product quality and guarantee of delivery time.

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2. Building ABCD materials classification model of coal enterprises

2.1 ANALYSIS OF CURRENT SITUATION OF MATERIALS CLASSIFICATION OF COAL ENTERPRISES

Coal enterprises often need to procure tens of thousands of raw materials, which requires that enterprise be able to give effective management to the whole supply chain, especially for the control of suppliers[5]. If proper measures cannot be taken, inventory of enterprise shall increase, management shall be out of control, and procurement cost shall rise. To manage so many materials with one procurement method, it shall certainly need to consider the most difficult and complex situations, thus the most sundry management method shall be adopted, and management cost shall increase sharply. Therefore, it is necessary to consider a method which can give reasonable classification to all materials and take different management methods for different materials.

For a long time, the main methods used by coal enterprises in procured materials management are classification management methods of the procured materials, which include ABC classification method, classification method by combining with procurement quantity stability and procurement amount and the flexible classification method. Although the research and application of the aforementioned procured materials classification methods have received certain results in varying degrees, there are also many problems existed. Classifications of the most enterprises are too simple, and they merely take procurement amount as the standard for materials management[6]. Although other materials classification methods change the limitation of the traditional ABC classification based on amount merely, the classification boundaries among various classes are much more fuzzy and general, the classification standard is ambiguous, and the operability is worse[7].

2.2 ABCD MATERIALS CLASSIFICATION MODEL OF COAL ENTERPRISES

By combining with the actual production conditions and aiming at materials characteristics of coal industry, this paper proposes a new materials method – ABCD classification method based on importance and demand stability, and the model is as shown in Fig.1.
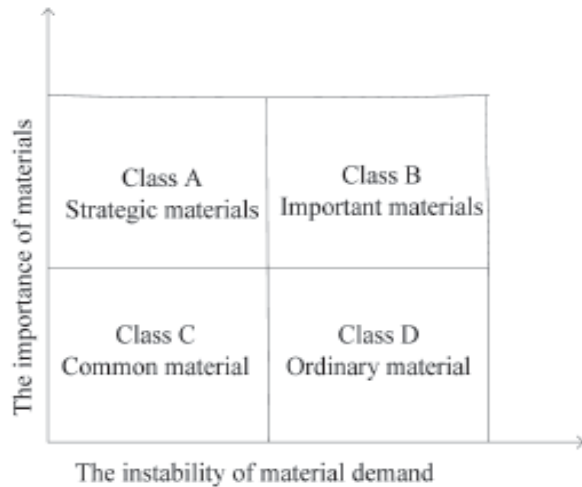
Fig.1 Materials classification chart of coal enterprises

Firstly, procurement amount shall be considered as the main indicator for measuring importance in materials supply management of all industries. Coal enterprises is no exception, the materials supplied in coal industry are in tens of thousands of kinds, and positions of the various materials in production process are different, so importance measurement needs to consider the loss caused to enterprise for material shortage and the influence of material on enterprise production safety.

Moreover, the condition of considering material stability as a measurement indicator is determined by the characteristics of materials supply of coal enterprises. High stockout cost, larger demand laws of various materials, great demand of various consumables, numerous emergencies, large demand fluctuation and special materials demand are the characteristics of materials demand of coal enterprises different from other industries, and they are also the factors needing concern of coal enterprises. When considering from these characteristics, stability of the material demand may affect the enterprise management, so it can be considered as an indicator at the time of materials classification.

3. Materials classification of coal enterprises and the application

3.1 MATERIALS CLASSIFICATION WITH FUZZY COMPREHENSIVE EVALUATION METHOD

Currently, evaluation of the coal industry group on material importance and market is mainly given according to judgment of the purchasing staff, and the subjectivity is stronger, so it is very necessary to give quantitative judgment to material importance by adopting fuzzy evaluation method[8]. It needs to set some indicators by aiming at current situation of coal group during evaluation process, weighting of various indicators can adopt qualitative analytic hierarchy process, and the following several items need to be considered mainly during material evaluation.

Main references of material importance: percentage of procurement amount in total procurement amount, loss caused to enterprise for material shortage, influence of material on enterprise production safety. Main references of material demand stability: fluctuation range of the procurement quantity in the corresponding period, difference between actual use and planned quantity demand.

When considering the two factors, enterprise can select more indicators other than the aforementioned several indicators, enterprise can increase or decrease indicators appropriately as to different materials, and materials supply can change along with production development, so enterprise needs to adjust the own strategy continuously [9]. It is not so simple in concrete analysis, and there is a layer of sub-indicators under many indicators, which is actually the multi-layered fuzzy comprehensive evaluation. During this process, importance and demand stability of each material need to be evaluated respectively, and category of the material shall be determined finally by utilizing the respective evaluation results[10].

As fuzzy evaluation involves in expert scoring, purchasing and inventory staff and material users of the company shall participate in the scoring in this step, as well as senior management of the company whose judgment is always more accurate. By judging the material, they can determine category of the material finally, and then different management method and strategy can be adopted. As to these given indicators, some of them are indicators for quantitative description, e.g. percentage of procurement amount in total procurement amount, and fluctuation range of the procurement quantity in the corresponding period, and the quantitative indicators can be reflected by some data. While other indicators not for quantitative description need to be solved by expert scoring. Fuzzy comprehensive evaluation mainly involves in the four important factors of factor set U, comment set V, single factor evaluation matrix R and weight vector W. the concrete evaluation steps are as follows:

Step 1: Building evaluation indicator set U

Adopt the improved DELPHI method, determine the evaluation indicator set U by collecting information and consulting experts, divide U into P and n subsets U_1, U_2, …, U_n, and satisfy that:

$$\bigcup_1^n U_i = U \ , \ U_i \cap U_j = \phi, \ i \neq j \qquad … \quad (1)$$

Then, obtain the second-level factor set $U/P = U_1$, U_2, …, U_n.

Step 2: Determining indicator weight set W

Construct the comparative judgment weight matrix by aiming at material evaluation system and adopting analytic hierarchy process, namely that:

$$, \sum_{j=1}^{m} W_{ij} = 1 \qquad \ldots \quad (2)$$

$$W_i = (w_{i1}, w_{i2}, \ldots\ldots, w_{in}), \sum_{j=1}^{m} W_{ij} = 1 \qquad \ldots \quad (3)$$

Of which, W_{ij} refers to weight of the second-level indicator U_{ij} in the first-level indicator U_i, and m refers to number of the second-level indicators of U_i.

Step 3: Building comment set V and score set F

Comment set V can be determined according to practical problems, and it supposes that five-level comment sets can be built by aiming at material importance, namely that $v = (v_1, v_2, v_3, v_4, v_5)$ = (very important, important, not too important, general important, not important), thus the corresponding score set shall be F = (1, 0.8, 0.6, 0.4, 0.2).

Step 4: Giving second-level fuzzy comprehensive evaluation to U_i

By giving single factor evaluation to each factor of U_i, one can obtain the fuzzy evaluation matrix R_i.

$$R_i = \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{i1k} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ & & \vdots & \\ r_{im1} & r_{im2} & \cdots & r_{imk} \end{pmatrix} \qquad \ldots \quad (4)$$

where, k refers to the number of levels of comment set, and r_{imj} refers to the degree of membership of U_{im} belong to the jth comment v_j. When giving comprehensive evaluation to U_i, we can obtain:

$$B_i = W_i \cdot R_i = W_i \begin{pmatrix} r_{i11} & r_{i12} & \cdots & r_{i1k} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ & & \vdots & \\ r_{im1} & r_{im2} & \cdots & r_{imk} \end{pmatrix} = (b_{i1}, b_{i2}, \cdots b_{ik}) \quad \ldots (5)$$

b_{it} can be obtained by adopting $M(\cdot. \oplus)$, namely that

$$b_{it} = \bigvee_{j=1}^{k} (w_{it} \wedge r_{ijt}) \qquad \ldots \quad (6)$$

where, $t = 1, 2, \ldots, k$, and B'$_i$ can be obtained by giving unification processing to B_i.

Similarly, after giving comprehensive evaluation to the several factors of U/P, we can obtain the overall evaluation matrix B.

$$B = (B_1', B_2', \cdots B_n')^T \qquad \ldots \quad (7)$$

Step 5: Giving fuzzy comprehensive evaluation to U

It supposes that the first-level fuzzy comprehensive evaluation result of U/P is Z.

$$Z = W \bullet B = W \bullet (B_1', B_2', \ldots, B_n') = (z_1, z_2, \ldots, z_m) \ldots (8)$$

Z_i ($i = 1, 2, \ldots, m$) can be obtained by adopting $M(\cdot. \oplus)$ operator, and then integrate score C of this material can be obtained:

$$C = ZF^T \qquad \ldots \quad (9)$$

Step 6: Determining the results

Category of the material shall be determined finally according to the C value obtained in steps 1-5 and the principle of the maximum degree of membership.

3.2 ANALYSIS OF THE APPLICATION EXAMPLE OF MATERIALS CLASSIFICATION

In this paper, it takes actual steels purchasing data of a coal industry group as example, the quantity of the steels purchased in half a year is 20,616 tonnes with value RMB 67,830,000 Yuan, while total value of the materials purchased by the enterprise in the corresponding period is RMB 570,000,000 Yuan, and steels procurement amount is about 12% of the total procurement amount. According to the investigation to enterprises, procurement percentages in the recent two years are all above 10%, growth rate of the total procurement amount is about 15% and higher than growth rate of the materials procurement amount of enterprise, and steels accounts for 14% in procurement budget of the enterprise for the next year.

By analyzing steels purchasing data of some coal industry group with fuzzy evaluation method, the importance can be determined. When determining material importance with fuzzy evaluation algorithm, it needs to confirm the indicator set firstly and select indicators according to the characteristics of concrete materials, while this is not changeless. As the degree of modernization of enterprise is promoted, the degree of dependence of enterprise on steels is increased, thus procurement amount can be deemed as the factor with obvious influence on importance. In this paper, the following indicators are selected for steels, as shown in Fig.2.
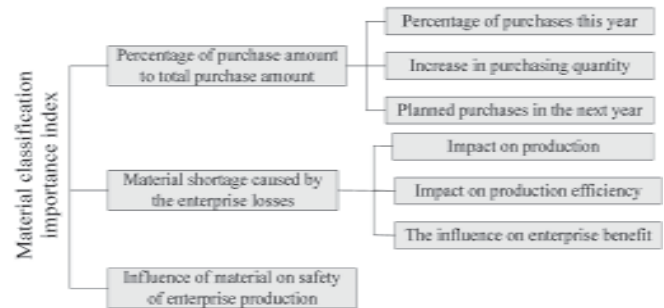

Fig.2 Material importance indicators of coal enterprises

(1) Determining the evaluation indicator set U

It can be known from the evaluation indicators shown in the figure above that:

$$U = (U_1, U_2, U_3)$$
$$U_1 = (U_{11}, U_{12}, U_{13})$$
$$U_2 = (U_{21}, U_{22}, U_{23})$$

(2) Determining weight of the evaluation indicator set W

Determine weight with analytic hierarchy process

$W = (0.4, 0.4, 0.2)$

$W_1 = (0.45, 0.27, 0.28)$

$W_2 = (0.37, 0.35, 0.28)$

(3) Building comment set V and score set F

Namely that $v = (v_1, v_2, v_3, v_4, v_5) =$ (very important, important, not too important, general important, not important), and the responsive score set is $F = (1.0, 0.8, 0.6, 0.4, 0.2)$.

(4) Fuzzy comprehensive evaluation

Single factor evaluation can be given to each factor of U_1 by scoring of purchasing staff and inventory management personnel of enterprise, and then one can obtain the evaluation matrix R_1

$$R_1 = \begin{bmatrix} 0.8 & 0.1 & 0.1 & 0 & 0 \\ 0.7 & 0.2 & 0.1 & 0 & 0 \\ 0.6 & 0.2 & 0.1 & 0.1 & 0 \end{bmatrix}$$

$$B_1 = W_1 \bullet R_1 = W_1 \begin{bmatrix} 0.8 & 0.1 & 0.1 & 0 & 0 \\ 0.7 & 0.2 & 0.1 & 0 & 0 \\ 0.6 & 0.2 & 0.1 & 0.1 & 0 \end{bmatrix} = (0.717, 0.155, 0.1, 0.028, 0)$$

$B_1' = (0.717, 0.155, 0.1, 0.028, 0)$

Similarly, one can obtain

$B_2' = (0.723, 0.166, 0.1, 0.011, 0)$

$B_3' = (0.64, 0.22, 0.14, 0, 0)$

$Z = W \bullet B = W \bullet (B_1', B_2', B_3')^T = (0.694, 0.1724, 0.108, 0.0156, 0)$

$C = ZF^T = 0.96$

It can be judged from the data obtained that steels keep a very important position in the enterprises, and they shall certainly belong to class A or class B materials. As the analytical method for material stability is the same as that for the importance as described in this section, it shall not be repeated here.

4. Materials procurement strategy based on ABCD classification

As for coal enterprises, materials classification is very necessary for enterprise management, and the objective of classification is to realize scientific management, so procurement strategies of various materials shall be different according to the own characteristics, and the corresponding suppliers shall not be treated equally, but be distinguished according to types of the materials supplied, and different methods shall be used in selecting suppliers supplying different types of materials. This "divide and rule" thought is also the advanced management thought in supplier management [11].

As to the class A strategic materials, the number of the cooperated suppliers is small, the procurement quantity is great, and such materials purchased as steels and mining mechanical equipment involve in coal mine safety production. Thus, coal enterprises shall concentrate on crucial suppliers, reduce intermediate links, reject the suppliers not obtaining standard scores in evaluation resolutely, and purify the procurement environment [12]. As for the suppliers reaching standard, coal enterprises can take full advantage of the modern information technology to share demand information with the suppliers and manage inventory jointly, adopt information stimulation, joint development stimulation for new products and organization stimulation, establish cooperative partnership with the suppliers, and advocate use of the method of storing and selling goods on a commission basis.

As to the class B materials, they also need greater procurement amount, so they are concerned by materials supply department of coal enterprises. As to the selection of main materials suppliers, purchasing by invitation to bid is mainly adopted on the premise of ensuring quality, and the measures of providing preferential purchasing conditions and more supply shares are used in stimulating the suppliers to serve the coal mine production [13]. As to the suppliers obtaining high scores in evaluation, coal enterprises can absorb them to hold materials supermarket in coal enterprises by taking informatization management as support and providing favourable cooperative conditions and superior service, as well as the preferential conditions for admittance of the suppliers, signing of supermarket materials agreement, and approaching, acceptance, issuing, loading and unloading, distribution, warehousing and settlement of supermarket materials[13]. Simultaneously, dynamic management is adopted as to materials supermarket, and those not reaching standard shall be cancelled the qualification for main suppliers. In addition, price stimulation, order stimulation, business reputation stimulation and elimination stimulation are also implemented.

As to the class C common materials, most of them are parts and components of coal mining equipment, the procurement batch number is small, the categories are various, and the consumption is great, so it needs to introduce competitive mechanism, conduct procurement by comparing prices, select the superior and eliminate the inferior, accelerate metabolism of the supplier team, reduce quantity of the suppliers, and promote the comprehensive quality[14]. As to this, coal enterprises mainly implements price stimulation and elimination stimulation, takes full advantage of inventory of suppliers and the third party, and purchases at the time of use. Although the demand of coal enterprises on these materials is also great, they can be obtained easy in market, and social inventory can be used. The procurement period is also very short, thus more simple method can be adopted to save cost.

As to the class D ordinary materials, the consumption shows no regularity, and the enterprise itself shall store certain amount of materials properly and establish procurement relation with suppliers based on orders. The whole cooperation between materials supply department and suppliers shall be realized in the form based on orders, namely that the orders generated by demand of production department shall be the driving factors for purchasing orders formulation of the materials supply department, and purchasing orders of materials supply department shall be the driving factors for the cooperation with suppliers. Only by this, materials supply shall be in order, and repeated procurement and invalid procurement can be avoided.

5. Conclusions

In this paper, it gives an in-depth research by focusing on the characteristics of coal industry and mainly aiming at materials classification method and procurement strategy in materials management. Firstly, it improves the traditional ABC classification method, and proposes the ABCD materials classification method based on importance and stability. Secondly, it builds materials classification model with fuzzy comprehensive evaluation algorithm, and gives analysis with examples. Finally, it gives corresponding materials procurement and suppliers selection strategies according to materials classification results. During the research in this paper, it combines with practical situation of the coal industry tightly and proposes new thought, with the purpose of providing early stage theoretical support for the establishment of intelligent information management system of the coal industry.

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