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The application of fuzzy mathematical method in the evaluation of the steel slag utilization

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Abstract

This study considered different influencing factors of the steel slag utilization including environmental benefit, economic benefit, technological adaptability and the scale of utilization, and based on the facors , fuzzy mathematical method was built to evaluate the steel slag utilization comprehensive benefits. Furthermore, this mode was applied in the benefit evaluation of a certain factory which is produced steel and iron slag cement, and “Good” grade was obtained . This mode provides scientific basis for utilization benefit of steel slag.

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Keywords: steel slag, resources utilization, fuzzy comprehensive evaluation;

1. Introduction

Steel slag is a solid waste from steel production. It can be categorized as carbon steel slag and stainless steel slag according to the type of steel, and as pretreatment slag, basic oxygen furnace slag (BOFS), electrical arc furnace slag (EAFS), ladle refining slag (LFS) and casting residue according to the steelmaking process[1]. Steel and steel slag annual output of 2014 in China reached 822.7 million tons and 120 million tons respectively. However, the current utilization rate of steel slag in China is only 22%, far behind the developed countries like USA, Japan, Germen, and France, of which the rate have been close to 100%. In the developed countries, 50% of slag has been used for the road project directly, with the remaining part for sintering and iron-making recycling in plant[2]. Improving the utilization rate of steel slag is an imperative way for the steel enterprise to realize sustainable development. Therefore, it is necessary to evaluate the utilization comprehensive benefit and determine its grade, so we can master the basis for decision. The fuzzy mathematical method can be used to evaluate the comprehensive benefit.

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2. The mathematical mode of steel slag utilization fuzzy comprehensive evaluation

2.1. The basic theory of fuzzy comprehensive evaluation

In practice, we must make an evaluation of something according to multiple factors or multiple indexes instead of only one infector or index. Virtually, this is so-called comprehensive evaluation method. Here evaluation means determining merits and bad things in accordance with the given conditions, comprehension means standard of evaluation contain multiple factors and multiple indictors. Therefore, comprehensive evaluation is a method used to solve problems that include many evaluation factors. In fuzzy mathematics, a multifactor fuzzy comprehensive evaluation model can describe this method[3].

Let $U=\{u_1, u_2, \ldots, u_m\}$, this set contains m factors, and $V=\{v_1, v_2, \ldots, v_n\}$, the set contains n standard evaluation. Because each factor has corresponding condition, there effects are not different. As a result, the standards of evaluation are also different. Virtually, people cannot make a clear positive or a negative respond to every standard. Instead, comprehensive evaluation is a fuzzy set, $B=(b_1, b_2, \ldots, b_n) \in F(V)$, which is a subset of set V. The set B depends on every factor's weight, so B is a subset of fuzzy set U and it can be described with $A=(a_1, a_2, \ldots, a_m) \in F(U)$, and the sum of a_i is 1, a_i express the weight of factor i. In other words, given the weight of A, a comprehensive evaluation B can be given. Therefore, a transformation from U to V can be established. If r_{ij} is the judge result of evaluation factor u_i to remark v_j so the judge decision-making matrix of *m* evaluation factors is as follows:

$$R=\begin{bmatrix} R_1 \\ R_2 \\ \mathrm{M} \\ R_m \end{bmatrix}=\begin{bmatrix} r_{11} & r_{12} & \mathrm{L} & r_{1n} \\ r_{21} & r_{22} & \mathrm{L} & r_{2n} \\ \mathrm{L} & \mathrm{L} & \mathrm{L} & \mathrm{L} \\ r_{m1} & r_{m2} & \mathrm{L} & r_{mn} \end{bmatrix} \tag{1}$$

Where R is the fuzzy connection of U to V and R_i is the fuzzy connection of u_i to V. One fuzzy subclass of aggregate *V* can be worked out by applying the synthetic operation of fuzzy transform, which is the comprehensive evaluation result:

$$B=A \bullet R=[b_1, b_2, \ldots, b_n] \tag{2}$$

Where B stands for a fuzzy aggregate of V. Fuzzy transform $A \bullet R$ changes into common matrix calculation, which refers to many factors in all directions and is suitable for multi-factors sequence. The calculation can be described as follows[4]:

$$b_j=\min\left\{1, \sum_{i=1}^{p} a_i r_{ij}\right\}, \quad j=1, 2, \ldots, m \tag{3}$$

2.2. The establishment of the steel slag utilization evaluation system

According to the establishment principle of the indicator system, and the actual characteristics of the steel slag utilization benefit, the system as follows was built: