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Research on fuzzy evaluation method of lifting machines

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ABSTRACT

On lifting machines product design evaluation, traditionally, generally using a qualitative analysis. Through the analysis of the current evaluation methods to lifting machines products, established found the comprehensive evaluation system of lifting machines products, proposed the lifting machines product design multistage fuzzy comprehensive evaluation method, promoted the degree of quantitative and Information.

KEYWORDS

Lifting machines;
Fuzzy mathematics;
Multi-level evaluation;
Fuzzy evaluation.

INTRODUCTION

With the development of science and technology, the scope and concept of the design of the hoist also changes[1]. In addition to meeting the mechanical hoist traditional requirements, it also need to meet the economic, reliability, and ecology (Human relations, environmental pollution) and other requirements[2]. in the conditions of meeting the basic requirements and functions, to carry out a variety of economic and technical analysis of the hoist's design, according to the comprehensive evaluation index, respectively compared, ultimately determine the best solution[3]. These work is important pilot significance for the subsequent technical design, construction design, testing, identification and information feedback etc.

THE THEORIES OF THE HOIST'S DESIGN EVALUATION

The design Evaluation design is means test to guarantee a good product, also the way of thinking for measuring the design process and methods.

The mathematical basis of fuzzy comprehensive evaluation of the hoist

The hoist's identification and evaluation need to make the whole performance grading of 'very good', 'good', 'fair', 'poor'[4]. But now assessed, generally test each hoist's individual performance; it hasn't been able to make an objective assessment of the overall performance of the machine. an indicator of evaluating that the so-called good, medium and poor is no absolute boundaries, it has a considerable fuzziness. Therefore, it is more reasonable for the Application of fuzzy mathematics on the hoist design[5,6].

Let comment collections (ie collections on behalf of rank, classification, etc.) as follows:

$Y = \{y_1, y_{2,\cdots,} y_m\}$

There are m levels. A collection of factors:

$X = \{x_1, x_2, x_3, x_4, x_5, x_6, \dots, x_n\}$

There are n factors. Let the i-th factor evaluation as

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follows:

$R = \{r_{i1}, r_{i2}, \cdots, r_{im}\}$

It can be seen as a fuzzy subset of Y. Wherein i denotes the factor r_{ik} judge the level of the k-th membership. Total factor evaluation matrix is n:

$$R = \begin{pmatrix} R_1 \\ R_2 \\ \vdots \\ R \end{pmatrix} = \begin{pmatrix} r_{11} & \cdots & r_{1m} \\ \vdots & \ddots & \vdots \\ r_{n1} & \cdots & r_{nm} \end{pmatrix}$$

Conducting comprehensive evaluation, it need to consider the role of the maximum membership principle of the various factors for the rating, it is formed a fuzzy subset on the factors set Y:

$A = (a_1, a_2, \ldots, a_n)$

a_i is the membership of y_i on the A,

after to A,R, the comprehensive evaluation operations are written in the form

$A^\circ R = B$

For taking a different operator, there are different models.

The evaluation indictor for hoist

Generally, the evaluation indictors of the hoist include the following aspects:

THE FUZZY EVALUATION MODEL VERIFICATION OF A MINE HOIST

Let's comprehensively evaluate the mine hoist design of 2JK-3/20A which are produced by Luoyang

No.	The first level indicator	The indicator Description	The second grade indexes
1	Function parameters	The ability of the hoist	maximum static tension, maximum static tension deviation, maximum lifting height, rope capacity, motor power
2	operating performance	the adaptability of the work process with the hoist	reliability, reliability of operation, overhaul period, maintainability, degree of automation, brake systems and brake reliability depth indicator
3	structural processes	the function achievement and the adaptability of the process with the hoist	reasonable structure, reasonable, rational design process, selection of parts pass rate, the consumption of scarce resources, parts processing quality
4	economy	the economy of the hoist operation and processing	manufacturing costs, operating costs, energy consumption, the machine heavy
5	degree of standardization	the extent of accordance with the standards	the proportion of standard parts, using the level of standards, the proportion of common parts products
6	The service and the whole set	the required ancillary equipment and service work (including software) to ensure the normal operation of the hoist	range of accessories, consumable supplies, full of information, staff training, replacement during the warranty period specified
7	man-machine relation	The effect of the hoist on people and the operating conditions	safety, operator comfort, requirements of the operator attention, modeling, color, decorating
8	security	the safety insurances of the hoist operation	explosion, fault monitoring, prediction and diagnosis, to prevent misuse facilities
9	environmental protection	The environmental impact of the hoists	Noise, vibration

Mining Machinery Plant:

Factor set X = {x_1 (function parameters), x_2 (operating performance), x_3 (structural processes), x_4 (economy), x_5 (standardization), x_6 (service and complete sets), x_7 (Human Relations), x_8 (security), x_9 (environmental Protection and social)}.

Set a set of evaluation factors:

Y = {y_1 (excellent), y_2 (good), y_3 (preferably), y_4 (general), y_5 (poor), y_6 (Poor)}

Firstly, conduct the evaluation of single factor. Invite relevant experts of the hoists, the corporate engineering and technical personnel, the users to evaluate:

The first step: x_1 (function parameters) were evaluated. 40% of the participating think that "good", 30% of people think that "good", 15% of people think that "good", 10% of people believe that "in general", 5% of people think, "poor", no one thinks "poor", then the evaluation results of X_1 are obtained:

(0.4, 0.3, 0.15, 0.1, 0.05, 0)

Analogously, conduct the successive evaluation of x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, the results are shown in TABLE 1.

Index factor	
x_1	(0.4, 0.3, 0.15, 0.1, 0.05, 0)
x_2	(0.25, 0.3, 0.1, 0.25, 0.1, 0)
x_3	(0.15, 0.4, 0.15, 0.2, 0.1, 0)
x_4	(0.1, 0.3, 0.25, 0.25, 0.1, 0)
x_5	(0.3, 0.25, 0.25, 0.1, 0.05, 0.05)
x_6	(0.1, 0.4, 0.25, 0.15, 0, 0.1)
x_7	(0.25, 0.25, 0, 0.4, 0.1, 0)
x_8	(0.4, 0.2, 0.15, 0.2, 0.05, 0)
x_9	(0.3, 0.3, 0.15, 0.2, 0.05, 0)

Due to many factors, taking the failure of the evaluation when using level synthesis caused by into account, simultaneously, the value of N is too large to determine for the factors weight. So use the multi-level model for solving. The evaluation factors are divided into three subsystems, that:

$X = \{X_1, X_2, X_3\}$

have $X_1 = \{x_1, x_2, x_3\}$; $X_2 = \{x_4, x_5, x_6\}$;

$X_3 = \{x_7, x_8, x_9\}$

The respectively correspond single factor evaluation matrixes:

$$R_1 = \begin{pmatrix} 0.4 & 0.3 & 0.15 & 0.1 & 0.05 & 0 \\ 0.25 & 0.3 & 0.1 & 0.25 & 0.1 & 0 \\ 0.15 & 0.4 & 0.15 & 0.2 & 0.1 & 0 \end{pmatrix};$$

$$R_2 = \begin{pmatrix} 0.1 & 0.3 & 0.25 & 0.25 & 0.1 & 0 \\ 0.3 & 0.25 & 0.25 & 0.1 & 0.05 & 0.05 \\ 0.1 & 0.4 & 0.25 & 0.15 & 0 & 0.1 \end{pmatrix}$$

$$R_3 = \begin{pmatrix} 0.25 & 0.25 & 0 & 0.4 & 0.1 & 0 \\ 0.4 & 0.2 & 0.15 & 0.2 & 0.05 & 0 \\ 0.3 & 0.3 & 0.15 & 0.2 & 0.05 & 0 \end{pmatrix}$$

The tendency of different factors when evaluating determine the different weights assigned, in that case, the weights were taken:

$A_1 = (0.4, 0.3, 0.3)$; $A_2 = (0.5, 0.25, 0.25)$;

Calculated as follows:

$$A_1 \circ R_1 = (0.4, 0.3, 0.3) \begin{pmatrix} 0.4 & 0.3 & 0.15 & 0.1 & 0.05 & 0 \\ 0.25 & 0.3 & 0.1 & 0.25 & 0.1 & 0 \\ 0.15 & 0.4 & 0.15 & 0.2 & 0.1 & 0 \end{pmatrix}$$

$= (0.28, 0.33, 0.135, 0.175, 0.08, 0)$

$= B_1$

$$A_2 \circ R_2 = (0.5, 0.25, 0.25) \begin{pmatrix} 0.1 & 0.3 & 0.25 & 0.25 & 0.1 & 0 \\ 0.3 & 0.25 & 0.25 & 0.1 & 0.05 & 0.05 \\ 0.1 & 0.4 & 0.25 & 0.15 & 0 & 0.1 \end{pmatrix}$$

$= (0.15, 0.3125, 0.25, 0.1875, 0.0625, 0.0375)$

$= B_2$

$$A_3 \circ R_3 = (0.3, 0.5, 0.2) \begin{pmatrix} 0.25 & 0.25 & 0 & 0.4 & 0.1 & 0 \\ 0.4 & 0.2 & 0.15 & 0.2 & 0.05 & 0 \\ 0.3 & 0.3 & 0.15 & 0.2 & 0.05 & 0 \end{pmatrix}$$

$= (0.335, 0.1275, 0.105, 0.26, 0.065, 0)$

$= B_3$

For the second stage evaluation, so:

$$R = \begin{pmatrix} B_1 \\ B_2 \\ B_3 \end{pmatrix} = \begin{pmatrix} 0.28, 0.33, 0.135, 0.175, 0.08, 0 \\ 0.15, 0.3125, 0.25, 0.1875, 0.0625, 0.0375 \\ 0.335, 0.1275, 0.105, 0.26, 0.065, 0 \end{pmatrix}$$

According to the *Coal Mine Safety Regulations*, *operating procedures*, *rules* and other data analysis, under the premise of functional requirements meted, the safety and reliability of the equipment occupy a more prominent position. So the weight assignment of X1, X2, X2:

A= (0.25 0.45 0.3), Then calculates the evaluation results:

$$B = A^{\circ}R = (0.25\ \ 0.45\ \ 0.3)$$

$$\begin{pmatrix} 0.28, & 0.33, & 0.135, & 0.175, & 0.08, & 0 \\ 0.15, & 0.3125, & 0.25, & 0.1875, & 0.0625, & 0.0375 \\ 0.335, & 0.1275, & 0.105, & 0.26, & 0.065, & 0 \end{pmatrix}$$

$$=(0.238,\ 0.2612,\ 0.1776,\ 0.2061,\ 0.067,\ 0.017)$$

According to the principle of maximum membership degree, comprehensive evaluation findings obtained in this design is “good”.

CONCLUSION

(1) The hoist design has been evaluated in a qualitative stage for the past many years. The method of fuzzy mathematics applied for a multi-level comprehensive evaluation in the design process improves information technology, quantitative evaluation of the hoist, and also verify the practicality and effectiveness of the fuzzy comprehensive evaluation method for the quantitative assessment of large equipment.

(2) Quantify the results of the evaluation, although the application of the principle of maximum degree of membership is most widely used, but the principle is not only in the actual evaluation work, should be quantified using a variety of principle.

(3) It is noted that the evaluation of mechanical products to enhance the accuracy, depending on whether the objective evaluation system. By learning how to build fuzzy random objective and comprehensive evaluation system is an objective need in the mechanical product design phase.

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