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Condition Assessment Model for Subsection Vacuum Switch in Service Based on Fuzzy Synthetic Evaluation

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Abstract

In order to solve the problems of subsection vacuum switch repair deficiency and blind repair and to improve the accuracy of the subsection vacuum switch condition assessment we put forward a strategy based on the theory of fuzzy evaluation. Firstly, a layered evaluation index system on the base of preventive experiments, including working surroundings, operation history, maintenance records, and accessories section and so on is built. Then, the relative impairment degree is introduced to describe the relative grade of subsection vacuum switch changing from actual conditions to faults. The member functions for qualitative indices and the quantitative indices are respectively determined with helps of a fuzzy statistic method and a fuzzy distribution method. An operation condition evaluation model evaluates the state of every grade and gives a comprehensive assessment of subsection vacuum switch, is established on the base of the fuzzy synthetic judgment. Example analysis shows t the method for the safe operation of the transformer condition assessment of reliability is higher and more accurate.

Keywords*: subsection vacuum switch, condition assessment, fuzzy synthetic evaluation*

1. Introduction

Subsection vacuum switch is important electrical equipment in power supply circuit, and is closely related to the operation of the power supply circuit. Timely and accurate grasp of the operation of the subsection vacuum switch information section for the maintenance of vacuum switch and the safe and stable operation of power grid has important meaning. At present, the domestic and foreign research is more through the expert system, fuzzy logic, neural network and genetic algorithm for fault status information. The structure of subsection vacuum switch is complex, the fault is varied, there is no clear division between various faults, it has a lot of fuzziness, and the existence of the fault degree also has a certain ambiguity, not to the absolute fault recognition to exist or not exist. Some scholars introduced the evidence theory; neural network and fuzzy theory method for evaluation model are studied. But the work such as the selection of indicators is not enough in-depth, the model of conditional probability, the initial grading subjectivity is larger; the key membership of fuzzy processing technology is lack of sufficient evidence.

This paper established the index system of evaluating performance of subsection vacuum switch, based on the analysis of subsection vacuum switch fault mechanism. Combined with fuzzy theory, establish the membership function, through the transformation and evaluation all sorts of state parameters of subsection vacuum switch is to determine its running state by adopting of trapezoid model and the fuzzy theory. Evaluation results can be divided into five grades, which is facilitating maintenance staff according to the result of level.

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2. Selection of Evaluation Factors

In order to make the evaluation indicator, really reflect the operation of subsection vacuum switch, considering the maneuverability of state evaluation, this paper selected state parameters from electrical test, vacuum degree, mechanical properties, environmental factors, exterior condition, maintenance records and the manufacturer selection of the seven aspects. The hierarchical evaluation index system of subsection vacuum switch state is shown in Figure 1.

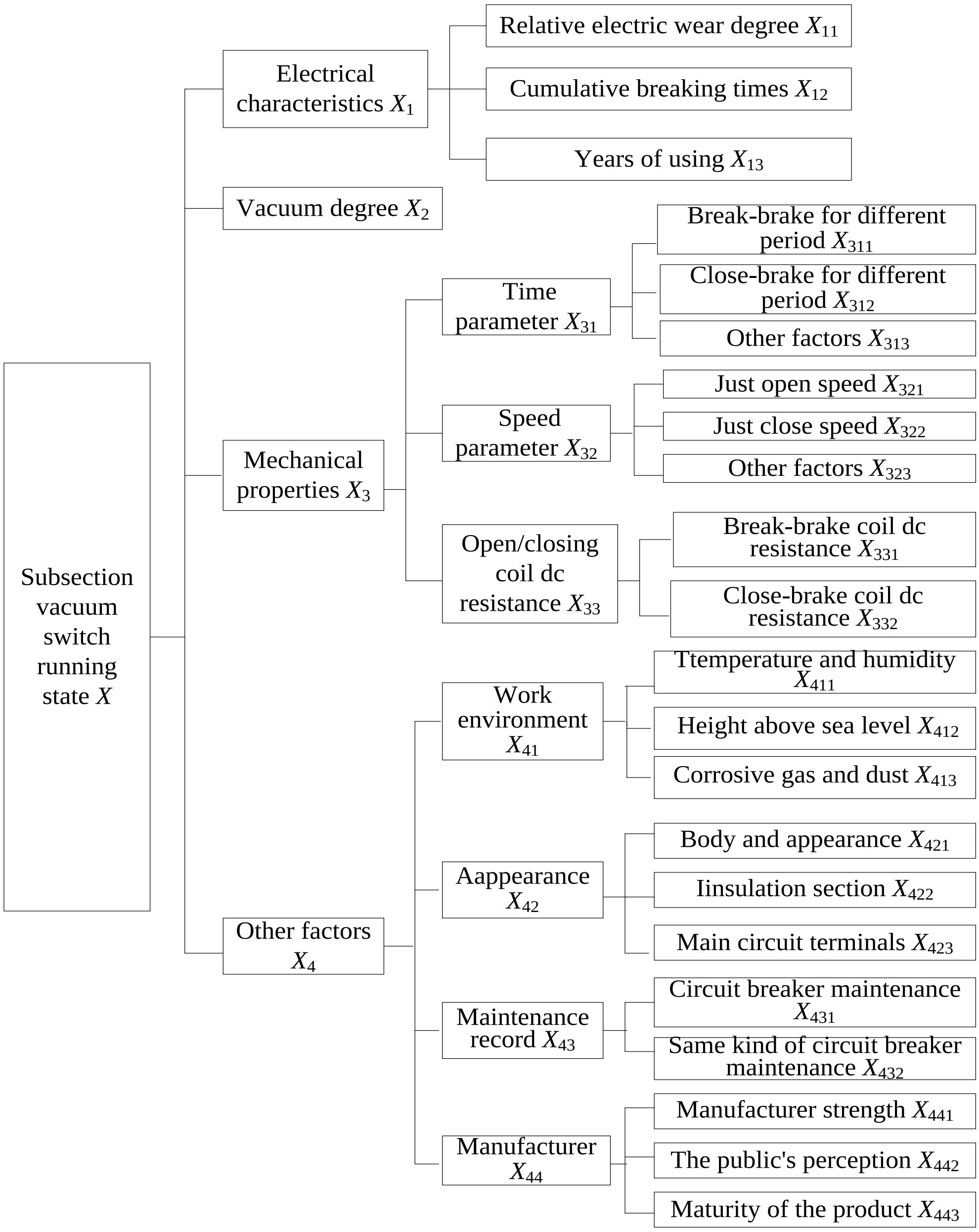

Figure 1. Condition Evaluation Indices System

3. Establishment of Fuzzy Comprehensive Evaluation Model

Considering various evaluation of the subsection vacuum switch factors to affect the result of fuzziness, multistage fuzzy comprehensive evaluation method is adopted to establish state evaluation model of the subsection vacuum switch.

3.1. Establish Factor Set of Evaluation Objects

Selected state parameters as evaluation factors, operation factors analysis diagram of subsection vacuum switch is established (Fig 1). It is a hierarchical index system. Target layer of subsection vacuum switch integrated state can be decomposed into four judge project in project layer: Ux =(Ux$_1$, Ux$_2$, Ux$_3$, Ux$_4$), then continue to decompose, the breakdown of each project to the next level component, component is decomposed into the final level indicators, the project is directly decomposed into target if no component layer. Such as mechanical properties can be decomposed into three sub projects, Ux$_3$= (Ux$_{31}$, Ux$_{32}$, Ux$_{33}$), among them, the time parameter component is decomposed into three indicators: Ux$_{31}$=(Ux$_{311}$,Ux$_{312}$,Ux$_{313}$).

3.2. Establish Evaluation Set

The operation state of the vacuum switch is divided into excellent, good, medium, waiting for check and quick check five kinds of situations. The evaluation sets is V= {excellent, good, medium, waiting for check and quick check} = {v_1, v_2, v_3, v_4, v_5}.

3.3. Establish Every Level Fuzzy Evaluation Matrix

Such as the indicators u_i for a subproject is used to evaluate subsection vacuum switch. Membership for state v_i in evaluation sets is r_{ij} (j=1, 2, 3), membership sets are available for R_i = {r_{i1}, r_{i2}, r_{i3}}, which is evaluation result according to the index u_i. Then, all indicators of the component are making up the fuzzy evaluation matrix.

For example, sub-project of time parameter X_{31}, judging matrix of time parameter is:

$$Rx_{31} = \begin{bmatrix} Rx_{311} \\ Rx_{312} \\ Rx_{313} \end{bmatrix} = \begin{bmatrix} r_{11} & r_{12} & r_{13} \\ r_{21} & r_{22} & r_{23} \\ r_{31} & r_{32} & r_{33} \end{bmatrix} \quad (1)$$

Similarly, based on fuzzy evaluation for the index layer can get judgment matrix of subproject layer $R_{j\times3}$, fuzzy evaluation results of all items of subprojects layer constitutes the evaluation matrix of project layer, finally, fuzzy evaluation matrix of all project layer is available for $R_{k\times3}$, such as the judgment matrix of the mechanical properties is:

$$Rx_{3} = \begin{bmatrix} Rx_{31} \\ Rx_{32} \\ Rx_{33} \end{bmatrix} = \begin{bmatrix} w_{11} & w_{12} & w_{13} \\ w_{21} & w_{22} & w_{23} \\ w_{31} & w_{32} & w_{33} \end{bmatrix} \quad (2)$$

3.4. Determine the Weights of Evaluation Factors at Different Levels

After establishing index system, it should be given the relative weight based on the corresponding importance of hierarchy and index. Analytic hierarchy process is based on expert advice, the various indicators in the complex system is divided into interconnected orderly hierarchy, the multi-level and multi-index weight assignment is simplified to two more of the importance of each index, and then mathematical processing, for each level and each index assignment, that has the characteristics of reliable, flexible and practical. Considering the subsection vacuum switch state evaluation is still at the start stage of study, get a lot of the clear evaluation conclusion samples is quite difficult, only with the aid of expert experience, and evaluation index system is hierarchical index structure, the paper used the AHP to give every index weight. Invited four experts according to the requirements of the AHP, can get the relative importance between two index given two to compare, the data is shown in Table 1 (Z1 ~ Z4 is respectively represent four experts, X1 *etc.* is on behalf of indicators).

Table 1. Weights of Every Index Assigned by Experts

Expert number	X_1	X_2	X_3	X_4	X_{11}	X_{12}	X_{13}	X_{31}	X_{32}	X_{33}	X_{41}	X_{42}	X_{43}	X_{44}
Z1	1	1	1	1/3	2	1	2	3	2	1	1	3	2	3
Z2	1	1	1	1/4	1	1	1	2	3	1	1	3	2	5
Z3	1	2	1	1/3	2	1	1	3	3	1	1	3	2	4
Z4	1	1	2	1/3	3	1	1	3	2	1	1	2	2	5

Table2. Weights of Every Index Assigned by Experts

Expert number	X_{311}	X_{312}	X_{313}	X_{321}	X_{322}	X_{323}	X_{331}	X_{332}	X_{411}	X_{412}	X_{413}	X_{421}	X_{422}	X_{423}
Z1	1	1	2	3	1	1	1	2	1	1	2	1	1	5
Z2	1	2	3	2	1	1	2	2	2	1	1	1	1	4
Z3	1	1	2	2	1	1	1	1	1	1	1	1	2	4
Z4	1	2	3	3	1	1	1	1	1	1	2	1	2	5

Use these data to calculate weight, the traditional way is to construct the judgment matrix and get the biggest characteristic value of matrix and its corresponding eigenvectors, this vector is the index weight. But in practice, the construction of judgment matrix with only roughly estimated to adjust is optional; that often need to adjust the satisfying consistency check for many times. This paper adopted the improved method, through calculating the optimal transfer matrix and making its natural satisfies the requirement of consistency, the relative weights of evaluation factors is directly calculated, calculation results are shown in Table 3.

Table 3. The Weight of Evaluation Index

Indicators	Sub-index weight of next layer	Indicators	Sub-index weight of next layer
X	0.518, 0.286, 0.143, 0.053	X_1	0.615, 0.130, 0.255
X_3	0.758, 0.112, 0.164	X_4	0.168, 0.210, 0.532, 0.090
X_{31}	0.6, 0.4	X_{32}	0.6, 0.4
X_{33}	0.5, 0.5	X_{41}	0.124, 0.356, 0.326, 0.194
X_{42}	0.273, 0.177, 0.088, 0.462	X_{43}	0.4, 0.6

3.5. Fuzzy Operator and Evaluation Indicators Processing

Fuzzy comprehensive evaluation expression is $B=A\circ R$, $\circ$ is the generalized fuzzy operator, there are various ways to choose, this paper choose the weighted average model of comprehensive evaluation, which is used $M\ (\bullet, \oplus)$ to express. Using this algorithm considering both the main factors that influence on subsection vacuum switch status, and keep all the information in a single factor, is more in line with the actual situation.

Through fuzzy comprehensive evaluation assessed value $b_j(j = 1, 2, \dots n)$, it must process the result of the assessment in order to get the final evaluation results. Adopting the maximum membership degree method, take judge element set v_k for evaluating results, which is corresponding to maximum assessment, $b_{\max}= \max\{b_j|\ j=1, 2, 3, 4\}$; Fuzzy distribution method may be adopted, the b_j is as directly to the evaluation results, so that the evaluators to evaluate subsection vacuum switch state have a comprehensive understanding.

From establishing the process of fuzzy comprehensive evaluation model is easy to find, the indicators membership function and the determination of weight of each evaluation factor is the key to judge, they are directly decided the rationality and accuracy of evaluation conclusion. The follow is mainly to discuss the determining method of the membership function for evaluation factors in the index layer.

4. Determination of Membership Function and Membership Degree for Index Layer

4.1. Relative Deterioration Degree

The introduction of the concept of relative deterioration degree is used to express the current actual status compared with fault state relative deterioration degree for subsection vacuum switch, it is a quantitative index, and value range is [0,1]. According to the different values reflect the degradation degree of the indicators status.

The indicators calculation for the smaller optimal is as follows:

$$l_i = \left[\frac{C_i - C_0}{C_{\max} - C_0} \right]^k \tag{3}$$

The indicators calculation for the bigger the better is as follows:

$$l_i = \left[\frac{C_i - C_{\min}}{C_0 - C_{\min}} \right]^k \tag{4}$$

In the above equation, l_i is the relative deterioration degree for state index i; C_0 is the allowable index value; $C_{\max}$ or $C_{\min}$ is limit value, they are determined by referencing power equipment preventive test procedures and the subsection vacuum switch operating procedures. C_i is for the measured values of index, k is the influence of equipment state because of the parameter change, in this paper, and we take 1.

4.2. Determine the Membership Function of Quantitative Indicators

The quantitative data of indexes used fuzzy distribution method for electrical characteristics and mechanical properties. Because of its simple shape of triangular membership functions, and the results with other more complex subordinate function difference is smaller. Therefore, this paper used triangle and half trapezoid distribution function; establish the membership function of the index corresponding to different state levels, as shown in Figure 2.

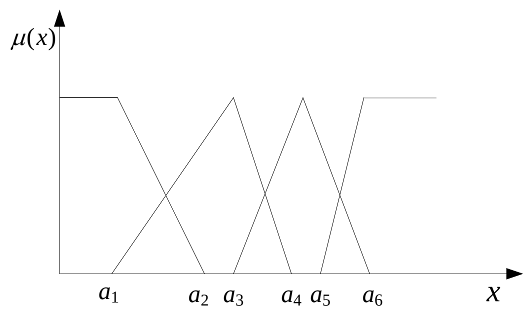

Figure 2. Membership Function Distribution Diagram of Half Trapezium and Triangle

The specific method to determine the membership function is: Degradation degree calculation for the raw data is according to the calculation formula of relative deterioration degree, then in accordance with the relevant regulations or expertise, determine the relative deterioration degree of the triangle and half trapezoid distribution combination function to fuzzy boundary of the interval for 5 kinds of state level, finally set up membership function for each state grade is for relative deterioration degree. For example, the evaluation factors of relative electric wear degree, its membership function corresponds to the state v_1~v_5 can be identified as respectively:

Membership function for the first level:

$$\mu(x)=\begin{cases}1 & x<0.1\\ \dfrac{4-10x}{3} & 0.1\le x<0.4\\ 0 & x\ge 0.4\end{cases} \tag{5}$$

Membership function for the second level:

$$\mu(x)=\begin{cases}5x-0.5 & 0.1\le x<0.3\\ \dfrac{5}{2}-5x & 0.3\le x<0.5\\ 0 & x<0.1 \text{ or } x\ge 0.5\end{cases} \tag{6}$$

Membership function for the third level:

$$\mu(x)=\begin{cases}5x-\dfrac{3}{2} & 0.3\le x<0.5\\ \dfrac{7}{2}-5x & 0.5\le x<0.7\\ 0 & x<0.3 \text{ or } x\ge 0.7\end{cases} \tag{7}$$

Membership function for the fourth level:

$$\mu(x)=\begin{cases}5x-\dfrac{5}{2} & 0.5\le x<0.7\\ \dfrac{9}{2}-5x & 0.7\le x<0.9\\ 0 & x<0.7 \text{ or } x\ge 0.9\end{cases} \tag{8}$$

Membership function for the fifth level:

$$\mu(x)=\begin{cases}5x-\dfrac{7}{2} & 0.7\le x<0.9\\ 1 & 0.9\le x<1\\ 0 & x<0.7\end{cases} \tag{9}$$

In the same way, can get the membership function of all the evaluation factors, there is no need to narrative everyone.

4.3. Determine the Membership Degree of Qualitative Indexes

The qualitative description data such as the environmental factors, appearance, maintenance records and the manufacturers adopted fuzzy statistical method.

Through expert survey form, evaluation index and the evaluation objects are given, making questionnaire, distributed to every expert, based on the results to determine the membership degree of various factors, single factor evaluation matrix is obtained, the expression is:

$$\text{Membership degree of factors } U_{ij}=\frac{\text{The number thinks of factors } i \text{ belong to evaluation set } j}{\text{The total number of evaluation experts}}$$

5. The Example Analysis

In this paper, ZW32-12 vacuum switch is as the research object, through the actual measured data to judge the running state of the switch. Its technical parameters are shown in Table 4.

Table 4. Subsection Vacuum Switch Technology Parameters

Switch type		ZW32-12	
nominal voltage(kV)	12	rated current(A)	630
nominal short circuit breaking current(A)	20	nominal short circuit closing current(A)	50
Rated current breaking number (time)	10000	rated short circuit current breaking number (time)	30
power frequency withstand voltage 1min(kV)	42	each phase galvanic circle resistance(μΩ)	<80
opening speed(m/s)	1.2±0.2	closing speed(m/s)	0.6±0.2
opening time(ms)	23 ~ 55	closing time(ms)	25 ~ 55

5.1. The Evaluation of Breaking Wear

The service life of subsection vacuum switch is 20 years according to the regulations of the manufacture; it has been used for 13 years, the number of the cumulative breaking current is to achieve 528, the breaking current data of subsection vacuum switch according to the records substitute into in the following formula.

$$Q_m = \sum \frac{I^2}{10000} \tag{10}$$

Solution of relative electrical wear is Q_m=0.561, using years is $f(x)$ = (13/20)2=0.423, accumulative breaking number is $f(x)$ = 528/1000=0.053, then put data into to the breaking wear membership function, get the fuzzy relation matrix is as follows.

$$R_{breaking\ \ wear} = \begin{bmatrix} 0 & 0 & 0.695 & 0.305 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0.515 & 0.485 & 0 & 0 \end{bmatrix}$$

According to the breaking wear weight is distributed $A_{breaking\ wear}$(0.615,0.130,0.255),

$$B_{\text{breaking wear}} = A_{\text{breaking wear}} \circ R_{\text{breaking wear}} = (0.615, 0.130, 0.255) \circ \begin{bmatrix} 0 & 0 & 0.695 & 0.305 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0.515 & 0.485 & 0 & 0 \end{bmatrix}$$

= (0.130, 0.131, 0.551, 0.188, 0)

5.2. Vacuum Degree Evaluation

The vacuum degree of vacuum circuit breaker is 3.2×10^{-3}Pa, put it in $f(x) = \frac{M - x}{M - N}$, $f(x)$=0.039, then put data into the membership function of the vacuum, get the vector of fuzzy relations $B_{\text{vacuum degree}}$=(1,0,0,0,0).

5.3. Mechanical Properties Evaluation

Separating brake for different period is 1.73ms according to preventive experiments of subsection vacuum switch, just points speed is 3.6m/s, closing speed is 3.1m/s, dc resistance of break-brake coil is 104Ω, dc resistance of closing coil is 117Ω. Vacuum section switch manufacturers requirements just points for speed is 3.4±0.8m/s, just close for speed is 3.2±0.2m/s, dc coil resistance of divide-shut brake is 110Ω, put the above data into membership function of mechanical properties, get the fuzzy relation matrix is as follows:

$$R_{\text{time characteristic}} = \begin{bmatrix} 0 & 0.333 & 0.973 & 0.307 & 0 \\ 0.350 & 0.650 & 0.433 & 0.325 & 0.217 \end{bmatrix}$$

$$R_{\text{speed characteristic}} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.997 & 0.005 & 0 & 0 & 0 \end{bmatrix}$$

$$R_{\text{DC resistance}} = \begin{bmatrix} 0.858 & 0.285 & 0 & 0 & 0 \\ 0.668 & 0.665 & 0 & 0 & 0 \end{bmatrix}$$

The weight distribution for time parameter, speed parameter points closing coil dc resistance as to mechanical properties of subsection vacuum switch is $A_{\text{DC resistance}}$=(0.758, 0.112, 0.164),

$$B_{\text{time parameter}} = A_{\text{time parameter}} \circ R_{\text{time parameter}} = (0.6, 0.4) \circ \begin{bmatrix} 0 & 0.333 & 0.973 & 0.307 & 0 \\ 0.350 & 0.650 & 0.433 & 0.325 & 0.217 \end{bmatrix}$$

$$= (0.14, 0.26, 0.5835, 0.1842, 0.0868)$$

$$B_{\text{speed parameter}} = A_{\text{speed parameter}} \circ R_{\text{speed parameter}} = (0.6, 0.4) \circ \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0.997 & 0.005 & 0 & 0 & 0 \end{bmatrix}$$

$$= (0.6, 0.002, 0, 0, 0)$$

$$B_{\text{DC resistance}} = A_{\text{DC resistance}} \circ R_{\text{DC resistance}} = (0.5, 0.5) \circ \begin{bmatrix} 0.858 & 0.285 & 0 & 0 & 0 \\ 0.668 & 0.665 & 0 & 0 & 0 \end{bmatrix}$$

$$= (0.429, 0.3325, 0, 0, 0)$$

$$B_{\text{Mechanical properties}} = A_{\text{Mechanical properties}} \circ R_{\text{Mechanical properties}} = A_{\text{Mechanical properties}} \circ \begin{bmatrix} B_{\text{Time parameter}} \\ B_{\text{Speed parameter}} \\ B_{\text{DC resistance}} \end{bmatrix}$$

$$= (0.758, 0.112, 0.164) \circ \begin{bmatrix} 0.14 & 0.26 & 0.5835 & 0.1842 & 0.0868 \\ 0.6 & 0.002 & 0 & 0 & 0 \\ 0.429 & 0.3325 & 0 & 0 & 0 \end{bmatrix}$$

$$= (0.106, 0.197, 0.442, 0.140, 0.066)$$

5.4. Other Factors Evaluation

According to the records of maintenance, adopt the method of fuzzy statistics; get the fuzzy relation matrix of working environment, appearance, maintenance records, and the manufacturer of subsection vacuum switch is as follows.

$$R_{\text{work environment}} = \begin{bmatrix} 0.2 & 0.25 & 0.2 & 0.25 & 0.1 \\ 0.15 & 0.4 & 0.2 & 0.25 & 0 \\ 0.1 & 0.2 & 0.25 & 0.15 & 0.3 \\ 0.55 & 0.15 & 0.1 & 0.2 & 0 \end{bmatrix}$$

$$R_{\text{appearance}} = \begin{bmatrix} 0.1 & 0.15 & 0.55 & 0.15 & 0.05 \\ 0.1 & 0.15 & 0.65 & 0.1 & 0 \\ 0.1 & 0.15 & 0.6 & 0.15 & 0 \\ 0 & 0.1 & 0.7 & 0.1 & 0.1 \end{bmatrix}$$

$$R_{\text{maintenance record}} = \begin{bmatrix} 0.2 & 0.1 & 0.2 & 0.5 & 0.3 \\ 0.1 & 0.3 & 0.6 & 0.6 & 0 \end{bmatrix}$$

$$R_{\text{manufacturer}} = \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.5 & 0 \\ 0.1 & 0.6 & 0.2 & 0.5 & 0.1 \\ 0.1 & 0.5 & 0.3 & 0.4 & 0 \end{bmatrix}$$

Weight distribution of the operating environment for other factors is (0.124, 0.356, 0.326, 0.194), weight distribution of appearance is (0.273, 0.177, 0.088, 0.462), the weight distribution for maintenance records is (0.4, 0.6), weight distribution for the manufacturer is (0.3, 0.5, 0.2), and the total weight distribution of other factors is

$$B_{\text{work enviroment}} = A_{\text{work enviroment}} \circ R_{\text{work enviroment}} = (0.124, 0.356, 0.326, 0.194) \circ \begin{bmatrix} 0.2 & 0.25 & 0.2 & 0.25 & 0.1 \\ 0.15 & 0.4 & 0.2 & 0.25 & 0 \\ 0.1 & 0.2 & 0.25 & 0.15 & 0.3 \\ 0.55 & 0.15 & 0.1 & 0.2 & 0 \end{bmatrix}$$

= (0.107, 0.142, 0.082, 0.089, 0.098)

$$B_{appearance} = A_{appearance} \circ R_{appearance} = (0.273, 0.177, 0.088, 0.462) \circ \begin{bmatrix} 0.1 & 0.15 & 0.55 & 0.15 & 0.05 \\ 0.1 & 0.15 & 0.65 & 0.1 & 0 \\ 0.1 & 0.15 & 0.6 & 0.15 & 0 \\ 0 & 0.1 & 0.7 & 0.1 & 0.1 \end{bmatrix}$$

= (0.273, 0.046, 0.323, 0.046, 0.046)

$$B_{\text{record}} = A_{\text{record}} \circ R_{\text{record}} = (0.4, 0.6) \circ \begin{bmatrix} 0.2 & 0.1 & 0.2 & 0.5 & 0.3 \\ 0.1 & 0.3 & 0.6 & 0.6 & 0 \end{bmatrix}$$

= (0.08, 0.18, 0.36, 0.36, 0.12)

$$B_{\text{manufacturer}} = A_{\text{manufacturer}} \circ R_{\text{manufacturer}} = (0.3, 0.5, 0.2) \circ \begin{bmatrix} 0.2 & 0.4 & 0.3 & 0.5 & 0 \\ 0.1 & 0.6 & 0.2 & 0.5 & 0.1 \\ 0.1 & 0.5 & 0.3 & 0.4 & 0 \end{bmatrix}$$

= (0.06, 0.30, 0.10, 0.25, 0.05)

$$B_{\text{other factors}} = A_{\text{other factors}} \circ R_{\text{other factors}} = (0.168, 0.210, 0.532, 0.090) \circ \begin{bmatrix} 0.107 & 0.142 & 0.082 & 0.089 & 0.098 \\ 0.273 & 0.046 & 0.323 & 0.046 & 0.046 \\ 0.080 & 0.180 & 0.360 & 0.360 & 0.120 \\ 0.060 & 0.300 & 0.100 & 0.250 & 0.050 \end{bmatrix}$$

= (0.057, 0.095, 0.191, 0.191, 0.064)

5.5. Comprehensive Evaluation

$$B_{\text{synthesis}} = A_{\text{synthesis}} \circ R_{\text{synthesis}} = (0.518, 0.286, 0.143, 0.053) \circ \begin{bmatrix} 0.130 & 0.131 & 0.551 & 0.188 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0.106 & 0.197 & 0.442 & 0.140 & 0.066 \\ 0.057 & 0.095 & 0.191 & 0.191 & 0.064 \end{bmatrix}$$

= (0.286, 0.069, 0.285, 0.097, 0.009)

Contrast evaluation set, it is concluded that the subsection vacuum switch is in a state of waiting for inspection, accords with the actual situation, all the test data of subsection vacuum switch is close to or reach alert value, there are obvious degradation trend, the chance of failure is bigger, compared with the similar subsection vacuum switch differences are more obvious. At this time, the subsection vacuum switch should be maintained as soon as possible according to the production situation and power supply security situation and so on.

6. Conclusion

Preliminary example analysis shows that the fuzzy evaluation model of subsection vacuum switch in this paper can make accurate and objective quantitative evaluation, and have strong operability; it can be used as reference for state maintenance of subsection vacuum switch and improve equipment utilization and save maintenance cost. Of course, the model in this paper still need more test samples.

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