Fuzzy Comprehensive Evaluation on the Harmfulness of Magnetic Field in 500kv Substations to Health of Workers

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Abstract. With the continuous growth of People's Republic of China's economy, the power industry is also developing rapidly, various voltage level substations have been put into operation, electricity is closely related to people's daily life, at the same time, more and more attention has been paid to the electromagnetic pollution caused by these substations. This paper analyzes and studies the data of 500kv substations power frequency magnetic field, and comprehensive evaluate whether the magnetic field around the 500kV substations would endanger the health to the workers from the two aspects of the different areas of substation and the residence time of workers by using two level fuzzy comprehensive evaluation method, and finally concluded that 500kv substations magnetic field environment for the health hazards of workers is very small, the fuzzy comprehensive evaluation method can be applied to evaluate the health hazards of the magnetic field in the 500kv substations.

1 Introduction

With the continuous development of the economy, People's Republic of China's power industry has also been development rapidly, a large number of high-voltage power transmission project to be put into operation officially, at the same time, the electromagnetic pollution caused by these high voltage substations has become one of the environmental problems[1]. The workers who work in 500kv substations have a long working life and are exposed to magnetic fields for a long time, whether the magnetic field generated by the 500kv substations is harmful to them is a question worthy of study. Studies have shown that long-term exposure to the magnetic field environment will lead to change the human body's nerve behavior, specifically for the behavioral function decline, unresponsive, etc[2]. Researchers have also studied about some children exposed to magnetic fields, results show that magnetic field exposure is associated with the decline of neurobehavioral function in children and the platelet abnormalities and elevated serum levels in adults[3]. There are also studies show that the frequency of magnetic field exposure may increase the risk of leukemia, brain tumors and Alzheimer's disease and other diseases[4]. In this paper, the fuzzy comprehensive evaluation method is used to analysis the frequency magnetic field environment of 500kv substations, it is one of the most basic methods in fuzzy mathematics，it has been used widely in many fields such as artificial intelligence, automatic control, information processing and so on[5].

2 Establishment of two level fuzzy comprehensive evaluation model

① Determine the hierarchy of evaluation objective factor set V, V is the target layer and consists of m factors, the set of M factors is the criterion layer, and the factors in the criterion layer are composed of n different sub factors, that is, the index layer.
② Create a weight set based on the importance of the factors in the criteria layer and the index layer $R = \{r_1, r_2, \cdots, r_m\}$ and $R_I = \{r_{i1}, r_{i2}, \cdots, r_{in}\}$.
③ Build a collection of reviews $U = \{U_1, U_2, \cdots, U_m\}$
④ First level fuzzy evaluation, establish the single judgment matrix for the index layer A_I, calculate the first level evaluation vector $B_I = R_I * A_I$
⑤ second level fuzzy evaluation, and establish the single judgment matrix for the criterion layer $A = \begin{bmatrix} B_1 \\ \vdots \\ B_m \end{bmatrix}$, calculate the first level evaluation vector $B = R * A$[6,7]

3 Application of two level fuzzy comprehensive evaluation in the Case

In view of the exposure limits of the frequency magnetic field, many countries have different provisions, through a large number of investigations, the standards of ICNIRP and IEEE and People's Republic of China as shown in Tab.1[8]。

Table 1 Frequency magnetic field exposure limits

Organization and country	Magnetic flax density(B/μT)	
	Public exposure	Occupational exposure
ICNIRP	100	500
IEEE	904	2710
People's Republic of China	22	78
	100	—

By analyzing the data in Table 1, with 10μT, 30μT, 50μT, 100μT as the boundary, and set up five levels namely comments set U={ very small（B≤10μT）、small（10μT <B≤30μT）、medium（30μT <B≤50μT）、large （50μT <B≤100μT）、very large（B>100μT）}

In the process of using fuzzy comprehensive evaluation to evaluate the health hazards of the magnetic field to workers of 500kV Substations, the 500kv substations is set as the target layer, and the five different areas of the 500kV substations include 500kv equipment area, 220kv equipment area, 66kv equipment area, 35kv equipment area and 500kv main transformer area are set as the standard layer, the different substations in each area are set as the index layer. According to the proportion of the residence time of each operator in the region and the proportion of the number of stations in each power station, as the weight of the criterion layer and the index layer.

4 Calculation process and results

The five single factor judgment matrices of the index layer are as follows：

$$A_1 = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0.924 & 0.071 & 0.005 & 0 & 0 \\ 0.800 & 0.176 & 0.012 & 0.012 & 0 \\ 0.929 & 0.071 & 0 & 0 & 0 \end{bmatrix}$$

$$A_2=\begin{bmatrix}1 & 0 & 0 & 0 & 0\\ 0.864 & 0.136 & 0 & 0 & 0\\ 0.682 & 0.318 & 0 & 0 & 0\\ 1 & 0 & 0 & 0 & 0\\ 0.974 & 0.026 & 0 & 0 & 0\end{bmatrix}$$

$$A_3=\begin{bmatrix}0.934 & 0.065 & 0 & 0 & 0\\ 0.749 & 0.042 & 0.062 & 0.042 & 0.104\\ 0.415 & 0.422 & 0.048 & 0.020 & 0.095\\ 0.567 & 0.135 & 0.108 & 0.270 & 0.162\end{bmatrix}$$

$$A_4=\begin{bmatrix}0.523 & 0.191 & 0.048 & 0.143 & 0.095\\ 0.413 & 0.117 & 0.176 & 0.206 & 0.088\end{bmatrix}$$

$$A_5=\begin{bmatrix}0.750 & 0.250 & 0 & 0 & 0\\ 0.875 & 0.125 & 0 & 0 & 0\\ 0.459 & 0.459 & 0.083 & 0 & 0\\ 1 & 0 & 0 & 0 & 0\end{bmatrix}$$

The weight vector of the index layer are as follows:

$$R_1=[0.190 \quad 0.220 \quad 0.348 \quad 0.162 \quad 0.080]$$
$$R_2=[0.207 \quad 0.282 \quad 0.234 \quad 0.117 \quad 0.160]$$
$$R_3=[0.104 \quad 0.185 \quad 0.568 \quad 0.144]$$
$$R_4=[0.029 \quad 0.971]$$
$$R_5=[0.143 \quad 0.143 \quad 0.489 \quad 0.286]$$

The first level fuzzy comprehensive evaluation vector are as follows:

$$B_1=R_1*A_1=[0.9355 \quad 0.0589 \quad 0.0037 \quad 0.0019 \quad 0] \qquad (1)$$
$$B_2=R_2*A_2=[0.8831 \quad 0.1169 \quad 0 \quad 0 \quad 0] \qquad (2)$$
$$B_3=R_3*A_3=[0.5531 \quad 0.2737 \quad 0.0543 \quad 0.0230 \quad 0.0965] \qquad (3)$$
$$B_4=R_4*A_4=[0.4162 \quad 0.1191 \quad 0.1723 \quad 0.2042 \quad 0.0882] \qquad (4)$$
$$B_5=R_5*A_5=[0.7440 \quad 0.2779 \quad 0.0406 \quad 0 \quad 0] \qquad (5)$$

The weight vector of the criterion layer is as follows:

$$R=[0.3142 \quad 0.3185 \quad 0.0679 \quad 0.1444 \quad 0.1550]$$

The single factor judgment matrices of the criterion layer is as follows:

$$A=\begin{bmatrix}0.9355 & 0.0589 & 0.0037 & 0.0019 & 0\\ 0.8831 & 0.1169 & 0 & 0 & 0\\ 0.5531 & 0.2737 & 0.0543 & 0.0230 & 0.0965\\ 0.4162 & 0.1191 & 0.1723 & 0.2042 & 0.0882\\ 0.7440 & 0.2779 & 0.0406 & 0 & 0\end{bmatrix}$$

The calculation results of the two level fuzzy comprehensive evaluation by MATLAB is shown in Fig.1:

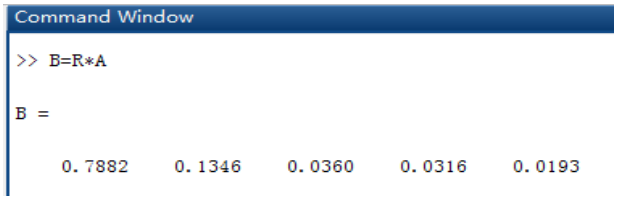

Fig. 1 Two level fuzzy comprehensive evaluation results

According to the principle of maximum membership, take the corresponding value of the maximal value as the result of fuzzy evaluation, by formula (1)(2)(3)(4)(5) can see that the maximum value

of the first evaluation vector are 0.9355,0.8311,0.5531,0.4162,0.7440, the results of the evaluation of the 500kV device area, the 220kV device area, the 66kV device area, the 35kV device area, and the 500kV main transformer area are all "very small" this level.

5 Summary

By analyzing the measured data, it can be seen that the flux density of a small number of 500kV substations exceeds the limits of exposure of some international organizations and People's Republic of China, but the workers stay very little time in there, so the result obtained by the two level fuzzy comprehensive evaluation method is the "very small" level, much less than the ICNIRP requirements for 100μT public exposure limits and 500μT occupational exposure limits and 22μT requirement and 78μT requirement of the People's Republic of China, it can not be explained that there is a large occupational health hazard to the workers of the magnetic field in the 500kv substations. The two level fuzzy comprehensive evaluation model established in this paper according to the different levels to analysis the magnetic field environmental problems, and the proportion of the residence time of the operator is taken as the weight of the criterion layer, which ensures the objective description of the evaluation object of the electromagnetic environment, it can be applied well to the assessment of the health hazards to the workers of the magnetic field in the 500kv substations.

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