Set $\partial L / \partial W_l = 0$, then, $KW + \lambda e = 0$ (16)

Among equation (16),

$$K = \begin{bmatrix} \sum_{i=1}^{m} B_{i1}^2 + m - 2 & -(B_{12} + B_{21}) & \dots & -(B_{1m} + B_{m1}) \\ -(B_{21} + B_{12}) & \sum_{i=1}^{m} B_{i2}^2 + m - 2 & \dots & -(B_{2m} + B_{m2}) \\ \dots & \dots & \dots & \dots \\ -(B_{m1} + B_{1m}) & -(B_{m2} + B_{2m}) & \dots & \sum_{i=1}^{m} B_{im}^2 + m - 2 \end{bmatrix} \quad (17)$$

$$W = [W_1, W_2, \dots, W_m]^T \quad (18)$$

$$e = [1, 1, \dots, 1]^T \quad (19)$$

$$m = 3 \quad (20)$$

Weight vector W is calculated:

$W = [0.3322, 0.2733, 0.3945]^T$

Then standard searching decision matrix S after weighted is written as:

$$S = \begin{bmatrix} 0.0997 & 0.0788 & 0.1211 \\ 0.0518 & 0.0706 & 0.1165 \\ \dots & \dots & \dots \\ 0.0638 & 0.0761 & 0.1072 \end{bmatrix}$$

Ideal solution $S^+ = \{0.0040, 0.0027, 0.0093\}$

Negative ideal solution $S^- = \{0.1036, 0.0788, 0.1211\}$

The distance to the ideal solution of each solution

$D_i^+ = \{0.1657, 0.1356, \dots, 0.1361\}$

The distance to the negative ideal solution

$D_i^- = \{0.0039, 0.0526, \dots, 0.0423\}$

The relative close degree of each solution to the ideal solution

E_i ={0.0232,0.2796,0.8919,0.5257,0.6986,0.5233,0.9030,0.7334,0.6377,0.7432,0.4052,0.3540,0.6105,0.5262,0.5004,0.4382,0.3266,0.2951,0.5202,0.8856,0.8478,0.9328,0.6724,0.6028,0.5949,0.1833,0.2831,0.5207,0.2432,0.4362,0.4278,0.2370}

According to value of E_i, order of searching scheme is determined. The scheme with the largest E_i should be search, detect and diagnose first. According to the above calculation search scheme, the rank of searching scheme is sorting for $X_{22}, X_7, X_3, X_{20}, X_{21}, X_{10}, X_8, X_5, X_{23}, X_9, X_{13}, X_{24}, X_{25}, X_{14}, X_4, X_6, X_{28}$, $X_{19}, X_{15}, X_{16}, X_{30}, X_{31}, X_{11}, X_{12}, X_{17}, X_{18}, X_{27}, X_2, X_{29}, X_{32}, X_{26}, X_1$, the result is shown in Fig.4

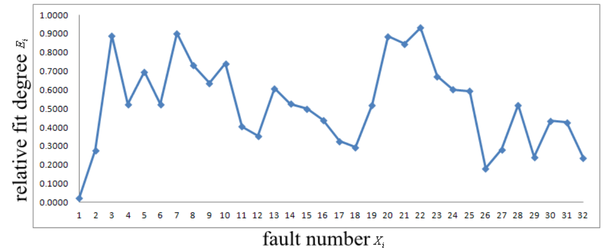

Fig.4 rank orders of searching scheme

If successfully searched, the diagnosis would be stopped. Otherwise, update the established fault decision matrix of fin stabilizer and the searching cost after test, in order to consider the previous results and the present detection result together, and then searching for a new solution until diagnosis is successful.

V . Conclusion

In this paper, on the basis of in-depth analysis of anti-rolling fin system, the fault tree model is established based on fault tree analysis method, and the main failure modes of anti-rolling fin system are found. Multi-objective optimization decision theory is applied, and multi-IF (impact factors) including fault probability, search costs and illuminating value provided by the searching are comprehensive considered, the most likely path to reach the problem solving is selected in the state space, and the optimal search strategy is determined. As the path of fault reason searching be simplified, the fault of anti-rolling fin system is quickly located, and the efficiency of diagnosis is improved, and it has use for reference for rapid fault location strategy of other complex systems.

References

[1] Weixin Zhu, “Research on stabilization of large ship,” *China Shipping*, vol. 12, May 2012: 249-251.

[2] Bin Hu, “Intelligent diagnosis system of fin stabilizer faults based on case-based reasoning,” *Ship Engineering:* vol. 33, February 2011: 90-92.

[3] Hang Luo, “Research on key issues of fault tree analysis”, Ph.D. Dissertation of university of electronic science and technology, 2010.

[4] Gongjing Yu, “Research on testability design and diagnostic strategy optimization technology of equipment,” *Electronic Measurement Technology:* vol. 24, March 2012: 8-11.

[5] Qiang Gai, “Research on failure modes of hydraulic system of ship based on AMET,” *Chines Journal of Scientific Instrument*.vol. 31, August 2010: 63-65.

[6] Huarui Zhang, “Research on the design of optimum searching parameters of phased array radar,” *Journal of China Ordnance*, vol. 33, March 2011: 1062-1065.

[7] Hui Tian, “Application of fault tree analysis in the reliability analysis of oil-gas long pipeline,” *American Society of Civil Engineers*,2013.

[8] Dong Yuhua,”Estimation of failure probability of oil and gas transmission pipelines by fuzzy fault tree analysis,”*Journal of Loss Prevention in the Process Industries*:vol 18, pp83-88, March 2005.

[9] Marko Čepin, “A dynamic fault tree,” *Reliability Engineering & System Safety*: vol.75, pp. 83–91, January 2002.