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Application of Analytic Hierarchy Process in Evaluation for Multi-disciplinary design of Ship

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Abstract—The evaluation for multi-disciplinary design of ship is very important for the effect of multi-disciplinary design optimization of ship. The evaluation for multi-disciplinary design of ship based on analytic hierarchy process is proposed in the study. The four discriminant matrixes: $R0$ $R1$ $R2$ $R3$ are generated by pairwise comparisons with the 1~9 ratio scale. By using the consistency ratio ,the consistency of the discriminant matrixes is checked. Then, weights of evaluation indexes are obtained. The experimental results show that the evaluation for multi-disciplinary design of ship based on analytic hierarchy process is effective.

Keywords- Evaluation; ship; analytic hierarchy process; multi-disciplinary design

1. Introduction

It is well-known that multi-disciplinary design optimization (MDO) is a very excellent design technology[1]. The evaluation for multi-disciplinary design of ship is very important for the effect of multi-disciplinary design optimization of ship. The evaluation for multi-disciplinary design of ship based on analytic hierarchy process is proposed in the study. Analytic hierarchy process (AHP) is a kind of multi-criteria decision-making technology, which can deal with complex decision problems considering both qualitative and quantitative[2-4]. Analytic hierarchy process is widely used decision-making field, which decomposes a complicated problem by a hierarchy structure[5,6]. The four discriminant matrixes:$R0$ $R1$ $R2$ $R3$ are generated by pairwise comparisons with the 1~9 ratio scale. The consistency of the discriminant matrixes is checked by using the consistency ratio. Then, weights of evaluation indexes are obtained. The experimental results show that the evaluation for multi-disciplinary design of ship based on analytic hierarchy process is effective.

2. Evaluation for Multi-disciplinary Design of Ship

2.1 The Evaluation Index for Multi-disciplinary Design of Ship

In order to evaluate the multi-disciplinary design of ship, the evaluation index for multi-disciplinary design of ship should be analyzed. The research demonstrates that the evaluation index for multi-disciplinary design of ship includes cost and weight, performance, power and volume. The evaluation index: cost and weight includes fabrication cost and weight. The evaluation index: performance includes operability, stability, drag, buoyant equilibrium and ship speed. The evaluation index: power and volume includes volume of compartment and main motor power. The evaluation indexes form the hierarchy structure, which is given in Fig.1.

2.2 The Evaluation Model for Multi-disciplinary Design of Ship

Analytic hierarchy process (AHP) is a kind of multi-criteria decision-making technology, which can deal with complex decision problems considering both qualitative and quantitative. AHP is widely used decision-making field, which decomposes a complicated problem by a hierarchy structure.

In the analytic hierarchy process technology, the discriminant matrix is created by pairwise comparisons with the 1~9 ratio scale, and consistency of discriminant matrix is checked by using the consistency ratio. If discriminant matrix is consistent, weight of the evaluation indexes is available. In the evaluation for multi-disciplinary design of ship, four discriminant matrixes are generated by pairwise comparisons with the 1~9 ratio scale. As shown in Fig.2, the four discriminant matrixes are $R0$,$R1$,$R2$,$R3$ respectively, which are expressed as followings:

$$R0=\begin{bmatrix} r_{11}/r_{11} & r_{11}/r_{12} & r_{11}/r_{13} \\ r_{12}/r_{11} & r_{12}/r_{12} & r_{12}/r_{13} \\ r_{13}/r_{11} & r_{13}/r_{12} & r_{13}/r_{13} \end{bmatrix} \tag{1}$$

$$R1=\begin{bmatrix} r_{21}/r_{21} & r_{21}/r_{22} \\ r_{22}/r_{21} & r_{22}/r_{22} \end{bmatrix} \tag{2}$$

$$R2=\begin{bmatrix} r_{23}/r_{23} & r_{23}/r_{24} & r_{23}/r_{25} & r_{23}/r_{26} & r_{23}/r_{27} \\ r_{24}/r_{23} & r_{24}/r_{24} & r_{24}/r_{25} & r_{24}/r_{26} & r_{24}/r_{27} \\ r_{25}/r_{23} & r_{25}/r_{24} & r_{25}/r_{25} & r_{25}/r_{26} & r_{25}/r_{27} \\ r_{26}/r_{23} & r_{26}/r_{24} & r_{26}/r_{25} & r_{26}/r_{26} & r_{26}/r_{27} \\ r_{27}/r_{23} & r_{26}/r_{24} & r_{26}/r_{25} & r_{26}/r_{26} & r_{27}/r_{27} \end{bmatrix} \tag{3}$$

$$R3=\begin{bmatrix} r_{28}/r_{28} & r_{28}/r_{29} \\ r_{29}/r_{28} & r_{29}/r_{29} \end{bmatrix} \tag{4}$$

Ratio scales of pairwise comparisons in the above discriminant matrixes are determined and consistency of discriminant matrix is checked. Then, weights of evaluation indexes are obtained, which is given in Tab.1.

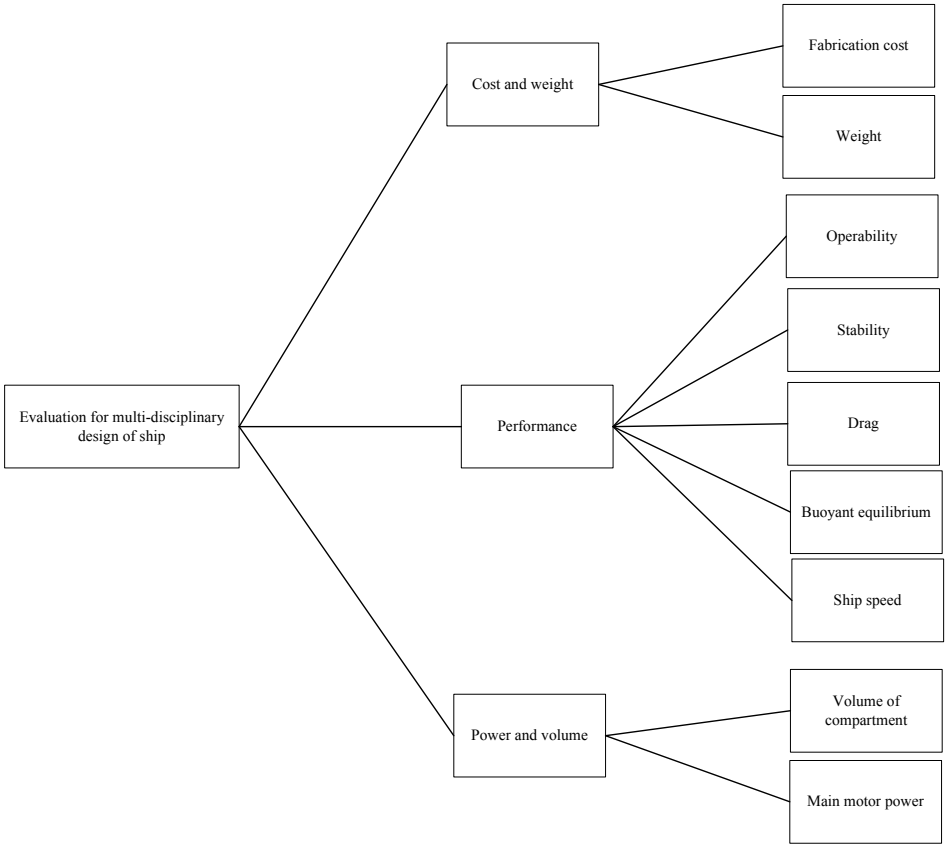

Figure 1. The evaluation index for multi-disciplinary design of ship

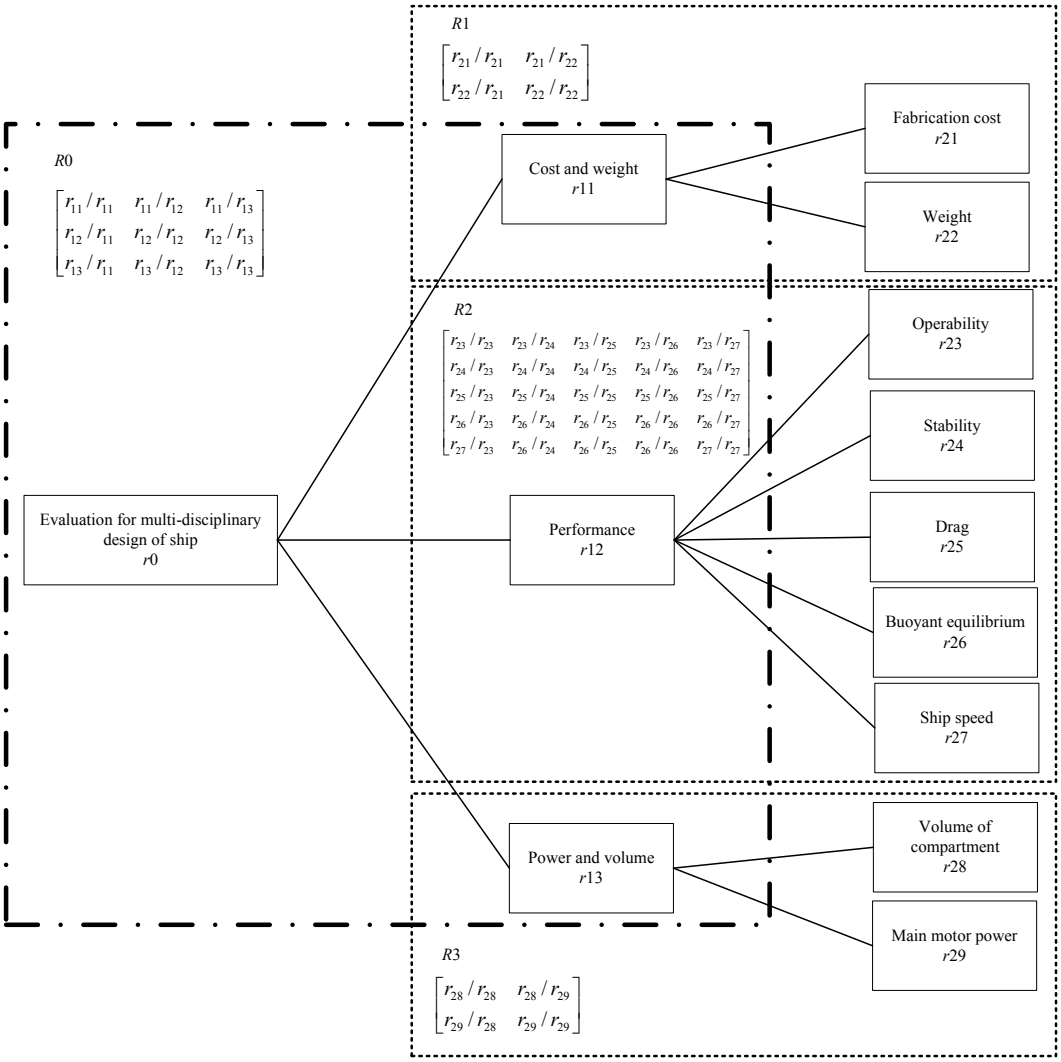

Figure 2. The discriminant matrix is created by pairwise comparisons with the 1~9 ratio scale

3. Application Ang Analysis

Multi-disciplinary design optimization (MDO) is a very excellent design technology. Compared with design model for ship by traditional design technology, multi-disciplinary design optimization has more excellent design performance.

The study demonstrates that analytic hierarchy process is a kind of multi-criteria decision-making technology. Analytic hierarchy process can deal with complex decision problems considering both qualitative and quantitative, which can widely be used decision-making field. Thus, analytic hierarchy process is used to evaluate multi-disciplinary design of ship in the study.

Cost and weight, performance, power and volume are the important evaluation index for multi-disciplinary design of ship. Among which fabrication cost and weight are the evaluation index of cost and weight, and operability, stability, drag, buoyant equilibrium and ship speed are the evaluation index of performance. Volume of compartment and main motor power are the evaluation index of power and volume.

We define 0~100 as the evaluation value of evaluation index for multi-disciplinary design of ship. Good, fair, bad are the evaluation levels of the multi-disciplinary design of ship, whose marks are 80~100, 60~79 and 0~59 respectively.

The evaluation for multi-disciplinary design of a certain ship is used to test the effect of analytic hierarchy process. In the evaluation for multi-disciplinary design of a certain ship, the four discriminant matrixes are created by pairwise comparisons with the 1~9 ratio scale, and consistency of discriminant matrix is checked by using the consistency ratio. Then, weights of evaluation indexes are obtained, which are shown as Tab.1.

The experimental results show that the evaluation for multi-disciplinary design of ship based on analytic hierarchy process is effective.

TABLE I. WEIGHTS OF THE INDEXES

indexes	weights	**weights of the bottom-level indexes for r_0**
r_{11}	0.1365	
r_{12}	0.6250	
r_{13}	0.2385	
r_{21}	0.5000	0.0683
r_{22}	0.5000	0.0683
r_{23}	0.2878	0.1799
r_{24}	0.1664	0.1040
r_{25}	0.1944	0.1215
r_{26}	0.1571	0.0982
r_{27}	0.1944	0.1215
r_{28}	0.6667	0.1590
r_{29}	0.3333	0.0795

4. Conclusion

The evaluation for multi-disciplinary design of ship based on analytic hierarchy process is proposed in the study. We gain the four discriminant matrixes:*R*0 *R*1 *R*2 *R*3 by pairwise comparisons with the 1~9 ratio scale. The consistency of the discriminant matrixes is checked by using the consistency ratio. Then, weights of evaluation indexes are obtained. We apply the evaluation for multi-disciplinary design of a certain ship to test the effect of analytic hierarchy process. The experimental results show that the evaluation for multi-disciplinary design of ship based on analytic hierarchy process is effective.

5. References

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