Sailing Safety Assessment of Laterite Nickel ore Ships in Inclement Weather

Li yiliang

Dalian Maritime University, Dalian, Liaoning

Liyiliangli1995li@163.com

Abstract. In order to reduce the accident rate of laterite nickel ore ships under severe weather conditions, this paper adopts the method of establishing fuzzy comprehensive evaluation mathematical model, which mainly considers the moisture content of the laterite nickel ore carried by the ship, the influence of wind and waves and the ship's own situation. The main factors and set the corresponding evaluation set, through the analysis of the importance of the corresponding factors, thus constructing a fuzzy set of choice levels, and then based on the principle of maximum membership, to comprehensively judge the dangerous level of the ship.

1. Introduction

Between 2008 and 2018, the accidents of laterite nickel ore ships emerged in an endless stream. The reason is fundamentally due to the problem of water content in laterite nickel ore, which is characterized by easy fluidization and at the same time In the case of weather, the wind and waves will cause the ship to be bumpy, so that the surface of the ore will be analyzed by water, forming a free liquid surface, which will have a huge impact on the stability of the ship and even cause the ship to tip over.

Therefore, this paper mainly discusses the construction of factors for the above factors in the case of severe weather conditions, for ships carrying different water content nickel mines under the influence of different levels or heights of wind and waves, and taking into account the problem of wind and wave angles. The importance degree coefficient of the factor, constructing the evaluation set, obtaining the fuzzy set of the selection level, and determining the degree of danger of the ship according to the principle of maximum membership degree, and finally obtaining a safety evaluation plan for the ship carrying the laterite nickel ore in bad weather conditions [1].

2. Construction factor set

For the selection of the factor set in the mathematical model, the paper mainly considers the following points. Firstly, considering the characteristics of the laterite nickel ore, the laterite nickel ore is more humid and rainy than the other concentrates, and the mining method and accumulation The reason for the method is that it contains more water. In the International Maritime Solid Bulk Goods Regulations (IMSBC), laterite nickel ore belongs to Group A of the cargo [2]. Therefore, during the voyage of the ship transporting laterite nickel ore, due to the ship's own bumps or the influence of wind and waves, the ore flows, and the surface of the ship is allowed to form water, so that it is easy to form a free liquid surface. According to the collected data, the transportable moisture limit (AML) of the transported laterite nickel ore was 32%, and the flowing water point was 35.7% [3]. The influence of the free surface on the stability of the ship is very great. In some serious cases, the overturning of the

ship and the influence of the free surface cannot be removed. In summary, the ore's own moisture content is one of the main factors.

Secondly, wind waves of different levels and different wave heights will have different impacts on ships, especially in bad weather conditions, which will often generate heavy winds and waves, which will often cause serious swaying motions. Therefore, wind waves for laterite nickel ore ships The impact must be considered more deeply, and it must also be one of the elements of the factor.

Finally, it is the condition of the ship itself, the size of the ship carrying the laterite nickel ore, whether the age of the ship has exceeded the corresponding safety standards, and whether the ship's own equipment is perfect, which will affect the safe navigation of the ship. Therefore, the ship's own conditions also need to be considered to be one of the factors.

3. Evaluation set

In reference [4], the authors made a statement about the risk level of a particular ship under heavy wind and wave conditions. In addition, since most ships carrying laterite nickel ore are also small and medium-sized bulk carriers, the risk level of the ship is The construction of the evaluation set is mainly selected as follows:

Ship Risk Level	General Risk	Moderate Risk	Serious Risk
Definition	At this time the risk is small and the ship can sail in this state, but the navigation regulations must be strictly observed when necessary.	The risk of the ship is large, and the ship itself can decide whether to sail under such conditions according to its own situation, but should avoid long-term navigation.	At this time, the ship's safety situation is greatly threatened, and the ship should completely avoid sailing in this state at this time.

In addition, according to the influence of the wind wave level on the risk level in reference [4], this paper concludes that when the wind reaches 5 to 6 or the wave height is 1.5 to 3 m, it is mainly general risk, when the wind reaches 7 to 8 or the wave height is 3~4m, it is mainly moderate risk. When the wind reaches 8 or above or the wave height is 4m or more, it is mainly serious risk.

4. Establishment of fuzzy comprehensive mathematical model

For a fuzzy comprehensive evaluation problem, if $U=\{u_1, u_2,...,u_n\}$ is a set of n factors of the evaluated object, it is called a factor set; if $V=\{v_1, v_2,...v_m\}$ is The evaluator's m-choice level (comment, that is, the evaluation result) that the evaluator may make is a collection of elements, which is called an evaluation set. And the correspondence between the n factors and the m comments is the fuzzy matrix (fuzzy binary relationship), which becomes the evaluation matrix, and the form is as follows[5]:

$$R = \begin{array}{c} \\ u_1 \\ u_2 \\ \vdots \\ u_m \end{array} \begin{array}{c} \begin{array}{cccc} v_1 & v_2 & \cdots & v_m \end{array} \\ \begin{pmatrix} a_{11} & a_{12} \ldots & a_{1m} \\ a_{21} & a_{22} \cdots & a_{2m} \\ \vdots & \vdots \ddots & \vdots \\ a_{n1} & a_{n2} \cdots & a_{mn} \end{pmatrix} \end{array}$$

According to the mathematical theorem, the evaluation matrix R determines a fuzzy mapping from U to V, where the row i describes the degree of correspondence of the single factor u_i with respect to each of the selection levels v_j (j = 1, 2, ..., m). Therefore, the row i of R is the evaluation vector for the factor u_i, and the element r_{ij} is the membership degree of the single factor u_i evaluation for the selection level v_j. However, the influence of various factors on the final evaluation results is different in the hearts of different types of people, so the degree of influence of each factor on the final evaluation results can be regarded as the fuzzy subset on U,A=(a1, a2... , an) ∈F(U). A is called U's factor importance degree fuzzy subset (referred to as factor fuzzy subset), and a_i is called factor's importance degree coefficient, which is a measure of the influence degree of the factor i on the final evaluation result. Its function is to adjust or limit the single degree of membership of the factor u_i to the selection level vj represents, to a certain extent, the ability of the single factor u_i to assess the final level. Sometimes, the factor of importance factor is replaced by a common weight factor[6].

Since the fuzzy relation R can induce a fuzzy transform TR from U to V, TR(A)=A ∘R∈F(Y) is a comprehensive evaluation result obtained by considering n factors comprehensively, which is a blur on V Set, called the decision level fuzzy set. If B = T_R(A) = A ∘R = (b1, b2...bm), then it is the mathematical model that constitutes the fuzzy comprehensive evaluation, where bj reflects the position of the choice level in the comprehensive evaluation results[7].

5. Fuzzy Evaluation of Ship Risk Level

For laterite nickel ore vessels sailing in inclement weather, we set the factor set and evaluation set as U={u_1 (nickel ore water content), u_2 (wind and wave level), u_3 (ship itself)}, V={v_1 (general risk), v_2 (moderate risk), v_3 (severe risk)}. According to the ship risk assessment, we assume that the importance of u_1, u_2, and u_3 are z_1, z_2, and z_3, that is, the degree of importance of the fuzzy subset is A=(z_1, z_2, z_3), assuming The three factors alone evaluate the navigation of the ship, and the degree of membership of the three dangerous levels can be obtained as follows[8]:

$$u_1 \to \frac{a_1}{v_1} + \frac{a_2}{v_2} + \frac{a_3}{v_3}$$

$$u_2 \to \frac{b_1}{v_1} + \frac{b_2}{v_2} + \frac{b_3}{v_3}$$

$$u_3 \to \frac{c_1}{v_1} + \frac{c_2}{v_2} + \frac{c_3}{v_3}$$

According to the mathematical model of fuzzy comprehensive evaluation, we can get the formula

$B=(b_1, b_2 \cdots b_m)=T_R(A)=A \circ R=(z1 \quad z2 \quad z3) \circ \begin{pmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{pmatrix}$

The final calculation results determine the risk level of the ship based on the principle of maximum membership.

6. Conclusion

Through the above analysis and argumentation, we can find that due to some characteristics of laterite nickel ore, such as easy fluidization, the formation of free liquid surface, resulting in poor stability of the ship, which makes the ship transporting laterite nickel ore has Many factors that can easily cause a ship to be in danger, especially when the ship is in bad weather conditions, are affected by heavy winds and waves, and the probability of causing danger is exacerbated. Therefore, various ways must be considered on the way to transport laterite nickel ore. The impact of factors, make appropriate preventive preparations, conduct corresponding risk assessments, and avoid the possibility of danger based on the corresponding results.

References

[1] Dagang Liu, Donghua Xu, Zhaolin Wu. *Risk Estimation Model of Navigation Ships in Heavy Wind Waves[J]*. Journal of Traffic and Transportation Engineering, 2005, (03): 83-86+97.
[2] Ming Zhang.*Hidden dangers and countermeasures of nickel laterite ore shipping [J]*. Shipyard Engineering. 2012(01)
[3] Jiulei Zhang. *Risk Assessment of Laterite Nickel Ships under Heavy Wind Waves[J]*. China Water Transport, 2015(1):72-74.
[4] Dagang Liu, Yiyang Xie, Binxian Liu, Yi Lin, Xiaojun Yang, Danzhu Wu, Bingui Wu, Hu Guo.*A Dynamic Assessment and Early Warning System for Ship Risk Status under Heavy Wind Wave Conditions[J]*.China Navigation,2015,38(01):63-
[5] Henan Li. *Comprehensive safety assessment of LNG ship loading and unloading [D]*. Dalian Maritime University, 2015.
[6] Lei Hai.*Safe transportation of laterite nickel ore powder [J]*. Navigation Technology. 2011(01)
[7] Jianhui Cui, Jianping Wang. *Safe Transportation of Marine Laterite Nickel Ore[J]*. Nautical Technology, 2011, (06): 30-32.
[8] Houxing Dai, Zhaolin Wu. *Dynamic Pre-evaluation System of Maritime Traffic Safety Risk in Bad Weather[J]*. China Navigation, 2016, 39(03): 73-76.