Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2021.020406
ISSN 2790-2706 Vol. 2, Issue 4: 44-51

Fusion Fuzzy Mathematics Key Issues in Ocean Engineering

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Keywords: Fusion of Fuzzy Mathematics, Marine Engineering, Key Engineering Problems, Mathematical Technology

Abstract: Marine engineering(ME) research is an interdisciplinary research field. Its purpose is to solve engineering problems related to marine environmental work and explore and utilize marine resources. This paper introduces the fusion fuzzy mathematics(FFM) analysis technology to explore and analyze the key problem(KP) of OE. There are many aspects of ME problems. This paper mainly explores the problems in the construction process of ME equipment, the quality control procedure of production process and the control process of quality improvement, and puts forward corresponding measures to solve the problems. Taking the construction of semi submersible project in a shipyard in China as an example, it analyzes and discusses the KPs in the construction scheme and process of ME semi submersible, The FFM analysis technology is introduced to test the friction and wear behavior of the armor steel wire layer of marine equipment engineering. The experimental results verify the effectiveness of the application of the FFM analysis technology to the analysis of KPs in ME, which has important guiding significance for the exploration of KPs in ME.

1. Introduction

Limited by land resources, people rely more and more on marine resources. Energy, minerals, food, medicines and so on can all come from the sea, and marine resources have become an important part of human social development. ME is one of the important factors to promote the development of marine economy. With the deepening of ME research, the scope of ME is more and more extensive. Driven by the development of electronic technology, artificial intelligence technology and Internet of things technology, OE is developing towards a distributed, network-based and intelligent system, achieving the goals of intelligent control, communication and navigation, and direct exchange of ship shore information. ME and related science and technology have entered a period of rapid development. This field is developing in the direction of interdisciplinary integration and technology intensive, showing the characteristics of intelligence and integration. In this paper, the KPs of OE are explored by integrating fuzzy mathematical analysis methods.

With the deepening of ocean research by scholars around the world, more and more papers have been published in the field of ocean engineering research. These papers published in different journals and conferences to a certain extent reflect the trends of the development of ME Science and research hotspots. Analyzing the research hotspots of these articles and mining the research directions of these articles can help us understand the development of ME and provide a basis for further research [1]. For the research of KPs in OE, some researchers have proposed that text mining can be used to improve the efficiency of research. Most researchers also show that the fusion of fuzzy mathematics technology can effectively and accurately explore the KPs in OE [2].

On the basis of previous studies, this paper introduces the FFM analysis technology to explore the KPs of OE. This paper mainly analyzes the problems existing in the construction of ME equipment, and takes the construction of semi submersible project in a shipyard in China as an example to analyze and discuss the KPs of the construction scheme and process of ME semi submersible. Finally, the armor layer components of marine equipment engineering are taken as the experimental test objects. The test results show that the friction and wear behavior is different from the behavior of materials, and many of them refer to the data given in the specifications, which is not universal for pipes with different structures and different working conditions; The surface wear caused by the mutual friction between even layers of armor layer components seriously reduces the fatigue life of flexible cable [3-4]. It is verified that the fusion of fuzzy mathematics analysis technology can find the KPs of OE timely and accurately.

2. Analysis of KPs in OE

2.1. OE Equipment Construction Process

Taking the construction of semi submersible project in a shipyard in China as an example, this paper analyzes and discusses the key issues of the construction scheme and process of ME semi submersible. Due to its unique lifting advantages in China, the shipyard's semi submersible construction mode is different from that of ordinary shipyards. Overall construction scheme: Taking the lower surface of the double bottom structure of the box deck as the boundary, the semi submersible platform is divided into upper and lower hull sections [5-6]. The upper hull includes a box deck, superstructure, drilling platform, etc., of which a helicopter platform and a life-saving platform are mounted on the superstructure; The lower hull includes appendages, columns, cross braces, etc. All sections are constructed, pre outfitted and painted according to the sectional standardized construction process, and the two general sections are closed on the horizontal berth. The two general sections carry out parallel operations respectively to expand the scope of ground outfitting, so that outfitting can be carried out more evenly and avoid the situation that outfitting work is concentrated at the wharf. Among them, the drilling platform is purchased as an independent drilling package project and assembled back to the factory. It will be closed after the main structure of the hull is underwater and lightered to the 300000 ton dock. After the upper and lower hulls are fabricated on the ground, they are closed in the dock [7-8].

2.2. Production Process Quality Control Procedure

The quality control procedure based on quality assurance is to ensure the quality of all stages in the quality loop by controlling the process of quality formation. In order to meet the requirements of total quality management and quality program, a series of quality assurance based process control procedures need to be developed, such as product identification and traceability control procedures, material tracking control procedures, process control procedures, welder control rules and welding control procedures, as shown in Table 1 [9].

Table 1. Classification of quality control procedures

program	Category
Quality control procedure	Welding control procedure
	Design control procedure
	Process control procedure
	Control procedure for product identification and traceability
	Material tracking control procedure
	Product quality information management procedure

Taking the control procedures for product identification, traceability and material tracking in the construction process of semi submersible as an example, the following describes in detail. The control procedures for product identification and traceability are applicable to the identification and tracking of materials, equipment, purchased parts, outsourced parts, work in progress and final products, as well as their inspection and test status. Identification refers to the words, numbers, letters or symbols attached to the product surface or other places to identify and describe the product and its inspection and test status; Traceability refers to the ability to track the history, application and location of the entity according to the recorded identification [10-11]. Figure 1 shows all stages and products of the offshore platform that need to be identified.

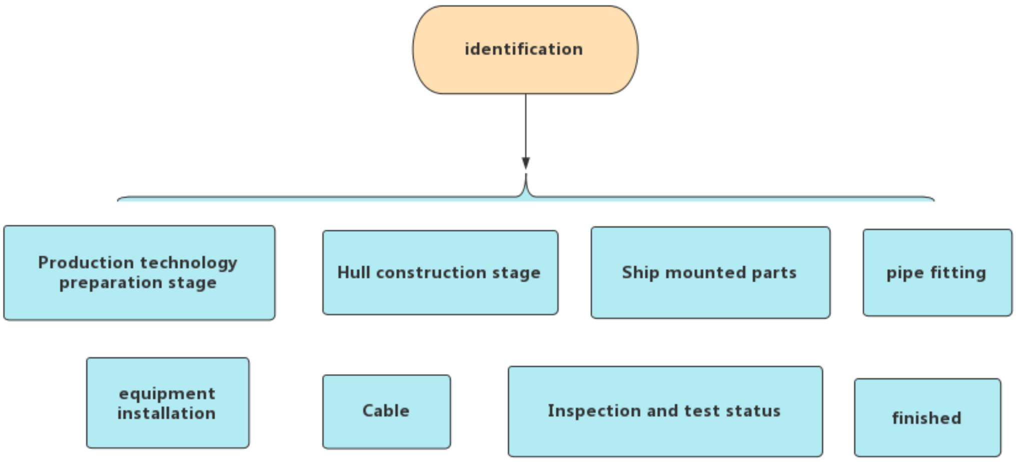

Figure 1. Structure diagram of identification classification

2.3. Control Process of Quality Improvement in Production Process

In order to ensure the final product quality and the operation of the quality system, it is necessary to carry out quality inspection on all links and intermediate products in the production process of the project [12]. The stages and contents involved in process inspection control are different, and the contents of quality inspection are different at different stages and according to different specialties. It mainly includes the inspection and tracing of materials before boarding, the inspection of intermediate products in the ship manufacturing process, the quality control of the overall performance of the ship, the overall commissioning and the quality control of the trial delivery [13].

The quality control procedure based on quality improvement is the continuation of the inspection process and the improvement and correction of problems in the production process. It mainly includes nonconforming product control process, non conformance report procedure, self correction activity, quality accident handling method and other procedures, as shown in Table 2 [14].

Table 2. Classification of quality improvement procedures

Program	Type
Quality improvement procedure	Nonconforming product control process
	Non conformance reporting procedure
	Prevention measures for collection, reporting and reissue of bad quality information

The following is a detailed introduction of the control procedure for nonconforming products. The nonconforming product control procedure specifies the control method of nonconforming products, so that nonconforming products produced in each production link can be timely marked, recorded, isolated, reviewed, disposed and communicated.

The discovery of nonconforming products mainly comes from inspection activities, including incoming inspection, process inspection, final inspection, patrol inspection, ship owner, ship inspection and other inspection processes [15-16]. Nonconforming products shall be reported to the quality inspection department level by level after being found, and shall be marked and isolated at the same time; The quality inspection department, in conjunction with relevant departments, judges and classifies nonconforming products, which are mainly divided into three grades: minor, ordinary and serious. Nonconforming products of different grades and processes are handled differently. Nonconforming products found during incoming inspection shall be isolated by the warehouse department and returned or repaired by the procurement department; Nonconforming products found in process inspection and final inspection shall be handled by each production department or workshop. After the treatment of nonconforming products, nonconforming product records shall be formed and archived [17-18].

3. FFM Analysis

3.1. Calculate Attribute Weight Vector

Entropy weight can make complex and fuzzy things orderly, and can accurately and quantitatively describe the relative importance of internal indicators of things. In order to obtain the characterization of the relative importance of the Deepwater completion evaluation index, the following calculation steps are required. In the optimization of key OE methods with X OE alternatives and y evaluation indicators, the entropy weight of the jth evaluation indicator is:

$$H_j = -\frac{1}{\ln x}\sum_{i=1}^{y} q_{ij} \ln q_{ij} \tag{1}$$

When qij = 0. It is specified that qijlnqij = 0. After obtaining the entropy weight of the jth evaluation index, the vector k = (K1, K2,..., KN) of attribute weight can be calculated, where:

$$k_j = \frac{1-H_j}{\sum_{z=1}^{y}(1-H_z)} \tag{2}$$

3.2. Calculation, Final Evaluation and Optimization

After the value is normalized by the matrix and the weight is calculated, the complex subjective judgment problem of the optimization decision-making of the analysis of KPs in OE becomes mathematical. Assuming that the final optimal evaluation value of the ith well completion method is VI (k), multiply the matrix Q and the weight vector by the following formula.

$$V_i(k) = \sum_{j=1}^{y} q_{ij} k_j, (i = 1,2,...,n) \tag{3}$$

Judging from the comprehensive evaluation results, it is obvious that the larger VI (k), the better the solution to KPs of OE, that is, the better the comprehensive adaptability.

4. Research on KPs of ME based on FFM

4.1. Research on Inspection Procedures during Production of OE Equipment

Production process inspection process refers to the inspection process of inspection items in the production process. After having an inspection plan for inspection items, in order to ensure the operation of the quality inspection plan and the effect of the quality management system, it is necessary to standardize the inspection process of various inspection items. This paper introduces the FFM analysis technology, which is divided into three categories according to the stage of the inspection items: incoming inspection, construction process inspection and final product inspection, and four categories according to the inspection types: self inspection, internal inspection, special inspection and external inspection. Through the multi-level inspection of the inspection items in the three stages of the production process, the quality problems can be found in time to ensure the quality of the production process, the project quality and the operation of the quality system.

Preparation for material warehousing inspection: after plates, profiles and pipes arrive at the factory, the purchaser of the procurement department shall provide relevant documents to the storekeeper of the logistics department. The documents shall include: material arrival list with specifications, grades, furnace batch numbers, quantities and other information, purchase order Po, material and equipment purchase application form MEO, material certificates, and technical agreements and drawings if necessary. The storekeeper of the logistics department prints the inspection application form and applies to the quality inspector of the quality management department for incoming inspection.

4.2. Statistical Analysis Technology of Quality Information

Through the management of inspection work by the quality management system, all kinds of information of quality inspection items are recorded systematically. Reasonable statistical analysis of these information can better ensure the continuous optimization of quality and achieve a virtuous cycle.

Type of quality information: according to the analysis of the current situation of quality information management in shipyards, the quality system of semi submersible platforms in the whole construction process is relatively mature and perfect, but the operation process of the quality system is greatly affected by human subjective factors. In order to ensure the objectivity and accuracy of the system operation, it is necessary to carry out more detailed and rigorous management of quality information, and use data to solve analysis and problems.

It seems reasonable to judge whether the production workshop or the contractor is qualified according to whether the first inspection pass rate is up to standard, but this quality information is not comprehensive enough. As shown in the table, if there are 138 inspection items applied for inspection in this cycle, 137 of which pass the first inspection, and the other inspection item passes after applying for inspection 8 times, then the statistics are consistent with the data in the table below, and the first inspection pass rate is also up to standard, but one inspection item passes after inspection 8 times, which indicates that this inspection item has a big problem and should be paid attention to, However, due to the qualified rate of the first inspection, such problems are not paid attention to and prevented from being re issued.

During the design of flexible pipe cable, the winding angle of armored steel wire can be designed around 20 °- 40 °according to the actual application environment and the function of pipe cable. In this test, the winding angle parameters of pipe cable are also divided into three groups: 20 °, 25 ° and 30 °. The summary of test parameters is shown in Table 3.

Table 3. Friction and wear test parameter

Test piece	Angle (°)	Contact load (n)	Frequency (Hz)	Reciprocating stroke (mm)
Steel wire / wire	40	60/80/100	5	3
Steel wire / wire	50	60/80/100	5	3
Steel wire / wire	60	60/80/100	5	3

In the test, the tangential force and load are monitored in real time, and the friction coefficient is calculated indirectly. Through the friction coefficient, the friction and wear characteristics between armored components are understood; After going through the wear process for a sufficient time, the surface morphology was observed under a high-power electron microscope to analyze the wear mechanism and damage of armored layer components. The specific wear surface parameters under different contact loads and friction angles are summarized in Figure 2.

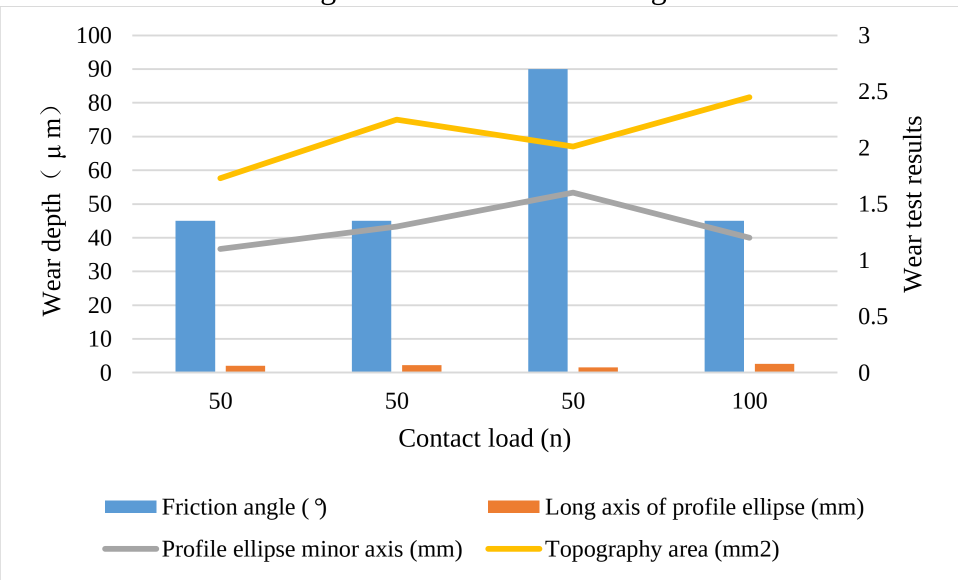

Figure 2. Wear test results

It can be seen from the data above that the size of load and the change of friction times will obviously change the wear morphology and depth of steel wire, of which the impact of load is particularly prominent. The wear morphology will also be different at different angles. When the steel wire is completely in the vertical friction condition, the wear morphology is round, while it is elliptical at other angles. With the increase of load, the number of load cycles increases, the area of wear ellipse becomes larger, and the degree of wear increases, which will accelerate the process of fatigue failure.

5. Conclusion

This paper discusses and analyzes the KPs of ME based on FFM, analyzes the KPs of ME equipment construction and production process quality, uses FFM technology to carry out experimental research on the friction and wear behavior of armored steel wire layer, and simply discusses the wear mechanism of armored layer components and its impact on fatigue problems, The following work has been done: To study the impact of friction and wear factors on the fatigue life of flexible cables, which have not received widespread attention at present, has reference significance for the future ME community to open and deepen the research in related aspects. The engineering experience of the practical application of offshore pipe and cable shows that other structural layers, such as carcass or pressure resistant armor layer, may also suffer from fatigue failure. As there is space allowance in many parts of the pipeline, other structural layers also have friction and wear behavior. The next work can further study the friction and wear behavior in the fatigue failure of other metal structural layers.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Prabhakar S , Goswami G . Design, Management and Key Success Factors of an Offshore Cathodic Protection System for Corrosion Control. International Journal of Engineering and Management Research, 2019, 9(2):171-177. https://doi.org/10.31033/ijemr.9.2.23

[2] Ahmed S , Hazarika G C . Investigation Of Variable Viscosity And Thermal Conductivity On Mhd Mass Transfer Flow Problem Over A Moving Non-Isothermal Vertical Plate. Journal of Naval Architecture and Marine Engineering, 2020, 17(2):183-197. https://doi.org/10.3329/jname.v17i2.48477

[3] Shan P , Wang Y , Wang F , et al. An efficient algorithm with new residual functions for the transient free-surface green function in infinite depth. Ocean Engineering, 2019, 178(APR.15):435-441. https://doi.org/10.1016/j.oceaneng.2019.03.003

[4] Valic M , Prpic-Oric J . Derivative Free Optimal Thrust Allocation in Ship Dynamic Positioning Based on Direct Search Algorithms. TransNav the International Journal on Marine Navigation and Safety of Sea Transportation, 2020, 14(2):309-314. https://doi.org/10.12716/1001.14.02.05

[5] Ekinci A . Effect of preparation methods on strength and microstructural properties of cemented marine clay. Construction and Building Materials, 2019,

227(Dec.10):116690.1-116690.11. https://doi.org/10.1016/j.conbuildmat.2019.116690

[6] Echternach--Jaubert M , Pellerin R , Joblot L . Litigation management process in construction industry. Procedia Computer Science, 2021, 181(1):678-684. https://doi.org/10.1016/j.procs.2021.01.218

[7] Najafi S , Abbaspoor M . Numerical investigation of flow pattern and hydrodynamic forces of submerged marine propellers using unsteady boundary element method:. Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment, 2019, 233(1):67-79. https://doi.org/10.1177/1475090217717174

[8] Nguyen V S . A Review Of Automatic Berthing Systems Based On Artificial Neural Networks For Marine Ship. International Journal of Civil Engineering and Technology, 2019, 10(4):763-769.

[9] Kumar T S , Reddy S , Babu K C , et al. Performance of CO 2 Cured Sugar Cane Bagasse Ash Concrete in Marine Environment. Civil Engineering and Architecture, 2020, 8(5):771-776. https://doi.org/10.13189/cea.2020.080504

[10] Ahmad S , Ul-Islam S . Numerical Investigation of Fluid Flow past Four Cylinders at Low Reynolds Numbers. Mathematical Problems in Engineering, 2021, 2021(2):1-24. https://doi.org/10.1155/2021/1127324

[11] Chai T , Xue H , Sun K , et al. Ship Accident Prediction Based on Improved Quantum-Behaved PSO-LSSVM. Mathematical Problems in Engineering, 2020, 2020(9):1-9. https://doi.org/10.1155/2020/8823322

[12] Chang J Y , Tsai C C , Young D L . Homotopy method of fundamental solutions for solving nonlinear heat conduction problems. Engineering analysis with boundary elements, 2019, 108(Nov.):179-191. https://doi.org/10.1016/j.enganabound.2019.08.004

[13] Doumari S , Givi H , Dehghani M , et al. Ring Toss Game-Based Optimization Algorithm for Solving Various Optimization Problems. International Journal of Intelligent Engineering and Systems, 2021, 14(3):545-554. https://doi.org/10.22266/ijies2021.0630.46

[14] Shin S C , Kim S Y , Noh C M , et al. Manufacturing process improvement of offshore plant: Process mining technique and case study. Ocean Systems Engineering, 2019, 9(3):329-347.

[15] Panagant N , Yldz M , Pholdee N , et al. A novel hybrid marine predators-Nelder-Mead optimization algorithm for the optimal design of engineering problems. Materials Testing, 2021, 63(5):453-457. https://doi.org/10.1515/mt-2020-0077

[16] Debnath S . About Rough Neutrosophic Soft Sets Theory and Study Their Properties. Science Journal of Applied Mathematics and Statistics, 2019, 7(6):95-102. https://doi.org/10.11648/j.sjams.20190706.11

[17] Hussain Z I , Sivarajah U , Hussain N . The role of a digital engineering platform in appropriating the creation of new work-related mind-set and organisational discourse in a large multi-national company. International Journal of Information Management, 2019, 48(Oct.):218-225. https://doi.org/10.1016/j.ijinfomgt.2018.09.014

[18] Ko L W , Lu Y C , Chang Y , et al. Multimodal Fuzzy Fusion for Enhancing the Motor-Imagery-Based Brain Computer Interface. IEEE Computational Intelligence Magazine, 2019, 14(1):96-106. https://doi.org/10.1109/MCI.2018.2881647