FUZZY MULTI CRITERIA DECISION MAKING MODEL FOR THE SELECTION OF MARINE ANTIFOULING PAINTS

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This work is dedicated to my parents and husband without whose caring supports it would not have been possible.

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ABSTRACT

Antifouling paint is applied on a ship's hull to prevent the formation of layer which can increase hull resistance. The use of antifouling paint is always considered as an investment since the cost per ship can be quite high. The selection of antifouling paint is considered as a major task for a large shipping company. Antifouling paint is selected based on a combination of criteria and the selection decision is normally done at two levels; engineer's level and manager's level. Decision by engineer is normally done based on technical merits and depends on discrete technical specification values. Decision by manager on the other hand, could consider criteria best gauged by approximation method. The research proposed a tool for the selection of antifouling paint by approximation method using fuzzy multi-criteria decision making method (MCDM). Five selection criteria have been selected and two of the criteria, market preference and local content have been established through survey by questionnaire and statistical analysis. The selection model has been developed based on MCDM approach and the selection algorithm for the computation of fuzzy selection value has been developed based on fuzzy method. The selection model has been transformed into a user friendly program using Microsoft EXCEL platform. The package has been tested for accuracy of output and the maximum inaccuracy is detected to be of 15%. For an extreme condition when all criteria are assigned with linguistic input "VL" (Very Low) representing a fuzzy number (1,1,2). An inaccuracy of 3.7% is detected when all criteria is assigned with linguistic input "VH" (Very High). The package has also been validated using a case study based on MISC BERHAD antifouling selection data. The validation result shows that the output from the package selects the same antifouling paint as by MISC BERHAD. The research has successfully developed the fuzzy MCDM model for the selection of marine antifouling paint.

ABSTRAK

Aplikasi cat anti-tumbuhan di lambung kapal adalah untuk mencegah pembentukan lapisan tumbuhan yang mampu meningkatkan rintangan kapal. Cat anti-tumbuhan dianggap sebagai pelaburan disebabkan kosnya yang tinggi. Pemilihan cat anti-tumbuhan merupakan tugas penting di dalam sesebuah syarikat pelayaran. Cat anti-tumbuhan dipilih berdasarkan beberapa kombinasi kriteria dan biasanya dilakukan pada dua peringkat; peringkat jurutera dan tahap pengurus. Keputusan oleh para jurutera biasanya dilakukan berdasarkan merit teknikal dan bergantung pada nilai diskret spesifikasi teknikal. Keputusan pengurus boleh melibatkan kriteria yang baiknya diukur menggunakan kaedah penghampiran. Kajian ini mencadangkan suatu program pemilihan cat anti-tumbuhan dengan kaedah penghampiran menggunakan kaedah anggaran (*fuzzy*) membuat keputusan pelbagai criteria (*MCDM*). Lima kriteria telah dipilih dimana dua criteria; kecenderungan pasaran dan kandungan tempatan ditentukan melalui borang kaji selidik dan analisis statistik. Model pemilihan telah dibangunkan berdasarkan pendekatan *MCDM* dan algoritma pemilihan untuk pengiraan nilai pemilihan *Fuzzy* dibangunkan berasaskan kaedah *fuzzy*. Perisisan Microsoft EXCEL digunakan untuk pembinaan program. Program ini telah diuji untuk ketepatan keluaran dan ketidak-tepatan maksimum yang dikesan adalah sebanyak 15%. Keadaan ekstrem terjadi apabila semua kriteria diberi masukan paling rendah atau 'VL' (*Very Low)* yang mewakili nombor *fuzzy* (1,1,2). Ketidak-tepatan sebanyak 3.7% pula dikesan apabila semua kriteria diberi masukan paling tinggi atau 'VH' (*Very High*). Program ini telah disahkan menggunakan kajian kes berdasarkan data pemilihan cat antitumbuhan oleh MISC BERHAD. Keputusan pengesahan menunjukkan bahawa keluaran daripada program memilih cat anti-tumbuhan yang sama oleh MISC BERHAD. Kajian ini telah berjaya membina model fuzzy MCDM untuk pemilihan cat anti-tumbuhan marin.

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LIST OF ABBREVIATIONS

MCDM	-	Multi Criteria Decision Making
DM	-	Decision Maker
AF*n*	-	Antifouling type *n*
FSV	-	Fuzzy Selection Value
c.o.g.	-	Centre of gravity
VL	-	Very Low
ML	-	Medium Low
L	-	Low
H	-	High
MH	-	Medium High
VH	-	Very High
VOC	-	Volatile Organic Compound
af*n*	-	Antifouling type *n*
v_i	-	Decision value for *i*th value
v_i''	-	Fuzzy form of v_i
w_n	-	Weightage value for Criteria *n*
C_n	-	Criteria *n*
Q.A	-	Question for part A
Q.B	-	Question for part B
Q.A.1	-	Question for part A1
Q.B.1	-	Question for part B1
M.E.P	-	Microsoft EXCEL Package
$\otimes$	-	Cross multiplication
$\oplus$	-	Cross addition

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter highlights the relevance of this research within the overall context of antifouling selection methodology. The problem statement and the research objective have also been stated. The scope of study and the significance of the research have also been itemized to show the research boundary and its strength and contribution respectively.

1.2 Research Background

The problem of marine organisms adhering to structures in the sea is as old as time. The problem is acute for the shipping industry. Fouling on a ship's hull leads to increased friction between the hull and seawater, causing 'hull roughness'. This, combined with the increased weight of fouling organisms which are attached to the hull, can lead to considerable increase in fuel consumption. A layer of algal slime, which is 1 mm thick, will increase hull friction by 80% and cause a 15% loss in ship speed, while a 5% increase in fouling for a tanker weighing 250,000 dwt will increase fuel usage by 17% (MER, 1996b). Whereas, a layer of marine organisms on a ship's hull decreases speed, manoeuvrability, and range, and it raises propulsive fuel consumption by as much as 30% (Brady, 2000).

For nearly a quarter century, tributyltin (TBT)-based self-polishing copolymer antifouling paints have provided an efficient and economic method of ship hull protection. The process involved slow and controlled release of the biocide as the link hydrolysed on contact with seawater, at the paint’s surface. These systems were highly effective. They could provide antifouling cover for five or more years and have been acclaimed widely as the most effective antifoulant ever devised (Bosselmann, 1996). Reduced fuel costs and less frequent need to dry dock and re-paint vessels were estimated to be worth US$5.7 billion per annum to the shipping industry during the mid-1990s (Rouhi, 1998). Not surprisingly, they dominated the market and were applied to more than 70% of the world's commercial shipping fleet (Evans *et al.*, 2000).

As we enter the 21st century, this important technology has been eliminated by new regulations proposed by the International Maritime Organization (IMO). This has created a major challenge for the scientific community and the marine paint industry and more so for ship owners. The challenge is to formulate replacement systems that meet or exceed the performance standards of TBT self- polishing copolymer coatings and that comply with present and future environmental regulations (Swain, 1999). Whereas, ship owners face difficulty in evaluating and choosing the right anti-fouling paint with so many introduced in the market by the marine paint manufacturers.

Multiple criteria decision making (MCDM) techniques have been used in recent years to solve a wide variety of problems (Sarker and Quaddus, 2002, Chen and Liao, 2004). However, in many decision-making situations, a high degree of fuzziness and uncertainty is involved in the data set, so fuzzy sets theory provides a framework for handling the uncertainty (Fan *et al.*, 2004). This research presents the application of a fuzzy MCDM approach to for the selection of an antifouling paint for the application to a ship's hull.

1.3 Problem Statement

i. The current method of selecting antifouling paint is too loose in the sense that the selection criteria are not defined as well as the importance of each criteria.
ii. The whole procedure has not been developed based on known/universally accepted method.

1.4 Research Objective

The objective of the research is to develop a MCDM model for the evaluation and selection of Marine Antifouling Paints for ship's hull application.

1.5 Scopes of Study

The research limits its scope in the respective areas:

(i) The selection criteria have been selected to represent antifouling selection priority suitable for decision making at managerial level only.

(ii) Fuzzification of data is based on six partition triangular fuzzy number only for easy of computation and without compromising results.

(iii) The model was developed based on MCDM approach and the selection algorithm for computation of fuzzy selection value has been developed based on fuzzy method.

(iv) The model was transformed into a user friendly package utilizing Microsoft EXCEL platform.

(v) The validity of the package was done using a case study based on MISC BERHAD antifouling selection data.

1.6 Significance of Research

The research will produce a framework in designing a decision making tool to assist decision makers in selecting a suitable antifouling paint. It incorporates established criteria practiced by industry obtained from literature reviews as well as additional criteria identified through normal practice by decision makers.

1.7 Organization of Thesis

This report consists of six main chapters where each chapter will focus on the topics as follows:

Chapter 1 is an introduction to the report where it describes briefly the background of the research, the problem statement, the research objective and the significance of the research.

Chapter 2 of the report contains literature review for the purpose of understanding the topic of the research in detail. This chapter contain related literature on fouling; antifouling paints and description for decision making approaches as well as fuzzy MCDM.

Chapter 3 describes the methodology adopted for the research.

Chapter 4 will show the developed antifouling selection model and its algorithm. It also contains the established decision making data that will be used in the algorithm. The final Excel package that is used for the model together with its verification and validation results are shown as well.

Chapter 5 discusses the result which shown in previous chapter in detail. The discussion to be made based on the result obtained in chapter 4. The arguments and evidences on the results also will be discussed further in this chapter as well.

This final chapter presents the overall conclusion and some recommendations for future research. This chapter will formulate the findings and the objectives of the project. At first, the objectives of the project will be reviewed and conclusions will be made based on the outcomes of study. To reinforce the outcome of this project, some recommendations were made at the end of this chapter where the proposed future studies to be carried out.