UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

UTILIZATION OF AHP FOR SELECTING CONCEPTUAL DESIGN OF PORTABLE OIL SPILL SKIMMER

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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Master of Manufacturing Engineering (Manufacturing System Engineering)

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A thesis submitted in fulfillment of the requirements for the degree of Master of Manufacturing Engineering (Manufacturing System Engineering

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2021

DECLARATION

I declare that this thesis entitled "Utilization of AHP For Selecting Conceptual Design of Portable Oil Spill Skimmer" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Mohammed Idrees Dhahir Dhahir

Date : 26th Sep 2021

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APPROVAL

I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of Master of Manufacturing Engineering (Manufacturing System Engineering)

. Signature : .....

Name : Ir. Dr. Lokman Bin Abdullah

Date : 26th Sep 2021

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DEDICATION

To my beloved country Iraq, my dear mother, my dear father, and all my beloved ones.

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ABSTRACT

One of the most important ways to preserve the surrounding environment after an oil leak is to carry out an oil spill response action plan. A quick response and a significant impact should be made in response to any emergency scenario to minimize contamination to the sea and marine life. A number of approaches were developed to deal with oil spills, including utilizing floating barriers, skimmers, storage barges, tanks, and other equipment. These solutions rely on the kind of spill and the tactics used by the emergency response team. To assist respond to oil spills, the project is being undertaken, providing an option for water treatment applications. The proposed design is aimed to address few issues such as the high cost of the current design, staticity, and inefficiency. This research presented the technical requirements of the portable oil skimmer which are obtained from the house of quality and presented four conceptual designs. The conceptual designs have been analyzed in the analytical hierarchy process and the best design has been selected. The first conceptual design had the highest priority among the four conceptual designs proposed which was 31.8%. A detailed design has been generated by using SOLIDWORKS software. Choosing the right concept for a product is a vital step in the development process. Inappropriate selection could lead to a high failure rate in the market for produced goods. The Analytical Hierarchy Process (AHP) is a tool that can be used to tailor the decision-making process. Almost all applications involving decision-making problems use AHP as a tool. The methodology and findings of a study based on the AHP idea are presented in this research. The procedures done can be used as a guideline to help designers or engineers assess numerous design requirements, options at the conceptual design stage, and finally make precise decisions. Part of this project is identifying the technical requirements of portable oil skimmer by utilizing the quality function deployment and selecting the best conceptual design using the analytical hierarchy process. The objectives of this research have been achieved as the user and technical requirements of the portable have been identified and the best conceptual design has been selected via the AHP. The research can be improved further by conducting an experiment on the proposed design to verify its efficiency.

ABSTRAK

Salah satu cara terpenting untuk memelihara persekitaran di sekitarnya setelah kebocoran minyak adalah dengan melaksanakan rancangan tindakan tindak balas tumpahan minyak. Tindak balas yang cepat dan kesan yang besar harus dibuat sebagai tindak balas terhadap senario kecemasan untuk mengurangkan pencemaran ke laut dan kehidupan laut. Sejumlah pendekatan dikembangkan untuk menangani tumpahan minyak, termasuk menggunakan penghalang terapung, skimmer, takung penyimpanan, tangki, dan peralatan lain. Penyelesaian ini bergantung pada jenis tumpahan dan taktik yang digunakan oleh pasukan tindak balas kecemasan. Untuk membantu menangani tumpahan minyak, proyek ini sedang dilakukan, memberikan pilihan untuk aplikasi rawatan air. Reka bentuk yang dicadangkan bertujuan untuk mengatasi beberapa masalah seperti kos tinggi reka bentuk semasa, ketahanan, dan ketidakcekapan. Penyelidikan ini menunjukkan keperluan teknikal skimmer minyak mudah alih yang diperoleh dari rumah berkualiti dan mengemukakan empat reka bentuk konsep. Reka bentuk konseptual telah dianalisis dalam proses hierarki analitik dan reka bentuk terbaik telah dipilih. Reka bentuk konseptual pertama mempunyai keutamaan tertinggi di antara empat reka bentuk konseptual yang dicadangkan iaitu 31.8%. Reka bentuk terperinci telah dihasilkan dengan menggunakan perisian SOLIDWORKS. Memilih konsep yang tepat untuk produk adalah langkah penting dalam proses pembangunan. Pemilihan yang tidak tepat dapat menyebabkan tingkat kegagalan yang tinggi di pasaran untuk barang yang dihasilkan. Proses Analisis Hierarki (AHP) adalah alat yang dapat digunakan untuk menyesuaikan proses membuat keputusan. Hampir semua aplikasi yang melibatkan masalah membuat keputusan menggunakan AHP sebagai alat. Metodologi dan penemuan kajian berdasarkan idea AHP dikemukakan dalam penyelidikan ini. Prosedur yang dilakukan dapat digunakan sebagai panduan untuk membantu pereka atau jurutera menilai banyak keperluan reka bentuk, pilihan pada tahap reka bentuk konseptual, dan akhirnya membuat keputusan yang tepat. Sebahagian daripada projek ini adalah mengenal pasti keperluan teknikal skimmer minyak mudah alih dengan menggunakan fungsi fungsi yang berkualiti dan memilih reka bentuk konsep terbaik menggunakan proses hierarki analitik. Objektif penyelidikan ini telah dicapai kerana keperluan pengguna dan teknikal mudah alih telah dikenal pasti dan reka bentuk konsep terbaik telah dipilih melalui AHP. Penyelidikan dapat ditingkatkan lebih jauh dengan melakukan eksperimen pada reka bentuk yang dicadangkan untuk mengesahkan kecekapannya.

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LIST OF ABBREVIATIONS

AHP	-	Analytical Hierarchy Process
QFD	-	Quality Function Deployment
HOQ	-	House of Quality
NGO	-	Non-Governmental Organization
CR	-	Consistency Rate
RI	-	Random Index

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CHAPTER 1

INTRODUCTION

1.1 Background

Oil is a general term that refers to any natural and nonpopular chemical substance, that usually comes as a viscous liquid encompassing temperatures. Petroleum in contrast is the non-renewable major resource of global energy that is formed of a complex mixture of many different organic materials that have been chemically converted over long periods of time under various geological circumstances (Wang, Fingas and Page, 1999). This oil needs to go through many human-handled processes such as extraction, transporting, and utilizing. During such a process, the oil is usually transported using freight tankers that move relatively large quantities of cured oils to different ports around the world.

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To ensure the safe handling of the crude oil during such a process, guidelines have been set to minimize the risks of oil pollution (Valdor, Gómez and Puente, 2015). Moreover, the International Maritime Organization (IMO) obliges its members to prepare a strategy for response in the event of oil pollution (*Maritime Security and Piracy*, no date). However, regular discharges from ships still occur unintentionally beside the illegal bilge discharge of water, drill rig, and shipwreck. Spills can occur for a variety of reasons during the exploration, extraction, and transportation operations, including over-pressurization, mechanical failure, pipeline corrosion, and ship collision, to name a few. According to (Tuan Hoang, Viet Pham and Nam Nguyen, 2018), about 5,710,000 tons of oil were spilled during the period from 1970 to 2010

from tanker incidents alone. The petroleum spillage is classified as hazardous waste (Saadoun, 2015). The estimated amount of oil spilled worldwide to the marine extends from 706,000,000 gallons per year (Pathare *et al.*, 2015), while Troisi, Barton and Bexton (2016) reported that it may extend from 500,000 to 8,400,000 tons per year. Human-caused discharges of liquid fuel hydrocarbons into the marine or shoreline areas are commonly referred to as marine oil spills. Crude oil spills from tankers, offshore platforms, drilling rigs, and wells are among them, as are spills of processed oil products (such as gasoline and diesel) and their by-products, heavier fuels used by big ships (such as bunker fuel), and spills of any oily white rubbish or waste oil.


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Figure 1.1: A photo was taken on 25th July 2020 in the coastal area of Mauritius shows an oil spill from A Japanese bulk carrier (Greenpeace International, 2020).

In marine environments, oil spills are common, and many little spills go unreported, especially in locations where green guidelines or regulations are weak, unenforceable, or absent. Those leaks may cause huge damage to the environment and the species living in it, and the amount of harm caused to each particular species is different from others. For instance, hundreds

of thousands of seabirds are dying because of oil spills, as the birds come into interaction with floating crude oil on the water which causes immediate suffocation (Troisi, Barton and Bexton, 2016). Moreover, the turtles population has been decreasing due to Deepwater Horizon oil spills (Putman *et al.*, 2015; Beyer *et al.*, 2016). A study conduct by (Perez *et al.*, 2017) proved that oiled birds need more time to fly which led to reduced weight and affected their migration. Some of the habitats such as Mangrove may be extinct in 30 years due to oil spills (Duke, 2016). Oil pollution is a serious problem that needs to be addressed urgently because it has a very dangerous impact on marine life besides the economic impact on the people whose livelihood relies on sea life and ocean resources.

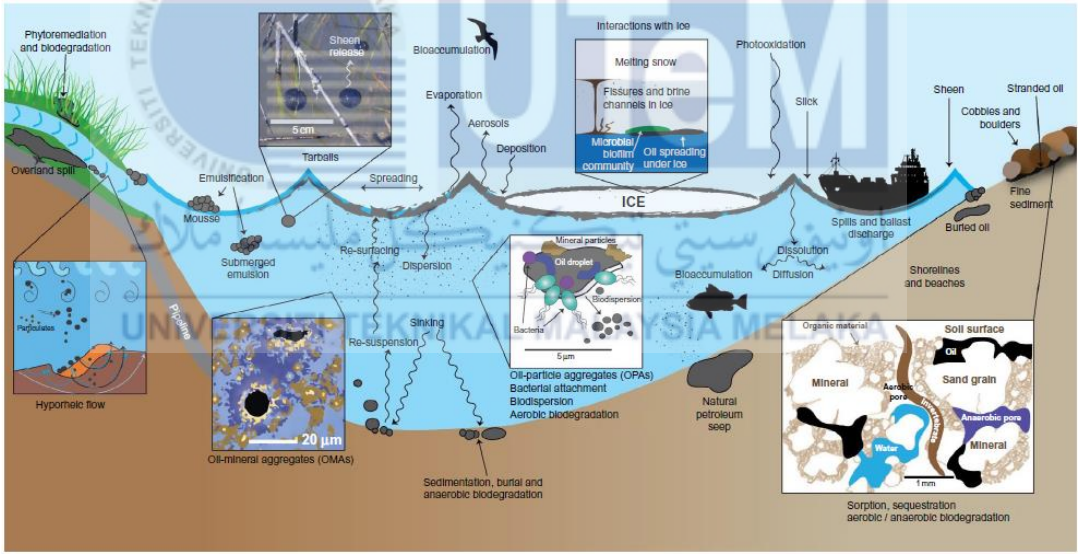

Figure 1.2: A large-scale diagram illustrates the Interactions of oil spillages on the environment (Zhang *et al.*, 2018).

Therefore, the need of finding ways to solve the problem of oil spills has been a point of interest to many researchers over the years. Many approaches to control oil contamination have been developed, those approaches aim to limit the oil spreading to the environment. The

developed approaches address the oil spill differently, some of them use physical barriers for the mechanically contain the spills and strict its spread. Those barriers are booms, skimmers, and absorbing materials (Spills and Environments, 1999).

According (Fingas, 2002), skimmers are "mechanical devices designed to remove oil from the water surface". The skimmers may differ in application, volume, design, capacity, and effectiveness. The amount of oil removed or from the water and quantity of water taken with oil rate the effectiveness of the skimmer. A skimmer is described as any mechanical device intended for removing oil (or the combination of oil and water) off the surface of the water, without affecting the physical and/or chemical properties of the water. The principles of skimmers function are based on fluidity characteristics of the oil and the oil and water mix, variations in density between oil or oil and water mixes, and water or variances in material adhesion (Patil *et al.*, 2017). These methods are often used for the cleanup of oil spills but are also widespread in industrial applications like removing oil from tool coolant and removing oil from water washing machines. They are typically necessary to remove oils, greases, and fats before further treatment to ensure compliance with environmental emissions. The removal of the top coat of oils may minimize water stagnation, odor, and ugly scum; placed in front of an oily water treatment system, the effectiveness of oil separation may increase for improving waste water quality. It must be remembered that every oil skimmer collects a proportion of water from the oil to achieve the concentrated oil.

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1.2 Objectives

The objectives of this project are as follows:

i. To identify the user and technical requirements of portable oil spill skimmer using the quality function deployment method.

ii. To select the best conceptual design of portable oil skimmer via AHP basic method.

1.3 Problem Statement

The current problems with regards to the current design of oil spill skimmers are the high cost of oil skimmers, portability, and inefficiency. The high cost of the oil skimmer is due to the manpower needed to use it as well as the equipment required. Moreover, the current oil skimmers are static and located on the shores or do not maneuver by itself. The inefficiency of the oil skimmer is due to the process followed in skimming the water. As the current process is to set physical barriers then start skimming. The problem with this technique is that due to the current and waves of the sea, the spilled oil increase, and the physical barriers need to be set again in a further place. This process is time-consuming and requires high manpower. Owing to this reason, it is a need to propose a design to address those problems.

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1.4 Scope of Project

The scopes of the project are as follows:

i. Identifying the technical specifications of the portable oil skimmer should be made by the QFD method.

ii. The selection of the best conceptual design shall be made using AHP.

iii. The conceptual design for the portable oil skimmer is to be drawn using SOLIDWORKS software.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The extreme danger of oil spills to the surrounding environment and the living animals and plants living in it has been the concern of many researchers and environmental NGOs. The oil spills are considered as great pollution that requires immediate attention to solve. The main cause of the oil leakage is human activities as Every year, more than 5,000,000 tons of crude oil are shipped across the globe by water, putting the environment at risk (Saadoun, 2015). Marine oil leaks are classified as thick oil with a density of more than 10 mm and thinner oil with a thickness of less than 10 mm in terms of oil spill treatment (Fingas, 2002). Furthermore, an oil film is a thin oil with a thickness of less than 1 mm that can be split into numerous levels based on its presence on the surface of saltwater.

Oil spillages have a substantial economic influence as well as a negative impact on public health. Orchid oil in the sea would impair the number of live species and would wash up on the shore for an extended length of time without being collected, causing harm to the fishing and aquaculture businesses. Oils that pollute the water lead fish to perish in large numbers because of a lack of dissolved oxygen. Oil adhering to the soil, rock embankments, and island banks, generating aesthetics and unpleasant smells, contributes to the tourism industry's significant losses (Zhang *et al.*, 2018). The oil spill had a negative impact on fishing terminals, shipbuilding, and shipbuilding plants. Due to the disturbance of floating oil, machinery, machinery for extracting minerals, and shipping canals have been disrupted.

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When spills from the water fronts travel through the harbor water for the distribution of diesel fuel to fishing boats, when vessels pump out oily bilge water in port, when engine oil is spilled overboard, and when a collision results in fuel oil leaks, chemical contamination occurs in seawater. Between 1970 and 2010, 5,710,000 tons of oil leaked due to ship collisions (Annunciado, Sydenstricker and Amico, 2005). The oil spill and oil slick's physical and chemical qualities have had a significant impact on sea life, ocean or water supply ecological structure, tourism, and entertainment activities (Atlas and Hazen, 2011). After an oil spill, several factors influence the formation of a slick, including climate, distribution velocity on the ocean's surface, drift in the ocean water, vanishing into the air, biodegradation, and emulsions between water and oil, all of which have a significant impact on changes in viscosity, density, and interfacial tension force (Basak, Nanda and Banerjee, 2012). Furthermore, most oxygenated oil spills and oil slick substances, such as aromatics, compounds, and alcohols, contaminated water for a long time. Several production methods, such as mechanical extraction or open burning, were utilized to clean up the oil spill. Bioremediation, solidifiers, and dispersants, in particular, were shown to be beneficial (Berna *et al.*, 2012). The practices were categorized based on the nature and size of the oil spill, as well as the meteorological and environmental conditions.

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2.2 Ecological and environmental impacts

Oil spillages have extensive and varied ecological and environmental consequences, depending on the type of substantial released, the amount released, the quantity of energy in the physical environment to effect hydrocarbon breakdown or mixing with water or sediment, and providing a means of transportation. The negative impacts are found all across the world,

albeit they seem to be concentrated in locations where extraction and transportation are more extensive.

2.2.1 Factors Affecting Oil Toxicity

The single element that influences the toxicity of spilled oil is its thickness, with some types of oil being heavier and hence more constrictive to the surfaces to which they stick. Oil harmfulness is also determined by the type of oil, which is determined by its origin. The Entire crude oils include significant amounts of PAHs, along with a variety of heavy metals, posing significant toxicity risks to humans and marine life. Various degrees of processed oil come up with varying amounts of toxicity and volatility, with toxicity often rising as volatility increases. The manifestation of oil's hazardous effects is depending on the subject engaging with it; for example, birds are harmed if they consume the oil or if it comes into touch beards body or feathers, which limits insulation of water therefore the ability to fly. Oil or oil weathering goods, such as tarballs and coastal asphalt cover, may be trapped in the respiratory passages of fish and big marine mammals if they are accidentally consumed or inhaled (Dupuis and Ucan-Marin, 2015).

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