Human Factors That Contribute To Maritime Accidents Involving Oil Tankers

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Abstract: An oil tanker is a ship designed for the bulk transport of oil or its products. Even though many safety measures are being practiced on board, oil tankers are known to encounter the most risk of being involved in a disaster. Maritime accidents can be caused by various factors including perils of the sea, nature of cargo, and human error. However, the main factor that induces the present situation is the human factor. The purpose of this research was to identify the human factors that contribute to oil tanker accidents, to identify the most prominent root cause of human factors, and to propose a suggestion for minimizing the risk of human factors that lead to oil tanker accidents. For this purpose, the data was collected through a questionnaire that focused on the causes of human factors that contribute to oil tanker accidents. The questionnaire was distributed to the targeted respondents, who were experts of the maritime industry, captains, deck officers, and deck cadets sailing onboard an oil tanker; the collected data were analyzed by using Statistical Package for the Social Sciences (SPSS) to achieve the objective of this study. The result of the research was as expected, where occupational fatigue was identified as the most prominent root cause. With the result of this research, a suggestion can be proposed to minimize the risk of human factors resulting in oil tanker accidents, thus, the number of oil tanker accidents can be greatly reduced, and the aftermaths can be hindered.

Index Terms: Human Factor, Fatigue, Maritime Accident, Oil Tanker, SPSS, Maritime Industry, Safety

1. INTRODUCTION

IT is commonly acknowledged that a ship's safe operation is not absolute since the risk of mishaps is consistently present (Gasparotti, 2010). The primary issue that oil tankers connote is the hazards that it might cause due to the cargo that is being transported. It is one of the most dangerous types of transportation; the aftermath may be destructive, or even fatal (Uğurlu, 2012). In the course of the most recent decade, international maritime authorities have made noteworthy endeavors to promote safety at sea in the maritime industry (O'Neil, 2003). Even though numerous steps have been taken, there are still a huge number of maritime accidents occurring worldwide to date. As stated by the Maritime Safety Authority of New Zealand (1996), human errors, technical and mechanical failures, and environmental factors are commonly underlined factors that contribute to maritime accidents. Maritime accidents may result in environmental damage, material damage, or even loss of human lives. Hence, the prevention of maritime accidents is still a focal matter of maritime interests (Celik, 2010).

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The International Maritime Organization (IMO) accepts marine accidents as a reference in the process of establishing rules and amendments to ensure maritime safety. Various international conventions deal with maritime safety, and one of the most significant is the International Convention for the Safety of Life at Sea, which is also known as SOLAS. SOLAS covers a wide scope of measures intended to improve the safety of shipping. SOLAS is one of the oldest conventions; the first version was adopted in 1914 after the sinking of the Titanic with the loss of more than 1500 lives (IMO 2004). Besides Titanic, there are also other significant marine accidents with solid consequences such as the Torrey Canyon, Amoco Cadiz, Exxon Valdez, Independa, Prestige, Erika, and Hebei Spirit. These accidents have driven the effort to take international level precautions. Therefore, it is crystal clear that lessons learned from past marine accidents have formed a basis for the conventions and contracts established for the prevention of maritime accidents. Due to the significance of these accidents and the potential human contribution that resulted in the mishap, this research aims to identify the human factors that contribute to maritime accidents involving oil tankers, to identify the most prominent root cause of human factors, and to propose a suggestion for minimizing the risk of human factors that lead to oil tanker accidents.

2 PROBLEM STATEMENT

Ship operation involves a great number of risks: social, to the property, to the environment, and could tarnish the company's image. At the point when an oil tanker leaves a safety route, it incurs a set of risks associated with collision and grounding events that have the potential to cause a great disaster. Maritime accidents can be caused by various factors including perils of the sea, nature of cargo, and human error. However, the main factor that induces the present situation is the human factor; human factors contribute to more maritime accidents than any other single factor. Numerous researches have been done and various measures have been implemented to inhibit human factors that contribute to maritime accidents involving oil tankers. However, the root cause has not been identified and thus the risk of human factors that contribute to oil tanker accidents could not be hindered. Therefore, the human factors that contribute to maritime accidents involving oil tankers, and

the most prominent root cause of human factors should be identified so that a suggestion for minimizing the risk of human factors can be proposed to greatly reduce the number of oil tanker accidents.

3 RESEARCH OBJECTIVES

This research has three objectives. Firstly, to identify the human factors that contribute to maritime accidents involving oil tankers. Secondly, to identify the most prominent root cause of human factors that contribute to maritime accidents involving oil tankers. Thirdly, to propose suggestions for minimizing the risk of human factors that lead to maritime accidents involving oil tankers.

4 LITERATURE REVIEW

4.1 Background of Oil Tanker

An oil tanker is a ship designed for the bulk transport of oil or its products. It is also known as a petroleum tanker. There are two basic types of oil tankers, which are crude tankers and product tankers. Crude tankers are ships intended to move massive quantities of unrefined crude oil from its point of extraction to refineries (Donaldson L., 1994). Meanwhile, product tankers are commonly much smaller in size and designed to move refined products from refineries to points near consuming markets. Oil tankers are generally classified by their size and in addition to their occupation. The size classes range from inland or coastal tankers with deadweight (DWT) which is normally of a few thousand metric tons, to the gigantic Ultra Large Crude Carriers (ULCCs) of 550,000 DWT. According to Thomas Barnes (2018), tankers move approximately 2,000,000,000 metric tons of oil every year.

4.2 Maritime Accidents and Risks

As in conceptual definition, an accident is defined as an unpleasant event, especially in a vehicle, that happens unexpectedly or is not planned, and causes injury or damage instead of something that happens expectedly (Oxford Advanced Learner's Dictionary, 2006). According to Stephenson (1991), an accident can be defined as an undesirable event that results in damage to humans, assets, or the environment. In general, an accident is an unplanned, unexpected, and undersigned event that occurs suddenly and may result in injury, loss, a decrease in value of resources, or an increase in liabilities. According to Piret (2008), a maritime accident is defined as an event that results in loss of life or extensive pollution, collision, fire, explosion, grounding, damages of the underwater hull of the ship that may cause flooding of one or more sections of the ship, and the total loss of the ship. Besides, risk can be defined as an evaluation of hazards in terms of severity and probability (Stephenson, 1991).

4.3 Maritime Accident Investigation

Accident investigations are typically conducted by or for government agencies, using largely legal logic that relies on the preponderance of evidence to determine the role of different factors in an accident's cause or causes, rather than on statistical inference as in empirical research [14]. The logic used in investigations is counterfactual, where investigators strive to determine whether an accident would have occurred in the absence of specified events and whether the events would have occurred in the absence of specific errors and/or system malfunctions [15].To determine if a mariner's error led to an accident, investigators must have sufficient evidence to allow a determination that without that error the accident would not have occurred. Applying the logic of accident investigations to determine the role of fatigue requires making three separate but related determinations to establish that a mariner was 1) fatigued 2) committed an error that is consistent with the research on cognitive performance degradations from fatigue, and 3) that no reasonable alternative can be found to fatigue to adequately explain the cause of the error. Therefore, to investigate the role that fatigue may have played in an accident, investigators need to establish first that the mariner was fatigued at the time. Research on fatigue causation cites essentially four-medical causes of fatigue, insufficient sleep in the hours immediately preceding an event, which leads to acute fatigue, sleep loss in the days or nights preceding the accident, which leads to chronic fatigue, extended time awake on the task that leads to fatigue from the effects of the extended wakefulness and the demands of the task over time, and shift work or rapid time zone change that leads to circadian sleep disruption.

4.4 Factors of Maritime Accidents

Maritime accidents may be caused by various factors. According to Clifford, C.B, and Ah, K.S. (2004), 50% of maritime accidents are caused by human factors, while another 30% of maritime accidents occur due to the failure of humans to avoid an accident; 30% of maritime accidents are results of inadequate conditions encountered by humans. There is a combination of characteristics in the maritime industry that could contribute to a huge number of accidents: fatigue, stress, work pressure, communication, environmental factors, and long periods away from home. According to Safahani, M. (2015). Furthermore, human factor may be defined as the scientific study of the man-machine interaction regarding human abilities and limitations concerning the design of systems (Akaahmia, 2014), 49% of maritime accidents are caused by human factors, while only 35% are contributed by technical factors, and 16% contributed by environmental factors respectively (Catherine, H., 2006). According to the Oxford Advanced Learner's Dictionary (2006), an error is defined as a mistake, especially one that causes problems or affects the results of something. Furthermore, the UK Marine Accident Investigation Branch (MAIB, 2000) has stated that human error is still the dominant factor that causes most maritime accidents. O'Neil (2003) also stated that the "human element" was often termed in the shipping literature. Hence, human error is an individual's mistake that may cause a problem or result in an accident.

5 METHODOLOGY

There are there primary and secondary data collected to complete this research. However, this research is quantitative research that needs to obtain data from primary and secondary data. One of the methods to get primary data is through a questionnaire. A questionnaire is a research instrument consisting of a series of questions to gather information from respondents. The researcher had done a questionnaire because it was cheaper and requires less effort as compared to other types of surveys, such as verbal or telephone surveys. Besides, questionnaires usually have standardized answers that make it simple and easier to compile the data obtained. The questionnaires are based on

the objectives of the study to find the experience with the current sailor on board ship. All the answers in question are based on personal experience and knowledge about the questions being asked. In this research, the researcher had distributed the questionnaire through the internet or online as a Google Form. The questionnaire consisted of various questions that were constructed based on factors, sub-factors, and then finally narrowed down to the focused matter. The primary focus was concentrated on identifying the causes of human factors that contribute to maritime accidents involving oil tankers. The questionnaire consisted of a total of 15 questions, which uses a 5 points Likert-type scale ranging from 1 = strongly disagree to 5 = strongly agree. The questionnaire was distributed to the targeted respondents, who were experts of the maritime industry, captains, deck officers, and deck cadets sailing onboard an oil tanker terminal operator. For this research, the researcher had used a series of questions in the form of a questionnaire as the instrument to obtain data. The questionnaire consisted of various questions that focus on the causes of human factors that contribute to maritime accidents involving oil tankers. Data analysis is the process of evaluating data using analytical and statistical tools to discover useful information and aid in decision making. The interview questions were addressed to the targeted respondents, who were experts of the maritime industry, captains, deck officers, and deck cadets sailing onboard an oil tanker as they have the most experience and knowledge regarding this issue. The questionnaire was used to gain information and knowledge on the causes of human factors that contribute to maritime accidents involving oil tankers. The constructed questions consisted of various causes of human factors, which include the limitations of human senses, perception and cognition, occupational fatigue, mental workload, the intoxication of a vessel's operator, communication barriers, working environment, and man-machine interface on vessels. This would be very useful for the researcher to identify the primary cause of human factor that contributes to maritime accidents involving oil tankers. Data analysis is the process of evaluating data using analytical and statistical tools to discover useful information and aid in decision making. In this study, Statistical Package for the Social Sciences (SPSS) method was used to analyze the data that was obtained. Quantitative and comprehensive data was analyzed and arranged in table forms and charts to display the percentage of each factor based on the data collection. Hence, the most prominent root cause of human factor that contributes to maritime accidents involving oil tankers could be identified.

6 RESULT

Based on the data obtained, there were various causes of human factors: Human senses, perception, and cognition, behavior, fatigue, mental workload, the intoxication of vessel's operator, communication, teamwork, work environment, human-machine interaction, specific issues in the design of maritime equipment, and crew response to technology.

Firstly, human senses include an individual's vision, hearing, tactile senses, and vestibular senses; perception and cognition comprise of attention, situation awareness, decision making, memory, and knowledge. Furthermore, behavior encompasses skill-based behavior, rule-based behavior, knowledge-based behavior, automated behavior, and risk-taking behavior. Moreover, occupational fatigue involves prolonged working hours, heavy workload, and fatigue during watch keeping, shift work, night work, simultaneous tasks, and distractions. Besides, mental workload consists of illness, pressure, concerns, stress, anxiety, and depression. Besides, the intoxication of the vessel's operator covers the consumption of drugs and alcohol, meanwhile, communication incorporates the usage of the local language or mother tongue, and poor mastery of Maritime English. Also, teamwork encompasses authority gradient, leadership styles, social rule, and power. Additionally, the work environment includes noise, vibration, lighting, climatic conditions, ship motions, accommodation, and social factors. Next, Human-Machine Interaction on vessels comprises of automation issues, lack of equipment standardization, and lack of equipment usability. Finally, specific issues in the design and integration of maritime equipment comprise visual warnings, controls and displays, and audible warnings such as alarms.

Fatigue recorded a majority of 43.9%, followed by communication with 9.6%, mental workload with 9.1%, human-machine interaction with 8.6%, crew response to technology with 8.0%, human senses with 4.8%, specific issues in the design of maritime equipment with 4.8%, perception and cognition with 3.2%, followed by behavior, the intoxication of vessel's operator, and work environment with 2.1% respectively, and finally teamwork with 1.6%.

Table 1: *Causes of Human Factor*

Causes	Frequency	Percentage
Human Senses	9	4.8
Perception and Cognition	6	3.2
Behavior	4	2.1
Fatigue	82	43.9
Mental Workload	17	9.1
The intoxication of Vessel's Operator	4	2.1
Communication	18	9.6
Teamwork	3	1.6
Work Environment	4	2.1
Human-Machine Interaction	16	8.6
Specific Issues in the Design of Maritime Equipment	9	4.8
Crew Response to Technology	15	8.0
Total	187	100.0

Based on Table 1, the frequency of each cause of the human factor was measured out of a total of 187 responses. These responses strongly agreed that the respective cause of human factors is the root factor that contributes the most to oil tanker accidents. Accordingly, 82 responses strongly agreed that fatigue is the root cause of human factor that contributes to maritime accidents involving oil tankers, followed by 18 responses for communication, 17 responses for mental workload, 16 responses for Human-Machine Interaction, 15 responses for crew response to technology, 9 responses for human senses, 9 responses for specific issues in the design of maritime equipment, 6 responses for perception and cognition, 4 responses for behavior, 4 responses for intoxication of vessel's operator, 4 responses for the work environment, and finally 3 responses for teamwork.

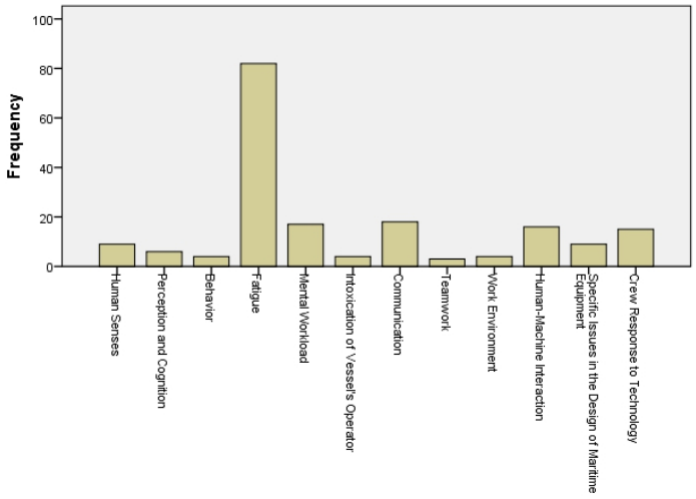

Figure 1: *Human Senses*

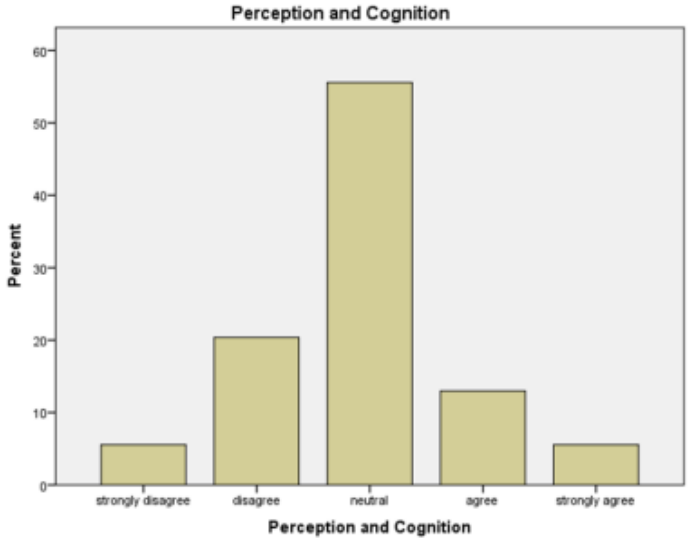

Figure 2: *Perception and Cognition*

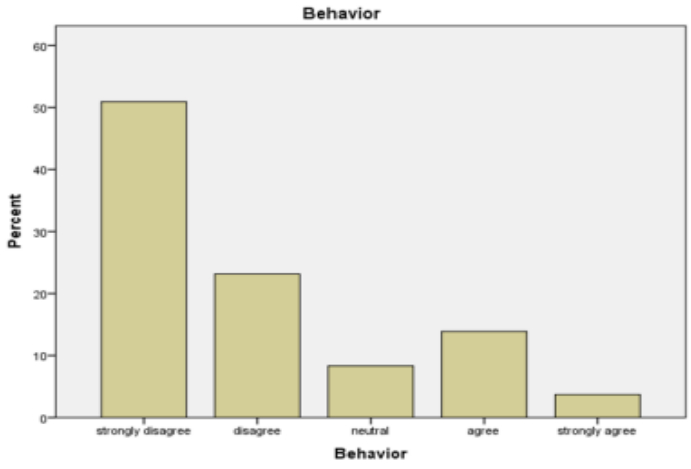

Figure 3: *Behavior*

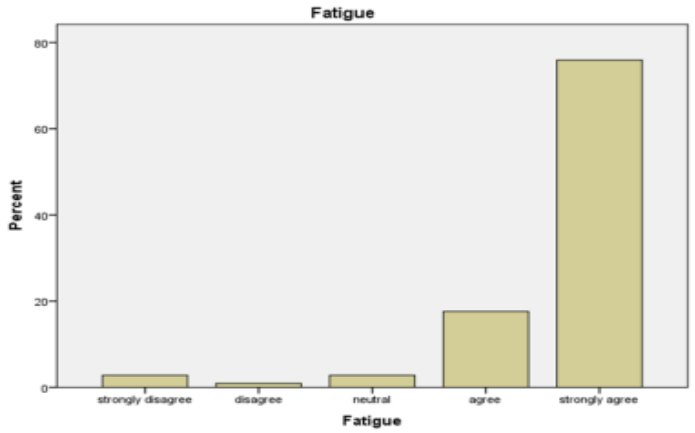

Figure 4: *Fatigue*

Figure 5: Mental Workload

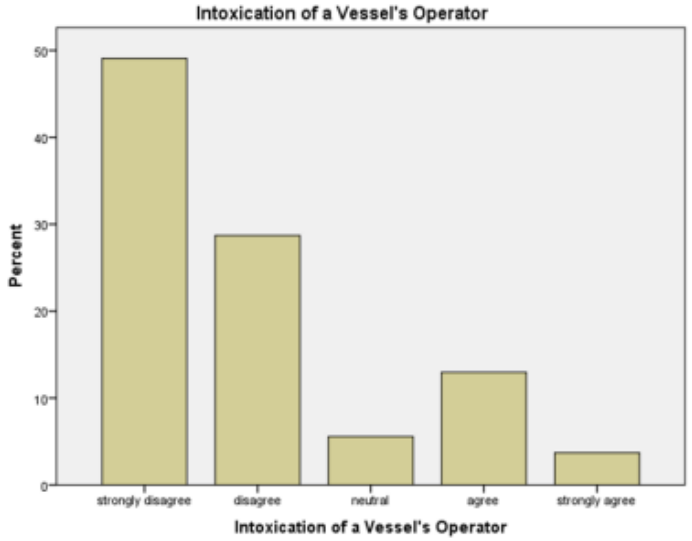

Figure 6: *Introxication of the Vessel's Operator*

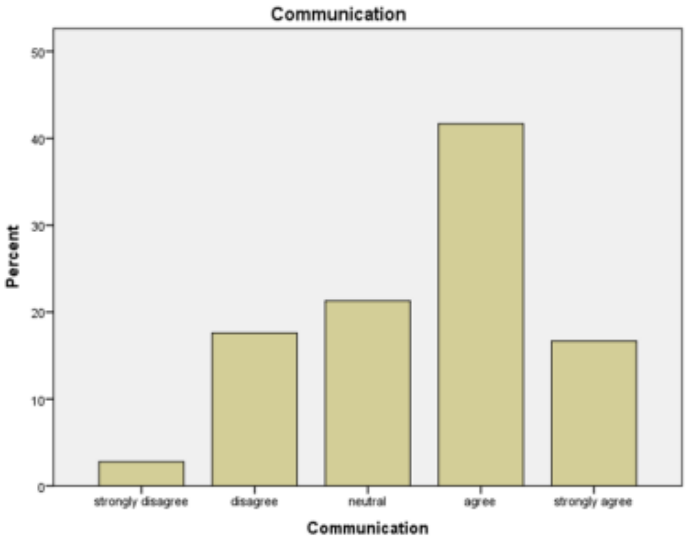

Figure 7: *Communication*

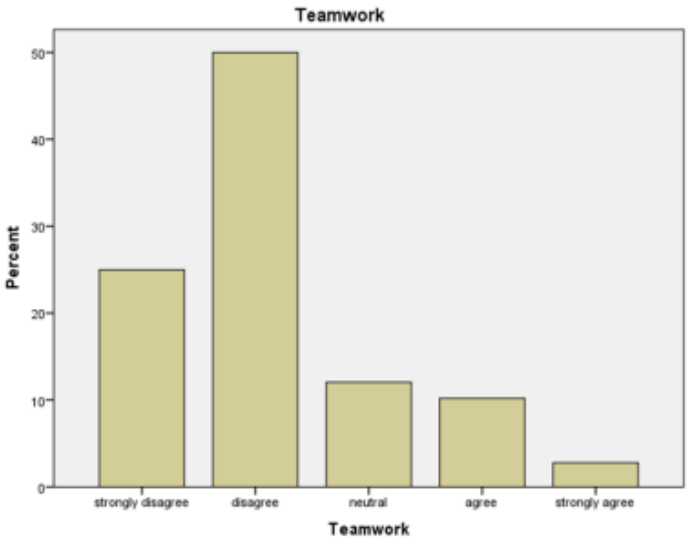

Figure 8: *Teamwork*

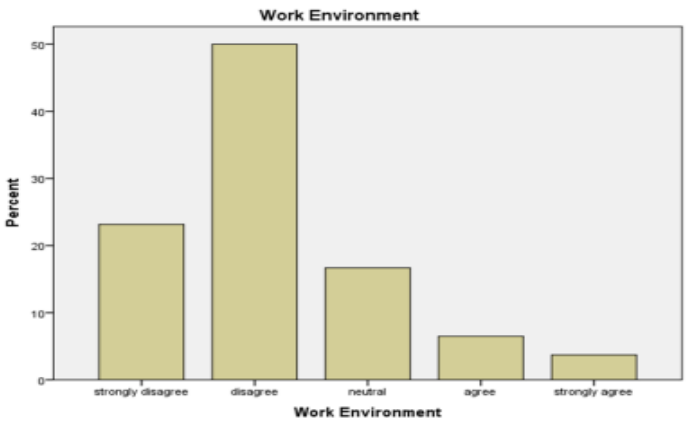

Figure 9: *Work Environment*

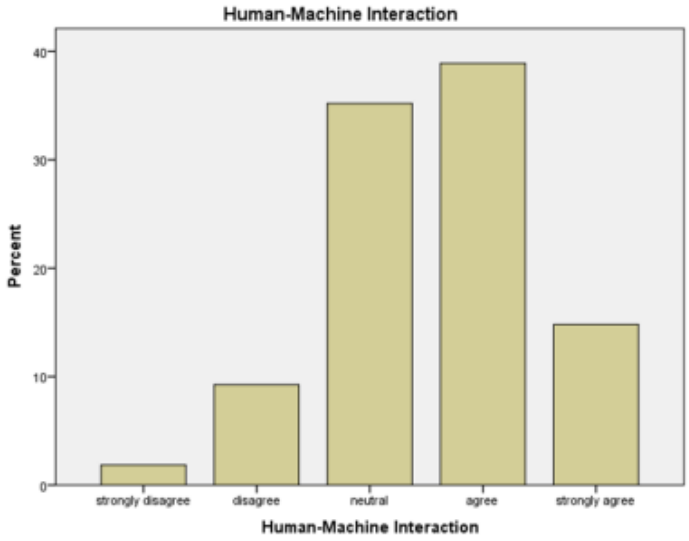

Figure 10: *Human-machine Interaction*

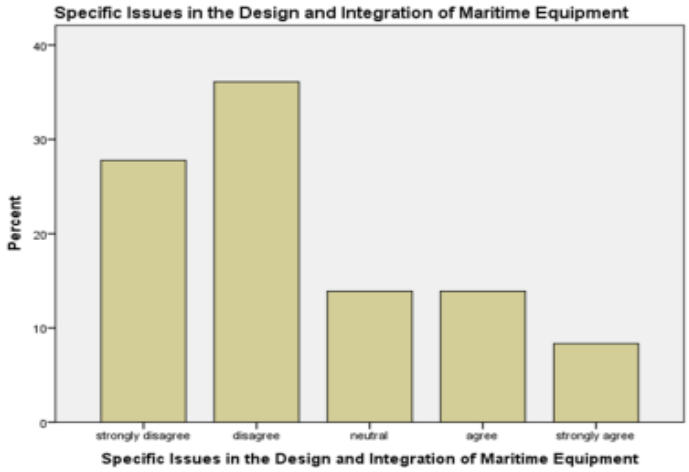

Figure 11: *Specific Issues in the Design of Maritime Equipment*

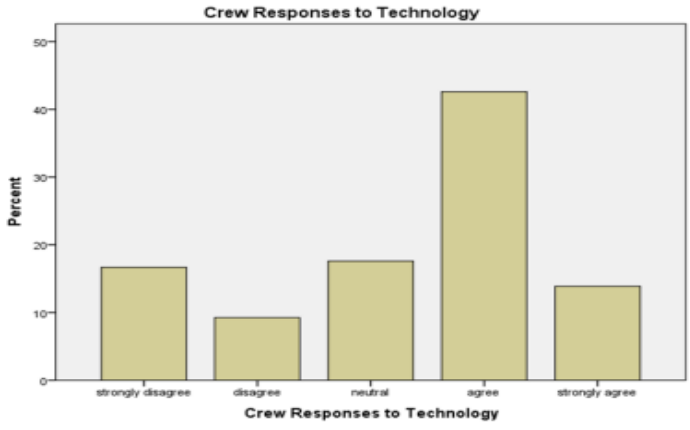

Figure 12: *Crew Responses to Technology*

DISCUSSION

Based on Figure 2,3,4,5,6,7,8,9,10,11,12, and 13, the frequency of each cause of human factor was measured out of a total of 108 responses. These responses strongly agreed that the respective cause of human factors is the root factor that contributes the most to oil tanker accidents. First and foremost, 104 respondents agreed while 4 respondents disagreed that the human factor is the primary cause of oil tanker accidents. Accordingly, 2 respondents strongly disagreed, 11 respondents disagreed, 24 respondents were neutral, 62 respondents agreed, and 9 respondents strongly agreed that human senses are the root cause that contributes to maritime accidents involving oil tankers. Furthermore, 6 respondents strongly disagreed, 22 respondents disagreed, 60 respondents were neutral, 14 respondents agreed, and 6 respondents strongly agreed that perception and cognition are the root cause that contributes to oil tanker accidents. Moreover, 55 respondents strongly disagreed, 25 respondents, disagreed, 9 respondents were neutral, 15 respondents agreed, and 4 respondents strongly agreed that behavior is the root cause that contributes to maritime accidents involving oil tankers. Besides, 3 respondents strongly disagreed, 1 respondent disagreed, 3 respondents were neutral, 19 respondents agreed, and 82 respondents strongly agreed that fatigue is the root cause that contributes to oil tanker accidents. Besides, 3 respondents strongly disagreed, 3 respondents disagreed, 11 respondents were neutral, 74 respondents agreed, and 17 respondents strongly agreed that mental workload is the root cause that contributes to maritime accidents involving oil tankers. Also, 53 respondents strongly disagreed, 31 respondents disagreed, 6 respondents were neutral, 14 respondents agreed, and 4 respondents strongly agreed that intoxication of the vessel's operator is the root cause that contributes to oil tanker accidents. Next, 3 respondents strongly disagreed, 19 respondents, disagreed, 23 respondents were neutral, 45 respondents agreed, and 18 respondents strongly agreed that communication is the root cause that contributes to maritime accidents involving oil tankers. Furthermore, 27 respondents strongly disagreed, 54 respondents disagreed, 13 respondents were neutral, 11 respondents agreed, and 3 respondents strongly agreed that teamwork is the root cause that contributes to oil tanker accidents. Moreover, 25 respondents strongly disagreed, 54 respondents, disagreed, 18 respondents were neutral, 7 respondents agreed, and 4 respondents strongly agreed that the work environment is the root cause that contributes to maritime accidents involving oil tankers. Besides, 2 respondents strongly disagreed, 10 respondents disagreed, 38 respondents were neutral, 42 respondents agreed, and 16 respondents strongly agreed that human-machine interaction is the root cause that contributes to oil tanker accidents. Besides, 30 respondents strongly disagreed, 39 respondents disagreed, 15 respondents were neutral, 15 respondents agreed, and 9 respondents strongly agreed that specific issues in the design and integration of maritime equipment are the root cause that contributes to maritime accidents involving oil tankers. Finally, 18 respondents strongly disagreed, 10 respondents, disagreed, 19 respondents were neutral, 46 respondents agreed, and 15 respondents strongly agreed that crew responses to technology are the root cause that contributes to oil tanker accidents.

8 RECOMMENDATIONS

Fatigue is the most prominent root cause that contributes to maritime accidents involving oil tankers, thus, strategic measures must be taken to hinder its consequences. Firstly, seafarers must be aware of how sleep deficit affects their daily performance, and they should avoid accepting a watch while undergoing fatigue since they may be unfit for the duty. In such cases, the crew should request another qualified watch keeping officer to take charge if possible, but if this is not possible then the crew should inform the Master and refuse duty until they are well-rested and able to conduct a watch safely. This is because the vessel's safety together with its crew should be the utmost priority. Furthermore, seafarers should consult with a qualified medical professional before consuming any medication as certain medications might cause sleepiness or dizziness and disqualify a crew from performing the watch. Besides, bridge resource management plays a vital role in the safe operation of an oil tanker; all crew on board must have adequate knowledge to utilize all available resources while facing a hazard with limited reaction time to ensure safe operation of the vessel. Finally, seafarers should always try to avoid distractions while conducting a watch, even though if it is necessary to communicate with crew members and perform other tasks simultaneously. Multi-tasking may not be avoided but utmost priority should always be given to the safe operation of the vessel. Therefore, these measures may help to reduce the risk of fatigue as the root cause of the human factor to greatly reduce the number of maritime accidents involving oil tankers.

9 RECOMMENDATIONS

The purpose of the study was to identify the human factors that contribute to oil tanker accidents, to identify the most prominent root cause of human factors, and to propose a suggestion for minimizing the risk of human factors that lead to maritime accidents involving oil tankers. This study was very important to increase awareness and inhibit the risk of human factors that contribute to oil tanker accidents. Based on the results obtained from this research, fatigue is the most prominent cause of human factor that contributes to maritime accidents involving oil tankers. The significance of these results advocates suggestions or recommendations to greatly reduce the number of oil tanker accidents soon. This research may again provide basic knowledge for developing preventive measures that may avoid the aftermath of an oil tanker accident in the future.

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