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A Review of User-Centred Design Methods for Designing a Portable Oil Spill Skimmer

R. Ramanathan*, L. Abdullah*†, M. S. Syed Mohamed* and M.H.F.M Fauadi*

*Faculty of Manufacturing Engineering, Universiti Teknikal, Malaysia Melaka, 76100 Durian Tunggal, Melaka, Malaysia

†Corresponding author: lokman@utem.edu.my

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ABSTRACT

Boom and skimmer are mechanical techniques in Oil Spill Response and Recovery (OSRR) that collect oil from the water surface. However, there are several drawbacks of using boom and skimmer, such as the oil could pass over the boom during strong wind and high tides. Moreover, the currently available oil skimmer designed by the engineers is heavy-duty; in consequence, it is ineffective in shallow water. Thus, there is a need to develop a portable oil spill skimmer to complement the current drawbacks. Several journals on the fabrication of the oil spill skimmer were reviewed. Findings from literature shows that the development of oil spill skimmer lacks user requirements when designing a portable oil spill skimmer. This article provides a systematic review of Kansei Engineering and the Analytical Hierarchy Process in the product development process. Therefore, Kansei Engineering and Analytical Hierarchy Process (AHP) can be incorporated in the early stage of designing a portable oil spill skimmer. This paper also includes the application of Kansei Engineering and AHP in design research articles. Findings from observed articles indicate a lack of design and development technologies relating to products for environmental protection; the AHP and Kansei Engineering application is somewhat lacking. Moreover, the fabrication of an oil spill skimmer focuses more on technical specifications and includes fewer user requirements. As a result, the characteristics such as ease of use, robustness, and safety cannot be evaluated. The AHP and Kansei Engineering methodology can be extended to the design and manufacture of products for environmental protection.

INTRODUCTION

A mechanism for removing oil that floats on a liquid surface is known as an oil skimmer. Depending on the technical configuration, it is used for a variety of purposes, including the remediation of oil spills as part of systems for treating oily water, the removal of oil from machine tool coolants and aqueous parts washers, and the processing of fat, oil, and grease in wastewater treatment facilities for the production of food. Oils, grease, and fats must be extracted using skimmers in industrial applications to comply with environmental discharge regulations before further processing. It may minimize water retention, odor, and unsightly surface scum by eliminating the top layer of oils. It should be observed that to extract condensed oil, all oil skimmers will accumulate a proportion of water with the oil, which will have to be decanted. Oil spill skimmers have a wide range of criteria to meet, such as buoyancy, the recovery rate of oil spillage, maneuverability, autonomous capacity, and many others to recover oil spills in any large body of water successfully. Buoyancy refers to the skimmer's ability to float in any water body without sinking too far successfully. Without falling overboard, it must even tolerate small waves or currents along lakes, rivers, and oceans. The spillage recovery rate refers to the speed at which the skimmer can extract oil within a given timeframe. Maneuverability is the skimmer's ability to travel about on water rapidly and reliably while moving about oil spillages. Last but not least, autonomous functionality can help users ease their workload when handling oil spillages by having to monitor the oil spill skimmer themselves. To satisfy the needs of the consumers, these technological specifications somehow need to be built into oil spill skimmers.

REVIEW ON OIL SPILL

Causes of Oil Spill

Chemical pollution of saltwater happens as a result of motor oil spills overboard, collision-related fuel oil leaks, and spills from the shoreline that transport diesel fuel to fishing boats. In oil spill treatment, marine oil leaks are categorized as thick oil with a density of more than 10 mm and thinner oil with a thickness of less than 10 mm. Besides, light oil with a thickness of less than 1 mm is known as oil film and, according to its presence on the water surface, can be divided into multiple levels.

Effects of Oil Spills

Oil spills cause significant economic damage and affect public health. The number of living species would be degraded by oil on the sea and washed up oil on the beach for an extended period without being retrieved, causing harm to the fishing and aquaculture industries. Due to a lack of dissolved oxygen, oils that pollute the water cause fish to die in huge numbers. Oil sticking to the soil, rock embankments, and island banks, creating aesthetics, and causing foul odors, adds to the tourism industry's significant losses (Zhang et al. 2018). Fig. 1 shows the occurrence of significant oil spills around the world.

Overview of Oil Spill Respond and Recovery Techniques

The modernized world needs speed in all areas. Therefore, the most critical thing is speed and fast work. Different devices and machinery are developed nowadays to achieve rapidity. In such a new age of globalization, scaled-down businesses support our country's development differently.

Mechanical recovery is recognized as the most effective and environmentally sustainable procedure of all these approaches. It is also the first preferred approach for the rehabilitation of oil spill systems (Mirajkar et al. 2019). Therefore, as an essential aspect of the general oil spill response and preparedness system, connectivity to the mechanical recovery capacity by skimmer is necessary.

Chemical spills and oil slicks are listed as follows in three groups in the aquatic setting (Tuan Hoang et al. 2018): Dispersion and solidifier are one of the methods that tackle oil spill issues in chemical techniques. Dispersant application's main objective is to decompose oil slicks into tiny droplets that can be immersed and dispersed quickly (Muizis 2013). They slow oil formation in water emulsions and are hazardous to marine life in general (Almeda et al. 2014). On the other hand, a solidifier possesses hydrophobic and oleophilic characteristics that attract oil while repelling water (Hum & Hamza 2016). High waves and water currents aid solidification by providing mixing strength to the oil and solidifiers. There are also in-situ oil burning and biodegradation methods in the OSRR techniques. In situ oil burning is the most efficient process since, without any advanced equipment, the maximum concentrations of spilled oil can be eliminated. The critical drawback of burning is that it produces secondary emissions that create toxic by-products that can pose risks to human health and the environment. Furthermore, the

goal of bioremediation is to promote the rate of natural biodegradation of oil without adversely affecting the atmosphere (Singh et al. 2020).

Physical Methods

The physical and chemical characteristics of the oil remained unchanged despite the use of physical techniques to restrict and avoid the spread of the oil spill and oil slick. Many obstacles have been used to contain oil leaks, such as booms, skimmers, adsorbent fabrics, and oil slicks (Fingas 2016).

Boom

The boom was a standard system used to prevent oil spills and spreading slicks (Fritt-Rasmussen & Brandvik 2011). Nevertheless, the efficient operation of booms was impacted not only by the boom's structure but also by the characteristics of the waves, such as wind speed, amplitude, and height. They gather the oil in more significant layers to recover quickly and easily from the water's surface. They are effective safeguarding devices for the marine environment, rivers, and seas since they can readily reroute an oil spill's path to preserve delicate ecosystems (Pagnucco & Phillips 2018). Skimmers or other techniques aimed at removing impediments to oil flow could be employed to recover the oil spills and slick. Different kinds of booms such as fence and curtain booms were illustrated in Fig. 2 (Gong et al. 2014).

Unfortunately, because it directly violates the natural tendency of oil to scatter, break, and disperse under the influence of wind, waves, and tides, this method has a number of structural problems (ITOPF 2018). Therefore, even though storage and extraction systems work within a few hours of the initial release, floating oil would appear to be encountered at a meager rate. The benefits of booms include being portable, limited storage space, corrosion resistance, immediate treatment, highly effective in calm waters (Hoang et al. 2018). In comparison, their key drawbacks were poor stability in the case of heavy winds and currents and low flexibility.

Skimmers

Skimmers are self-propelled machines that mechanically remove floating oils from the water surface (skimming). They are frequently employed in the physical recovery of oil spills and may be found in a range of equipment. They are commonly used in conjunction with booms and mainly consists of a reservoir tank for collection and settling of oil after removal (Fingas 2016). The major benefit of skimmers is that they can function in inclement weather and do not alter the oil's properties. The recovered oil might be refined or burned for further treatment. Skimmers shown in Fig. 3 might be classified as oleophilic skimmers, weir skimmers, elevating skimmers, submersion skimmers, suction/vacuum skimmers, and vortex/centrifugal skimmers (Kauble 2011).

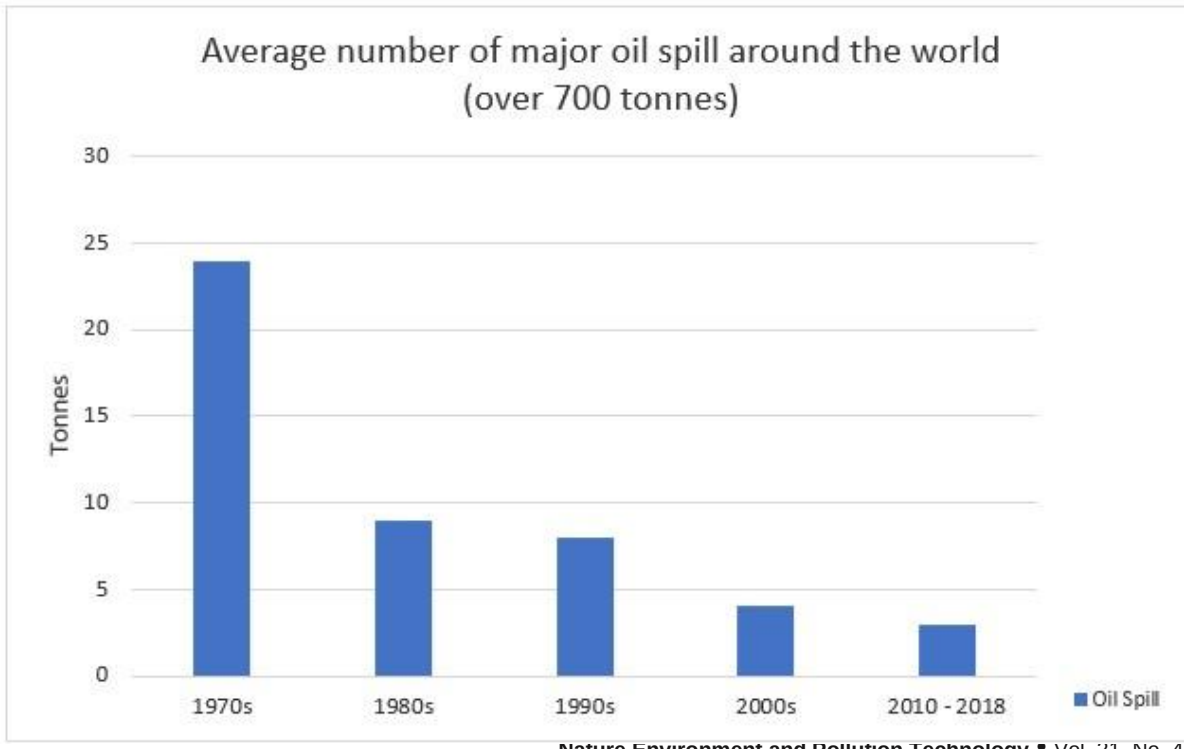

Fig. 1: The average number of significant oil spills around the world.

Development of Oil Spill Skimmer

A boat-type oil skimmer has been innovated and researched to improve the oil skimmer in design and skimmer design requirements. The modification improves the oil skimmer design, including shaft size, sorbent material, oil scrapping design, scrapper placement speed, and scrapper material. Manivel & Sivakumar (2020) claimed that the efficiency of the new boat oil skimmer has slightly improved after the design modification.

A research was conducted to design and fabricate a belt-type oil skimmer. The belt-type oil skimmer is then tested for its efficiency by using various types of belt material

Fig. 2: The types of booms used to control the oil spill spread (Gong et al. 2014).

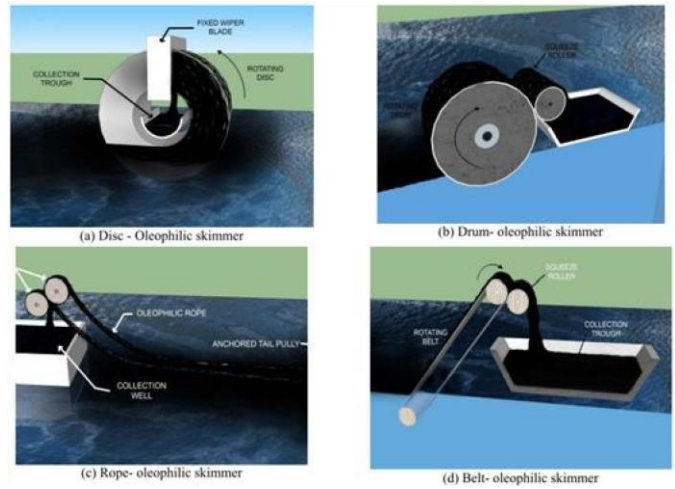

Fig. 3: Oleophilic Skimmers (Kuable 2011).

Patel (2013) concluded that belt-type oil skimmer significantly improved the oil recovery efficiency. The oleophilic belt was chosen as the best material to recover oil compared to steel, nylon, rubber, and polyurethane. However, Pawar et al. (2020) recommended polyurethane as the best material. Research by Widiaksana et al. (2018) analyzed the effectiveness of oil spill recovery using a disc-type oil skimmer. Based on the research done theoretically and experimentally, the increase in surface area of discs dipped in water increases the oil recovery significantly.

A more advanced oil skimmer was fabricated by Mathews et al. (2018), where a power source from solar was implemented. The oil skimmer robot has the ability to keep collecting oil for several weeks with the aid of a solar system with renewable energy. Recent research by Shirbhate et al. (2018) created an oil-skimming aqua robot to tackle the oil spill disaster. The robot helps to segregate the oil layer from the water and uses GPS to monitor the robot's location. Also, the ultrasonic sensor scans the level of oil collected in its storage.

All this fabrication and design research was done with minimal conscience of the user requirement of the Oil Spill Skimmer. It is due to difficulties for industrial engineers to analyze the user requirement. Only the aspects of technical requirements and designers'/researchers' opinions were considered while designing the oil spill skimmer. In conclusion, there is a need to consider user requirements and technical requirements to design and fabricate an Oil Spill Skimmer. The oil skimmer's maneuverability, however, was not specified as it is only stated that the oil skimmer could only float on water. There is no evidence of the oil skimmer's maneuverability in the literature examined. A dynamic skimmer is a device that is either moved through the water or stationery, and the water and oil are moved by it (Pawar et al. 2020). Most skimmers are designed to be dynamic. As a result, an oil skimmer with portability and maneuverability attributes must be designed and manufactured.

Multiple-Criteria Decision-Making (MCDM)

In manufacturing, there are several fundamental processes that need to be considered such as material selection, design development, performance analysis and after sales service. Concisely, the most crucial process that should not be ignored are design development and performance analysis. During design development stages, MCDM approach could be utilised (Renzi et al. 2017) whereas the precision functionality analysis could be used for performance evaluation (Abdullah et al. 2015). Due to the diverse and personalized functionality needed by end-users, decision-making in engineering design has drawn the interest of design engineers. The phases of the design process are affected by these personalized features. Many design criteria are now considered during concept exploration, model creation and selection, configuration design, and parametric design (Renzi et al. 2017). Multicriteria decision-making (MCDM) is a term for selecting the best option from a set of possibilities by weighing them against a set of parameters. When considering options, decision-makers should use multi-criteria decision-making approaches as scientific equipment. Researchers and engineers have suggested and implemented a variety of MCDA approaches to decision-making in engineering design. Choosing the right MCDA approach to compare various options is crucial since different methods will generate different outcomes for the same problem (El Amine et al. 2014).

Application of MCDM

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

Anugraha et al. (2019) researched the best concept selection of dry-soybean machines using the TOPSIS method. The method successfully selected the best concept in which the defect rate is lowered to 6.5 percent, and the manual separating process is removed. Water consumption is reduced to 800 liters per 35,125 kg of tempe produced. A critical review done by El Amine et al. (2014) proved that TOPSIS was the approach that was more compliant with decision makers' preferences since the findings produced were very respectful of the decision makers' preferences after comparing several types of multi-criteria decision analysis (MCDA) by ranking alternatives. In the initial conceptual design phase for aircraft production, a method of assessing and selecting different alternative configurations based on devised standards using AHP, TOPSIS, and QDF was researched by Bae et al. (2017).

A hybrid Fuzzy TOPSIS and multi-objective particle swarm optimization (MOPSO) implementation of a multidisciplinary product optimization was introduced by Renzi and Leali (2016) for solving issues related to the conceptual design of heel tips for women's shoes. In addition, unique parameters have been introduced within the MOPSO to improve solution precision and reduce the computational cost, such as the chaotic inertia weight. For the final selection method from the Pareto front, Jafaryeganeh et al. (2020) conducted a comparative analysis using Weighted Sum, Weighted Product, TOPSIS, and ELECTRE for determining the evaluated rank of alternatives.

An article investigated seven widely used multi-criteria decision-making assisting approaches (weighed sum, weighted product, compromise programming, TOPSIS, quadratic mean, and ELECTRE I) (El Amine et al. 2016). Thus, the weighted product was determined to be the optimum multi-criteria decision-helping technique based on these criteria.

Analytical Network Process (ANP)

A novel mixture of fuzzy decision-making trial and assessment laboratory (DEMATEL), undefined analytical network method (ANP), and fuzzy technique for order choice by similarity to ideal solution (TOPSIS) was used by Vinodh et al. (2016) in the analysis to improve the effectiveness of concept collection. Liu et al. (2021) published a paper to propose a realistic approach for dealing with pandemic circumstances through urban

furniture design, utilizing an integrated technique of Quality Function Deployment (QFD) and Analytic Network Process (ANP). The research focuses on the design selection of a product to select the best quality design of a wheelchair by using Analytic Network Process (ANP) as the decision-making method. Also, the Theory of Inventive Problem Solving (TRIZ) was used to solve several issues related to the market demand for wheelchairs (Hambali & Amira Farhana 2018).

The combination of the theory of innovative problem solving (TRIZ), morphological chart, and analytic network process (ANP) was used in the recent advanced design creation of a creep testing rig for a full-scale cross-arm (Sharaf et al. 2020). This technique is a rigorous concurrent engineering process for developing concepts, refining ideas, developing design methodologies, and selecting the best option. Asyraf et al. (2019) used similar hybridized approaches to create and choose the best design idea for product development based on product design criteria (PDS). By integrating the theory of innovative problem solving (TRIZ), morphological chart, and analytic network process (ANP) techniques, a study was conducted to analyze the framework of the conceptual design of a portable fire extinguisher constructed of carbon fiber-reinforced polymer composites. It displays the ability to generate ideas, create design methods, and choose the best design concept (Asyraf et al. 2020).

VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

In the presence of competing and non-commensurable (attributes of separate units) parameters, VIKOR is an MCDM approach that focuses on rating and choosing from a finite range of viable alternatives. It uses a multi-criteria rating index to determine how similar a solution is to the "ideal". Mardani et al. (2016) stated that as a consequence, the derived compromise solution is a realistic solution nearest to the positive ideal solution and the furthest from the negative ideal solution. A compromise is described as an agreement achieved by mutual compromises between the alternatives.

Research by Qi et al. (2020) identifies the best product idea that matches or exceeds most consumers' standards while still adhering to design requirements. In IR-VIKOR, customers' preferences for design attribute values, significance scores of design criteria, and features are integrated to find the best solutions for generating the rough evaluation index of each design alternative. Furthermore, in comparing the types of VIKOR methods, Chatterjee and Chakraborty (2016) found that fuzzy VIKOR is preferred to other VIKOR methods. Traditional VIKOR and fuzzy VIKOR and robust and updated VIKOR processes are found to behave similarly.

Analytical Hierarchy Process (AHP)

The Analytical Hierarchy Method (AHP) is a decision-making tool developed by Saaty Thomas (1980) that aims to enhance the decision-making of engineers and researchers. In the analysis by Ayu Nariswari et al. (2019) in handling the stock of spare parts in the aircraft industry, the use of AHP can be seen. The findings indicate that AHP can lead to a highly informative, accurate, straightforward, rapid, and systematic classification model with an output comparable to traditional approaches. AHP has also been utilized by Du et al. (2020) to select the right remanufacturing of heavy-duty machine tools. The result indicates that the AHP classification model is more efficient and transparent than the current mathematical models.

Researchers have combined many approaches with AHP in their studies in recent years. (Diouf & Kwak 2018), for instance, incorporated Fuzzy Analytical Hierarchy Method (FAHP) and Data Envelopment Analysis (DEA) to rate and pick their company's best supplier. The research study found that other businesses facing similar challenges would adopt both the AHP and DEA systems. Also, Yazdi (2017) mentioned that the combination of fuzzy fault tree analysis (FFTA) and FAHP was added in a case study. The research aims to apply FAHP to improve the objectivity of experts' opinions and test them by FFTA for failure likelihood analysis.

AHP has also been used widely in ergonomics and has been reviewed by Abdul Aziz et al. (2018). The key aim of the study was to determine and verify the potential of work-related musculoskeletal disorders (WMSD) by using AHP to calculate the risk factor. In addition, the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and AHP was paired with the aid of the Human Factor Analysis and Classification Scheme (HFACS) to classify human error causes in emergency departments (Hsieh et al. 2018). Besides, Nazim developed the AHP-SCOR Integrated Model (ASIM) to facilitate decision-making in the supply chain (Nazim & Yaacob 2017). They evaluated the best provider and picked it according to the parameters chosen.

Using the Analytical Hierarchy Process (AHP) system to analyze the development of a suitable wheelchair configuration, Ahmad et al. (2017) conducted research to improve the design of existing wheelchairs to reduce

physical tiredness and promote older persons' independence or ability. A study by Liao and Chen (2018) suggested using the renowned benefits, opportunities, costs, and risks (BOCR) as an assessment factor and using the AHP decision model and sensitivity analysis to assess organizational results. Sensitivity analysis can determine the best solution to developing criteria to understand the complicated relationships among competitive advantages.

Advantages and Disadvantages of Multi-Criteria Decision-Making Method

According to Siksnelyte-Butkiene et al. (2020), the distinguished advantages and disadvantages of MCDM methods will help to establish which way is the most suitable for the assessment of design selection, technologies, and many more. Finding common MCDM approaches and characterizing their strengths and weaknesses is a crucial step in developing the research's framework. This process leads to a survey of users to ascertain which benefits and downsides are more prevalent for each methodology (Velasquez & Hester 2013). Table 1 shows the advantages and disadvantages of MCDM methods.

Kansei Engineering

A literature review by Vieira et al. (2017) on Kansei Engineering (KE) claimed that it aims to define the feel-good aspect of the client in a product's design process. Ginting & Ali (2019) noted that the Kansei Engineering (KE) goals are to recognize human needs and preferences and provide mathematical and statistical attributes to relate technical requirements with responses. A comment in a study from Mele & Campana (2018) is that it is possible to create a successful interface between human and virtual design environments by integrating KE to incorporate both engineering specifications and consumer experience in product design. This technique is used to improve customer satisfaction by developing the product.

Hartono (2020) integrated the Kansei Engineering approach along with Kano and TRIZ in a study. By enhancing consumers' quality, imaginative ideas, and emotional satisfaction, the new approach was tested and effective. Also, the integration of KE with Kano and QFD can be seen in a study by Hartono et al. (2017) conducted to strengthen the computational structure of a logistics operation. The combined strategy effectively appreciates what can be understood and adopted by the service provider in optimizing the services offered while concentrating on prioritized options for limited capital. On top of that, in a surgical glove case report, Ginting & Ali, (2019) integrated KE and QFD. The study findings demonstrate that the integration of KE and QFD defines more acceptable technological goals for the technical characteristics used in the quality and quantity of a component. The single semantic product of the CNC machine is difficult to express the shape features effectively, and therefore cannot effectively meet users' relatively vague semantic preferences. Thus, according to Chen et al. (2012), there is a need

Table 1: The advantages and disadvantages of the Multi-criteria Decision Making (MCDM) method.

Method	Advantages	Disadvantages	Source
AHP	• One of the most often employed techniques and often combined with others. As compared to other MCDM systems, this approach is faster. • The approach has a comprehensible logic that is commonly used to answer energy policy/project selection questions, and it is also widely used for technology assessment and location selection. • In comparison to other approaches, the computing method is elementary. • Since the approach is based on a hierarchical system, it focuses more on each analysis parameter.	• A dditional research is needed to confirm the findings, and different parameter hierarchies can affect the weight allocation differences. • W hen it comes to assigning weights, the more engineers involved, the more complicated the issue gets. • Interdependence among alternatives and goals may contribute to an erroneous outcome.	(Kaya et al. 2018, Kumar et al. 2017, Siksnelyte et al. 2018, 2020)
TOPSIS	• T OPSIS is a very simple to compute and algorithmically organized approach that significantly simplifies implementing it. • T he principle is represented in a straightforward mathematical structure that has logical and understandable logic. • Because of its simplicity, it is one of the most widely used MCDM techniques • I n terms of the idea of being separated from optimal systems, it has a genuinely instinctive physical significance.	• T OPSIS, in its standard form, is deterministic and ignores ambiguity in weightings, making it easy to use but potentially unstable. • This approach is suitable for a challenge with a single source of information only. • It functions mainly on the principle of Euclidian distance and thereby ignores the distinction between negative and positive factors.	(Abdulgader et al. 2018, Jato-Espino et al. 2014, Kumar 2018, Siksnelyte et al. 2018)
VIKOR	• R emoves the effect by calculating the combination between positive and negative ideal solutions. • In the measurement phase, the approach accepts the value variations. • adapted to respond to a variety of energy issues	• W hen a conflicting issue happens, it may be challenging to be dealt with. • When working with different types of data, modifications are needed because modeling a real-time model becomes difficult.	(Gul et al. 2016, Liao et al. 2014, Liu et al. 2014, Siksnelyte et al. 2018)
ANP	• The ANP method considers the feedback relationship and between model stages and the interconnections among components. • I t shows how the criteria in the objectives or higher-level success criterion are interdependent and affect each other.	• A complicated mathematical process • In ANP, multiple pairwise comparison matrices are needed more than in AHP. • It can't be judged solely based on one aspect. • It is more time-intensive and more complex than the AHP.	(Chou 2018, Jato-Espino et al. 2014, Wu et al. 2018, 2019)

to build a combination of product semantics corresponding to user semantics preferences and obtain the product features corresponding to this combination of semantics. Thus the Kansei Engineering approach is introduced. Kansei Engineering technology discusses how to transfer consumers' imagined feelings towards a product into the technology of its design elements to communicate product aesthetics concepts and images through the scientific analysis method. Also, it can be applied to almost all industrial design fields, including the design of heavy machines such as CNC machine tools (Chen et al. 2017).

Furthermore, until recently, the emotional aspects of machine tool design were overlooked. With the advancement in the industrial design of machine tools, it is essential to statistically and adequately comprehend the users' emotional expectations; thus, Kansei Engineering is implemented (Liu et al. 2013). Mental concepts of users are often challenging to identify and, consequently, a satisfactory product is difficult to design (Huang et al. 2012). In particular, designing injection molding machines (IMMs) often lacks user feedback and relies heavily on manufacturers' technical specifications and imaginary targets. Technical specifications are frequently used to make decisions on which machine to buy or use. Although these technological characteristics can be assessed, critical machine needs, such as simplicity of use, safety, and robustness, are challenging to quantify and compare. As a result, Mondragón et al. (2005) use Kansei Engineering to demonstrate how the technique may measure the perception of those aspects.

Combination of AHP and Kansei Engineering

In recent years, researchers have thoroughly researched the adaptation of KE and AHP. The priority of emotional architecture in KE was studied by integrating the AHP process (Syaifoelida et al. 2018). In the user requirement aspect, the design of the car center stack was analyzed based on their emotional feelings, and the produced designs were evaluated using AHP to choose the best design. Besides, AHP and Kansei were used to investigate the

interface architecture of electric cars (Wu & Kang 2020). Meanwhile, Impho et al. (2018) constructed a drinking water filtering system using AHP, KE, QFD, and TRIZ. KE was combined with QFD to achieve consumer specifications, whereas TRIZ was used to solve issues around technological requirements.

In deciding the technique for selecting the right music school, AHP and KE were also included. When used to create selection programs and evaluation frameworks for choosing music colleges, the variants of the Nagai method (5W1H), AHP, ISM, and GRA were tested (Sheu et al. 2016). Interface modeling using KE and AHP for mobile learning has been researched (Hadiana 2017). As a result, a mobile learning system interface prototype based on an emotionally dynamic and easy concept was launched to have a high effect on the interface and increase the accessibility of the mobile learning system. AHP and KE were introduced in the design of Jun Porcelain to reinvent the graphic style and improve the tradition (Chai et al. 2016). In promoting the business process in an organization, the application of a helpdesk plays a significant role. Therefore, Hadiana & Abdurrohman, (2018) analyzed clients' desires in terms of emotions using KE and AHP to optimize the new helpdesk framework. A research was conducted by Huda & Hadiana, (2020) to study consumer emotions against the existing helpdesk framework. The best alternative recommendations were selected using AHP to enhance the current helpdesks with the affected parameters.

Environmentally focused technologies such as oil spill skimmers have been created chiefly only through the efforts of engineers, as so few to none emerge from the skimmers' potential consumers. As customer perceptions of oil spill skimmers can shift from time to time, it is important to adjust this design technique, creating the need to integrate consumers into the design process. Kansei Engineering and Analytical Hierarchy Process (AHP) are the two commonly used techniques for integrating user requirements into engineering architecture. Nevertheless, in the design and development of technologies relating to products for environmental protection, the AHP, and Kansei Engineering strategy is somewhat lacking. The AHP and Kansei Engineering methodology can be extended to the design and manufacture of products for environmental protection.

CONCLUSION

In conclusion, the fabrication of a portable oil spill skimmer lacks the involvement of user requirements. An oil spill is a disaster that could harm the environment and the ecosystem. Although there are several techniques to overcome the tragedy, the mechanical methods themselves have some limitations. Due to its limitation, a portable oil spill skimmer is a complementary technique that helps the boom and skimmer technique collect the oil residue. Thus, it eliminates the reset-up boom and skimmer, which consumes a lot of workforce and cost.

The development of conceptual designs starts with implementing the Kansei Engineering method to analyze the user requirement and technical specifications through human emotion and feelings. AHP has also grown in popularity as a tool for organizing, analyzing, and modeling complicated choices. As a result, AHP is used to pick the most refined Kansei Engineering-developed conceptual design. This article sought to explore Kansei Engineering and AHP's use in product design development to understand Kansei Engineering and decision issues that AHP might effectively address. The paper's goals were to summarise current literature on Kansei Engineering and AHP applications in the design development process and determine user and technical requirements using Kansei Engineering and choose the optimum conceptual design using AHP.

The study indicates that the fabrication of an oil skimmer was more concerned with technical specifications than with customer requirements. As a result, technical requirements cannot be directly compared to robustness, safety, or ease of use. Kansei Engineering can therefore be used to assess the robustness, safety, and ease of use of the system. There was also no argument or evidence that the oil spill skimmer could be maneuvered. The findings from the articles also show that there is a limitation in the design and development of technologies related to environmental protection goods and the AHP and Kansei Engineering applications.

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