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A REVIEW OF MULTICRITERIA DECISION MAKING APPROACHES: A CASE STUDY ON SELECTION OF CUTTING FLUIDS

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Abstract

Surface grinding is a metalworking process that removes materials from such a soft work piece surface by rapidly rotating an abrasive grinding wheel. Because it offers better surface texture, accurate geometries, and surface quality at lower costs and better material removal rates, surface grinding is a common machining technique in the industry. Surfaces that are perfectly flat and/or smooth can be produced using surface grinding machines for machine parts. To produce precision parts, most grinding machines must use grinding wheels whose size are appropriately matched to the job. The grinding machine carries the part having ground under the grinding wheel while rotating the grinding wheel incredibly quickly and holding it perfectly in position. With each passing over a work piece, surface grinder can eliminate as little as one thousandth of an inch of material.

Keywords: MCDM, WASPAS, Machining, Cutting Fluid.

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1. Introduction

In the grinding process of machining, an abrasive grinding wheel is rotated at a high speed to remove material from a softer work piece surface. Cylindrical grinding is a popular machining method in the industry because it produces improved surface quality, precise geometry, and better surface finish at lower costs and higher material removal rates. Surfaces of machine parts produced by cylindrical grinding machines may be perfectly smooth. These grinding machines require the use of grinding wheels whose size is adequately matched to the task in order to produce precision parts. The grinding machine moves the part having ground under the grinding wheel while rotating the grinding wheel incredibly quickly and holding it perfectly in position. With each pass over a work item, cylindrical grinders can eliminate as little as one thousandth of an inch of material. In spite of mechanical considerations, environmental concerns are now especially crucial in every manufacturing company because they cause significant complications when the product is being made. Because cutting fluid used during the manufacturing process is the main source of health and environmental risks, the ISO-900 quality management system standards, the ISO-1400 environment management system standard, and the OHSAS-18001 which belongs to work place related health and safety management series were all available for the entire manufacturing industries.

"To enhance the ongoing tribological processes on the tool-work piece contact surfaces, cutting fluids were introduced into the cutting process. Cutting fluids help to faster, more economical cutting speeds and increase the effectiveness of the entire manufacturing system. Although they are frequently employed as a coolant in the machining process to maintain a smooth machining operation, cutting fluids are actually a significant source of pollution. Modern production places a rising emphasis on carefully choosing effective cutting fluids that are both efficient and environmentally benign because of the multiple negative effects that cutting fluid wastes have on people and the environment" (Mardani et al., 2015).

"Making decisions is essentially a mental process that humans engage in. Making decisions has always been one of the most challenging tasks for humans, dating back to ancient times. In general, it is influenced by a number of factors, including people, institutions, groups of people, and environmental factors. In the case of humans, decisions such as choosing home utilities, selecting the best school or institute, and selecting a career play an important role in daily life. However, at the organizational level, it is one of the most difficult and difficult duties, such as selecting qualified employees for the company. When decision-making procedures were first used at an industrial level, they were organized into several options and analyzed using numerous conflicting criteria, which made things more complicated" (Malkin and Guo, 2008).

2. Literature Review

In the grinding process of machining, an abrasive grinding wheel is rotated at a high speed to remove material from a softer work piece surface. Cylindrical grinding is a popular machining method in the industry because it produces improved surface quality, precise geometry, and better surface finish at lower costs and higher material removal rates. Surfaces of machine parts produced by cylindrical grinding machines may be perfectly smooth. These grinding machines require the use of grinding wheels whose size is adequately matched to the task in order to produce precision parts. The grinding machine moves the part having ground under the grinding wheel while rotating the grinding wheel incredibly quickly and holding it perfectly in position. With each pass over a work item, cylindrical grinders can eliminate as little as one thousandth of an inch of material. In spite of mechanical considerations, environmental concerns are now especially crucial in every manufacturing company because they cause significant complications when the product is being made. Because cutting fluid used during the manufacturing process is the main source of health and environmental risks, the ISO-900 quality management system standards, the ISO-1400 environment management system standard, and the OHSAS-18001 which belongs to work place related health and safety management series were all available for the entire manufacturing industries.

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Since 1960s, multi-criteria decision making (MCDM) starts gaining its popularity. It becomes most emerging field for research. MCDM techniques have been applied in various fields. Due to ease to apply, these methods are very helpful for ranking the alternatives wherever there is any ambiguity while making decisions. "Over the most recent couple of decades, a number of MADM methods and their different invariants, for example, simple additive weighting (SAW) (Churchman and Ackoff, 1954), the analytic hierarchy process (AHP) (Saaty, 1986), VIekrite-rijumsko KOmpromisno Rangiranje, or the multi-criteria optimization and compromise solution (VIKOR) (Opricovic and Tzeng, 2004), Technique for the Order of Preference by Similarity to an Ideal Solution (TOPSIS) (Hwang and Yoon, 1981), Preference Ranking Organization Method for Enrichment of Evaluations (PROME-THEE) (Brans et al., 1986), Elimination and Choice Translating Reality (ELECTRE) (Benayoun et al., 1966), and grey system theory (Julong, 1989) have been introduced to discover the solution for a bunch of activities relying upon conflicting criteria. Bodin and Gass (2004) explained the root theory of analytical hierarchy process (AHP) to the students of business administration on the basis of six exercises. Exercises contains: i) Explanation of the pair-wise comparison scale; ii) analysis of sensitivity and inconsistency; iii) ratio scales; iv) the rating models; v) approach to solve AHP problem; vi) AHP and resource allocation" (Chatterjee and Chakraborty, 2012). Dagdeviren (2008) "implemented a combined model of AHP and PROMPETEE for the selection of milling machines for an effective manufacturing system. Ic et al. (2012) developed AHP model for selecting machining parameters and compared with two other MCDM techniques" (Chatterjee and Chakraborty, 2012).

"Opricovic and Tzeng (2004) had worked together for comparative evaluation of two eminent methods i.e., TOPSIS and VIKOR. Their research significantly focuses on the similarities and differences between the methods which were demonstrated with the help numerical illustrations. Srikrishna et al. (2014) adapted TOPSIS method to solve the problem correlated to the purchasing of automobiles and specifically for new customers would like to buy car. Their work suggests the buyers to purchase a car with top specification at moderate cost. Yang et al. (2009) developed a new VIKOR method to appraise the decision makers with projects gaps and aid to improve these gaps. Chang and Hsu (2009) had involved VIKOR method to confer a concrete solution in order to rank the land-use restraint strategies. Digkoglou et al. (2017) employed integrated model by combining two MCDM techniques i.e., AHP and VIKOR to assess the ranking of eight European countries on the basis of their hotel and tourism facilities. In this paper AHP method involved to collect the values of criteria and further with the aid of VIKOR method ranking of alternatives had been determined. Singh and Malik, (2014) had developed this paper to select the most fit alternative from the various option by the help of three MCDM method i.e., WSM, AHP and TOPSIS"Chatterjee and Chakraborty (2012).

In spite of the fact that OCRA can be classified as a once in a while utilized MCDM method. This technique was developed by Parkan in the year 1994 (Kundakci, 2017). The method OCRA had been effectively utilized for solving various decision-making issues in various regions. for example, execution and efficiency measurement (Parkan and Wu, 1997 and 1999; Ozbek, 2015 and 2016), manufacturing (Jayanthi et al., 1999; Madic et al., 2016; Chatterjee and Chakraborty, 2014), the site selection (Chakraborty et al., 2013), the material selection (Chatterjee and Chakraborty, 2012; Darji and Rao, 2014), the hotel selection" Isik and Adali, 2016, etc

Much heat is produced in the cutting zone while machining operations as a result of friction between the work piece material, chips, and cutting tools as a result of the plastic deformation of the work piece material. The heat generation raises the temperature of the tool tip as well as the work piece, that reduces hardness and reduces the life of the tool. For cutting fluid selection, a work piece temperature prediction is

crucial (Tanikic, 2010). Additionally, the surface finish would be much less smooth, as well as the likelihood of a built-up edge will rise (Rao, 2007). Cutting fluids and lubricants are frequently used in the metal cutting industry during machining operations to minimize friction, heat transmission, and to eliminate tiny metal particles from the cutting zone (Abhang and Hameedullah 2012). Friction reduction decreases cutting forces while machining and slows down the wear process of the cutting tool, extending tool life. Although the actual machining operation can be completed without using cutting fluids, the quality of the work piece surface will suffer and tool wear will be more severe (Rao, 2007).

Different properties of cutting fluids/lubricants include cooling, lubricating, mechanical, diffusing, and flushing. Cutting fluids must also meet a few other criteria, such as not being toxic to people or the environment, being easily biodegradable, and not producing smoke while being used in machining. The right choice of cutting fluids is crucial since they perform numerous helpful activities during machining while also accounting for a significant amount of the overall manufacturing cost. In order to reap the greatest benefits from any machining process, the best cutting fluid must be chosen (Akir et al., 2007). But as Rao (2007) pointed out, choosing cutting fluids is more of an art than a science because there isn't really a standardized procedure for this purpose. The current method of choosing a cutting fluid for any specific machining application is primarily determined by the combination of the materials used for the work piece as well as the machining process itself.

The features of the machining process are the most crucial factor in the choosing of cutting fluids. Different machining techniques would show a connection between the work piece material, cutting tool, and chip combinations. More cutting fluid will be required for the toughest machining operation (Çakīr et al., 2007). The competing cutting fluids are often assessed by taking into account a number of crucial machining performance metrics, including standards for dimensional accuracy, tool wearing, cutting forces, and heat in the cutting zone. Production engineers, who are responsible for making decisions in a manufacturing environment, can rely on the usage on multicriteria decision making or MCDM approaches because they have been shown to be effective mathematical tools for handling ranking and selection issues. According to the literature, there are still very few instances where MCDM techniques are used to address lubricant/cutting fluid selection issues (Rao, 2007).

For the selection, identification, and comparison of cutting fluids, Rao and Gandhi (2002) presented the graph theory and matrix approach (GTMA) method. In order to assess the effectiveness of grinding fluids, Sun et al. (2001) described a two-grade fuzzy synthetic decision-making system that makes use of an analytical hierarchy process (AHP). Tan et al. (2002) created a multi-objective decision-making model for the gear hobbing process choice of cutting fluid. The acquired findings demonstrated the developed model's applicability and usefulness. Rao (2004) suggested a mixed multiple attribute decision making method for the performance assessment of cutting fluids for green manufacturing. On two examples, Rao (2007) showed how various MCDM techniques, including the GTMA, the simple additive weighting (SAW) method, the weighted product method (WPM), the AHP and its variants, the technique for order of preference by similarity to ideal solution (TOPSIS), and modified TOPSIS methods, could be used. The improved preference ranking organization technique and enrichment evaluation (PROMETHEE) technique was used by Rao and Patel (2010) to offer a method for such selection of cutting fluids.

Abhang & Hameedullah (2012) used the integrated TOPSIS and AHP approach to choose the cutting fluids while using tungsten carbide inserts to machine En-31 steel work pieces. The application of the weighted aggregated sum product assessment (WASPAS) method for resolving various decision-making issues in the manufacturing enterprise, including the cutting fluid selection problem, was examined by Chakraborty and Zavadskas in 2014. Deshamukhya & Ray (2014) created a decision support in an unstructured setting utilizing the AHP technique in order to choose the best cutting fluid with the least negative effects on the environment. Three cutting fluids being taken into consideration, and the one with the most beneficial characteristics was chosen as the best cutting fluid to support green manufacturing. The proposed model took into account the following factors: cost, quality, and environmental impact. Jagadish and Ray (2014) analyzed the recently created MCDM approach, known as the multiobjective optimization somewhat on basic principle of simple ratio analysis (MOOSRA) method, using the MCDM model created by Deshamukhya and Ray (2014). When turning AISI304L, Tiwari and Sharma (2015) developed a decision matrix for choosing the best cutting fluid. Two MCDM approaches were used to evaluate and rank various vegetable and industrial cutting fluids, according to Chakraborty & Zavadskas (2014).

The aforementioned literatures make it clear that many researchers have conducted extensive research on MCDM selection problems in the past using a variety of MCDM approaches, primarily complicated as well as time-consuming old traditional techniques like TOPSIS, PROMETHEE, ELECTRE, etc. However, there will be a need using a simple, clear, and systematic formula to guide a decision-maker through creating an accurate selection of best cutting fluid for a specific engineer. This study's primary goal is to assess the applicability and capabilities of two MCDM approaches, COPRAS and ARAS, for determining which cutting fluid or coolant is best for a particular engineering application. It is clear that none of these MCDM methods has been used to their full potential, and there have been relatively few engineering-related applications, particularly in the field of cutting fluid selection. Therefore, there is a fantastic chance to investigate these two MCDM strategies in more detail and use them to show how well they work to solve cutting fluid selecting decision-making problems (Haksiz,2014)

3. Conclusion

In this work, cutting fluid selection issue for an industry situated in Industrial area Bhilai has been considered and analyzed profoundly. The basic requirement for the industry is to choose best cutting fluid for cylindrical grinding operation. The industry management meant to choose the most suitable cutting fluid for their work environment. Under this circumstance, four cutting fluids are under consideration and feasibility of MCDM techniques are needed to be checked. The Entropy approach, Additive Ratio Assessment (ARAS), and Weighted Aggregate Sum Product Assessment (WASPAS) methods are successful applications of these concepts, which are branches of MCDM. Utilizing the weights derived using the Entropy approach, the ARAS and WASPAS strategies will be tested, and the options will be ranked. in order to choose the ideal lubricant throughout cylindrical grinding operations from a variety of lubricants. Eight parameters, including wheel wears (WW), tangential forces (TF), grinding temperatures (GT), surface roughness (SR), recyclability (R), toxic harm rate (TH), environment pollution propensity (EP), and stability, were used to evaluate four cutting fluids, or alternatives (S). R and S are the only helpful factor out of the eight selection criteria. Water soluble based, straight mineral oil based, chlorinated oil based, and sulfochlorinated oil based are the four options being considered (Rao, 2007).

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