Techniques Used in Selection of Material: Literature Review

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Abstract*—This The selection of materials must include technical aspects, industrial design and environmental considerations to ensure material function safely at low cost throughout the product life cycle. In this globalized era, organizations are focusing to make sound decisions which help in successful operation of business. The justification of decision in evaluation processes is highly recommended prior to execution. In this paper, a systematic review on material selection approach has been addressed. An attempt has been made to identify the MADM approaches used in evaluation of material. Literature showed that AHP method is most frequently used by researcher to find subjective weights of attributes. It has been observed that application of hybrid weight makes the ranking of alternates more reliable.

Keywords*—Material Selection, MADM methods, Literature review

INTRODUCTION

A material consists of numerous properties such as mechanical properties, thermal properties, environmental properties, chemical properties etc. The design manager, material manager and production manager must involve in material selection process to extract properties which are related to the application of product. Innovation and improvement in material science & technology are success factors to improve competitive strategies of organizations. The performance of group decision making depends upon the mood of individual (Staw and Barsade, 1993). The decisions without supporting methodology may be biased and not appreciated by top management. Now days, organizations are focusing on group decision making process rather than individual's decision to reduce risk factor.

The exponential growth in development of advanced material adversely affects the material evaluation process. The material evaluation approach must not be restricted to design of new product or redesigning of products but should be done during intermediate stages of product development (Karana et al., 2008).

The Chinese market is dominating Indian market in terms of production volume and number of manufacturers. In material selection process, extra attention is required towards design parameters such as functional requirements, process ability, and resistance to service conditions etc. to compete in globalized world. The wrong choice of materials may reduce the quality of product and hence performance of industry. The use of mechanical properties such as density, elongation, strength should be done according to the application of product. The applications of product also help to differentiate the beneficial and non-beneficial attribute. The role of decision maker is much crucial to find appropriate best alternate during selection of material.

The purchase department is involved in many evaluation processes such as selection of vendor, material, process etc. Top management has taken initiative and given alert that evaluation process must be done by group decision making process and supported methodology. To accomplish the objective of organization, a problem of material selection is demonstrated by using multi MCDM approaches. The article is structured as follows: Section II narrates the review of literature related to selection of material, Finally, Section III provide the summary of present work.

REVIEW OF LITERATURE

Researchers have used various MCDM techniques in evaluation problem. Literature revealed that analytical AHP/ANP technique is most frequently used in selection problems. A few researchers have used hybrid methodology in material selection problem depending upon the complexity of problem. The literature based on material selection method was narrated in functional manner. The

importance of material selection in different functional discipline was well defined. The Guidelines were provided for material evaluation especially in engineering design (Sapuan et al., 2009).

A. MADM techniques used in material selection problem

Peng and Xiao, (2013) used two MADM approaches named as PROMETHEE and ANP in material selection of journal bearing. The ANP was implemented to find weightage of attributes and later on PROMETHEE was used to achieve final ranking of alternates. Graphical user interface-based (GUI-based) software was used for mathematical computation.

Milani et al., (2013) applied ANP approach to solve a MADM problem of material selection. The multifunctional design parameters such as thermal performance, mechanical performance, and weight were considered as criteria to solve a material selection problem of non-metallic gears.

Girubha and Vinodh, (2012) made an effort to apply VIKOR approach under fuzzy environment for the selection of instrument panel material. The environmental aspects of problem were included in case problem. Polypropylene was found to be the best alternate material for the case problem i.e. instrument panel.

İpek et al., (2013) used a simply expert system approach for selection of material in manufacturing environment. The selection of material for bumper as well as flywheel has been experienced by using different properties. The results showed that stainless steel and polymeric materials viz. polyvinyl chloride and PE were suggested as the good materials in automotive industry and the results were also compared with past researcher results.

B. Hybrid/Novel/modified MADM techniques used in selection of material

Rao, (2006) used the application of graph theory and matrix approach to find best alternates in material selection problem. A new term material suitability index was proposed and ranking of alternates was done on the basis of material suitability index. Two examples were explained to show the effectiveness of proposed methodology.

Manshadi, et al., (2007) prpresented a novel approach consists of digital logic method and non-linear normalization for selection of materials. Two case examples of mechanical design have been demonstrated to show the consistency of proposed methodology. The obtained results were compared with existing classical weighted property method to ensure the validity of proposed novel approach.

Rao and Patel, (2010) presented a innovative integrated MADM method for material evaluation process. The proposed methodology included objective weight of importance and subjectivity preference value. The fuzzy logic was used to convert qualitative data in to quantitative data. Three material selection examples of a high-speed naval craft, flywheel and cryogenic storage tank were presented to validate the proposed method.

Maniya and Bhatt, (2010) developed a novel preference selection index (PSI) for decision making problem. Three material selections problems were demonstrated and obtained results were compared with traditional MADM approaches. It was observed that results of PSI have good correlation with published results by using TOPSIS and GTMA. It was recommended to use PSI index due to its simplicity.

Jahan et al., (2011) presented a modified version of VIKOR method for problem of material selection. A modified normalization technique has been developed to minimize the short coming of existing VIKOR method. Five different examples have been demonstrated to show the effectiveness of proposed modify VIKOR approach.

Karande et al., (2013) presented utility concept and desirability function method for selection of material. The proposed mathematical approach is easy to apply and having strong fundamental logic in mathematical techniques. The results were compared with existing published work to show the effectiveness of present method.

Liu et al., (2014) proposed a novel hybrid MCDM frame work for selection of material. The proposed methodology included DEMATEL-based analytical network process (DANP) and modified VIKOR based on both target based criteria and beneficial criteria. A selection problem of bush material was demonstrated to show the effectiveness of proposed frame model.

Kasaei et al., (2014) presented a modify QFD tool to optimize the process of material selection. The proposed work showed that modified QFD can capture a large number of attributes which results in more appropriate selection of material. Two case materials selection problems of mechanical engineering design has been demonstrated to present the effectiveness of modify QFD approach.

Liao (2015) used type-2 fuzzy based TOPSIS concept which help in finding the appropriate best desirable material. Two case examples were demonstrated to illustrate the effectiveness of type-2 fuzzy based TOPSIS method.

Nelson et al., (2016) made an attempt to apply integration compliant arrays (CAs) for material selection. An effective method having capability to analysis both the material and geometric properties was presented. The result were validated experimentally and demonstrated to show the application of method.

The rest of literature review is presented in Table 1.

Table 1. Literature review

S.No	Author	Year	Description
1	Fayazbakhsh et al.,	2009	*Presented Z*-transformation concept Overcome the limitation of digital logic methods
2	Mayyas et al.,	2011	Applied QFD and AHP Different grades of steel are best for BiW panels
3	Zander and Sandström	2011	Selection of material for cooling plate Considered heat flow and strength as design criteria Applied control area diagram
4	Jahan et al.,	2011	Presented a aggregation technique Guidelines were provided incase alternatives lead to similar performance
5	Chatterjee and Chakraborty	2012	Gear material selection problem
6	Ribeiro et al.,	2013	Material selection for Ecodesign by intergared analysis Selection decision was supported by mapping the alternatives.
7	Khorshidi and Hassani	2013	Selection of Al–5%SiC composite Applied AHP-TOPSIS and PSI
8	Hafezalkotob and Hafezalkotob	2015	Used MULTIMOORA method Solved material selection problem in biomedical application
9	Das et al.,	2016	Examine design parameters and material selection of gear Presented hybrid methodology

SUMMARY

Since last decade material selection become a emerging research field in material design field. In this paper, an effort has been directed to explore the application of various MADM approach in selection of material. It has been observed that researcher have used subjective as well as objective weights of attribute in selection of material. Moreover, researchers have used modified MADM and novel approaches as per the structure of decision matrix. The MADM method highlighted here could be used in any decision making process. The outcome of present study will help researchers to use correct MADM method in material selection.

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