

Chapter 15

Material Selection Using a Novel Multiple Attribute Decision Making Method

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ABSTRACT

Selection of a most appropriate material is a very important task in design process of every product. There is a need for simple, systematic, and logical methods or mathematical tools to guide decision makers in considering a number of selection attributes and their interrelations and in making right decisions. This paper proposes a novel multiple attribute decision making (MADM) method for solving the material selection problem. The method considers the objective weights of importance of the attributes as well as the subjective preferences of the decision maker to decide the integrated weights of importance of the attributes. Furthermore, the method uses fuzzy logic to convert the qualitative attributes into the quantitative attributes. Two examples are presented to illustrate the potential of the proposed method.

INTRODUCTION

An ever increasing variety of materials is available today, with each having its own characteristics, applications, advantages, and limitations. When selecting materials for engineering designs, a clear understanding of the functional requirements

for each individual component is required and various important criteria or attributes need to be considered. Material selection attribute is defined as an attribute that influences the selection of a material for a given application. These attributes include: physical properties, electrical properties, magnetic properties, mechanical properties, chemical properties, manufacturing properties, material cost, product shape, material impact

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on environment, availability, fashion, market trends, cultural aspects, aesthetics, recycling, target group, etc.

The selection of an optimal material for an engineering design from among two or more alternative materials on the basis of two or more attributes is a multiple attribute decision making (MADM) problem. The selection decisions are complex, as material selection is more challenging today. There is a need for simple, systematic, and logical methods or mathematical tools to guide decision makers in considering a number of selection attributes and their interrelations. The objective of any material selection procedure is to identify appropriate selection attributes, and obtain the most appropriate combination of attributes in conjunction with the real requirement. Thus, efforts need to be extended to identify those attributes that influence material selection for a given engineering design to eliminate unsuitable alternatives, and to select the most appropriate alternative using simple and logical methods.

Various approaches had been proposed to help address the issue of material selection (Ashby, 2004; Edwards, 2005; Sapuan, 2001; Zha, 2005; Jalham, 2006). However, these systems and methods are complex and knowledge intensive. Jee and Kang (2000) proposed TOPSIS method for material selection. Shanian and Savadogo (2006a, 2006b) presented material selection models using a multiple attribute decision making (MADM) method known as ELECTRE. However, ELECTRE method uses the concept of outranking relationship and the procedure is rather lengthy. Only a partial prioritization of alternative materials is computed in ELECTRE models. Shanian and Savadogo (2006c) proposed TOPSIS method for material selection of metallic bipolar plates for polymer electrolyte fuel cell. However, the TOPSIS method proposed by them does not take into account the qualitative nature of the material selection attributes. Further, the 'entropy' concept used by the authors for deciding the relative importance of attributes does not give

scope to designer's preferences and it involves more computation.

Rao (2006) presented a material selection model using graph theory and matrix approach. However, the method does not have a provision for checking the consistency made in the judgments of relative importance of the attributes. Rao and Davim (2006) proposed TOPSIS method combined with AHP for material selection. Manshadi et al. (2007) proposed a numerical method for materials selection combining non-linear normalization with a modified digital logic method. However, the method does not make a provision for considering the qualitative material selection attributes. Chan and Tong (2007) proposed weighted average method using grey relational analysis to rank the materials with respect to certain quantitative attributes. Rao (2008) proposed a compromise ranking method known as VIKOR and Chatterjee et al. (2009) proposed VIKOR and ELECTRE methods for material selection.

Fayazbakhsh et al. (2009) used Z-transformation in statistics for normalization of material properties for materials selection in mechanical design using. Khabbaz et al. (2009) proposed a fuzzy logic approach for material selection. However, the procedure needs many fuzzy IF-THEN rules and the quantitative values of the attributes are to be converted to fuzzy descriptions to fit into the fuzzy rules. Maniya and Bhatt (2010) proposed preference selection index (PSI) method for material selection. The method uses only the objective weights of the attributes and doesn't take into consideration the decision maker's expertise and judgment. Furthermore, the method doesn't have enough mathematical validity and no separate steps were suggested for conversion of a qualitative attribute into a quantitative one. Jahan et al. (2010) proposed a linear assignment technique for material selection. However, the linear assignment technique may not be as precise as other MADM methods when the material selection is based on quantitative material properties.

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