Applied Mathematical Modelling 38 (2014) 1052–1063

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

Application of fuzzy compromise solution method for fit concept selection

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ARTICLE INFO

Article history:
Received 2 August 2012
Received in revised form 16 June 2013
Accepted 16 July 2013
Available online 31 July 2013

Keywords:
Fit manufacturing
Lean manufacturing
Agile manufacturing
Multi Criteria Decision Making
Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR)

ABSTRACT

The modern manufacturing environment is highly turbulent so as to satisfy the dynamic needs of customers'. To enable the achievement of competitiveness in this complex business environment, newer manufacturing strategies have been introduced for enabling waste elimination and enhancing flexibility and responsiveness of systems. Fit manufacturing is a competitive manufacturing paradigm which includes lean and agile systems coupled with sustainable benefits. This article presents a study in which the concept selection in fit environment was formulated as Multi Criteria Decision Making (MCDM) problem and solved using fuzzy based compromise solution method, Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR). The selected concept design of automotive component was subjected to implementation in the case organisation.

1. Introduction

The increasing competition and dynamic customer demands forces the manufacturing systems to exhibit transition. The manufacturing systems witnessed a transition from craft-mass-lean-agile-fit era. Fit manufacturing [1] encompasses lean, agile and sustainable principles. Lean system focuses on waste elimination thereby enabling cost reduction. Agile system enables the production of variety of products within a short period of time in a cost effective manner [2]. Sustainability focuses on minimization of environmental impact and thereby developing environmentally friendlier products [3]. Fit system encompasses these principles for developing customised products. In the present study, there existed a need to select the best concept design of an automotive product. Since the concept design selection in the context of fit system is a typical Multi Criterion Decision Making problem, fuzzy based compromise solution method, Vlsekriterijumska Optimizacija I Kompromisno Resenje (VIKOR) [4] was used. The details of the study are presented in the following subsections.

2. Literature review

Fit manufacturing is an advanced manufacturing concept which includes the integration of principles of lean, agile and sustainable manufacturing [2]. Pham et al. [1] introduced a new manufacturing strategy by integrating lean and agile principles in order to achieve economic sustainability. This makes them ready to compete and survive in continuously changing market conditions and to attain product flexibility.

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http://dx.doi.org/10.1016/j.apm.2013.07.027

Pham et al. [5] proposed concepts for the company to find ways for achieving economic sustainability in competitive market. Fit manufacturing is achieved by integrating the principles of lean manufacturing, agile manufacturing and sustainability.

Pham et al. [6] proposed a principle by making interlinks between lean manufacturing, agile manufacturing in order to achieve sustainability. Then the relations between those concepts are grouped into four categories and proposed as the fundamental aspects of manufacturing system.

Pham and Thomas [3] proposed a concept to achieve economic sustainability and proceeded on the initial work made on fit manufacturing and proposed Fit Manufacturing framework and developed a model which is capable of managing all modern manufacturing challenges. Fitness of an organisation links in four major manufacturing themes which are: strategy, leadership, process and technology into a cohesive framework to deliver sustainability solution for industry.

Pham et al. [2] developed a fit paradigm. Using that paradigm, they proposed a new manufacturing management strategy which helps them to create an economically sustainable manufacturing organization. The general aims of integration, the different levels and types of integration, and the potential benefits and drawbacks are also being explained in this article.

Jeya Girubha and Vinodh [7] applied fuzzy VIKOR in material selection of an automobile component. Several criteria are selected for material selection along with weights for selection of proper criteria with various environmental considerations. MCDM technique is used for material selection. The main objective of this study is to provide an efficient method for selection of best material for an automobile component based on the application and material requirement. They demonstrated that fuzzy VIKOR could be used for effective material selection considering multiple criteria.

Shemshadi et al. [8] applied fuzzy VIKOR for supplier selection. In business environment efficient supplier plays a key role in the supply chain management. Hence proper and efficient decision making is required. Shannon entropy concept is used for selecting the proper weights suggested by decision makers. These weights are converted in form of linguistic terms and then transformed into trapezoidal fuzzy numbers. Then final result was obtained by fuzzy VIKOR and Shannon entropy concept.

Opricovic [4] applied fuzzy VIKOR in water resource planning. Fuzzy VIKOR was developed in order to prevent the problem with criteria having different units. Thus both weights and criteria are converted in terms of fuzzy numbers. Thus fuzzy VIKOR provides proper solution for multi criteria problem. Fuzzy VIKOR was applied in water resource planning for developing water harvesting system from Mlava River for enhancing the drinking water supply.

Devi [9] extended VIKOR method into fuzzy environment in order to solve Multi criteria Decision Making in which weights of criteria and alternatives are taken as triangular fuzzy set. This study enabled the selection of robot for material handling process.

Sanayei [10] proposed group decision making process for supplier selection with VIKOR under fuzzy environment. Selection of supplier is the major key in supply chain. The selection of supplier is considered to be a complex Multi- Criteria Decision Making method. In this paper linguistic values are used to represent the ratings and weights, and these linguistic values are expressed as trapezoidal or triangular fuzzy numbers. Then Multi criteria Decision Making model based on fuzzy set and VIKOR is proposed for supplier selection.

Vinodh et al. [11] presented the application of fuzzy VIKOR for concept selection in the context of agile systems. The best concept design was identified in the context of agility. The results derived from fuzzy VIKOR were compared with fuzzy TOPSIS.

2.1. Research gap

Only very few researchers concentrated on fit manufacturing paradigm; fit manufacturing research has been reported from the perspectives of development of concept model, and identification of enablers/criteria. There exists a vital need for exploring various research avenues in fit manufacturing. In this context, this case study reports the formulation of fit concept selection as a typical MCDM problem. Based on the prior studies, fuzzy VIKOR was found to derive compromise solution for several applications. Hence, fuzzy VIKOR was selected as solution methodology in the present study.

3. Methodology

The methodology followed during this case study is explained as follows: The first stage is the literature was reviewed on fit manufacturing and application of fuzzy VIKOR. Then it is followed by the concept model creation for selecting the best fit concept. After this, the input data are obtained from the experts of the case organisation in terms of linguistic variables followed by the conversion of these linguistic variables into trapezoidal fuzzy numbers. Next stage include processing these values and determining the utility, regret and VIKOR indices for the organisation followed by ranking of the fit concepts based on these indices. Finally, a compromise solution will be derived. The methodology is shown in Fig. 1.

4. Case study

The details about the case study are presented in the following subsections.