Chapter IV
Fuzzy Sets and Analytical Hierarchical Process for Manufacturing Process Choice

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ABSTRACT

The aim of this chapter is to investigate the decision process of manufacturing systems (MSs) under uncertain conditions. The decision process needs a systematic approach to structure the system requirements and highlight the management preferences while considering vague criteria. In order to establish a suitable empirical approach for the decision process compatible with the current/future requirements, the analytical hierarchical process (AHP) is employed for structuring the criteria influencing the process choice. The application of the proposed AHP model for the selection of manufacturing process is demonstrated using numerical examples. In addition, due to dealing with vague data in the decision process, the uncertain criteria are characterised by typical fuzzy sets. The integrated fuzzy AHP is then analysed within the boundary conditions of the fuzzy criteria using the Expert Choice software. The proposed model is intended to be generic in structure and applicable to many firms.

INTRODUCTION

To survive in today's competitive market, customisation of manufacturing processes is the main requirement. Customers' requirements and their irregular behaviour are relatively unpredictable to the manufacturers. Therefore, manufacturers need to find solutions for fast adaptation of their resources to the dynamic market. In this way, an integration of process engineering and manufacturing management along with standardisation of products and processes are essential. Changing manufacturing processes provides the opportunity to grow in the different market situ-

ations. However, this might necessitate changes in the operations and resources that impose extra capital/operational cost to the system. As a result, the process choice must be selected by trading off between the technological elements and economical factors.

High quality products, high productive and low cost manufacturing are to be achieved by overcoming existing limits of technologies. These objectives can be obtained through activating the full potential of resources such as materials, manufacturing facilities, and operators' skills. In addition to these conventional objectives, manufacturers need to respond rapidly to changes in market demands. Consequently, responsiveness is becoming another objective to be considered for the manufacturing process selection. The responsiveness criterion is characterised by a fuzzy set in the AHP model and analysed within its fuzzy domain in order to evaluate the alternative manufacturing choices.

Different kinds of manufacturing processes will have different impacts on the system performance and customer satisfaction. Three different manufacturing choices are considered as the alternatives for the proposed model. A dedicated manufacturing is considered as one of the process alternative in which limited product types can be produced using transfer lines. This kind of manufacturing process is suitable and cost effective when there is a stable market for existing products. A responsive manufacturing is another system that its capacity and functionality are adjustable to fluctuations in product demands within the existing production range and also new products introduced to the system. The hybrid manufacturing choice is the other alternative which can cope with both situations in which limited products hold firm demands, but some other products have sharp changes in demands and/or new products with new manufacturing operations introduced to the system. The alternative processes are analysed with respect to the criteria and actors for the identified planning horizons, that is, long term, mid term, and short term through a case study.

BACKGROUND

Manufacturing processes need to be modelled in order to clarify the process requirements, better understand the system behaviour, and solve various problems of existing systems. Most related work in manufacturing system (MS) modelling has been involved with resource allocations, layout configurations, and job scheduling. Most existing analytical models attempt to simply minimise a static measure such as transportation cost, lead time, and/or work-in-process (WIP) subject to available resources. Reconfigurations and product variety have made the process of modelling notoriously difficult. This difficulty is due to a lack of analytical models, which are capable of evaluating the effects of product mix and resources reconfigurations on the manufacturing performance. In most conventional studies for MS modelling, the importance of changeover time, changeover cost, and product variants have been ignored. In addition, uncertainty caused by external/internal factors might lead to an ineffective decision; as a result, the conventional analytical models must be reformulated to obtain a comprehensive structure considering a variety of quantitative/qualitative parameters under uncertain conditions.

Advanced manufacturing processes need to be more flexible than ever before for their survival in the competitive environment. In the most studies, capital investment, operation cost, and WIP have been the major objectives of production planning to be minimised. However, considering new qualitative/quantitative requirements in manufacturing environments such as customer satisfaction, capacity changes, functionality requirements, and changeover cost and time, the decisions made by cost based models can no longer justify the investment for manufacturing processes. As a result, the top management and