Chapter 8

An Ergonomic Compatibility Perspective on the Selection of Advanced Manufacturing Technology: A Case Study for CNC Vertical Machining Centers

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ABSTRACT

Evaluation and Selection of Advanced Manufacturing Technology (AMT) is a complex problem involving multiple attributes difficult to consider in their entirety. The Axiomatic Design Theory have been used successfully to solve this problem. This chapter presents a literature review for applications of Axiomatic Design Theory in decision making and develops an Ergonomic Compatibility Evaluation Perspective case study for the selection of two vertical CNC machining centers. A new Hierarchical Fuzzy Axiomatic Design methodology was used as a decision aid for evaluation of technology in a more complete manner, while considering human factors and ergonomics aspects neglected in actual AMT evaluation and selection models. Methodology for the data analysis is described. A group of three experts was conformed for the case study. 26 articles were organized in a data matrix. The alternative which best meet established Design Ranges in terms of Ergonomic Compatibility was selected among two alternatives, according to the Ergonomic Incompatibility Content (EIC) in a fuzzy environment.

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1. INTRODUCTION

Decision making is a matter of every day in all kind of areas in the world and especially in the area of process engineering and optimization of systems. Mostly, making decisions problems involve evaluating and selecting among alternatives that must satisfy multiple requirements and criteria, which may even be contradictory. As alternatives and decision criteria are increased, the difficulty to reach the best decision also increases. Because of this complex problem, research efforts for solutions have been extensive in different disciplines. Multiple and single criteria models have been developed to address decision making problems and according to Kulak et al. (2005), these can be classified as deterministic and non-deterministic and include a wide variety of them. However, a growing and innovative approach offered by Axiomatic Design Theory (AD) has been applied effectively for this purpose.

Table 1 shows the classification of some decision making models.

This theory was developed by Nam P. Suh to provide scientific basis for the design of engineering systems that enables the designer to enhance this process based on logical thinking and rational foundation. According to Suh (1990), two axioms are established as design axioms: Independence (InA) and Information Axiom (IA). These axioms were established when common elements found in good designs were identified by a process of logical reasoning. Both axioms have been validated to create and develop better, more robust and reliable designs at a lower cost. The InA establishes that independence between the Functional Requirements (FRs) should be kept to develop designs. Using the IA a measurement for the uncertainty associated with the design is proposed by obtaining the information content (I). IA states that information content of the design must be minimized. Thus, the theory of Axiomatic Design (AD) provides scientific basis for the engineering design of systems that enables the designer with tools for logical thinking and rational basis. Also, for the Complexity Theory (CT) proposed by Suh (2001), the understanding of the two axioms of design provides the theoretical foundation for designing complex systems that normally occur in the area of engineering. It is applicable to engineering systems and discernment of natural systems such as biological. In this matter, complexity is defined as a measure of uncertainty of trying to meet the design goals of the established Functional Requirements (FRs) and is treated as a function of the relationship between the (Design Range, DR) set by the designer as the desired performance of design and the Range System (System Range, SR) or actual performance of the created design. The independence axiom states that the independence of functional requirements

Table 1. Decision making models (Kulak et al. 2005)

Single Criterion		Multiple Criteria	
Deterministics	**Non Deterministics**	**Deterministics**	**Non Deterministics**
Net present value (NPV)	Sensibility Analysis	Score and Goal Models	Fuzzy Logic
Internal rate of Return (IRR)	Decision Trees	Analytic Hierarchical Proces	Expert System
Cost/Benefit Ratio (C/B)	Optimistic/Pessimistic	Decision Making support systems	Utility Models
Return Period (RP)	Montecarlo Simulation	Productivity Model	Game Theory Model
Mathematical Programming		Multiobjective Mathematical Programming 0-1	Intuitionistic Model
Minimal annual revenue requirement		Dynamic Programming	