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Development of a decision support system for machining center selection

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ABSTRACT

The machining centers are key resources for manufacturing companies in their dealing with their fierce competitive market environments. However, although selecting the most appropriate machining center is a very important decision for manufacturing companies, the availability of wide-range of types and models makes the selection process a complex and difficult task. In this study, a decision support system (DSS), namely MACSEL, is developed to help the decision makers in their machining center selection decisions. Several issues and applicability of the MACSEL is illustrated with case problems in the paper.

Within the developed DSS, to select the feasible set of machining centers fifteen questions are placed in the elimination (pre-selection) module. The developed DSS uses fuzzy analytical hierarchy process (FAHP) or fuzzy technique for order preference by similarity to ideal solution (FTOPSIS), which are extended versions of multi-criteria decision making approaches, to rank the feasible machining centers. In the DSS, FAHP is used if a detailed pair-wise weighting of the hierarchically structured criteria is wanted. On the other hand, when a simpler separate weighting of each criterion is be considered as enough, FTOPSIS is used.

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1. Introduction

When a manufacturing company decides to purchase a new machining center, the selection has to be performed among hundreds of different models and types considering many conflicting specifications such as: table size, spindle speed, power, axis travel, positioning accuracy, repeatability, work-piece material and sizes, cutting tool requirements, etc. (Kalpakjian & Schmid, 2001; Tlusty, 2000). In the literature, there are various papers that proposed models to solve machine selection problems. For example, Cimren, Budak, and Catay (2004), Lin and Yang (1996), Oeltjenbruns, Kolarik, and Schnadt-Kirschner (1995), and Yurdakul (2004) proposed AHP models for machine selection problem. Vasilash (1997) developed a computer programme called "machine tool selector" which obtains a feasible set of machine tools by searching its data base and eliminating unsuitable ones. Sun (2002) presented a CNC machine selection methodology using DEA. Georgakellos (2005) uses a scoring model that incorporates technical and commercial criteria of machines in their approach. In other studies, Layek and Lars (2000) and Gopalakrishnan et al. (2004) proposed expert systems for selection of machining centers.

For the machine or equipment selection problems where vagueness and imprecision are involved, fuzzy multi criteria decision making (FMCDM) approaches are proposed. For example, Chu and Lin (2003) proposed a fuzzy TOPSIS (FTOPSIS) model for robot selection. Wang, Shaw, and Chen (2000) proposed a FMCDM model to assist the decision-maker to deal with the machine selection problem for a FMC (flexible manufacturing cell). Pegero and Rangone (1998) and Jiang and Hsu (2003) use fuzzy AHP (FAHP) for selection of Advanced Manufacturing Technologies (AMT). Furthermore, Devedzic and Pap (1999) presents a study that selects the most suitable machine tool among the alternatives by using fuzzy linguistic approach.

The proposed models in the literature generally try to solve either the elimination phase that produces a feasible set of machining centers or the ranking phase of the machining center selection problem. The literature survey shows that there is a need for a complete self-sufficient model that integrates various phases of the selection problem along with a flexible structure that fulfills differing needs of the decision-makers. The proposed model in this paper, namely MACSEL (*MA*chining *C*enter *SEL*ection), aims to fill this gap in machining center selection problem.

2. Description of the structure of the developed decision support system (MACSEL)

The developed decision support system incorporates three separate modules, namely elimination, fuzzy AHP (FAHP) and fuzzy

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TOPSIS (FTOPSIS), and makes its selections from the database that currently contains data of 164 machining centers (Fig. 1). Elimination module provides the users 15 questions to eliminate the unsuitable machining centers and obtain a feasible set of machining centers. The feasible set of machining centers are then ranked either by FAHP and FTOPSIS modules. Details of the modules and examples are provided in the following sections.

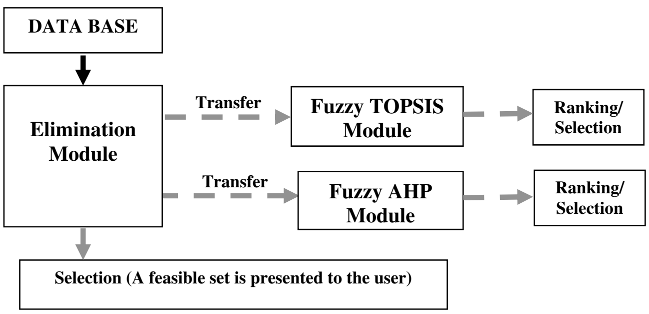

Fig. 1. The structure of MACSEL.

2.1. Description of the elimination module

In the elimination module, the work requirements are entered by the user as answers to 15 questions and the unsuitable machining centers are eliminated (Fig. 2). The user has the flexibility to answer any number of questions in MACSEL.

The minimum and maximum necessary table size is entered in the first question. The minimum required levels of table size, *X*-, *Y*-, and *Z*-axis travel, number of tools, tool length, tool diameter and maximum workpiece weight on table are entered through questions 2–6. The maximum levels of available floor space and allocated fund are entered in questions 7 and 8 (Fig. 2A).

Question nine calculates the spindle speed and power requirements based on the softest and hardest material types that will be machined (Fig. 2B). Once the material types are selected, the recommended values of V_C, f_z and K are input by the program automatically and the spindle speed and power are calculated using Eqs. (1) and (2) (İç, 2006). The user can change the recommended input values if necessary and the program calculates the new values of spindle speed and power accordingly

$$n = \frac{V_C \times 1000}{\pi \times D_C} \tag{1}$$

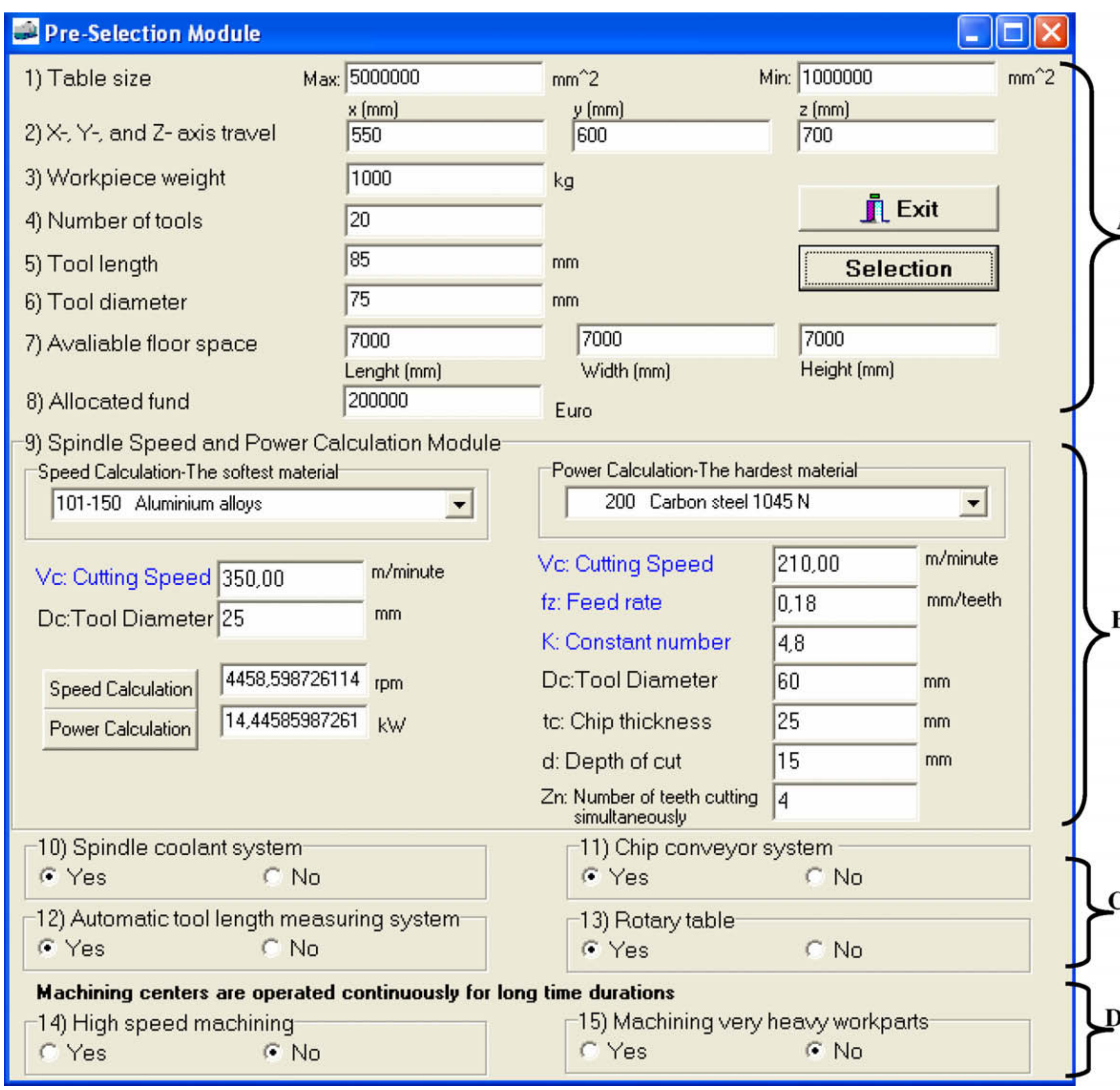

Fig. 2. Pre-selection screen of MACSEL.

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