ELSEVIER

Materials and Design 22 (2001) 337–351

Materials & Design

A computer-based intelligent system for automatic tool selection

K.O. Edalew, H.S. Abdalla*, R.J. Nash

Department of Design Management and Communication, De Montfort University, The Gateway, Leicester LE1 9BH, UK

Received 24 July 2000; accepted 27 November 2000

Abstract

This paper presents a computer-based intelligent system for the automatic selection of cutting processes and tools within a concurrent engineering environment. The main objective of the research work was to develop a procedure for the selection of cutting tools, develop a dynamic programming-based system that utilises mathematical modules and heuristic data to determine and calculate cutting parameters and total component cost. This will help the designers and manufacturing planners to select an optimal set of cutting tools and cutting conditions for different material properties and to give users alternatives on how to reduce cost and time. The system comprised of several modules; the knowledge acquisition module, the knowledge base module, the inference engine, the user interface, and the database. The developed system, which was designed to cover different component shapes including cylindrical, prismatic, different types of machining techniques, conventional and less conventional, has the potential to deal with complex products that are made up of multiple components. The system is capable of selecting cutting tools. It calculates cutting conditions and estimates component cost, based on the properties of the work piece material and features attributes, which include surface finish and tolerances, as well as using a number of production criteria such as material removal rate, tool life, machining time, and cost.

Keywords: Concurrent engineering (CE); Process optimisation; Tools selection; Knowledge acquisition; Cost estimation

1. Introduction and background

Over the last few decades, the range of engineering materials encountered in machine shops has increased greatly, as has the variety of cutting tools that are capable of machining these materials. In the early 1980s research work was undertaken in the area of computer-aided manufacturing and process planning. A number of systems have been developed to select a tool or a set of tools for a specific operation or a set of operations. The automatic tool selection system (ATS) which selects the optimum tools for rough turning and finishing operations was used by Maropoulos and Hinduja [5,6,8,9]. A knowledge-based module for an intelligent tool selection system ITS–KBS [10] was used for

* Corresponding author. Tel.: +44-1162-577097; fax. +44-1162-577052.

E-mail address: ha@dmu.ac.uk (H.S. Abdalla).

0261-3069/01/$ - see front matter
PII: S0261-3069(00)00106-0

turning and boring operations performed on a cylindrical component. An integrated computer-based system for the selection of tool management (TLPM) for cylindrical components, was devised by Maropoulos and Alamin [11,16]. This system was used in milling operations to select cutter size and cutter path for prismatic parts [7,9,13,17]. These systems contained a simplified technology module, which calculated cutting conditions, selected tools and estimated tool life in turning, boring, and milling operations.

Abdalla et al. [1–4] introduced an approach for integration of product, processes and tooling design and a systematic method for acquiring and analysing information about the capabilities of the manufacturing process.

The problem of determining the optimum machining conditions, for single pass and multi pass operation, was described by Agapiou [18]. It also took into account the production cost and time. Some systems dealt with the cost estimation at an early stage of design. Cakir and Gurarda [19] described a procedure for turning operations that would minimise production cost and time. Yang and Lin [14] developed a system to estimate the manufacturing cost of a design according to the shape and required precision for its features, together with estimation of the machining time. Baker and Maropoulos [12] adopted this to conduct such evaluation in the early stages of design process.

Some systems dealt mainly with the geometrical problem occurring during turning or milling. These concentrated upon prismatic components or cylindrical components. Other systems took into account the component material and geometric features but ignored selection of the cutting tool material and tool specification. An expert system, which is presented in this paper, is designed to deal with cylindrical and prismatic components, and different types of machining techniques (traditional and non-traditional techniques). This system has the ability to deal with complex products that are made up of many components. It has the ability to select cutting tools, calculate cutting parameters and estimate costs [20] for various machining techniques. It takes into consideration mechanical and thermal properties of the component material in order to select a suitable tool material, which can machine the desired component. At the same time, it will ensure that the required attributes of a feature such as surface finishing and tolerance are obtained.

The main aim of this research is to help designers and manufacturing planners to select optimal cutting tools and optimum cutting conditions to reduce cost and time.

2. Overall system description

The proposed system comprises of a user interface, knowledge acquisition, inference engine, knowledge base, and database. Fig. 1 illustrates the structure of the proposed system.

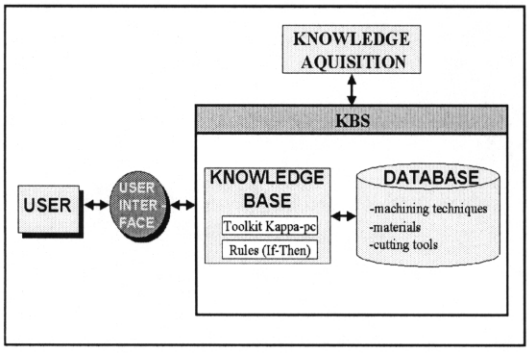

Fig. 1. Structure of the proposed system.

2.1. Knowledge acquisition

Developing a knowledge base system requires that several problems are overcome. One of these problems is the fact that much of the expert knowledge is of a diffuse and heuristic nature and used at a subconscious level. A major difficulty is to capture and examine the various knowledge elements used in the solution of a problem.

Several literary sources were used to complete the prototype system. The main sources for cutting tool selection were machinery handbook [22], production handbook [23] and from major cutting tool manufactures including Sandvik AB and Guhring GmbH.

Further sources of expertise came from consultations and discussions with experts from industry and academic research groups.

2.2. User interface

The proposed system comprised of several elements.

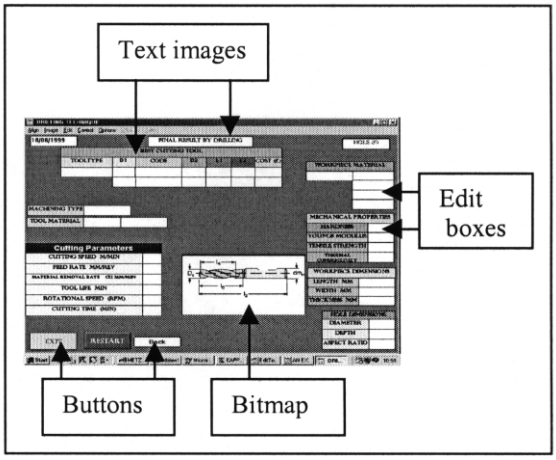

Fig. 2. ATS software windows.