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An Expert Carbide Cutting Tools Selection System for CNC Lathe Machine

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Abstract –*The paper describes the application of an expert system to develop the carbide cutting tools selection system for computer numerical control (CNC) lathe machine. The aim of the development is to select the optimum tool holder, carbide cutting tools, insert, feed rate, and turning speed for CNC lathe machine. The system is able to select the suitable tips tool based on the dimension, machining parameters, feed rate, turning speed and materials of the work piece. The expert system shell was used to develop the system. Constrain values for the selection procedure is based on design database and international standard. A case study was conducted to verify the capability of the developed system. The developed system helps the manufacturing engineers and technicians to choose the right carbide tool and suitable turning speed for CNC lathe machine.*

Keywords: *Carbide Cutting Tools, CNC Lathe Machine, Expert System*

I. Introduction

Nowadays, computer is used for most of the manufacturing activities to perform the task like process planning, design, scheduling. Due to the low cost and the advancement of the computer technology, the computer is embedded into the manufacturing process in order to improve the quality and reduce the manufacturing cost. Computer technology, such as artificial intelligence, computer-aided design and computer numerical control has given an important impact to manufacturing industry. The information technology has been integrated with the manufacturing practice in order to shorten the time from product conceptual to product marketing. Computers are an important tool for manufacturing engineer to produce higher quality products to markets in a short time and effectively. Various computers program such as expert system [1]-[5] and neural network [8]-[10] have been used in the industry to improve the process as well as to improve the quality of products.

An expert system is an intelligent program that follows the expert thinking and behaviour within-defined domain of knowledge [1]. The expert system is able to computerize the expert knowledge into the database to offer fast and reliable solutions to solve the specific problem. The expert system is an interactive support system for the experts [11,12,13]. The expert system has been used by many engineers to diagnose the problem, select engineering parts, manufacturing process and engineering materials. An expert system to select the cutting tools and turning operation condition was developed by Arezoo et al. [2]. Sapuan et al. [3] developed the expert material selection system of ceramic matrix composites for vehicle components. Er and Dias [4] developed a rule-based expert system to select the casting process for manufacturing of engineering components. An expert system, namely EXTOOL, has been developed by Mookherjee and Bhattacharyya [5] which based on the customer requisite material and geometry, to select the insert for turning and milling process automatically.

The developed expert systems consist of several modules such as an inference engine module, a user interface module and knowledge acquisition module. In the development of the system, the backward chaining method was used. The developed system allows user to select carbide-cutting tools in the automotive industry. In order to input the data into the system, an interface with images, menu and buttons was created and complete results. The engineers and technicians can select the right tools easily for lathe process to reduce the time loss and improve the product quality.

II. Computer Numerical Control Lathe Machine

Majority of the components machined in the industry are of the cylindrical shape and as such, the CNC lathes are important machine tools. The major innovation provided in the CNC lathes is the provision of slant bed to help remove the chips from machining zone more efficiently, while a large variety of software functions to machine the most complex axi-symmetric shapes [6].

Various cutting tool materials, such as cemented carbide, coated carbides, ceramics and high speed steel (HSS) have been used in the industry for different application [6]. For these work, the carbide cutting tool materials was used.

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II.1. Cemented Carbide

Cemented carbides are produced by the cold compaction of the tungsten carbide powder in a binder such as cobalt, followed by liquid-phase sintering. These have a very large number of advantages compared to the other cutting tool materials. Cemented carbide being expensive are available in insert form in different shapes such as triangle, square, diamond and round [6].

II.2. Coated Carbide

The life of the coated tools is two to three times than the uncoated, also these can be used at higher cutting speeds, thus increasing productivity and reduce processing time. These coatings are titanium carbide, titanium nitride and aluminium oxide. Coated carbides being increasingly used in the industry in comparison to uncoated varieties [6].

III. Description of the Expert Carbide Tool Selection System

There are a number of major phases of the expert carbide tools selection system. The major phases including design of the user interface, carbide cutting tools specification, defining the right selection mechanism, constructing the program tree structure, program codes writing, program testing and validation of program.

The Kappa-PC expert system shell [7] has been used to develop the expert carbide tools selection system. In the expert carbide tools selection system have four component, such as the knowledge acquisition module, the knowledge-based, the inference engine as well as the user interface. The architecture of the developed expert carbide tools selection system is shown in Fig. 1.

The developed software and interface consist of a main window, which is the SESSION. In the SESSION, there is four processes to be selected. There are facing, grooving, threading and boring processes. Fig. 2 shows the main user interface of the system.

In the selection of carbide cutting tools for CNC lathe machine using expert system, the system is developed to identify the best solution the problems when the expert is unavailable. The flows of the user interface as shown in Fig. 3.

IV. Results and Discussion

The expert carbide cutting tools selection system for CNC lathe machine had been developed and tested. The developed system able to select the right insert, carbide cutting tools, tool holder, feed rate and turning speed. The expert system database can be customized and upgraded by user. The developed system interpreted 36 rules to acquire the best solutions. Ten possible scenarios was developed to test the developed system.

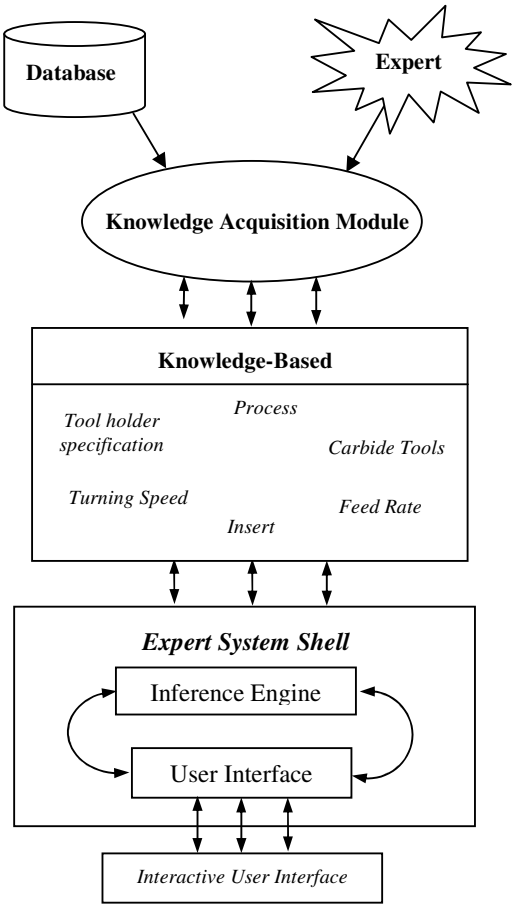

Fig. 1. The architecture of the developed system

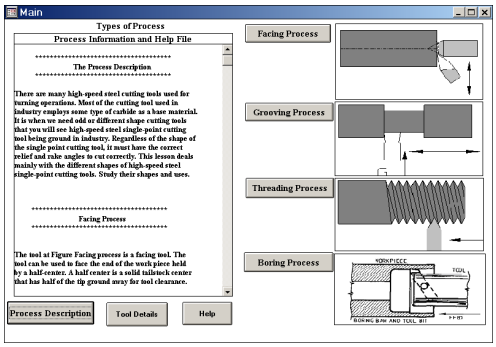

Fig. 2. The main user interface

The system is able to give error message if the user wrongly enters the required information or answering the question. For the validation purpose, a case study was used to demonstrate the capability of the developed expert carbide tools selection system.

IV.1. Case Study

The facing process was choosing for the case study. The facing process is the term used to describe cutting of the

flat surface as the work piece revolves in the lathe in order to square the end with the sides, or reduce the stock to a desired length. The single point tool feeds along a line perpendicular to the spindle axis as depicted in Fig. 4.

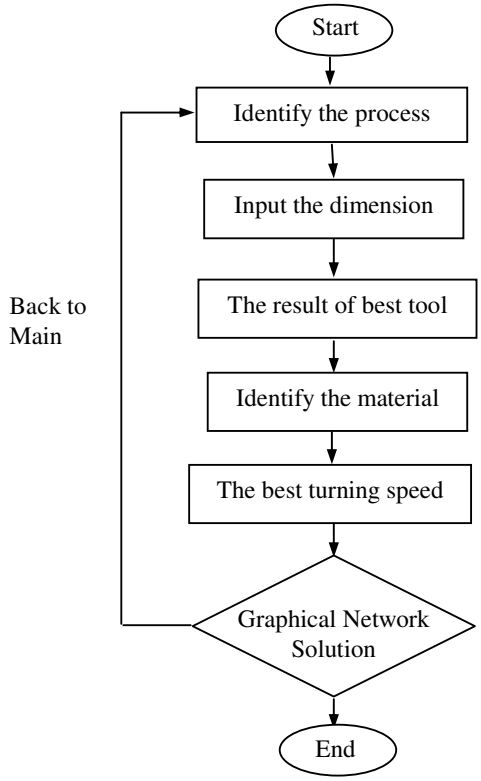

Fig. 3. The flow of the user interface

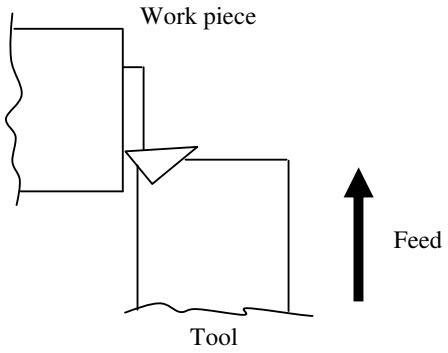

Fig. 4. The relationship of tool, work piece and feed in turning operation

The facing process was selected from the main user interface as shown in Fig. 2. The user interface for the facing process is shown in Fig. 5.

To obtain the result for the tool, the button "click for dimension" will be activate. These function is set to the range from 1 mm to 22 mm. Fig. 6 shows the window for data input of facing process.

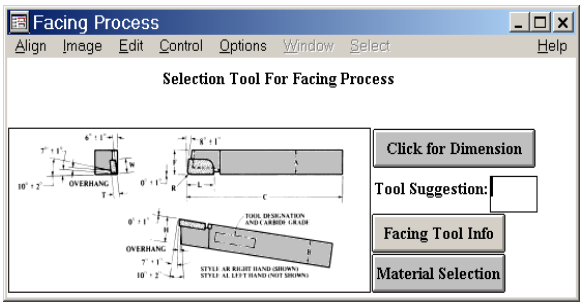

Fig. 5. The user interface for facing process

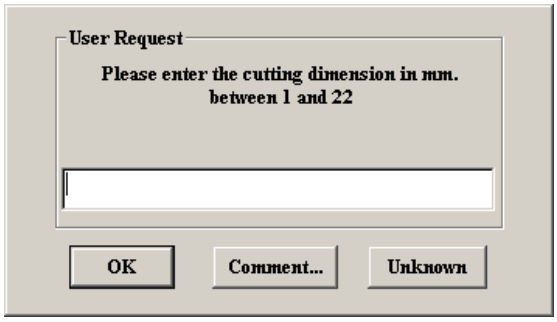

Fig. 6. The window of the data input

If the value that input into the system is in the range of the database, then the inference browser will show the result as green light. For example, the input data is 8 then the selected tool will be A10. The tool detail is shown in the 'Facing Tool Info'. The inference browser for the inference process is shown in Fig. 7.

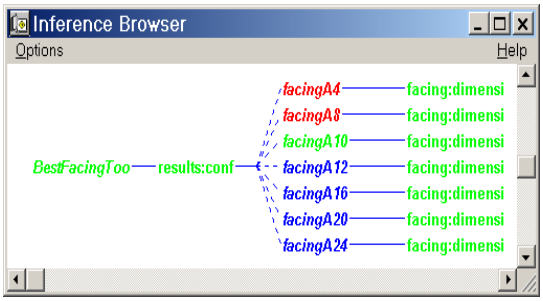

Fig. 7. The Inference Browser of facingA10 tool

The best solution will shown in the 'Tool Suggestion' as refer to Fig. 5. Through the case study, it shows the developed system can help an individual to acquire any data that related to the carbide cutting tool. The result shows the solution for user to get the best result.

V. Conclusion

An object-oriented and expert system based carbide-cutting tools selector has been developed. The developed expert carbide cutting tools selection system includes a carbide tool selection module, a knowledge-based system and a user interface. The

advantage of this system is that it allows user to find the best solution for the carbide cutting tool in the automotive industry. The developed system is easy to use and modular-based where the carbide cutting tools database can be upgraded to make the system more comprehensive.

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