

# An Expert Machine Tools Selection System for Turning Operation

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**Abstract.** The turning machining process is an important process in the manufacturing industry. It is important to select the right tool for the turning process so that the manufacturing cost will be decreased. The main objective of this research is to select the most suitable machine tools with respect to user input requirement. The selection criteria are based on rule based expert system and multi-criteria weighted average method. The developed system consists of Knowledge Acquisition Module, Machine Tool Selection Module, User Interface Module and Help Module. The system capable of selecting the most suitable machine along with its full specification and ranks the machines based on criteria weighted. The main benefits from using the system is to reduce the complexity in the decision making for selecting the most appropriate machine tools to suit one requirement in the turning process for manufacturing industry.

## 1. Introduction

In metal based industries, the efficiency of the manufacturing system is depending on the selection of machine tools. The machine tools will influence the manufacturing systems such as time to market, precision, productivity, etc. Traditionally, the selection of machine tools in industry is done manually by expert machinist or experience engineers. Thus, the process to select the most suitable machine for an application is a long and complicated process. An expert system is developed to perform the similar task like expert when the he/she is absent. Application of rule-based expert system in manufacturing systems selection has been reported by various investigators. Among others are cutting tools selection, ceramic material selection, rapid prototyping selection, robot selection and material handling selection. Maropoulos and Gill [1] developed a tool selection system for machining cylindrical components. The

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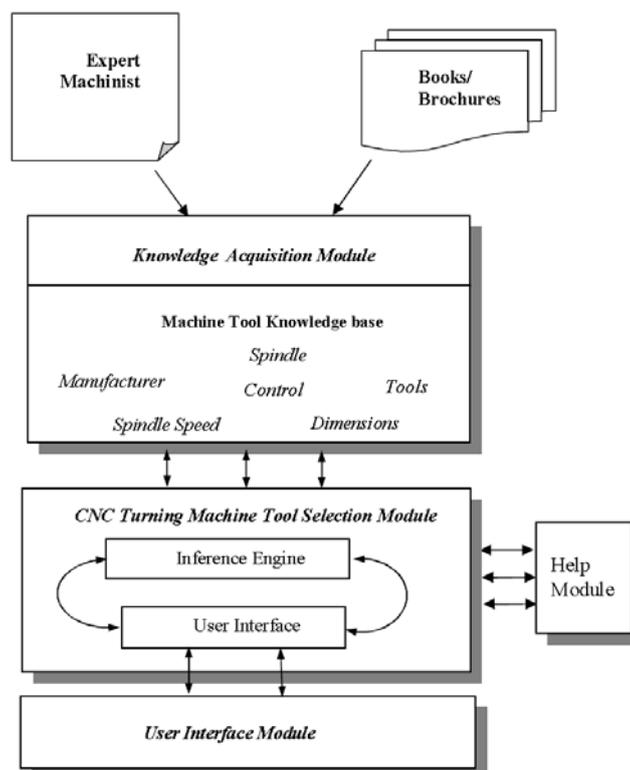
tool selection system was developed based on knowledge and logic approach to select the suitable tool to machine the cylindrical components.

Arezoo et al. [2] demonstrated the used of expert system to select the cutting tools and conditions of turning operation. In addition, an expert system for turning and rotating tool selection also developed by Moorkherjee and Bhattacharyya [3]. The aim of the work was to select the most suitable material for the automotive engine components. Another work by Massod and Soo [4] used rule based expert system to select the rapid prototyping. The input for the developed expert system is the commercial available rapid prototyping systems in the market. Chu and Lin [5] developed a fuzzy method for robot selection. It uses various rating alternatives verses subjective criteria and the weights of all criteria are assessed in linguistic terms represented by fuzzy numbers. Work by Chan et al. [6] used expert system to select the material handling equipment selection. Er & Dias [7] developed a rule-based expert system to select the cast components for manufacturing process. Various development of expert system for industry application has been reported [8-10].

This paper describes the development of rule based expert system for selection of CNC machine tools especially turning operation. The system involves the user providing answers to specific questions or entering the required data. The system uses rule based and multi-criteria weighted average method (MCWA) [11] as the decision-making approach. Recommendations and suggestions of the appropriate machine tools based on input requirement are displayed on the screen at the end of the program.

## 2. Overall System Development

The flow chart of the CNC turning machine tools selection system that used KAPPA-PC expert system shell [12] is shown in Figure 1. The system has for basic modules namely the Knowledge Acquisition Module, CNC Turning Machine Tool Selection Module, User Interface Module and Help Module.



**Figure 1.** Flow chart of the developed system.

### 2.1 Knowledge Acquisition Module

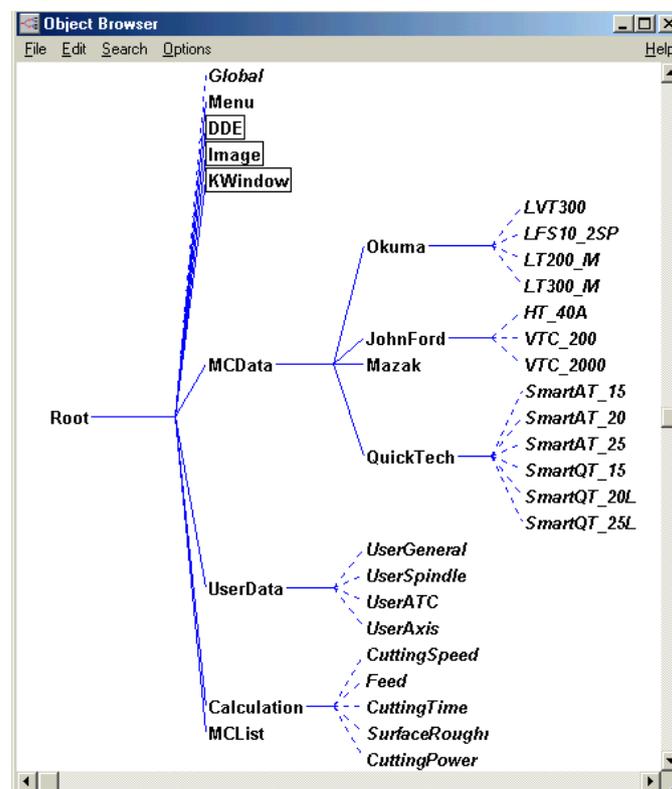
Knowledge and information used to develop the system are obtained from brochures, vendors, books, journals and internet. The information related to the CNC turning machines is shown in Table 1. Classification of machine tools are based general view about the machine, spindle, tooling, work support, axis and physical specification. Currently, the database contains 3 machines manufacturers and 17 types of CNC machine tools.

**Table 1.** Classifications of Machine Tools.

1	General	manufacturer, model, machine type,
2	Spindle	spindle type, no. of spindle, spindle direction type, taper number, max speed, motor power
3	Tooling	standard tool size, number of tools, tool diameter
4	Work Support	table size, rotary table
5	Axis	rapid traverse speed, number of axis
6	Physical	machine dimensions (height, length, width)

### 2.2 CNC Turning Machine Tools Selection Module

Grouping the detail of machines into the database is the next step in the methodology of development of CNC turning machine tools selection system. Since different machine manufacturers use different terms in describing the machine parameters, the development of the database needs more effort to recognize the same parameters. The database of the machine tools is created into a hierarchy tree in the Kappa-PC as shown Figure 2.



**Figure 2.** Hierarchy database of machine tools.

The domain of rule-based expert system is consists of frames or objects. The objects can be classes or instances within classes [13]. The relationship between the objects is linked together by a tree hierarchy. Information related to machine tool manufacturer are represented as objects, and machine tool types are classes. Slot represents important properties of an object or class. The characteristics or specification of machine tools such as number of axis, programming language, number of tool holder are defined as slot in KAPPA-PC.

This system uses rule-based with “IF-THEN” rules and multi-criteria weighted average method (MCWA) is used as the decision-making approach in forward chaining principle. Each turning machine tool in the database is assigned a score according to its properties in relation to the data input. After this, the system will rank the turning machine based on the input scores by the user. The machines are ranked using Multi-Criteria Decision Making (MCDM) Method where the ranking is from best to worst using machine specifications and criteria weights. The alternatives are weighted average and hierarchy tree is used for the selection process.

### 2.3 User Interface Module

Another important step in the development of expert system is the designing of the user interface. The user interface windows are linked to one another by using functions. A user-friendly interface is created using button, text images and bitmaps. A session window, which is the basic components of KAPPA-PC interface is used to create application interface. Figure 3 shows the main user interface developed in this system. Some of the examples data requires by the system is the general data input, types of spindle, automatic tool changes, axis as shown in Figure 4. Figure 5 shows the sub-menu of “general” data input.



**Figure 3.** Main menu.

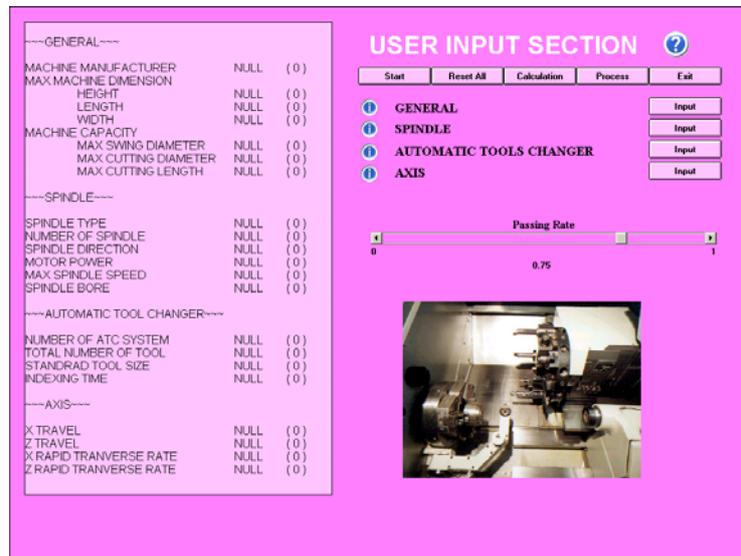


Figure 4. User Data Input interface.

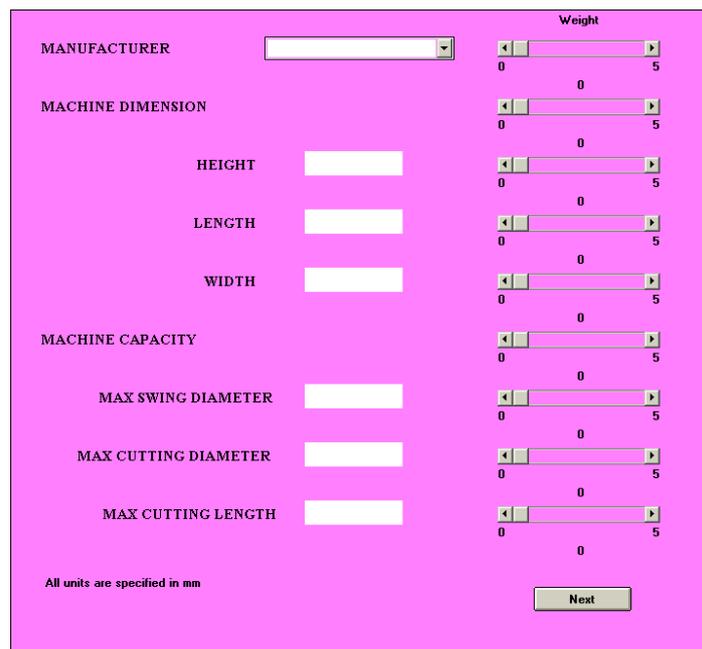


Figure 5. Sub-menu of “General” User Data Input.

### 2.3 Help Module

User’s guide and some extra information are also included in the system. Figure 6 shows some of the examples of help menu in the decision support system. This system provides machinability calculation to assist the user in determining some machining parameters for particular machine tools.

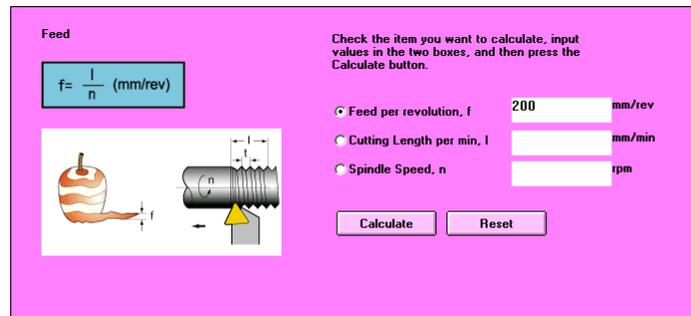


Figure 6. Help module.

### 3. Result and Discussion

The developed expert turning machine tools system is able to select the suitable turning machine tools based on the ranking by the user. The system is able to show the capability to manipulate the variations of the inputs. Currently, the system has three machine tool manufacturers and seventeen machines inside the database. Figure 7 shows the output menu where the highest score machine will be arranged first according to preferred passing rate. As an example the initial passing rate is 0.75. The details of machine parameters can also be displayed for easy reference.

RESULT		MACHINE MODEL		
		LFS10_2SP	Enter	Print
			Ba	
MACHINE	SCORE	MACHINE	USER INPUT	
LFS10_2SP	0.895	MANUFACTURER	OKUMA	
LT300_M	0.661	MODEL	LFS10_2SP	
LT200_M	0.594	MACHINE HEIGHT	2500	NULL
HT_40A	0.509	MACHINE LENGTH	1876	NULL
SmartAT-20	0.500	MACHINE WIDTH	1300	NULL
SmartQT-15	0.500	MAX SWING DIAMETER	450	450
SmartAT_25	0.500	MAX CUTTING DIAMETER	120	120
		MAX CUTTING LENGTH	80	80
		SPINDLE TYPE	140 FLAT	A2_8
		NUMBER OF SPINDLE	2	1
		SPINDLE DIRECTION	HORIZONTAL	HORIZON TAL
		MOTOR POWER	10	NULL
		MAX SPINDLE SPEED	6000	NULL
		SPINDLE BORE	53	NULL
		NUMBER OF ATC SYSTEM	2	NULL
		TOTAL NUMBER OF TOOLS	20	NULL
		STANDARD TOOL SIZE	20	NULL
		INDEXING TIME	0.3	NULL
		X TRAVEL	130	NULL
		Z TRAVEL	145	NULL
		X RAPID TRANSVERSE RATE	24000	NULL
		Z RAPID TRANSVERSE RATE	24000	NULL

Figure 7. The output window

## 5. Conclusion

A rule-based expert system for CNC machine tools selection has been developed. The system uses rule based and multi-criteria weighted average method (MCWA) as the decision-making approach. Recommendations and suggestions are displayed on the screen at the end of the program. Furthermore, on line help facilities are also include in the system. Currently the database in the system is not exhaustive for all applications. Nevertheless, it does illustrate the basic concept in developing an expert system for machine tools selection. One of the capability and potential of this system is to become a useful tool for machinist in metal based industries.

## Acknowledgment

Special thanks to the Centre of Research and Innovation Management and Faculty of Mechanical Engineering for the support.

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