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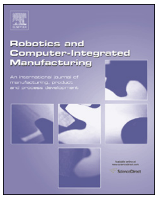

Full length Article

A research on the cutting database system based on machining features and TOPSIS

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ABSTRACT

Cutting parameters play a significant role in machining processes. The traditional cutting database usually neither include all information about part machining nor provide the best alternative of cutting parameters automatically when several alternatives meet the requirements for retrieval. The paper presents a cutting database system based on machining features and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) for selecting the best alternative of cutting parameters. Following the object-oriented idea, machining features are organized by part feature, geometric information, material information, precision information and manufacturing resources information, which is very convenient for the database to store and manage the necessary machining information. The multiple criteria decision making matrix D is constructed by spindle speed, feed rate, cutting depth and cutting width. And the best alternative of cutting parameters is selected according to the closeness coefficient by TOPSIS. In addition, a prototype system based on Web browsing mode has been developed. Finally, an example is used to validate that the proposed system is feasible and effective.

1. Introduction

With the highly automated and computer integrated manufacturing environment, many industries have introduced (flexible manufacturing system) FMS as a strategy to meet the widely different needs of various customers in the highly competitive market [1]. The selection of cutting parameters is very important in any machining process and it is major issue that these industries must face every day [2]. Proper selection of cutting parameters can fully utilize various automated processing machines, CNC machine tools, machining centers and other machine tools in FMS. For such expensive equipment it is of great importance to increase productivity, reduce machining costs and improve equipment utilization. Traditionally, the cutting parameters are usually obtained from the machining data handbooks, the experience of the operator, or cutting tests et al. [3]. But alternative ways of obtaining cutting parameters have also been explored to meet the current development of the times.

Combining with the advanced technology of computer database, many cutting database have been established to manage tools, machine tools, cutting parameters and other basic information, which provide an important basis for the development of various kinds of modern advanced manufacturing technology, such as CAPP, FMS, CIMS, etc. Developed from the first cutting database MDC, CUTDATA is still one of the most famous cutting databases until now. Some well-known tool manufacturers have also established their own cutting database system to provide users with accurate and timely service of cutting parameters. For example, Sandvik Coromant provides a network database for their tool products. SECO has developed the software WinTool. Others include Kennametal's KATMS and ToolBoss, Walter's TDMeasy software, etc. On the academic side, M.V. Ribeiro proposed a cutting parameter and tool selection optimization system CATA [4]. Arezoo et al. established a turning data expert database EXCATS [5]. Cakir established an expert system COROSolve, covering turning, milling and drilling data [6]. Worth noting, traditional databases only consider part material information in order to recommend tools and machining parameters. They rarely consider the geometric information, precision information, manufacturing resources and processing stages. In order to consider the above factors, machining features are analyzed. A detailed survey on the research and development in machining features can be found in the literature [7–10].

The continuous accumulation of cutting parameters used in actual production and obtained by cutting tests etc. will produce massive data for the database system, so in searching for cutting parameters will most likely yield several alternatives that meet the

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requirements. TOPSIS is a very useful technique in dealing with multi-attribute or multi-criteria decision making problems in the real world [11]. It assists decision makers in selecting the best alternative. In recent years, TOPSIS has been successfully applied to the areas of product design [12], energy management [13], human resources management [14], manufacturing [15], and chemical engineering [16], etc. The high flexibility of this technique enables it to be easily accommodated to various situations. Therefore, this paper adopts TOPSIS to choose a set of the optimum cutting parameters.

The paper is organized as follows. In the next section, the definition and classification of machining features are discussed. Section 3 focuses on the selection of optimal cutting parameters using TOPSIS. Section 4 presents a cutting database system developed based on machining features and TOPSIS, which provides an effective way to assist the selection of part, machine, tool and cutting parameters. In Section 5, the application of a real case is illustrated. In Section 6, conclusions are presented.

2. Definition and classification of machining features

Feature is the carrier of high-level semantic information and basic transmission unit, and it stands for different meanings in different contexts depending on the specific domain. For example, a feature in design could be referred to a web or a notch section, while in manufacturing it refers to a plane or a hole, while in inspection it could be used as a datum or reference for inspecting the part [17].

According to standard for the exchange of product model data (STEP), part features are divided into planar, curved surface, hole, boss, groove and rib etc., where planar includes the general plane, inclined plane, side surface and step surface; curved surface includes spherical, conical surface, cylindrical surface, torus; hole includes via hole, blind holes, threaded hole, square hole; groove includes straight slot, T-shape groove, V-shape groove, dovetail groove etc. A part feature is used to describe the information about part design and part modeling. A part model can be obtained by a series of Boolean operations of part features.

Related to a part feature, there are corresponding machining features, described by machine processing and associated attributes. The quest for a set of standardized machining features had been actively pursued for many years until 2001 when the International Organization for Standardization (ISO) delivered the first edition of the standard for “Mechanical product definition for process planning using machining features” as one of the application protocols (APs) in ISO 10303, otherwise known as STEP [18]. The machining feature is defined as an information-set including part feature (PF), geometric information (GI), material information (MI), precision information (PI) and manufacturing resources information (MRI). According to this definition, the mathematical representation of machining features can be written as: $MF=PF+GI+MI+PI+MRI$, where PF can be planar, curved surface, hole, boss, groove and rib etc.; GI includes position and size dimensions; MI includes material type and hardness value; PI includes dimensional tolerance, positional tolerance, and surface roughness; MRI includes machine tools and cutting tools. Its structure is illustrated in Fig. 1.

Using the object-oriented idea to represent machining features, part information related to processing is gathered together to form one information unit. All information associated with a machining feature is divided up into some information families, and every information family also contains more detailed information. Since a manufacturing system might design new part features, introduce new processing methods or new processing technologies in the manufacturing environment, the database system is designed in a way so that it is unnecessary to change its structure to ensure the system's scalability and evolution, thereby realizing dynamic management of cutting parameters [19].

In the manufacturing of part, there are many different

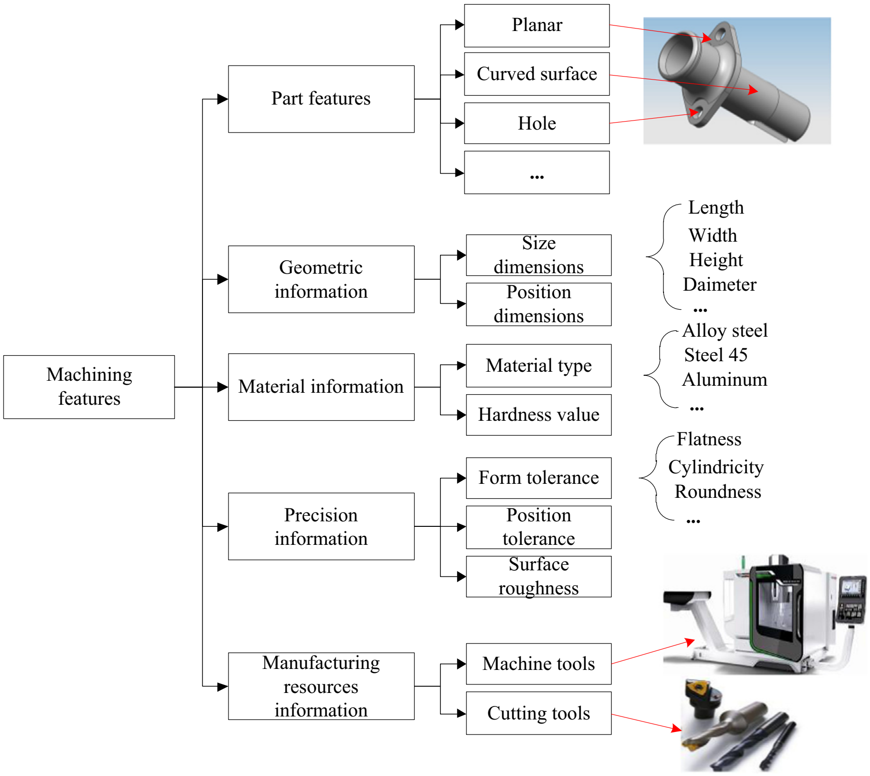


Fig. 1. The structure of machining features.

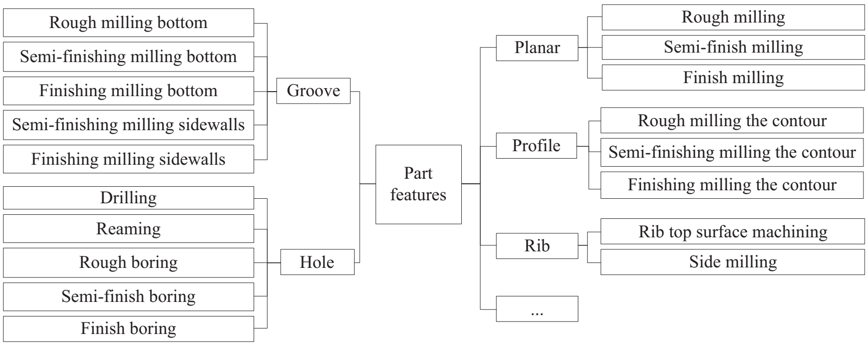


Fig. 2. The processing stages of each part feature.

processing methods, including turning, milling, grinding, drilling, etc. For each part feature, generally it should be machined via a number of different processing stages. In accordance with the accuracy class, the processing stages of each part feature are classified as shown in Fig. 2.

3. Selection of the best alternative of cutting parameters

In case that several alternatives of cutting parameters meet the requirements, the selection of best alternative of cutting parameters is an important step in cutting database system. Determining the best option from all of the feasible alternatives is a multiple criteria decision making (MCDM) problem. A MCDM problem can be concisely expressed in a matrix format as:

$$D = \begin{array}{c c} & \begin{array}{cccc} C_1 & C_2 & \cdots & C_m \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ \vdots \\ A_n \end{array} & \begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(m) \\ x_2(1) & x_2(2) & \cdots & x_2(m) \\ \vdots & \vdots & \vdots & \vdots \\ x_n(1) & x_n(2) & \cdots & x_n(m) \end{bmatrix} \end{array} \tag{1}$$

$$W = [w_1 w_2 \cdots w_m] \tag{2}$$

where A_1, A_2,…, A_n are all possible alternatives among which decision makers must choose; C_1, C_2,…, C_m are criteria with which alternative performance are measured; $x_i(j)$ is the rating of alternative A_i with respect to criterion C_j ; w_j is the weight of criterion C_j [20].

TOPSIS is a classical MCDM method, which was initially presented by Hwang and Yoon in 1981 [21]. The basic concept of TOPSIS is that the chosen alternative should have the shortest Euclidean distance from the positive ideal solution ($S+$), and the farthest from the negative ideal solution (S-). The $S+$ is a hypothetical solution for which all criterion values correspond to the maximum criterion values in the database comprising of all the satisfactory solutions; The S- is the hypothetical solution for which all criterion values correspond to the minimum criterion values in the database. Then, a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives. The higher value of closeness coefficient indicates that an alternative is closer to $S+$ and farther away from S- simultaneously.

The process of TOPSIS to select the best alternative is presented as follows [22]:

Step 1: Calculate the normalized decision matrix $R = \{r_{ij}\}_{n \times m}$. Each element $r_{ij} \in \mathbf{R}$ is transformed using the following equation:

$$r_{ij} = x_i(j) \Bigg/ \sqrt{\sum_{i=1}^{n} x_i(j)^2} \quad (i = 1, 2, \ldots, n; j = 1, 2, \ldots, m) \tag{3}$$

Scale normalization is needed to account for the unbalanced effect of magnitude differences among criteria.

Step 2: Construct the weighted normalized decision matrix V.

$$V = \{ v_{ij} \}_{n \times m} = \begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_m r_{1m} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_m r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ w_1 r_{n1} & w_2 r_{n2} & \cdots & w_m r_{nm} \end{bmatrix} \tag{4}$$

where w_j is the weight of the jth criterion, and $\sum_{j=1}^{m} w_m = 1$.

For any MCDM model, properly determining each criterion's weight is very important. The more important a criterion is, the larger the weight shall be. In this paper, the entropy method is used to determine the weight, because it not only makes full use of the inherent information of criteria, but also removes the subjectivity of decision maker in determining the weight [23]. In information theory, entropy is the expected value (average) of the information contained in each message received (each criterion in the context of this study) and used to determine the uncertainty or disorder, and in turn the utility in system information. The smaller entropy value means the smaller disorder degree of the system. Entropy is zero when one message is certain, implying the high importance of the criterion. The entropy value H_j can be obtained as [24,25]:

$$H_j = -k \sum_{i=1}^{n} [f_{ij} \ln(f_{ij})], \tag{5}$$

$$\text{where} \quad f_{ij} = r_{ij} \Bigg/ \sum_{i=1}^{n} r_{ij}; \ \ k = 1/\ln n \tag{6}$$

The objective weight for each criterion C_j (j=1,2,…,m) is given by

$$w_j = \frac{1 - H_j}{m - \sum_{j=1}^{m} H_j} \tag{7}$$

Note that w_j is (1–H_j) normalized by sum so that $\sum_{\forall j} w_j = 1$. As a result of the weight normalization, the values of weights will be small; but the relative importance of criteria will show through their differences.

Step 3: Define the positive ideal solution $S+$ and the negative ideal solution S-.

$$S+ = (v_1+, v_2+, \cdots, v_m+)\ ;\ S- = (v_1-, v_2-, \cdots, v_m-) \tag{8}$$

$$\text{where } v_j+ = \max_i\{v_{ij}\}\ ;\ \ v_j- = \min_i\{v_{ij}\} \tag{9}$$

Step 4: Calculate the Euclidean distance of each alternative from $S+$ and S–, respectively.

Table 1
The characteristics of data sources.

The data source	The characteristics
Machining data handbooks	Systematization; data richness; easily be collected
Software simulation	Economical; data needed to be validated by experiments before application
Laboratory experiments	Less reliable than shop experience but better than simulation
Shop experience	Data scatterness; good reliability

$$d_i+ = \|v_i - S+\| = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j+)^2}$$

$$d_i- = \|v_i - S-\| = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j-)^2} \tag{10}$$

Step 5: Calculate the closeness coefficient (CC_i) to the ideal solution. The closeness coefficient of the alternative A_i with respect to $S+$ is defined as:

$$CC_i = \frac{d_i-}{(d_i+) + (d_i-)} (i = 1, 2, \cdots, n) \tag{11}$$

Step 6: According to the closeness coefficient, the ranking order of all alternatives can be determined. The best alternative of cutting parameters is the one with the highest score of CC_i .

4. A cutting database system based on machining features and TOPSIS

For computer numerical control machine tool such as machining center, the cutting database system is not only the data provider, but also serves as the basis for realizing the advanced technology of CAM and CAPP. The cutting parameters are obtained from machining data handbooks, software simulation, laboratory experiments and shop experience. The characteristics of data sources are given in Table 1.

4.1. Database design

Database design is a very important task in developing the system. Generally, the design of database can be divided into four phases: requirements analysis, concept structural design, logical infrastructure design and physical infrastructure design. The last phase is not considered here because of wide availability of existing database software [26]. In the requirements analysis phase, the scope of processing methods to be supported, turning, milling, drilling, and so on should be decided, and the cutting parameters according to part information and its processing stages should be obtained.

Entity–Relationship (ER) model is used to carry out the concept structural design, after getting familiar with the application needs in the requirements analysis phase. In the E–R model, rectangle represents entity; ellipse represents entity attribute; diamond represents the link between entities. The key to building an E–R model is properly distinguishing the relationship between attributes and entities. Currently, the database is composed mainly of four types of machining processes, i.e., turning, milling, drilling and grinding. The E–R diagram of each process is similar, and the E–R diagram of milling is taken as an example, as shown in Fig. 3.

The purpose of logic design is to transform the entities described in the E–R model to the data model supported in SQL Server. It includes the definition of data tables, definition of data types and length of fields and definition of primary keys and foreign keys of tables. So, basic tables are defined which includes table of tools information, table of part material information table, table of cutting parameters information, and so on. According to the E–R diagram above, the relationship of the data tables of the milling parameter database system is designed, as shown in Fig. 4.

4.2. Development of the cutting database system

The intended users of the cutting database system are mainly the technical staff and field workers. In anticipation of the possible expansion and changes in the future, the function modules of the cutting database system are planned, as shown in Fig. 5.

Considering the amount of data, compatibility, convenience,

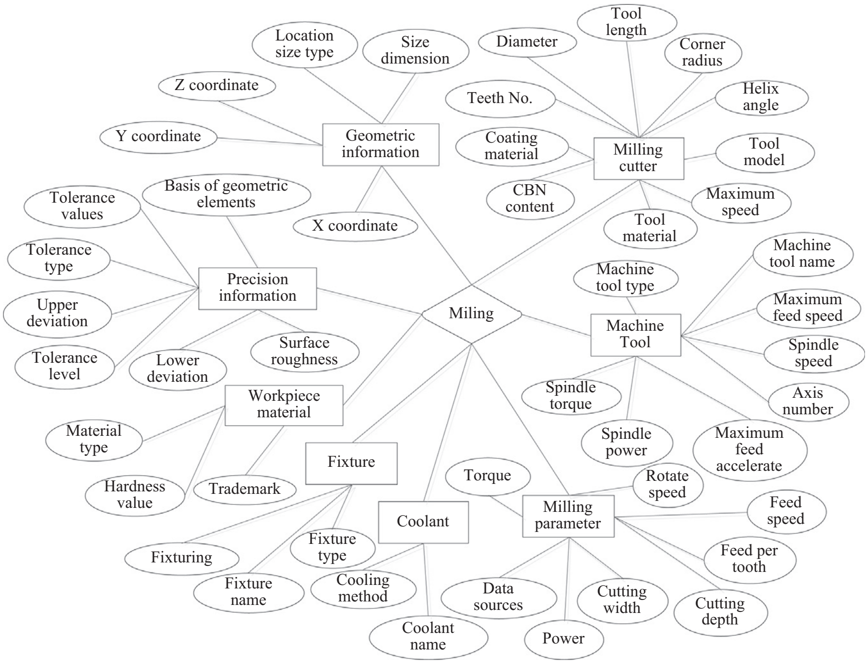


Fig. 3. E–R diagram of milling.

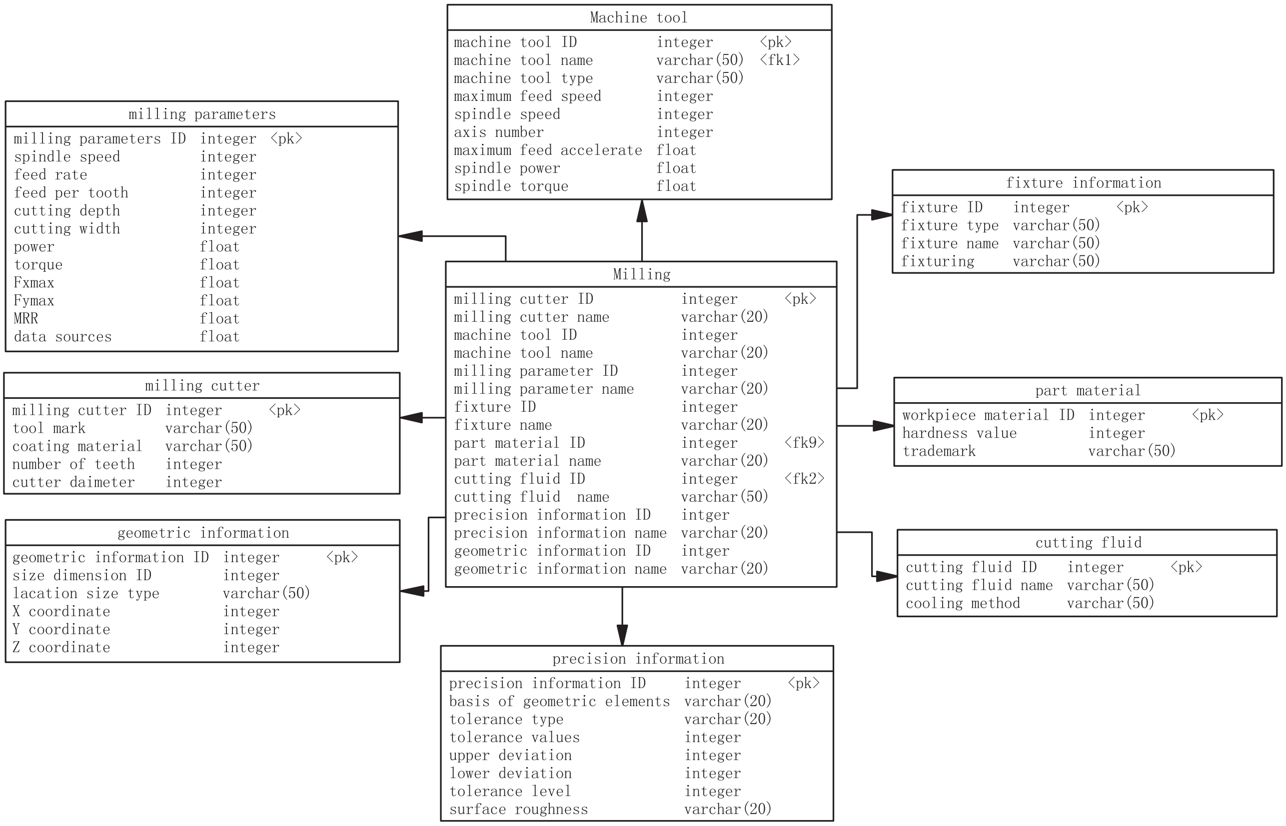


Fig. 4. Data tables of milling parameters and their relationships.

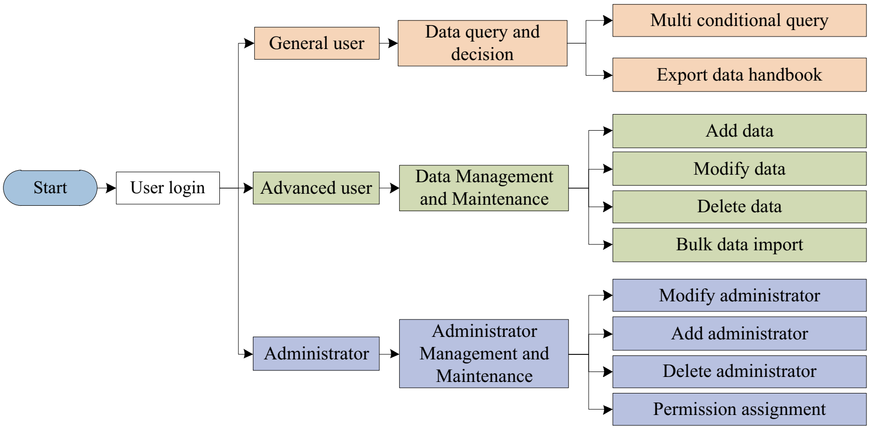


Fig. 5. The function modules of the cutting database system.

and interface with CAM/CAE/CAPP in the system, Microsoft SQL Server is selected as the database platform. The web application of ASP.NET is constructed with C# based on the structure of Browser/Server (B/S). Combining with ADO.NET for accessing to the SQL Server database, the database is developed. Users can use various mobile terminals to access the system, as shown in Fig. 6.

Since the database does not have the calculation function, the cutting database system implements the function of selecting the best alternative of cutting parameters through calling the MATLAB program using the development tool C#. In other words, the system takes advantage of the C# to design the interface and makes use of MATLAB's strong computation ability

The contents of the database system are divided into four parts: machine tool, tool, part and cutting parameters. Data can be inquired, added, modified, and deleted at the same time. The machine information is taken as an example as shown in Fig. 7, which includes all machine information in the database. The cutting data information is shown in Fig. 8; it can be seen that users can choose basic information such as part no., part feature, tool and so on. Finally, the best alternative of cutting parameter can be selected by TOPSIS and exported.

5. An illustrative example

Panel parts are common in the field of aerospace. They are complex structures with many part features such as hole, stiffener, planar, groove and so on. In this section, we take the processing of panel part as an example to test the feasibility and effectiveness of the cutting database system. The geometric model of the panel

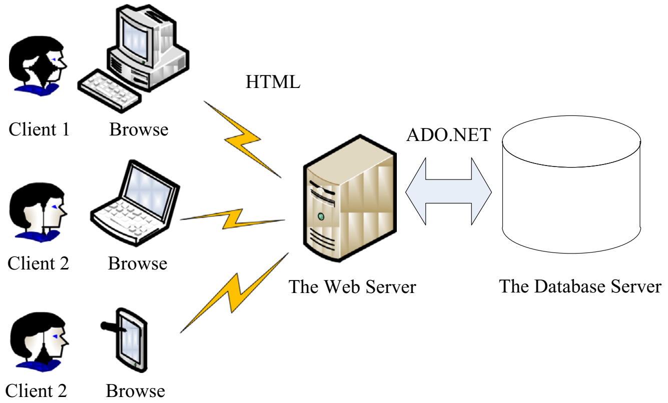


Fig. 6. The three-layer structure model of B/S structure.

part and its dimensions are shown in Fig. 9, and the material is aluminum alloy (AlCu4MgSi).

Processing the part requires a number of machining processes. Because applying this system to determine the cutting parameters for each process is the same, this paper explains only the application of the cutting database system for the rough milling of the groove (in red box in Fig. 9).According to the known information about the part, the system returns the following results: the cutting tool is XCP-EM2B12; the machine tool is VMC0656mu; the processing operation is rough milling; and the cutting parameters are shown in Fig. 10 via clicking the button “Query data”.

In the real production, cutting parameters include spindle speed, feed rate, cutting width, cutting depth must be chosen, so these parameters are used to construct the multiple criteria decision making matrix D as:

$$D = \begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \end{array} \begin{array}{cccc} \text{SS} & \text{FR} & \text{CW} & \text{CD} \\ \end{array}$$

$$D = \begin{array}{cc} & \begin{array}{cccc} \text{SS} & \text{FR} & \text{CW} & \text{CD} \end{array} \\ \begin{array}{c} A_1 \\ A_2 \\ A_3 \\ A_4 \\ A_5 \\ A_6 \\ A_7 \end{array} & \begin{bmatrix} 11000 & 1100 & 1 & 4 \\ 11000 & 2200 & 1 & 4 \\ 7300 & 1900 & 1 & 3 \\ 6000 & 2000 & 1 & 4 \\ 5000 & 800 & 0.8 & 2 \\ 7000 & 1200 & 1 & 5 \\ 8000 & 1800 & 2 & 6 \end{bmatrix} \end{array}$$

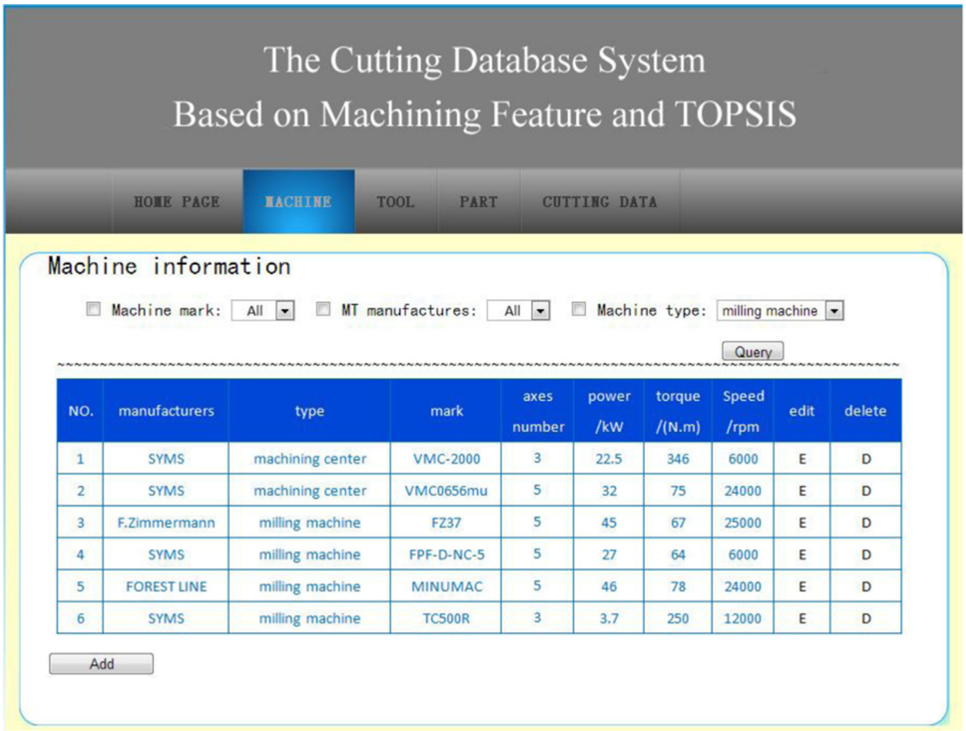
where SS, FR, CW and CD separately represent spindle speed (r/min), feed rate (mm/min), cutting width (mm), cutting depth (mm), and $A_i(i=1,2,\ldots,7)$ is alternative i (there are seven alternatives of cutting parameters all together).

The process of TOPSIS to select the best alternative is presented as follows:

(1) Calculate the normalized decision matrix R by Eq. (3) based on the matrix D.

$$R = \begin{bmatrix} 0.51 & 0.27 & 0.32 & 0.36 \\ 0.51 & 0.53 & 0.32 & 0.36 \\ 0.34 & 0.46 & 0.32 & 0.27 \\ 0.28 & 0.49 & 0.32 & 0.36 \\ 0.23 & 0.19 & 0.26 & 0.18 \\ 0.32 & 0.29 & 0.32 & 0.45 \\ 0.37 & 0.44 & 0.64 & 0.54 \end{bmatrix}$$

(2) Construct the weighed normalized decision matrix V.
First, compute the entropy value H_j ($H_1=0.9817$, $H_2=0.9736$, $H_3=0.9764$, $H_4=0.9752$) using Equations (5,6). Note that relative small differences between those entropy values. Hence, at least four decimal places are recommended. Then calculate the weight for each criterion w_j ($w_1=0.1967$, $w_2=0.2838$, $w_3=0.2533$, $w_4=0.2662$) by Eq. (7). Due to the normalization process, the normalized weights are relatively



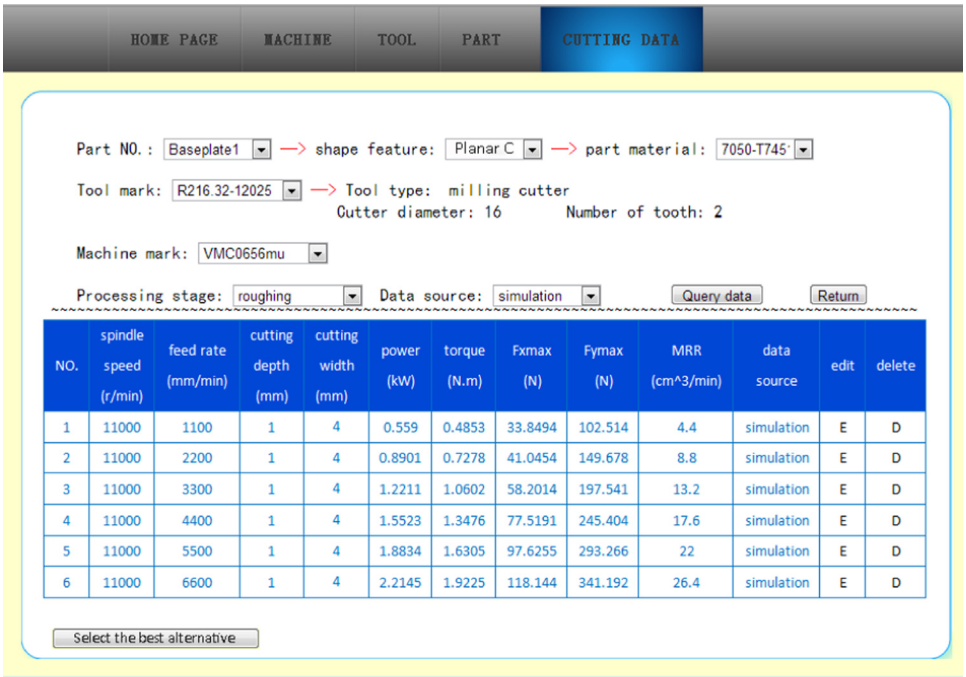
The Cutting Database System
Based on Machining Feature and TOPSIS

Machine information

☐ Machine mark: All
☐ MT manufactures: All
☐ Machine type: milling machine

NO.	manufacturers	type	mark	axes number	power /kW	torque /(N.m)	Speed /rpm	edit	delete
1	SYMS	machining center	VMC-2000	3	22.5	346	6000	E	D
2	SYMS	machining center	VMC0656mu	5	32	75	24000	E	D
3	F.Zimmermann	milling machine	FZ37	5	45	67	25000	E	D
4	SYMS	milling machine	FPF-D-NC-5	5	27	64	6000	E	D
5	FOREST LINE	milling machine	MINUMAC	5	46	78	24000	E	D
6	SYMS	milling machine	TC500R	3	3.7	250	12000	E	D

Fig. 7. Machine information interface.



Part NO.: Baseplate1 ⟶ shape feature: Planar C ⟶ part material: 7050-T745

Tool mark: R216.32-12025 ⟶ Tool type: milling cutter

Cutter diameter: 16 Number of tooth: 2

Machine mark: VMC0656mu

Processing stage: roughing Data source: simulation

NO.	spindle speed (r/min)	feed rate (mm/min)	cutting depth (mm)	cutting width (mm)	power (kW)	torque (N.m)	Fxmax (N)	Fymax (N)	MRR (cm^3/min)	data source	edit	delete
1	11000	1100	1	4	0.559	0.4853	33.8494	102.514	4.4	simulation	E	D
2	11000	2200	1	4	0.8901	0.7278	41.0454	149.678	8.8	simulation	E	D
3	11000	3300	1	4	1.2211	1.0602	58.2014	197.541	13.2	simulation	E	D
4	11000	4400	1	4	1.5523	1.3476	77.5191	245.404	17.6	simulation	E	D
5	11000	5500	1	4	1.8834	1.6305	97.6255	293.266	22	simulation	E	D
6	11000	6600	1	4	2.2145	1.9225	118.144	341.192	26.4	simulation	E	D

Fig. 8. The cutting data interface.

small; but note that the differences between weights are larger than those shown in the entropy values. Finally the weighted normalized decision matrix V is obtained by using Eq. (4).

$$V = \begin{bmatrix} 0.10 & 0.07 & 0.08 & 0.10 \\ 0.10 & 0.15 & 0.08 & 0.10 \\ 0.07 & 0.13 & 0.08 & 0.07 \\ 0.06 & 0.14 & 0.08 & 0.10 \\ 0.05 & 0.05 & 0.06 & 0.05 \\ 0.06 & 0.08 & 0.08 & 0.12 \\ 0.07 & 0.12 & 0.16 & 0.15 \end{bmatrix}$$

(3) Obtain the positive ideal solution $S+$ and the negative ideal solution $S-$ by Eqs. (8) and (9):$S+=(0.10,0.15,0.16,0.15)$; $S-=(0.05,0.05,0.06,0.05)$.

(4) Calculate $d+$,$d-$ and CC_i (shown in Table 2) by Eqs. (10) and (11).

According to the closeness coefficient CC_i in Table 2, the ranking order of all alternatives is: $A_7 > A_2 > A_4 > A_3 > A_6 > A_1 > A_5$, so A_7 (8000, 1800, 2, 6) is the best alternative. The above process is implemented by calling the MATLAB program that implements the methodology using the development tool C# in this system, and the user can get the best alternative by clicking the button labeled “Select the best alternative”. Generally speaking, machining data handbooks usually provides more conservative cutting parameters ($FR_3=7300$ mm/min $<$ $FR_7=8000$ mm/min) for user in order to adapt to various types of machine tools, so the material removal rate is often lower ($MRR_3=6.7$ cm^2/mm $<$ $MRR_7=19.2$ cm^2/mm). Consequently, machines tools with outstanding characteristics might not be taken full advantage of if the best alternative of cutting parameters is not chosen. On the other hand, software simulation often simplifies the actual machining to build its underlying mathematical model. Therefore, the cutting parameters obtained by simulation tend to be over-optimistic with a

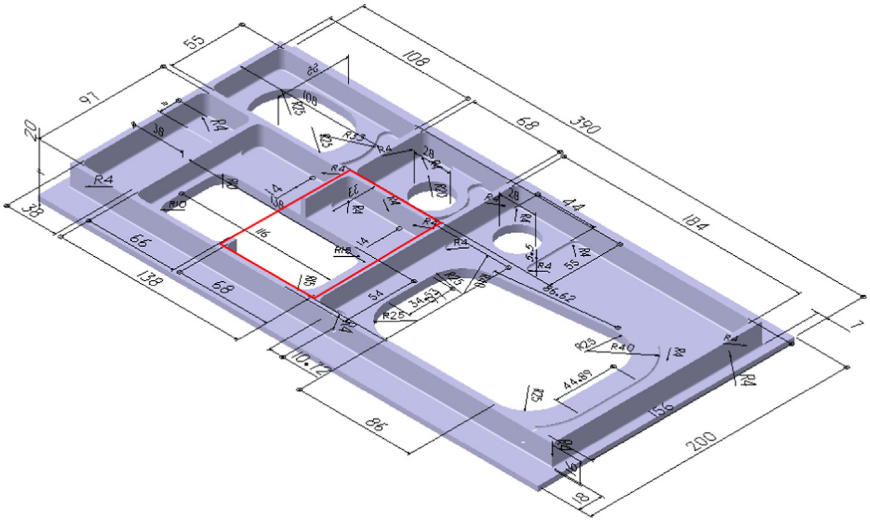
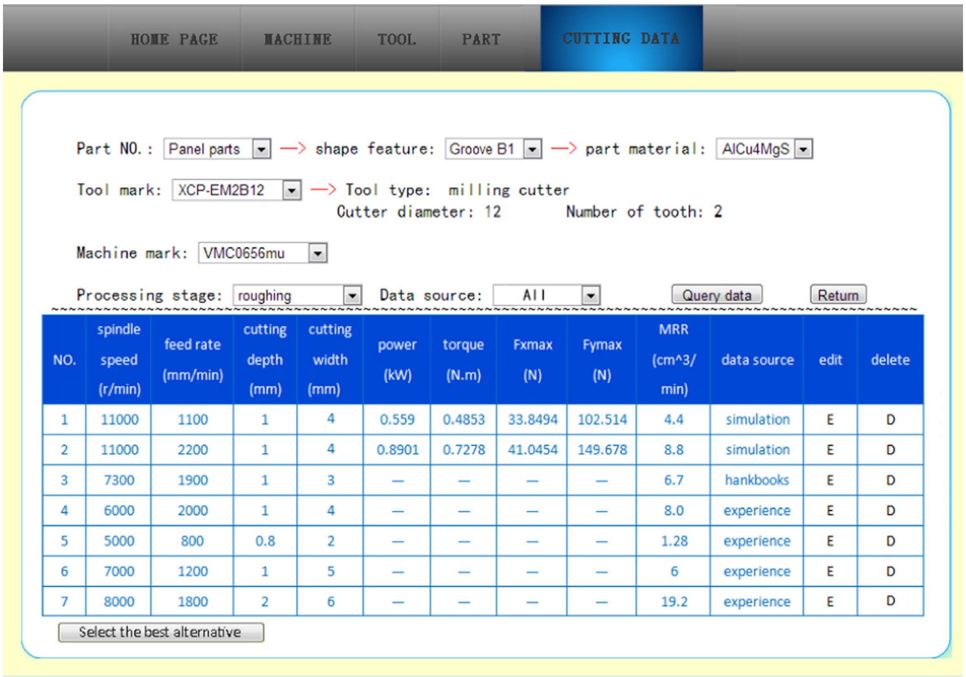


Fig. 9. The geometric model of the panel part and its dimensions. (For interpretation of the references to color in this figure, the reader is referred to the web version of this article.)



Part NO.: Panel parts —> shape feature: Groove B1 —> part material: AlCu4MgS

Tool mark: XCP-EM2B12 —> Tool type: milling cutter

Cutter diameter: 12 Number of tooth: 2

Machine mark: VMC0656mu

Processing stage: roughing Data source: All

NO.	spindle speed (r/min)	feed rate (mm/min)	cutting depth (mm)	cutting width (mm)	power (kW)	torque (N.m)	Fxmax (N)	Fymax (N)	MRR (cm^3/min)	data source	edit	delete
1	11000	1100	1	4	0.559	0.4853	33.8494	102.514	4.4	simulation	E	D
2	11000	2200	1	4	0.8901	0.7278	41.0454	149.678	8.8	simulation	E	D
3	7300	1900	1	3	—	—	—	—	6.7	hankbooks	E	D
4	6000	2000	1	4	—	—	—	—	8.0	experience	E	D
5	5000	800	0.8	2	—	—	—	—	1.28	experience	E	D
6	7000	1200	1	5	—	—	—	—	6	experience	E	D
7	8000	1800	2	6	—	—	—	—	19.2	experience	E	D

Fig. 10. The results of query.

Table 2
$d+$, $d-$ and CC_i for all alternatives.

No.	$d+$	$d-$	CC_i
A_1	0.12	0.08	0.39
A_2	0.10	0.12	0.57
A_3	0.12	0.09	0.43
A_4	0.11	0.10	0.49
A_5	0.18	0.01	0.04
A_6	0.11	0.08	0.42
A_7	0.04	0.16	0.81

recommendation of using higher spindle speed ($SS_1=SS_2=$ 11,000 r/min > $SS_7=8000$ r/min) or feed rate ($FR_2=$ 2200 mm/min > $FR_7=1800$ mm/min). Above all, the maximal material removal rate of A_7 among all alternatives explores fully the characteristic of the machine tool for roughing milling. So we adopt the data of A_7 to mill the groove using the NC milling machine (VMC0656mu), and the machining process is shown in Fig. 11 (a).

The same system was applied to determine the cutting parameters for the semi-finish milling of the groove in the same manner as that shown in details for rough milling, and the resultant machining process is shown in Fig. 11 (b).

6. Conclusions

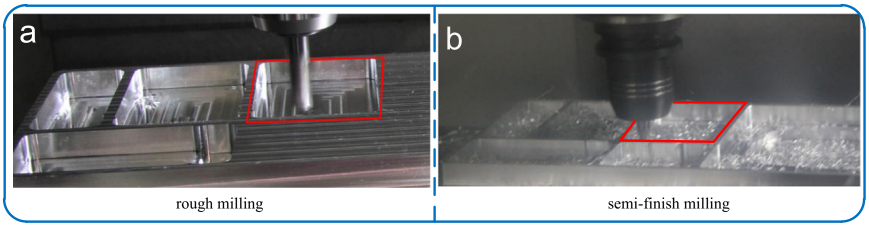
With the objective of resolving the problems associated with traditional cutting database, the paper presents a cutting database system based on machining feature and TOPSIS. Specifically,

(1) All kinds of necessary machining information such as part feature, geometric information, material information and so on can be integrated by machining features, which make storing and managing cutting parameters convenient. Besides, the B/S structure is used to build the cutting database prototype system, which strengthens the integrated and networked function of the system.

(2) With an increase in cutting parameters collected in the database, many alternatives of cutting parameters are expected to meet the requirements of retrieval for a new machining operation. Taking spindle speed, feed rate, cutting width and cutting depth as criteria to construct multiple criteria decision making matrix D, followed by the use of the entropy method to determine the weight of cutting parameters to establish the weighed normalized decision matrix V, the Euclidean distance of each alternative is calculated, and finally the best alternative can be selected according to the values of the closeness coefficient CC_i, which can keep the operator with different levels of experience from choosing not-the-best alternative when faced with many alternatives of cutting parameters.

(3) Finally, by applying this prototype cutting database system to plan for the machining of panel parts, this system is proved to be effective and practical.

As it is, our approach is not able to provide the optimal cutting parameters for machining free-form surface such as impeller



rough milling semi-finish milling

Fig. 11. Groove milling processing.

blades. For such applications, cutting parameters should be determined by considering the dynamically changing tool loads (cutting forces). This study will be extended along this direction in the future.

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