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

Chong Peng [a,*], Hanheng Du [a], T. Warren Liao [b]

[a] School of Mechanical Engineering and Automation, Beihang University, Beijing, 100191, China
[b] Department of Mechanical and Industrial Engineering, Louisiana State University, Baton Rouge, LA, 70803, USA

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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

* Corresponding author.
E-mail addresses: pch@buaa.edu.cn (C. Peng), duhanheng@163.com (H. Du), ieliao@lsu.edu (T. Warren Liao).

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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

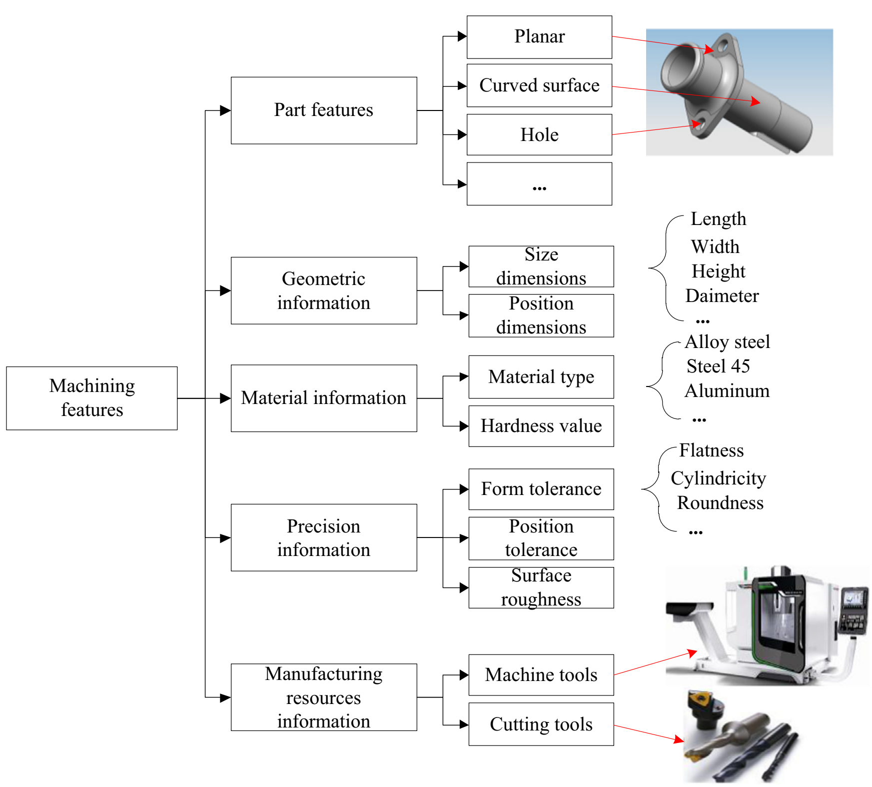

Fig. 1. The structure of machining features.