Expert Systems with Applications 38 (2011) 12537–12547

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Automation of mold designs with the reuse of standard parts

Hak-Soo Mok [a], Chang-Ho Kim [b], Chang-Bong Kim [a,*]

[a] Department of Industrial Engineering, Pusan National University, Jangjeon-dong, Keumjung-gu, Busan 609-735, South Korea
[b] Department of Mechanical Engineering, Dong-eui University, 995, Eomgwang-no, Busanjin-gu, Busan 614-714, South Korea

ARTICLE INFO

Keywords:
Design automation
Standard part
Reuse
Retrieval
Part list

ABSTRACT

This study has developed an effective reuse and retrieval system that can easily register modeled standard parts using a simple GUI (graphic user interface) even though designers may not know the rules of registration for a complex database. Also, the automatic generation of the optimized parts list has been investigated. The system has been developed in the Windows XP environment using an Open API (application programming interface) and a commercial CAD/CAM/CAE solution. It consists mainly of three kinds of module, i.e., a standard part module, parts-list module, and retrieval-system module. The standard part module is helpful for designers to effectively reuse or modify standard parts after registering them using a GUI. The parts-list module generates a parts list using either standard and/or non-standard parts. The retrieval-system module allows the effective retrieval and classification of standard parts. The system was applied to standardize mold bases and mold parts. It was applied to Hyundai Heavy Industry, S. Korea, which resulted in the reduction of design errors and design time.

1. Introduction

Commercialized 3D CAD (computer-aided design) systems provide algorithms that might describe a master model that defines the correlation of each feature with the parametric structure. The model has shape information that satisfies design rules and attributes that represent character information. The attributes of parts should be managed from the commencement of design. Then, product attributes can be identified in the entire assembly structure in a PDM/PLM (product data management/product lifecycle management) system that is related to 3D CAD. Therefore, in a design automation system, the reuse of standard parts and the effective management of attributes, including those of non-standard parts, are required.

Because current 3D CAD systems do not offer convenient methods for the effective management and reuse of standard parts, it is inconvenient for users to modify standard parts and to specify various conditions for assembling standard parts with existing parts. Also, they do not provide effective retrieval methods.

Researchers have studied design reuse methodologies or design reuse systems for reusing past designs. Wognum and Smith (1996) discussed the knowledge-based system, proposing a 4-step reuse model for system development, namely, retrieval, determination of adaptation focus, generation of new specifications for the part to be adapted, and adaptation, along with the system development procedure for computer-aided redesign. Sivaloganathan and Shahin (1998) carried out a meta-study on design reuse, where they dealt with seven aspects of design reuse: focused innovation, cognitive and computational perspectives on design reuse, use of standard components, design reuse tools and methods, design reuse systems, and other relevant issues. Some researchers have shown the reuse of design system based on the design model underlying design function deployment. The product concept, solution concept, embodied design, and detailed design are seen as the design data required by the designer to efficiently and effectively reuse an earlier design (Shahin, Andrews, & Sivaloganathan, 1999). Andrews, Shahin, and Sivaloganathan (1999) reported two methods, specifically, the generative and variant methods, for the storage and reuse of detailed engineering designs for efficient and adaptive reuse. Also, the four case-studies presented therein successfully demonstrated the ability of both generative and variant methods to store and modify detailed engineering designs. Ong, Xu, and Nee (2006) have recently proposed a design reuse methodology for product family design. A three-stage process model was used to accommodate the requirements of product family design as well as the major processes in design reuse. Also, in a case study, product families of a cellular phone were developed using the proposed design reuse methodology. Ong and Guo (2004) described an integrated and systematic framework to computerize the design reuse process and implemented a prototype online design reuse system. The systematic framework can guide the users in analyzing their original function requirement, find the most reusable existing design and adapt it into a new design at the detailed design level or suggest a reuse solution. The design reuse process is supported by an intelligent reasoning

* Corresponding author. Tel.: +82 10 8525 1388.
E-mail address: cbkim@pusan.ac.kr (C.-B. Kim).

0957-4174/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2011.04.040

mechanism together with intensive user interactions to secure a more pertinent reuse result. Finally, it can be easily adapted to facilitate collaborative design or product customization.

Kong et al. (2003) developed a Windows-native 3D plastic injection mold design system by using API based on the commercial software of SolidWorks 99. They demonstrated that consisting of 4 modules, data prepare, filling design, mold base, and parting design, this system could be efficiently applied to mold designs. In addition, faster mold design and more efficient standardization were made possible because it offered the designer a more interactive CAD environment. Lou, Jiang, and Rusan (2004) proposed a new procedure for mold base design, based on which an integrated knowledge-based system was developed. Among the technologies used for developing the system were product modeling, frame-rule structures, case-based reasoning, and neural networks technologies, while these technologies were proven to be instrumental in the advancement of individual CAD/CAM/CAE systems into a universal knowledge-based system. Some researchers have suggested a prototypical, Internet-based intelligent design system for injection molds (Mok, China, & Lan 2008). The architecture of the system was designed in a way that an interactive KB mold design system could be operated in a web-based environment. Under this system, the three types of modules used for designing mold bases, computational module, knowledge base module and graphic module, were put together into an interactive CAD-based framework. Further, the mold design of mouse cases was performed in order to test the effectiveness of the developed system. Huang, Jou, Zhang, Wang, and Huang (2009) developed a web-based parametric design system for building mold bases, where designers only had to use a browser to finish the design by means of a visualized web-based user interface without any CAD software. This system provided visualization, editing, and review in the process of interface design. Also, the system interface used maps as well as parametric feature-based database to facilitate the design process.

In this paper, an effective reuse and retrieval system is presented. Standard parts can be registered easily using a simple GUI (graphic user interface) even though designers may not be knowledgeable enough about the rules of registration for a complex database to edit designs in it. The system has been developed in the Windows XP environment using an Open API (application programming interface) and a CAD/CAM/CAE solution. It mainly consists of three kinds of module, i.e., a standard part module, parts-list module, and retrieval-system module. The standard- part module is helpful for designers to effectively reuse or modify standard parts after registering them using GUI. The parts-list module generates a parts list using either standard and/or non-standard parts. The retrieval-system module allows the effective retrieval and classification of standard parts. The system was applied to standard mold bases and mold parts for mold design.

2. Implementation of the system

2.1. System processes

Fig. 1 shows the process that registers standard parts and stores their attributes in this system as follows:

- Selection and classification of standard parts.
- Storage of the design variables for standard parts in the database.

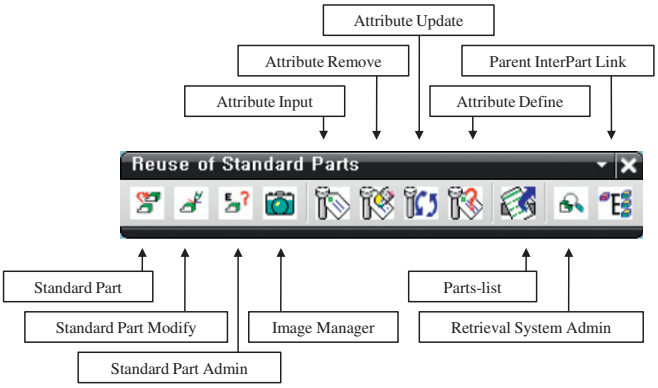

Fig. 3. User interfaces of the developed system modules.

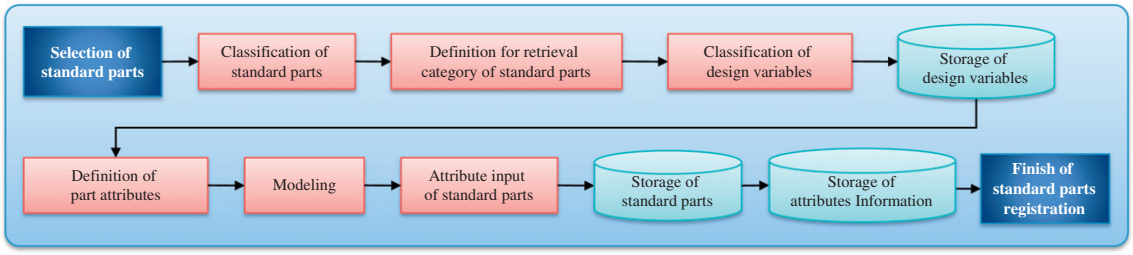

Fig. 1. Registration process for standard parts and part attributes.

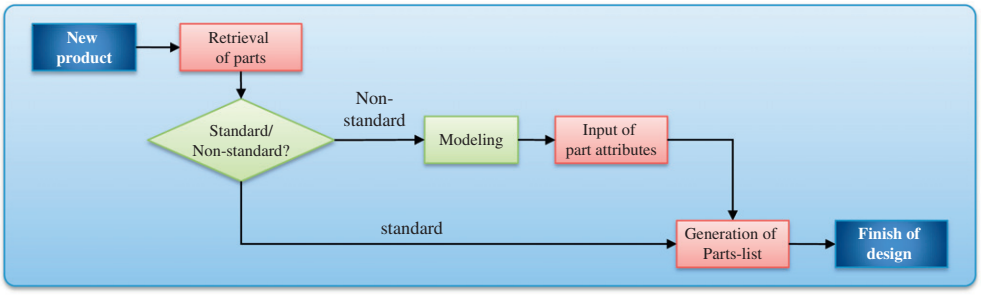

Fig. 2. 3D design process using standard and non-standard parts.