Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 207 (2017) 502–507

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on the Technology of Plasticity, ICTP 2017, 17-22 September 2017, Cambridge, United Kingdom

Development of Knowledge-Expandable Ontology-Based Expert System for Process Planning in Cold Forging of Flange Nuts

Che Wei Chang, Rong Shean Lee*, Ting Wei Chang

Department of Mechanical Engineering, National Cheng Kung University, 1 University Road, Tainan, Taiwan

Abstract

This paper proposed a new method of constructing an ontology-based expert system with an expandable knowledge base for process planning in cold forging of flange nuts. There are two essential parts of this method. In the first part, the software Protégé is used for expressing the experiential knowledge as a Web Ontology Language (OWL) ontology and Semantic Web Rule Language (SWRL) rules. The inference is executed in Java by means of the API provided by Jess, the rule engine for the Java platform. In the second part, new knowledge is acquired from parameter optimisation experiments, combing process simulation and Taguchi methods.

Deform-3D was adopted as the process simulation engine. Then the tool wear of front punch at the 4th stage was predicted for the tool life evaluation. A modified Archard wear model is used for tool wear prediction during the simulation. On the other hand, Taguchi methods is used for designing an optimal tool which makes the tool life longer than that of the existing design. The novelty of the proposed system is that the new knowledge is represented as an OWL ontology and SWRL rules, which makes the knowledge base of the system expandable. The knowledge base can thus be expanded if there are modifications or new knowledge. The system is capable of inferring a workable forging process for flange nuts. It could recommend dimensions of tools after the necessary information, such as the nominal size and specifications of the product, has been input. Users are able to reduce tool design time by taking the results from the system as a process planning decision support. In this way, when the manufacturer gets a new quotation from the client, engineers can search from the company tooling database for feasible forging tools and make the cost estimation based on the forging process plan generated by this system.

Peer-review under responsibility of the scientific committee of the International Conference on the Technology of Plasticity.

Keywords: Expandable knowledge base, Expert system, Flange nuts, Process simulation, Taguchi methods.

* Corresponding author. Tel.: +886-6-2757575 ext 62147.
E-mail address: mersl@mail.ncku.edu.tw

1877-7058
Peer-review under responsibility of the scientific committee of the International Conference on the Technology of Plasticity.
10.1016/j.proeng.2017.10.812

1. Introduction

A complete cold forging plan involves establishing appropriate operating conditions and forging processes. Operating design includes the selection of the type of forging machines, forging force, speed and stroke, tool materials, hardness and life, interface lubrication, and the method of rotating workpieces between two molds. To determine an ideal process, engineering information accumulated in each sequence of the forging process has to be taken into consideration in routing design.

The evolution of process planning can be divided into two stages: artificial planning, which depends on the experience of planners, and variant computer aided process planning (CAPP), which classifies workpieces into specific families according to their similarities[1]. A standard process plan for each family is stored in a database. The disadvantage of variant CAPP is that it creates only a rough outline plan that needs to be adapted. With generative CAPP, process plans are generated by making use of logical rules, workpiece geometry and materials, algorithms, etc. Plans are produced automatically after part specifications have been input manually. Nevertheless, the systems are difficult to develop and maintain as there is a large database of rules that have to be consistent in all conditions. Sevenler et al. (1986) proposed a knowledge-based system to conduct process design in cold forging based on experience[2]. Various process planning systems based on an expert system or artificial intelligence have since been developed for cold forging.

In this paper, the main objective is to make the engineers quickly respond to the customer inquiry by generating a cold forging process plan with an expert system for reducing cost and lead time.

2. Ontology-Based Expert System

2.1. Knowledge Acquisition and Knowledge Base Establishment

A domain knowledge is usually derived from expert interviews, research papers, technical reports, etc. Unfortunately, not every domain expert has the time or ability to establish a knowledge base[3]. As a result, knowledge engineers play a vital role in building an expert system, as shown in Fig 1(a) knowledge engineer needs to be capable of extracting the knowledge from available documents or the experience of domain experts, then organizing it systematically, and eventually transforming it into ontologies. A knowledge engineer thus bridges domain knowledge and the expert system[4, 5].

The expert system is divided into the following categories: Interpretation, Prediction, Diagnosis, Design, Planning, Monitoring, Debugging, Repair, Instruction and Control. Early studies on expert systems focused on diagnosis whereas current studies focus on planning and design. The ontology-based expert system can be used for planning the process.

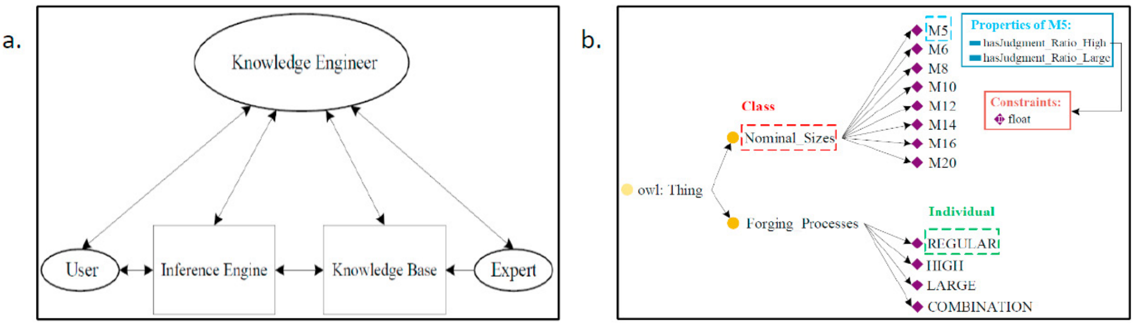

Fig. 1 (a) Role of knowledge engineers in building expert system. (b) Scheme of OWL ontology.

This paper demonstrates an OWL ontology-based expert system for hexagon flange nuts in cold forging [6-10]. DIN 6923 is the international standard of hexagon flange nuts, including flange diameter, across flats, across