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Development of an expert system for cold forging of axisymmetric product
Horizontal split and optimal design of multi-former die set

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Abstract This paper deals with an automated computer-aided process planning and die design system by which the designer can determine operation sequences even if they have little experience in process planning and die design for axisymmetric products. An attempt is made to link programs incorporating a number of expert design rules with the process variables obtained by commercial FEM softwares, DEFORM and ANSYS, to form a useful package. The system is composed of four main modules. The process planning and the die design modules consider several factors, such as the complexities of preform geometry, punch and die profiles, specifications of available multi-former, and the availability of standard parts. They can provide a flexible process based on either the reduction in the number of forming sequences by combining the possible two processes in sequence, or the reduction of deviation of the distribution on the level of the required forming loads by controlling the forming ratios. In the die design module optimal design technique and the horizontal split of the die insert were investigated for determining appropriate dimensions of components of the multi-former die set. It is suggested that the proposed method can be beneficial for improving the tool life of the die set in practice.

Keywords Die design · Extrusion · Process planning · Split insert

1 Introduction

Cold forging has its major advantages for making axisymmetric parts of small or medium sizes in multistage automatic forging machines or on conventional presses in several steps. It can produce parts with good surface finish, dimensional accuracy and improves mechanical properties, and also eliminates extra post-processing such as trimming and machining [1].

However it has a weak point that it needs much more time and cost to carry out a process and die design when compared with other processes.

Recently, computers performing repeated jobs accompanied by process design have helped to design effectively.

In this study, a cold forging expert system is developed by a various process and die design through expert system’s module, which contains the production feasibility check, process, and die design. The production feasibility check module generates process planning drawings feasibly according to the design rules [2]. The process planning module chooses the best suitable process to the product through the redesign function, which changes of the initial billet size and type, the sequence of upsetting and forward extrusion, and carries out a flexible process based on either reduction in the number of forming sequences by combining the possible two operations in sequence, or the reduction of deviation of the distribution on the level of the required forming loads by controlling the forming ratios. The die design module calculates stress by thick-walled cylindrical theory after carrying out elastic finite element analysis [3]. Calculating the maximum permissible inner pressure of the die insert, carrying out design of the stress ring, horizontal split of the die insert and vertical split of the die insert, and obtaining optimal design parameters, can help to generate die set drawings automatically [4].

2 Structure and working principle of the system

The automated process planning and die design system for the quasi-axisymmetric forging product is composed of input and shape treatment, production feasibility check, process planning, and die design modules. It is accomplished in one operation and has the merit of being processed without interruption as each module holds the rule and database in common. It is easy to use, as the dialogue boxes are user-friendly with appropriate prompting statements for the dimension, the tolerance, and the material of the product.
After a drawing of a product is inputted to the developed system through the applicable dialogue boxes, the input and shape treatment sub-module automatically recognizes the drawing of the product and produces the input data for the product. Then the material properties and forming limits required by process planning are extracted from the database and transferred to the production feasibility check module to generate process planning drawings feasibly according to the billet diameters by design rules. The results from the production feasibility check module are transferred to the process planning module to carry out separation or combination of operations to distribute the forming load. Then the results from the process planning module are transferred to the die design module to generate parts and the assembly of the multi-former die set. The configuration of the system is shown in Fig. 1. The functional description of the modules of the system is presented in detail as follows.

2.1 Input and shape treatment module

2.1.1 Input sub-module

A user inputs material type and the dimensions of the product through the dialogue boxes and the input sub-module automatically reads information about the mechanical properties of the material from the database. It determines the size with variables of each point of the shape of the product and displays it on