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A study on the development of computer-aided process planning system for electric product with bending and piercing operations

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Abstract

This paper describes a research work of developing computer-aided design of product with bending and piercing operation for progressive working. Approach to the system is based on the knowledge-based rules. Knowledge for the system is formulated from plasticity theories, experimental results, and the empirical knowledge of field experts. The system has been written in AutoLISP on the AutoCAD with a personal computer. It is composed of four main modules, which are input and shape treatment, flat pattern layout, strip layout, and die layout modules. The system is designed by considering several factors, such as bending sequence by fuzzy set theory, complexities of blank geometry, punch profiles, and the availability of a press equipment and standard parts. The strip layout and die layout drawings automatically generated by formularization and quantification of experimental technology will make minimization of trial and error and reduction of period in developing new products. Results obtained using the modules enable the manufacturer for progressive working of electric products to be more efficient in this field.

Keywords: Bending sequence; Die layout; Flat pattern layout; Fuzzy set theory; Knowledge based rules; Strip layout

1. Introduction

Standardization of design is need of the time according to trends of miniaturization, lightening, and speeding in nowadays industry. Shear forming by which parts with a desired shape are manufactured from a sheet metal especially using a punch and a die needs this kind of standardization with a view to compatibility and accuracy of components. But experiences and intuitional decision have mostly accomplished strip layout and die layout of forming as piercing and bending. In order to solve this problem, researches have been reported automation of computer-aided process planning for the designed product by formulizing these experiences of skillful engineers [1–5]. Nakahara et al. [1] introduced the system for a progressive die design. Wang and Chang [2] studied on determination of the bending sequence in progressive die design, and See Toh et al. [3] developed system for feature-based flat pattern. Also, Choi et al. [4,5] developed the automated process planning and die design system for blanking or piercing of irregular shaped sheet metal product. In this study, the developed system decides the sequencing process of electric product with intricate piercing and bending operations by considering several factors on bending and adopting fuzzy set theory. It constructs fuzzy matrix for calculating fuzzy relationship value and determines the optimum bend by combining several rules with fuzzy reasoning. The strip layout module of the system is able to carry out bending and piercing operations of 3D electric product. Using the data of the strip layout, the die layout module generates the parts of a die as punch, die, die plate, punch plate, stripper plate, guide plate, guide pin, spring, fastener, dowel pin, and lifter.

2. Constitution of system

The system is composed of four modules, which are input and shape treatment, flat pattern layout, strip layout, and die layout modules. It is accomplished without interruption while processing as each module holds rules and database in common. It is easy to use, as the dialogues are user-friendly with appropriate prompting statements for the various data required. The configuration of the system can be seen in Fig. 1.

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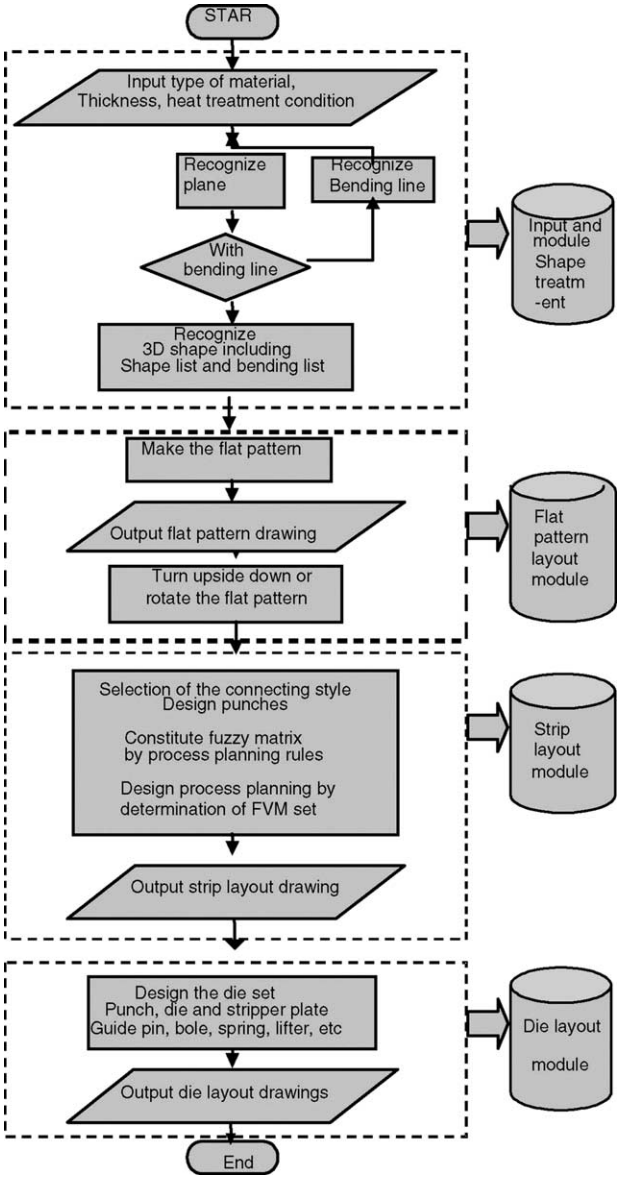

Fig. 1. Configuration of the system for progressive working.

For an electric product with piercing and bending operations, a user inputs the items, which are the shape of product, the bend angle, and the bend radius required in the input and shape treatment module. Then the system carries out the recognition process of these data and transfers the results of shape treatment into the flat pattern layout module. A flat pattern layout drawing considering bend allowances is generated in this module and the results are transferred into the strip layout module to automatically carry out strip layout. The results of the strip layout module are transferred to the die layout module to generate parts and an assembly of the die set. The functional description of the modules of the system is presented.

Each of internal and external shape composed by the closed loops has list of one plane. By assembling these plane lists, shape lists of product are organized as follows:

$$(((\text{``}P_1\text{''}(\text{external feature}\quad \text{internal feature}(1)\quad \text{internal feature}(2)\quad \cdots\quad \text{internal feature}(n))$$
$$((\text{``}P_2\text{''}(\text{external feature}\quad \text{internal feature}(1)\quad \text{internal feature}(2)\quad \cdots\quad \text{internal feature}(n))$$
$$\vdots$$
$$((\text{``}P_n\text{''}(\text{extenal feature}\quad \text{internal feature}(1)\quad \text{internal feature}(2)\quad \cdots\quad \text{internal feature}(n)))$$

2.1. Input and shape treatment module

Information of bend angle and line and relationship of planes connected with one another should be defined for product with bending and piercing operations. The information of a bending operation is composed of the entities of bend line, bend angle, bend radius, and the movement of bend line. The information of a plane is composed of list of mother plane and rotated children plane.

$$((\text{``}B_1\text{''}(\text{information bend line})\ \text{bend line}\quad \text{bend radius}\quad \text{information of bend line movement}\quad \text{referenced plane}\quad \text{rotated plane})$$
$$(\text{``}B_2\text{''}(\text{information bend line})\ \text{bend line}\quad \text{bend radius}\quad \text{information of bend line movement}\quad \text{referenced plane}\quad \text{rotated plane})$$
$$\vdots$$
$$(\text{``}B_n\text{''}(\text{information bend line})\ \text{bend line}\quad \text{bend radius}\quad \text{information of bend line movement}\quad \text{referenced plane}\quad \text{rotated plane}))$$

2.2. Flat pattern layout module

The flat pattern layout module calculates bend allowances with bend radius, bend angle extracted from bend list recognized in the shape treatment module, and coefficient according to material type read from the database.

2.3. Strip layout module

The strip layout module automatically decides shapes of punch profiles for the external area of product and carries out piercing. The module also decides the order of the process, which is capable of progressive working based on the rule, influencing strip layout of electric product. Rules are as follows.

2.3.1. Strip layout

The definition of ''mother plane'' is the fixed plane without rotation to all bending operations. Rotating plane is called ''children plane''. The determination of ''mother plane'' is as follows: