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MODEL FOR DEVELOPING A FEATURE RECOGNTION SYSTEM FOR A RECONFIGURABLE BENDING PRESS MACHINE

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Abstract

Sheet metal products are often designed without a systematic consideration of downstream product development requirements, such as process planning, manufacturability, production scheduling and manufacturing optimization. This can often result in a lot of expensive and time consuming reworks. Consequently, it affects the quality, cost and delivery time of the product. In this paper, a framework for developing a web - based feature recognition system (FRS) has been proposed to recognise bending features on a reconfigurable bending press machine (RBPM). The research explores the current literature and design approaches used to develop feature recognition systems in the current manufacturing industries. This model will help to offer a suitable method for designing a web based feature recognition system for sheet metal bending using RBPMs. This model will be applied to feature recognition systems in other manufacturing industries. The model consists of the integrated platform system, information model, part model, geometric modelling and the feature model. The proposed models will aid the designer right at the design stage with useful design and the feature recognition system. The designer will be able to relate process technology to product design instead of specifying the geometric definition alone. Design of these models will provide a more convenient design environment and an easier way to integrate CAD/ CAM activities. After developing the model the designer will be able to use the CAD software to develop patterns, interpret drawings and transfer dimensions to sheet materials and sections to meet the required specification.

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Keywords: Sheet metal, feature recognition, bending

1. Introduction

Nowadays the production of high quality products of the lowest possible cost is the main objective of manufacturing companies. Increased competition has forced industries to search for other possibilities to the modern approaches to design, manufacturing and management. Competition is now stiff in the sheet metal production sector, in order to lower the production cost and shorten the delivery times whilst retaining a large market share, companies need to change their production planning systems [1].

Gwangwava et al. [2], proposed a new design of a reconfigurable bending press machine (RBPM). The design, which is scalable, customizable and flexible, is a means of increasing sheet metal bending productivity by increasing the capability of the manufacturer to deal with mass customization. The RBPM design has two major objectives, namely geometric transformation and productivity adjustment. Geometric transformation is achieved through vertical and horizontal configurability, while productivity adjustment is enabled by plug and produce devices [2].

This work mainly focuses on developing a model which will aid in the design of a feature recognition system for a reconfigurable bending press machine. This paper is organized as follows: Section 2 presents the literature review on feature recognition, feature extraction and CADCAM systems. The structure of the sheet metal bend is discussed in section 3.

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Section 4 describes the feature classification approach. The summary of this research is concluded in section 6.

2. Literature Review

2.1. Feature recognition

Previous research on feature recognition focus on the issues of intersecting features and multiple interpretations, but do not address the problem of custom features representation [3]. Feature recognition has been an important research area over the past decade. Much effort has been conducted in this area and many kinds of feature recognition approaches have been proposed. On the other hand, due to the difficulty of feature recognition, there are still many problems with the current feature recognition methods, which need to be solved to make feature recognition more powerful [4].

Feature recognition is the process of transforming a CAD model into a feature model with manufacturing information attached to it. Feature recognition can be further decomposed into manageable modules, which are Translate model, surface feature recognition, relate surfaces, extract features and validate features [5].

Marchetta & Forradellas. [6] presented a hybrid procedural and knowledge-based approach based on artificial intelligence planning , it addressed both classic feature interpretation and also feature representation problems. STEP designs are presented as case studies in order to demonstrate the effectiveness of the mode.

Han et al [7] designed a system that recognizes only manufacturable features by consulting the tool database, and simultaneously constructs dependencies among the features. Then, the A* algorithm was used to search for an optimal machining sequence by the aid of the feature dependencies and a manufacturing cost function. An effort for integrating the two activities: feature-based machining sequence generation primarily based on tool capabilities was designed [7].

Nasr and Kamrani [8] proposed an intelligent feature recognition methodology (IFRM) that develops a feature recognition system which has the ability to communicate with various CAD/CAM systems. The proposed methodology was developed for 3D prismatic parts that are created by using solid modelling package by using CSG technique as a drawing tool. The system takes a neutral file in Initial Graphics Exchange Specification (IGES) format as input and translates the information in the file to manufacturing information.

Han et al [9] defined feature recognition as sub-discipline of solid modelling that focuses on the design and implementation of algorithms for detecting manufacturing information from solid models produced by computer-aided design (CAD) systems

2.2. Feature Extraction

Research on computer integrated design and manufacture based on feature extraction (FE) so far has been largely focused on finding all or some possible features, and the task of manufacturing analysis is shifted to process planners [10].

A feature extractor based on the directional maximum is proposed to estimate the nose tip location and the pose angle simultaneously [11]. Gupta and Gurumoorthy [12] proposed a new algorithm for extracting Free-Form Surface Features (FFSFs) from a surface model. Automated feature recognition has been an active research area in solid modelling for many years and is considered to be a critical component for integration of CAD and computer-aided manufacturing [8]

The design and implementation of a system for automatic recognition of features from freeform surface CAD models of sheet metal parts represented in STL format was developed and it contains three major steps viz. STL model preprocessing, Region segmentation and automated feature recognition [13].

2.3. CAD/CAM systems

Representation of features is an important aspect for making feature recognition more applicable in practice. Process planning plays a key role by linking CAD and CAM. Its front-end is feature recognition, but feature recognition research has not been in accord with the requirements of process planning. A new approach to introduce computer aided process planning into sheet metal blanking dies industry was described [14]. The proposed system consists of two modules which are the CAD module and CAPP module.

A new hybrid (graph + rule based) approach for recognizing the interacting features from B-Rep CAD models of prismatic machined parts was designed. The developed algorithm considers variable topology features and handles both adjacent and volumetric feature interactions to provide a single interpretation for the latter [15]. A methodology for implementing the feature recognition system for achieving the Computer Aided Design/ Computer Aided Manufacturing (CAD/CAM) integration goals was designed [16]. Current 2D face recognition systems encounter difficulties in recognizing faces with large pose variations. Many two-dimensional (2D) feature recognition systems have recently been developed to salvage the massive store of engineering knowledge in 2D form and bring the benefit of computer-aided design (CAD)-computer-aided manufacturing (CAM) integration to 2D CAD users [17]. There are many computer-aided design (CAD) systems to take care of product design, computer-aided process planning (CAPP) systems to generate optimal tool paths and plans and computer-aided manufacturing (CAM) systems for various manufacturing requirements [18].

3. Sheet metal bending

3.1. Feature representation for sheet metal bending

Sheet metal product design, processes planning and manufacturing are normally carried out in a sequence of stages using different computer-aided software tools [18]. In order to describe sheet metal part features, the parts can be divided into several planar components and curved components.

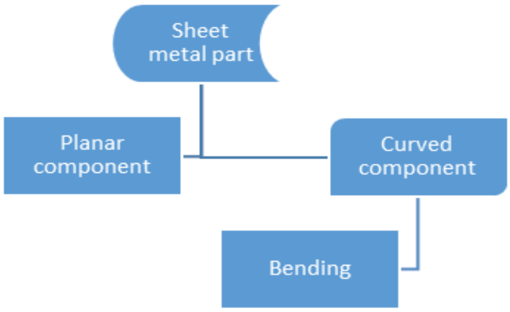

Fig. 1. Hierarchical structure for sheet metal bending

This reduces complexity representation. The hierarchical structure is illustrated in Fig. 1 it shows the planar and curved components which are defined as master features. Bending is identified as a manufacturing feature. The shape of the bent is called a primitive feature

3.2. Feature based model

Feature based model as illustrated in Fig. 2 works in concurrence with design with features and feature recognition. The aim of this paper is to generate a model to be used to designing a feature recognition System for Reconfigurable Press Brake Bending Machine. Two approaches have been developed to identify features in a design: feature recognition and design-with-features.

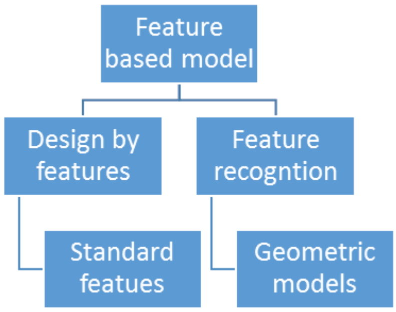

Fig. 2. Feature based model

The feature recognition approach searches the geometric description of a part for known patterns and then labels the geometry subsets with a feature name. Design by features can be used to build a product model. Feature recognition is a process of extracting information from the CAD database to reduce the lead time between design and manufacturing.

3.3. The part model

The geometric model contains geometric information about the part to be manufactured that is face, vertices and edges, as well as additional non-geometric information. The information model as shown in Fig. 3 has been divided into four parts: the geometric layer, the feature layer, the part layer and the non-geometry layer. The part layer shows the general information of part this include part name. Part numbers etc. Features are classified into face-based, edge-based and transitive (between faces) features.

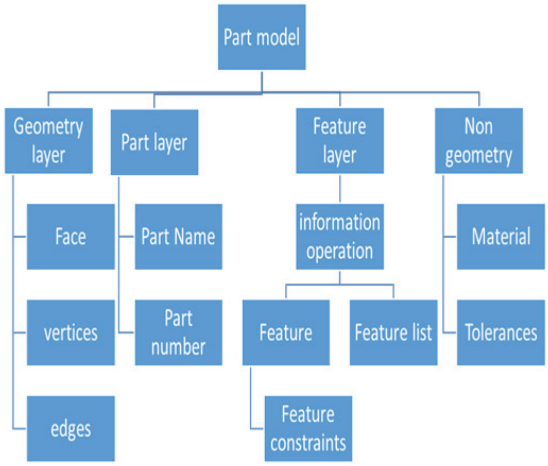

Fig. 3. The part information model

The constraints are those variables which govern the output of the system but are not changed by it. These are standards and constraints, and production plans. In this paper, the bend part has been proposed to be used in the feature recognition system

A feature is considered as a region of interest on a free form sheet metal. Features are classified into face based, edge based and transitive based. The transitive feature lies between faces. The taxonomy of a sheet metal feature such as a bend is illustrated in Fig. 4.

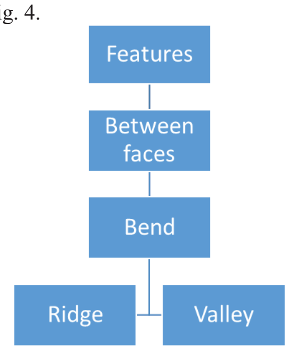

Fig. 4. The taxonomy of a bend

3.4. Classes and attributes of a bend feature

The highest level data class in this hierarchy is the designed object. The shell consists of manufacturing features which have been classified into simple form features. A simple form feature is the bend which is the result of two intersecting general geometrical surfaces.

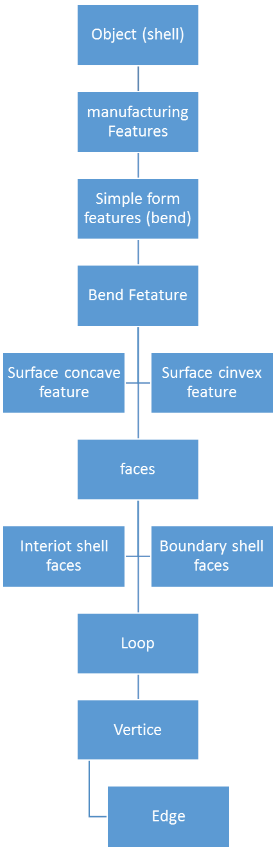

Fig. 5. Hierarchy of classes and attributes of a bend feature

Features have been classified into internal shell faces and boundary shell faces as shown in Fig. 5. Concave features consist of two or more concave faces, and convex features are decomposed of either one or more convex faces or the interaction between other features in the object.

4. Conversion of CAD files

Feature technologies can be used to obtain the feature based cad model. The feature classification approach for converting from CAD to feature based modeling is given in Fig. 6

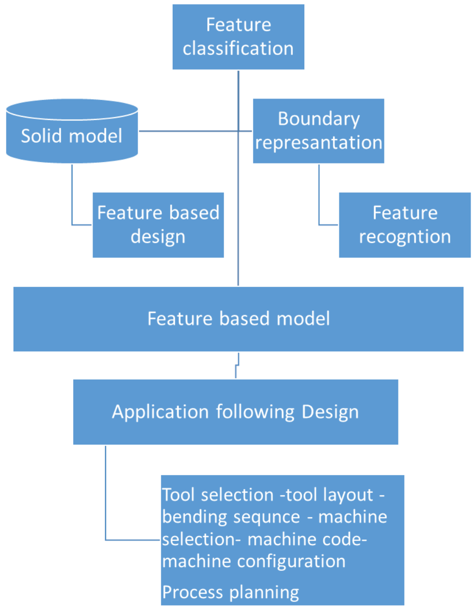

Fig. 6. Bend feature classification

4.1. The Feature Extraction methodology

The CAD software generates and provides the geometrical information of the part design in the form of an ASCII file (IGES) that is used as standard format which provides the proposed methodology the ability to communicate with the different CAD/CAM systems. Feature extraction steps are shown in Fig 7.

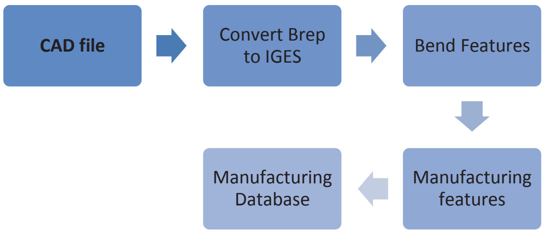

Fig. 7. Feature Extraction steps

The boundary (B-rep) geometrical information of the part design is analysed by a feature recognition program that is created specifically to extract the features from the geometrical information based on the geometric reasoning and object oriented approaches. The feature recognition program is able to recognize bend features. These features are called manufacturing information that can aid in process planning.

4.2. Transforming a CAD model

Feature recognition as presented in Fig. 8 is the process of transforming a CAD model into a feature model which has manufacturing information attached to it. At this stage the operator, CAD software packages and custom programs are the tools used for this transformation. Constraint rules govern the determination of features.

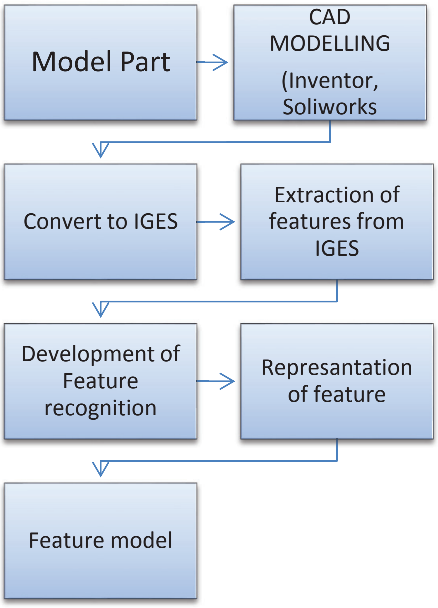

Fig. 8. Feature recognition

5. The Feature recognition activities

Feature recognition can be further decomposed into manageable modules, which are Translate model, surface feature recognition, relate surfaces, extract features and validate features. These modules work hand in hand with each other to determine bending features and working parameters from CAD geometry, tolerances and the type of material employed [5].

5.1. The Feature Model

The feature model is what the system must produce from an input of a geometric model. Information provided by the feature model can be used for various aspects such as manufacturability analysis, automated redesign, process planning and design database which all entail machine and tool selection. The information specified by a feature model is tabulated in Table1 below:

Table 1. Feature Model

Item	**Description**
Bend position	The position of a bend on the unfolded part. It is also represented by a 2D edge.
Bend radius	Radius of a concave bend 3
Bend length	Length of bend
Bend height	Height of bend
Bend angle	Angle between two faces connected by a concave bend
Bending force	Force required to produce a concave ben
Connected planes to bend	Features for example faces, walls and flanges connected to a particular bend
Material thickness	Thickness of part

6. Skills implications

Designer will be able relate process technology to product design instead of specifying the geometric definition alone. Design of these models will provide a more convenient design environment and an easier way to integrate CAD/ CAM activities.

The designer will be able to use the CAD software to develop patterns for machine and interpret drawings and transfer dimensions to sheet materials and sections to meet the required specification.

7. Conclusion

The significance of this research is in the development of a models for feature recognition. Feature based model and the part information model in this paper have been designed to assist in the design of a feature recognition model for a reconfigurable bending press machine. The models have been designed based on the previous research and the bending press machine. The current literature has been reviewed. Future work will focus on the web based feature recognition and extraction system.

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