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Activity model and computer aided system for defining sheet metal process planning

J. Ciurana [a,*], I. Ferrer [b], J.X. Gao [c]

[a] *Department of Mechanical Engineering and Industrial Construction, University of Girona, Spain*
[b] *Department of Business Administration, Management and Product Design, University of Girona, Spain*
[c] *Department of Enterprise Integration, Cranfield University, United Kingdom*

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Abstract

This paper focuses on the problem of choosing the manufacturing route and characteristics in sheet metal processes, a very important element in computer aided process planning (CAPP) systems. At present, decisions concerning the operations, die, machine and process parameters used in sheet metal are based on experience.

One of the objectives of this work has been to develop an activity model to help define sheet metal processes. This activity model allows focusing on the second objective, which is to implement a computer aided system to select and define the parameters of the process definition in the case of drawing operations with sheet metal. The result is the selection of parameters related to the operations chosen, the kinds of operations, the sequence of these operations and the lay-out die dimensions for the product.

A range of parts were evaluated. They were chosen because they were considered to be representative cases. The results obtained by the system are compared with the values proposed in reference manuals, and by experienced experts. The work has served to determine how to adjust the computer aided system.

Applying the method helps to make the right decisions about the sheet metal operations related to drawing processes. The experiments have led to a reduction in processing times.

Keywords: Sheet metal processes; Computer aided process planning; Activity model; Drawing processes; Decision support system

1. Introduction: process planning

Process planning is the act of preparing detailed operating instructions for turning an engineering design into an end product, i.e. the part. This implies the need to translate the design specifications of a part into the required manufacturing operating instructions, to convert it from the raw material to the part in its final state [1].

There is a great deal of manufacturing data involved in process planning, such as the identification of machines, tools, flanging, parameters selection for the process, operations, etc. [2]. All of this data has to be evaluated in order to select the sequence of operations that will make up what is known as the sheet route. The sequence is generally made to conform with particular objectives, such as, for example, the shortest time and/or the minimum cost.

Process planning requires many kinds of human abilities, which should be present in the process planner [1].

The traditional approach to resolving the process planning task is the one commonly used in a manufacturing company; the plans are handed over to the manufacturing process experts who then specify the procedures to make the product. The process planners, using their experience and knowledge, generate instructions for manufacturing the products based on the design specifications and the available installations and operators. The fact that there are few experienced process planners and that, when faced with the same problem, different process planners would probably come up with different plans is an indication of the heterogeneity that exists in process planning [1]. Consistent and correct planning requires two things: knowledge of manufacturing processes and experience [3]. This has led to the

* Corresponding author at: Department of Mechanical Engineering and Industrial Construction, University of Girona, Av. Lluís Santaló s/n, 17071 Girona, Spain. Tel.: +34 972 419822; fax: +34 972 418098.
E-mail address: quim.ciurana@udg.es (J. Ciurana).

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development of computer aided process planning (CAPP) systems, which are becoming more and more important in this field.

The most maturely developed area so far has been focused on machining applications. Research and development in manufacture applications such as heat treatment, forging, injection moulding, and sheet metal manufacture is still premature, and the reported systems for sheet metal manufacture rely on a high level of interaction from the expert who provides the decision-making at different stages of planning [4].

Sheet metal components are widely used in various industries like aerospace, electronics, machine tools, refrigeration and air conditioning, etc., and they form a significant part of manufacturing activity. Sheet metal components are important not only from a functional point of view, but also from an aesthetic point of view, since they are used as enclosures to cover products and are visible to the outside world. These components vary in size, shape and complexity. Therefore, sheet metal processes receive a lot of attention and are widely used by the metal working industries [3].

The manufacturing processes required for sheet metal components are identified by analyzing the component layout, and then design information is manually translated into manufacturing information [5]. To overcome inherent difficulties and limitations associated with human beings, research work is progressing into the area of automatic transformation of design information into manufacturing information through feature recognition [3].

The main aim of this research is to develop a computer aided system for sheet metal manufacture. The purpose of the system developed is to calculate the manufacturing parameters needed for drawing components to be produced. The idea is not to replace the role of expert process planners, but instead, to provide a tool to assist them to be more efficient and consistent in their work.

This project was set up in collaboration with a manufacturing company. In the company sheet metal forming processes such as bending and drawing are used to manufacture some components. Further development of these processes will allow the user to enter the product data as a feature for simple sheet metal components. Future developments in the system will make it capable of coping with the remaining, more complex components and possibly of being modified for prismatic and other rotational parts.

The initial stage of the research was conducted on-site at the company, in order to understand the manufacturing processes and process planning tasks, and to find out the user requirements for computer aided process planning functions. The second stage was to develop the first iteration of the computer aided system. The underlying methodology can also be tailored to general sheet metal fabrication.

The goal of this work is to contribute to developing a tool to help the planning process applied to sheet metal processes. This work focuses on drawing processes. The work helps the engineer to decide on manufacturing parameters such as the operations sequence and the die dimensions for a drawing sheet metal process. This work is based on the knowledge obtained from the collaboration with the enterprises.

The future proposal will be a tool which is capable of defining a route sheet without depending on the sheet metal processes it is considering. The work will cover different processes such as flanging, blending, punching, trimming, drawing, etc. The integration of future recognition starting on CAD systems is necessary. There has been no work which covers this so far. However, to obtain this goal the research should start with a more concrete objective, which is presented in this paper.

2. CAPP systems

CAPP systems are beginning to be developed as a link between design and manufacturing, filling the existing gap between CAD (computer aided design) and CAM (computer aided manufacturing), along with the need for MRP (material requirement planning) to work with standard and optimised routes which can be used in schedule production [2]. Based on the CIM strategy, CAPP allows the user to develop an integrated structure that deals with the flow of information between CAD, CAPP, MRP and numeric control (NC) activities within the company [6], as shown in Fig. 1.

CAPP systems have evolved from the traditional/manual approach into two recognised approaches: the variant approach and the generative one.

The traditional or manual approach means examining the drawing of the engineering part and developing plans and instructions for the manufacturing processes based on an understanding of the machines, the tools, the materials, the related costs and the working practices of the company.

The variant approach is based on getting the plan of a similar process carried out previously and modifying it. In these kinds of CAPP systems, the parts are sorted into groups for which process plans are made that are then stored in the computer to be recovered as required for new parts or for modifications. In this case, Group Technology helps to identify a suitable group to which the new part can belong. The main disadvantage of this is that the quality of the process planning still depends on the prior knowledge of the process planner [1,6].

The systems using the generative approach are designed to automatically draw up an individual plan for each part, using the appropriate algorithms that process the information in the manner required by the decisions that need to be taken. The first versions of these generative systems used tables and decision trees to represent the logic of manufacturing [7].

The result, i.e. the output of a CAPP system, is a route sheet. The route sheet is the sequence of manufacturing operations which contains the details of the process. This sequence has to be the optimal sequence, and is obtained from the defined objectives, but even so, the optimum process plan may not guarantee the best way of manufacturing the part in the plant at a specific moment, as it could lead to the overloading or under use of some machines with subsequent bottle-necking. For this reason, the generation of a single plan is not recommended [8].

Different researchers have proposed different sequential schemes with regard to the steps taken by a computer aided planning system. All of these systems have been programmed and implemented, but performance has been poor, especially because