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SIMULATION OF PROCESSES OF MANUFACTURING WORKPIECES BY SHEET METAL FORMING

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МОДЕЛЮВАННЯ ПРОЦЕСІВ ВИГОТОВЛЕННЯ ЗАГОТОВОК З ЛИСТОВОГО МАТЕРІАЛУ

In the recent years, the role and importance of metal forming processes in manufacturing industry have been continuously increasing primarily due to its material- and cost-effective nature. It is further emphasised by the recent advances in tools, materials and design, which in turn provide significant improvements in the mechanical properties and tolerances of the products. Moreover, in the recent years metal forming develops in the direction of net-shape or near-net-shape manufacturing to reduce the need for subsequent machining operations and to minimise the total manufacturing cost. Consequently, in metal forming both the process planning and the tool design represent very important and complex tasks. The global competition also requires that manufacturing industry – besides the skill and the experience accumulated in the shop practice – should increasingly utilise proven techniques of Computer Aided Engineering for rapid and cost effective process design and tool manufacturing. The application of various methods of Computer Aided Engineering has become one of the most important topics in manufacturing industries.

The application of various CAE techniques practically covers the full product development cycle from the conceptual product design through the process planning and die design up to the manufacturing phase of the production. CAE techniques are widely used in sheet metal forming, for example to predict the formability, to determine the type and sequences of manufacturing processes and their parameters, to design forming tools, etc. The importance of the application of CAE tools becoming more and more important as the manufactured parts are becoming ever increasingly complex. As the need for the widespread application of CAE techniques driven by the demand of global competitiveness accelerates, the need for a robust and streamlined Process and Die Design Engineering (PDDE) becomes more and more crucial. Recently, there are two main approaches to achieve these goals. One of them is the application of knowledge-based expert systems, which are generally based on simplified plasticity theory and empirical technological rules. There are a great number of papers dealing with the use of knowledge-based systems both in sheet and bulk metal forming.

However, the exclusively knowledge based solutions have certain disadvantages: they usually cannot provide an enough accurate solution to the problem since these systems are generally based on simple technological rules with limited validity. Therefore knowledge-based systems cannot predict for example the material flow, and usually cannot provide the accurate stress and strain distribution inside the component. As another approach, numerical techniques (recently mainly finite element modeling) are applied for the analysis of the plastic deformation.

The main objectives of the application of numerical process simulation in metal forming are to determine appropriate process parameters and to develop adequate die design by process simulation, to improve part quality by predicting process limits and preventing flow induced defects. Besides these, numerical process simulation also leads to reducing process and die try-out, as well as shorter lead times, while significantly reducing manufacturing costs. But the exclusive use of numerical modeling – like it is the case in the

exclusive use of knowledge-based systems – has also some drawbacks, too. In spite of the enormous development of hardware and software facilities, the reliability of results is often dependent on the experiences of the user. It is partly due to the large number of operating parameters whose influence should be investigated, and partly due to the numerical difficulties caused by the complexity of the applied mathematical model to describe the material behavior. Therefore, in the recent years the integration of these two fields (i.e. the knowledge-based systems and numerical modeling) has gained primary importance.

Sheet metal forming is one of the most widely applied manufacturing processes in manufacturing industry. Parts made from sheet metal can provide, with appropriate design, a high strength to weight ratio. They are increasingly used from small electrical components through the automobile industry up to large aircraft structures. Despite the increasing number of applications of sheet metal parts, surprisingly little quantitative design information is available in the technical literature.

Most companies use internal guidelines for part design, based on experience with the geometries and materials used in that specific company. While such design guidelines are extremely useful and practical, they do not necessarily consider in detail the fundamental reasons for selecting a given design. Thus, when a new part, a new material, or a new process is introduced the entire set of experience-based design guidelines must be re-evaluated and modified.

Therefore, it is necessary to develop generic design methods based on metal forming analysis and on systematic experimental investigation. This tendency can be clearly observed in the development of various knowledge-based systems for designing sheet metal parts and for process planning of forming procedures. As in many other metal forming applications, process planning and design of dies for sheet forming can benefit from a combined application of knowledge based systems and process modeling.

Recently, many companies are applying CAD/CAM techniques and knowledge-based expert systems to improve and partially automate die design and manufacturing function. Several program packages were elaborated for metal forming processes at the University of Miskolc at the Department of Mechanical Engineering. Among them, first a general CAD/CAM system for the process planning of sheet forming processes performed in progressive dies should be mentioned.

The general scheme of this knowledge based expert system can be seen in Fig. 1. In this system, the process planning and the die-design functions are integrated into a knowledge-based expert system. It has a modular structure with well defined tasks of each module and providing streamlined data and information flow between the various modules. It consists of a geometric module for creating, exporting and importing the object geometry, a blank module for determining the optimum shape, size, and nesting of blanks, a technological design module for designing the process sequence based on empirical rules and technological parameters, a tool design module for designing the tools and selecting a tool of standard size, and an NC/CNC post processor module for preparing programs for NC/CNC manufacturing of tool elements.

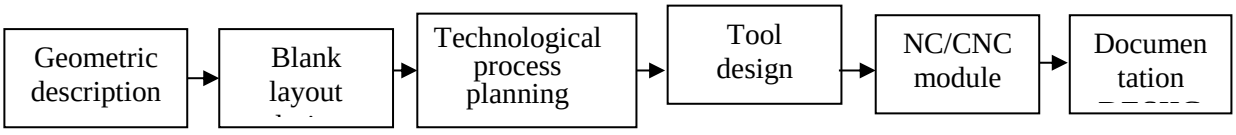

Figure 1 - Conventional process planning and die design in CAD environment