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COMPUTER AIDED PROCESS DESIGNING OF MANUFACTURING WORKPIECES BY SHEET METAL FORMING

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АВТОМАТИЗОВАНЕ ПРОЕКТУВАННЯ ПРОЦЕСІВ ВИРОБНИЦТВА ЗАГОТОВОК З ЛИСТОВОГО МАТЕРІАЛУ

During the recent 10-15 years, Computer Aided Process Planning and Die Design evolved as one of the most important engineering tools in sheet metal forming, particularly in the automotive industry. This emerging role is strongly emphasized by the rapid development of Finite Element Modelling, as well.

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.

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 for various purposes. 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 processes. 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 modelling. Recently, many companies are applying CAD/CAM techniques and knowledge-based expert systems to improve and partially automate die design and manufacturing function.

Among them, a general system for the process planning of sheet forming processes performed in progressive dies should be mentioned. 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.

The forming simulation in sheet metal forming technology and its industrial applications have greatly impacted the automotive sheet metal product design, die developments, die construction and tryout, and production stamping in the past decades. It led to significant progresses not only in fundamental understanding of sheet metal formability, forming mechanics, numerical methods, but also to the fruitful industrial applications in a wide range of industrial production.

The automotive die and stamping industry benefit most from the stamping simulations. The technology advancement speeds up the historical transition in automotive die development and stamping from a tryout-based workshop practice to a science-based, technology-driven engineering solution. The applications and benefits may be summarized as follows:

1. Stamping simulation is used as a Design for Manufacturability (DFM) tool to assess and validate the product styling surface designs to ensure a formable sheet product design;
2. It may be used as a die engineering tool in stamping die developments.
3. It may be used as a tryout tool to shorten production die tryout and thus to significantly reduce die cost and lead-time.
4. It may be used as a problem solving tool for production troubleshooting to reproduce manufacturing problems, and to provide solutions for process control improvements.
5. It may be used as a simulation-based manufacturing guide to use the simulation output to drive consistency among die engineering, die construction, and production stamping.

Due to the global competition – and this is particularly valid for the automotive industry – there is an overall demand to improve the efficiency in both the process planning and in the die design phase, as well as to reduce the time and product development costs and to shorten the lead times. It requires the efficient use of simulation techniques from the earliest stage of product development, to give feedback from each step to make the necessary corrections and improvement when it takes the least cost. This principle is illustrated in the schematic flow chart of simulation based process planning and die design as shown in Fig. 1.

With this approach, stamping defects may be minimized and even eliminated before the real die construction stage. If any correction or redesign is needed, it can be done immediately, with a very short feedback time, thus it leads to a much smoother die try-out if necessary at all and to significantly shorter lead times with less development costs.

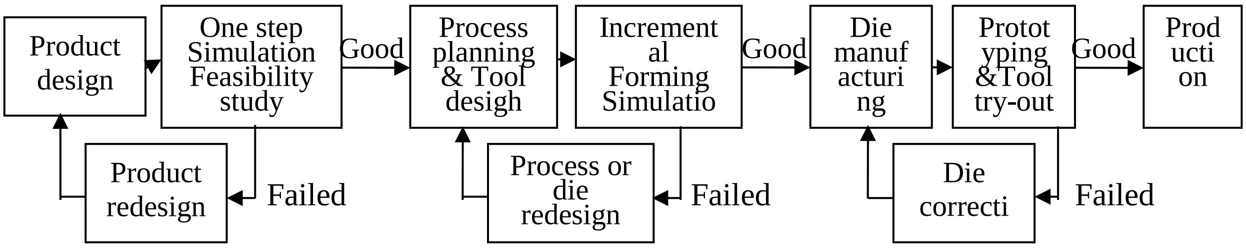

Figure 1 – Workflow in simulation based process planning and die design