Process Solutions for Automatic Manufacturing and Elimination of Remachining in Tool and Mold Manufacturing

Galozy, St.
Tebis-Technische Informationssysteme AG, Martinsried/Planegg, Germany

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Abstract

Complexities involving auto body sheet metal parts and new sheet metal material with springback effects that are difficult to calculate lead to a great deal of manual work for the spotting process on the tool in the press as well as to higher tool costs. This article describes two software-supported processes that demonstrably reduce the manufacturing and correction expenditure. 1.: The integrated Tebis small part process automates the process for the manufacturing of small parts, for example through exact solids and multiple clamping. The optimized process provides time and cost advantages as well as greater safety. 2.: The Tebis die surface process replaces the manual spotting processes and integrates the toolmaker in the die surface development process. Springback effects are thoroughly compensated for and the sheet metal thinning is introduced without transitions in the die surfaces. This process saves days or weeks of spotting work per tool.

Introduction

When manufacturing forming and cutting tools, there are a manifold of challenges. The complexities involving auto body sheet metal parts are increasing, and new sheet metal materials make it more difficult to predict springback effects. Result: The manual work for the spotting process on the tool in the press is immense. This is also reflected in the cost of the tool: For German mold manufacturing companies, prices are often too high in comparison to the international competition. The challenges:
• Cost and deadline pressures – High demands on quality
• Shortage of skilled employees – Increasing complexity
• Virtual world – Real world (man and machine)
• Automation and standardization – High flexibility

With the aid of specialized software-supported processes, manufacturing and correction expenditures can be demonstrably reduced and manufacturing costs can be lowered. Standardized interfaces improve the flow of information and increase safety. Quality and productivity are increased.

Figure 1: The five process solutions (goals) of Tebis AG

The task for software and process suppliers, such as Tebis AG, increasingly involves the interconnection of the virtual world with the real world. That only works, however, if suppliers become partners and solution providers.

Tebis fulfills the networking challenge with four pillars:

• Consulting: manufacturing-related consultancy, e.g. for securing investments
• Software: for design and manufacturing processes, shop floor viewer and PDM solutions
• Implementation: by structuring processes, training for the software and setting up of postprocessors and virtual machines
• Support: via a helpdesk and individual customer support, before, during and after the implementation phase

Figure 2: The four pillars of Tebis AG
1 Automation in manufacturing, example of a Tier-1 supplier

Figure 3: Small part manufacturing with multiple clampings and innovative setup system

1.1 Motivation

Small parts such as inserts, trim steel and jaws offer a great savings potential, and not only due to their large number. More than 1000 pieces are manufactured by a medium-sized Tier-1 supply company for the automobile industry every year. Small parts are individual single pieces in the entire tool, however, from the setup point of view they are very similar and therefore permit a high degree of standardization. Companies pursue two main goals for a smooth process:

- Increasing reliability
- Automating manufacturing

A crucial question many companies as themselves is: "Where do I stand in comparison to the competition?" Tebis Consulting answers this and many other questions. Specialists thoroughly examine the process chain with manufacturing-specific know-how and entrepreneurial thinking. An example of a mid-sized automotive supply company clarifies the weak points in the small part process:

- Organization of the input data
- Manufacturing-oriented data processing for NC programming
- The NC programming itself
In manufacturing, often the set-up of the first and second clamping as well as the actual machining on the machine represent the largest amount of work. However, also the ancillary processes such as measuring on the machine are often not integrated in the overall process and therefore lead to additional work for the machine operator.

Current status of programming

Current status of manufacturing

Figure 4: Overview of the main tasks in NC programming and manufacturing of small parts
The weaknesses indicated above have an impact on the expenditure and therefore the manufacturing costs for small parts. Illustration 5 shows that on average, 9.8 hours are required to manufacture a small part, without design. The expenditure in the CAD/CAM process is only slightly less than the mechanical machining on the machine tool.

Every year, a mid-sized die manufacturing company produces up to 3510 small parts out of solid material. Multiplied by the average expenditure and corresponding overhead costs, this means there are Euro 2.9 million of manufacturing costs every year. On average, a component costs Euro 835. The problem is that the prices are too high when compared on an international level.

1.2 The Tebis small part process

Today, procedures are normally not very consistent. In addition to multiple people, also multiple systems are involved. Interfaces are created and information is lost. An integrated process solution must overcome the following obstacles:

- The die surface and solid data must be prepared separately by the NC programmer.
- Up until now, manufacturing allowances could only be introduced virtually in the manufacturing process, causing collision controls to fail, for example.
- Additional expenditures are required on the machine tool for set-up and approach, because the position of the small parts on the machine tool is not clear.

![Figure 5: Limits of today's process solutions in the small parts area](image)

A new trend towards exact solids is emerging. Exact solids contain all the manufacturing-relevant information. Offsets and colors are no longer virtually managed in the process, rather they are realistically and automatically designed. The exact representation of the processing status already in the CAD model makes it possible to perform measurements on the machine tool in addition to color-based NC programming. Multiple small parts can be programmed individually in different files and then brought together at the end in multiple clampings. Regardless if one or up to eight small parts are clamped on the machine tool, all toolpaths are collision-proved and can be worked through even on the weekend with little operator intervention.

**With the integrated Tebis process, small part automation is already a common practice!**
As exact solids always have the same properties (colors, for example) they are perfectly suited for NC programming with a machining template. The strategy for how a small part should be optimally processed is developed once, stored as a template and then applied to each additional component. This permits a high degree of automation and ensures a consistent level of quality.
With the small part process, Tebis offers a unique level of consistency, from preparation and NC programming up to manufacturing with multiple clamping.

1.3 Result: Increased efficiency in the small part process

Reduction of the average expenditure to 6.5 hours per small part (24 percent faster) means a 21 percent increase in efficiency for small parts out of solid material. In the case of the analyzed mid-sized supplier, 842 more small parts can be produced per year.
In addition to cost reduction, the following advantages can be obtained:

- Highly automated CAD/CAM processes
- Enormous time savings
- Collision-checked programs
- Highly-efficient manufacturing
- Multi-machine operation

The correct process chain and the support of implementation specialists permit more than time and cost advantages. Reliability and smooth processes are obtained in small and large manufacturing companies.

2 Reduction of the spot-grinding work in the forming press, with the example of OEM die manufacturing

![Figure 9: Draw die punch of a side panel tool after the spot-grinding process](image)

2.1 Motivation

Today, integrated manufacturing processes require much more than the mechanical machining of tools. Upstream and downstream processes increasingly determine the requirements. In particular in die manufacturing, in addition to the manufacturing process, there is great potential in the tool spotting process in the press. This process which up until now has been manual requires a large amount of worker
effort and a great deal of experience. This contributes significantly to the tool costs. In addition, the requirements on component quality are continuously increasing with the contemporaneous shortening of timelines.

Figure 10: Example of a timeline for the manufacturing of a drawing and cutting tool (excerpt)

The particular challenge for mold manufacturing companies in addition to lowering tool costs is above all:

- increasing quality
- improving the flow of information related to upstream and downstream processes

This is particularly difficult, as there is often a break between development and manufacturing. That means precisely:

- The draw process is simulated and the springback of the sheet metal is compensated for in the die surfaces. Thinning and thickening are often ignored in this process.
- Based on experience from comparable projects, the die surfaces split in the compression and flank areas. The allowances are implemented by means of virtual offsets in NC programming.
- This results in visible edges in the tool surfaces, which are then rounded while in the press by the toolmaker.

Figure 11: Today's tryout processes for outer and inner parts
Tool quality often suffers because the tryout information is not considered in the design phase. One reason for this is that the timelines do not permit a better die surface preparation. Another reason is that the correct software tools are available in the existing die surface processes.

The result: A lot of manual tool remachining, which makes the tool quality strongly dependent on the experience of the tool maker. This requires a large amount of know-how about how to grind the tool to obtain a clean spot image. This costs time and money.

2.2 The Tebis die surface process

Today’s try-out phase requires a lot of manual work. The trend is moving towards “milling instead of grinding”. The following problems must be solved in order to implement this vision:

- Milling on different surfaces with visible edges must be avoided
- Sheet metal thinning must be done before arriving in the press
- The data process must be stable and valid, the milled surfaces have ultra-high quality requirements

![Figure 12: Comparison of tool surfaces from current and future processes](image)

The Tebis process solution integrates the tool maker in the process for developing the die surface. Springback effects are thoroughly compensated for and the sheet metal thinning is introduced without transitions in the die surfaces. The data
correspond to those of the tool to be machined and they are milled 1:1. The tools can be fit in the press without any remachining.

With the integrated Tebis process consisting of die surface and NC programming, the tool try-out phase is clearly reduced!

The tool quality is of particular importance in this process. Transition-free die surfaces that connect different compression and flank areas without visible steps improve quality. The NC contours on the machine make the difference. Innovative milling strategies and highly efficient HFC milling tools generate a homogeneous
path layout between simple guide curves. The result is an optimal tool surface, which further reduces remachining.

Figure 14: Path layout between guide elements

2.3 Result: Shortened try-out time

The advantage is obvious: Days or weeks of spotting work is saved per tool!

A process implementation at an OEM mold manufacturing company resulted in savings, such as:

- 15 percent reduction in tool start-up, from 400 hours to 340 hours (for a side panel tool)
- More than a 30 percent reduction in the work for die surface preparation
- Reduction in the processing time on the milling machine of 15 percent on average (through the use of HFC tools)

In addition to time savings, a continuous process is established. This comprises:

- an innovative Tebis die surface process with optimal software tools for transition-free surfaces, for example
- NC template technology in which individual machining strategies for optimal tool surfaces are stored
• accurate machine tools that comply with tolerances of less than 0.02mm for a side panel tool
• the integration of the tool maker in the overall process, whereby the manufacturing knowledge is already incorporated in the design
With the consistency of a system, all relevant information is simple to access and requests for feedback or errors are reduced.

This lowers the tool costs, shortens the timeline and simplifies the process.

Figure 15: Remachining in the tryout only necessary in individual areas

3 Summary outlook

Today's process solutions must have one thing in common: "They should reduce effort and simplify processes – interconnection."

This interconnection takes place also in the small part process. Here, the processes for manufacturing preparation, NC programming and setup are perfectly linked. The exact solids prepared in Tebis can be automated and programmed to a large extent with NC template technology due to its consistent geometry properties. Together with an individual clamping concept and implementation of multiple clampings, an average increase in efficiency of more than 20 percent is obtained for all small parts. The process – a result of consulting, software, implementation and support.

The tryout process combines even more individual processes. By integrating the tool maker in the die surface design phase, manual activities can now be carried out in CAD. Tebis has specialized tools available for this, simplifying time consuming
tasks. Transition-free compression and flank surfaces help achieve great savings potential during NC programming and tryout. Virtual NC attributes and steps in the tool surfaces are eliminated due to the transition-free die surfaces. This simplifies the preparation for the NC programmer. Highly accurate milling strategies with open guide elements create a perfect tool surface and, together with the use of high-feed milling tools, reduce the milling time by more than 15 percent. The tryout process has the largest potential. Due to the fact that visible edges are practically eliminated and the experience of the tool maker is considered one-to-one in the die surfaces, the tools can be fit directly from the milling machine in the forming press. Time-consuming grinding is eliminated and the total expenditure of 400 hours for a side panel tool is reduced 15 percent.

Interconnections can be transferred to new manufacturing processes. The use of robots in tool and mold manufacturing becomes very significant. Common uses include:

- Grinding and polishing
- Surface penning
- Laser hardening

Machining processes with robots are fully integrated in the Tebis process chain. The advantages for you: Robots and machining centers are optimally combined with a system in order to further increase process effectiveness.

Figure 16: Robot integration for tool part grinding (blank holder)