Fraunhofer IWU

FRAUNHOFER INSTITUTE FOR MACHINE TOOLS AND FORMING TECHNOLOGY IWU

TOOL AND MOLD MAKING

OPTIMIZATION

Process Chains

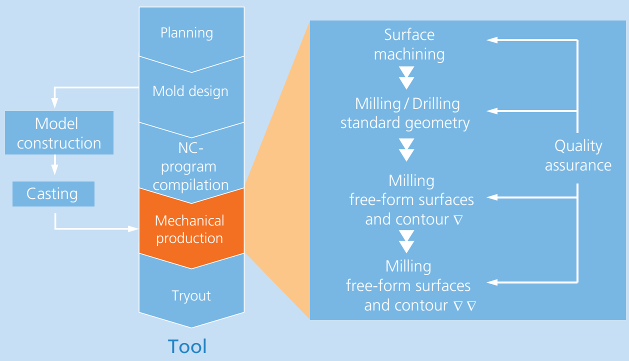
Tool and mold making emerge at the crossroads of burgeoning product diversity and simultaneously plummeting product cycle times. Reducing throughput times is highest on the order of priorities while simultaneously driving down manufacturing expenditures is only possible by redesigning and enhancing the entire process chain.

Extensive analyses of production routines form the basis for discovering potential enhancements and laying the basis for creating future production and machine designs.

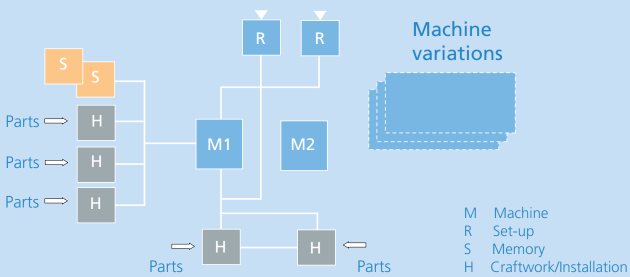
The method applied is broken down into:
– analyzing the process chain in order to identify all of the interrelationships and dependencies
– derivation of potential for optimization including documentation of effects
– coming up with new ideas for mechanical production including upstream and downstream steps in the process
– rough and detailed planning of technological processes and
– dimensioning processing machines

Process chain optimizing

Analysis of the processes



Development of new production concepts



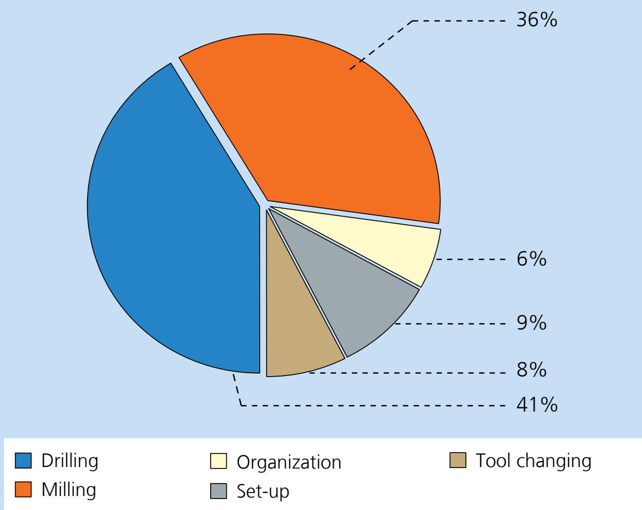
Derivation of new production concepts

Optimization of Machining Time

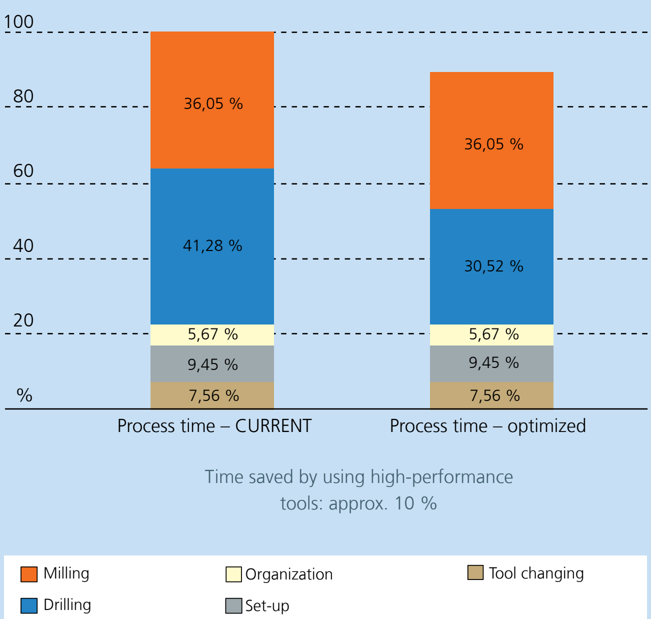
It is not only necessary to apply the effects of state-of-the-art technology and the potential of cutting materials to downscale production times in metal-cutting production. It is also necessary to analyze and enhance the current production process. We can discover time reserves by enhancing technology, engineering and organization.

The points of concentration in relation to the analyses are:
– analyzing the technological routines in mechanical production
– evaluating and enhancing specific stages of production in terms of the options of reduced main and secondary processing times and
– reduction in machine loading times

Analysis of time proportion of the 2D processing



Time reserves based on the use of modern tools



PRODUCTION PROCESS

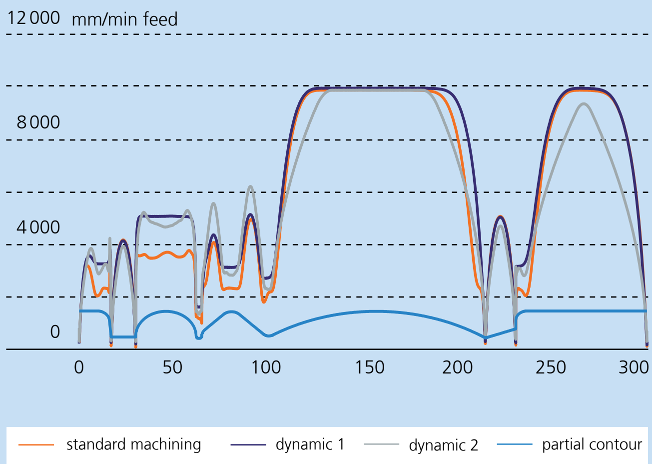
Machine Analysis

There is a heated debate going on these days on the potential for boosting productivity and accuracy in tool and mold making. The entire manufacturing process is dominated by the costs and time needed for mechanical machining due to the major proportion of free-forming geometries and predominant small-scale and job lot production. Beyond this, the accuracy of production defines the effort required for reworking.

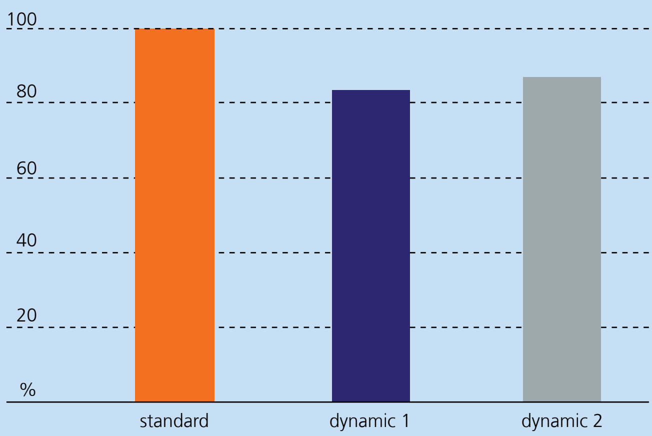
Furthermore, finishing is extremely important both because of the great amount of time it requires and as a basis for subsequent breaking-in and adjustment work. Since the machining velocities to be achieved with the performance of the cutting materials used are limited, the greatest potential is to be found in enhancing the dynamic properties of the processing machine. And indeed, aligning CAM tolerances, NC control tolerances and dynamic NC control settings can save as much as 20 percent in time without even changing the machining strategy. Of course, this requires a holistic analysis of the machining process and adapting the parameters in the process to the machining job.

That means that we can make statements on the working precision of tool machines under various process and environmental conditions based upon a comprehensive analysis of the impact of faults along the mechanical machining process chain. They offer users and tool machine manufacturers the point of departure for improvements in producing tools or designing machine elements.

Contour related motion profile



Program runtime



5-Axis Machining

The amount of machining effort and time required for manufacturing free-form surfaces in tool manufacture is very high so that it is necessary to find alternatives to conventional 3-axis milling machining for fast and economical tool production.

Using efficient 5-axis chip removal technologies enables us to substantially scale back machining times. For example, we can measurably reduce the aspect ratio of tools when machining cavities and similar topological shaping, thus guaranteeing reliable-process production conditions. On the other hand, using 5-axis machining strategies for planing and pre-finishing machining makes it possible to substitute ball-headed milling tools with more efficient torus milling tools.

The major characteristic of surfaces made by 5-axis machining is slight values for scallop-height and roughness because the machining tool is excellently aligned to the workpiece surface. This is the reason why reworking effort can be reduced to the minimum while boosting the tool's contact width and substantially driving down the machining time.

There are major demands made of the machine equipment used especially with 5-axis machining of tool components made of cast iron and steel materials. And the oscillating axes of the machining centers need a very high level of retention moments in position-regulated operation especially with roughing down and pre-finishing operations. Adapting the machining strategies to the machine's specific characteristics enables us to achieve major benefits.

Milling Thermally Sprayed Hard Metals

Using hard metal in tool and mold making frequently appears to be uneconomical due to the high level of material and machining costs. Previous options have not offered any form of efficient or economic hard metal machining with complex-contour geometries.

State-of-the-art production techniques such as high-velocity oxy fuel (HVOF) enable us to apply the hard metal material onto highly stressed tool zones which makes it possible to measurably improve protection against wear and tear. These layers have hardnesses in excess of 1,000 HV, giving them approximately the same properties as sintered hard metals, although they require a final finishing in spite of a high level of dimensional accuracy.

A new and even highly economical machining option is milling thermally sprayed hard metals where setting up the process and selecting tools in alignment with the technique make it possible to measurably boost economy and flexibility. We were able to document a 60 percent reduction in costs for hard metal machining with geometrically intricate contours in comparison to conventional techniques (such as contour grinding or electric discharge machining – EDM). Finally, milling of hard metal with superhard cutting materials not only generates a virtually damage-free edge zone, but also excellent surface qualities.

1 *5-axis machining of an exterior vehicle part*
2 *Milling of a hard-metal coated forging die*

Rough Drilling

The production of deep cavities in mold making involves a very high level of machining and expenditure in terms of time. In order to cope with the need for rapid tool production, alternatives to conventional milling need to be considered here too.

Making use of rough drilling means that the rough machining can be optimized to a considerable extent. The process is based on machining operations acting exclusively in the direction of the axis of the spindle, the use of optimized tools as well as a high level of productivity due to an extended radial machining distance.

The advantages of the machining strategy are
– reduction in machining time by up to 30 percent by comparison with conventional processes
– boosting the rate of metal removal
– reducing the radial machining forces
– reduction in rise of component temperature as a result of targeted chip discharge
– incresase in process reliability

3 *The state of machining after rough drilling*
4 *Precise electrochemical machining of a punching die*

Precise Electrochemical Machining

Erosive machining technologies enhance tool manufacture and mold making by machining materials regardless of their mechanical properties. The mostly force-free machining is a substantial advantage for maximum precision and smallest structures.

The development of technologies in the field of electrochemical machining processes is concentrating on expanding the range of materials that can be machined and coming up with hybrid technologies for integrating the technique into production process chains. The topics of research work focus both on investigating the process, localizing the ablation area, process simulation and optimization, as well as the application specific development of technology and equipment and producing prototypes. The subject of investigations is electrochemical machining with closed electrolytic free jet (jet ECM) and precise electrochemical machining (PECM).

Electrochemical machining enables a force- and burr-free machining regardless of mechanical workpiece properties such as hardness and toughness. Furthermore, there are no changes in the mechanical properties or thermal damage to the workpiece surface.

These EC processes are used when producing basic geometries and secondary shape elements, for finishing component parts, microstructuring component part surfaces and producing tools.

WHAT WE OFFER

Services

Process chain development

– Market analysis
– Process chain analysis
– Process optimization
– Cost/benefit accounting
– Development of manufacturing concepts
– Outline and detailed planning of technological processes
– Technological dimensioning of processing machinery
– Recommendations on machinery investments

Development and assessment of processing strategies

– Market analysis
– Feasibility study
– Development of technology
– Formulation of process parameters
– Formulation of optimized processing strategies
– Benchmarking of CAD/CAM systems

Quality assurance

– Photogrammetrical logging of component and tool geometry
– Measurement of micro-components using confocal microscopy and strip projection
– Machine and tool measuring using laser trackers
– Structural analysis using a scanning electron microscope

Equipment

Machine technology available

– 5-axis Hexapod milling machine Mikromat 6X HEXA
– 5-axis multifunction machine Dynapod
– 5-axis HSC milling machine DIGMA 850 HSC
– 5-axis micro milling machine KUGLER
– 4-axis horizontal machining center HEC 500D XXL
– 3-axis vertical machining center CSK 400
– CNC-turning machine N20 with high pressure
– Turning and milling machining center GMX 250 linear
– Universal grinding machine KEL-VARIA UR 175/1500
– Jig grinding machine SKoE 400
– Nagel VARIOHONE VSM 8-60 SV-NC
– PEM Center 8000 (precise electrochemical machining)

Software available

– CAD systems: Inventor, Pro-Engineer, CATIA
– CAM systems: Tebis, GIB CAD&CAM
– Finite-Elemente software: ABAQUS, MARC, ANSYS

Measuring technology available

– Precision measuring machine PRISMO7S-ACC (ZEISS)
– Various optical roughness and profile measuring devices
  - Confocal microscope, ITO University of Stuttgart
  - White Light interferometer, ITO University of Stuttgart
  - MikroCAD, GFM Teltow
  - Vcheck, GFM Teltow
  - Scanning electron microscope, LEO Oberkochen
  - EDX system, Oxford Instruments
  - Optical measuring station UBM
– Contact roughness and profile measuring devices HOMMEL and Mitutoyo
– Mold measuring device F2002, HOMMEL
– Ultrasound devices for measuring wall thickness
– Profile projector PJ 300

Editorial
Fraunhofer Institute for
Machine Tools and Forming Technology IWU
Reichenhainer Straße 88
09126 Chemnitz, Germany

Phone +49 371 5397-0
Fax +49 371 5397-1404
info@iwu.fraunhofer.de
www.iwu.fraunhofer.de

Department Cutting Technology
Dipl.-Ing. Carsten Hochmuth
Phone +49 371 5397-1811
Fax +49 371 5397-1811
carsten.hochmuth@iwu.fraunhofer.de