

RESEARCH CENTER OF MANUFACTURING TECHNOLOGY | RCMT

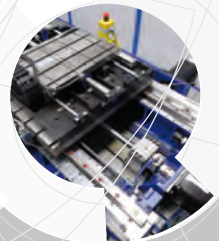
The main research center for manufacturing technology in the Czech Republic.

We are a highly professional research and educational institution, which uses its high-tech equipment to provide services to the industry of cutting and forming machines.

Cooperation with the industry
is among our core activities.

RCMT FOCUSES ON R&D IN THE FIELD OF

- Research on productive, reliable and accurate machine tools
- Research on machine tool properties; machine tool diagnostics and measurements
- Research on productive and eco-friendly technologies



WE OFFER

- Customized R&D with your team
- Comprehensive support for machine tool development
- Accredited Testing Laboratory services on your machines placed in Europe
- Design on machine tool diagnostic systems
- Energy and environmental optimization of machine tool design
- Optimization of machining technology
- Solutions reducing production costs

RESEARCH PROGRAMME

RCMT – Research Center of Manufacturing Technology and Department of Production Machines and Equipment focuses on applied research in three main fields:

01



Research on productive, precise, reliable and eco-friendly machine tools

- New machine tool concepts
- Machine frames
- Drives and control systems
- Virtual prototyping
- CAD/CAM

02



Research on machine tool properties; machine tool diagnostics and measurements

- Machine tool accuracy
- Manufacturing productivity
- Thermal stability
- Post-process checking
- Risk and safety analysis

03



Research on productive and eco-friendly technologies

- Hard machining
- Eco-friendly machining
- High-speed machining
- Hard-to-cut machining
- Micromilling
- Laser technology
- Production cost cutting

SUPPORT TO CZECH MACHINE TOOL INDUSTRY



The production machine field ranks among high-tech sectors of the industry in the Czech Republic with more than 150 years of continuous production.

- Czech Republic – worldwide 7th biggest producer of production machines per capita
- A number of successful companies based in the Czech Republic
- 8 Czech producers classified among the first one hundred European manufacturers
- Czech Republic – 4th biggest machine tool exporter to Germany
- Worldwide references



RCMT is a proud R&D partner of Czech Machine Tool Companies.

Important industrial partners of the RCMT



DESIGN AND IMPLEMENTATION OF MANUFACTURING TECHNOLOGIES

We offer the complete delivery of technical and technological manufacturing planning, including the implementation of prototype part production.

In each design and implementation phase, we provide a wide range of support and services.



Manufacturing documentation

The input is a part drawing, together with information on both the precision required and part quality.

Technology design

We offer manufacturing strategy design (metal cutting and laser technology design), including recommendations for cutting tools, clamping methods, and the design of necessary fixtures.

Technology implementation

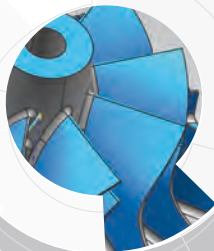
We perform NC code preparation and NC code verification, including collision analysis. We create post-processors.

Technology optimization

We optimize both new and existing technologies: NC code optimization, cutting conditions optimization, drive and control system setup, and analysis of process energy consumption.

Final part production

We produce individual prototype parts using 4- and 5-axis machining technologies, and laser processing (production on our own as well as external machine tools).



Smart Machine Tool

To improve the efficiency of piece and small-series production with the financial effects of mass production, close man-machine cooperation is required. Machine and its operator need to know what is happening in the machine and the process, how to understand it in the context of the production, what to do to minimize negative impacts and how to prevent them in the future. Such an advanced support provides a so-called smart machine tool.

- Intelligent machine tool is equipped by additional sources of inputs for feed back
- Currently, the resulting intelligence of the machine tool is a combination of predefined algorithms and data acquired from the operator and other systems
- Autonomous reaction to unexpected situations is a current research goal



Data logging of internal data
(e.g. position, current, temperature...)



Additional sensors for direct measurement
(e.g. length, temperature...)



Additional sensors for indirect measurement
(e.g. vibration...)

Additional sensors

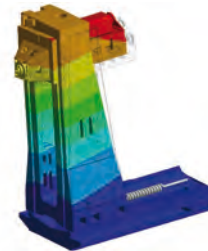
Smart machine tool



Enhanced communication



Communication with other real machine tools



Communication with digital twin
(virtual machine tool)



Communication with operator



Communication with other integrated devices



Communication with superior systems
(SCADA, MES, ERP)

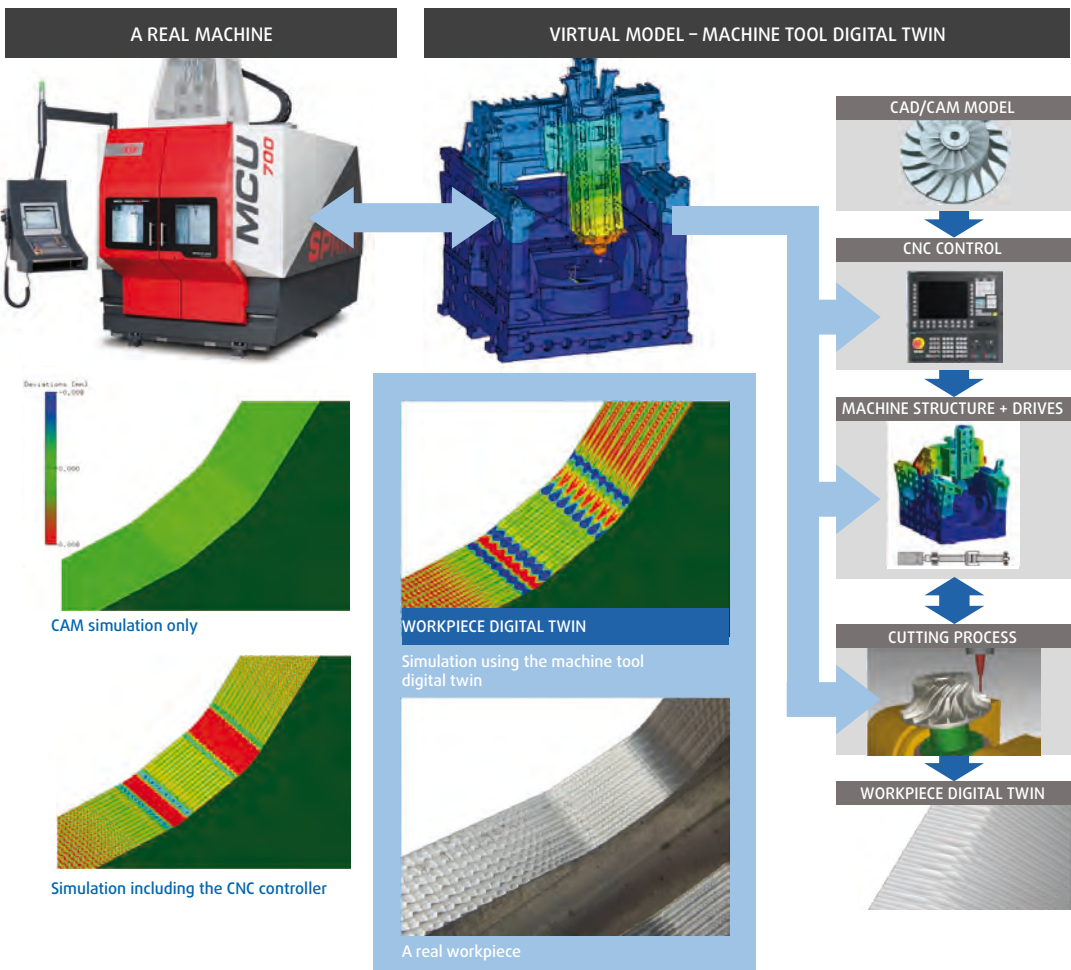


Communication with other database systems

Virtual Machining

Virtual machining control offers a quick possibility to verify the machining results before the real machining on the machine starts. This significantly reduces the time for machine tool and machining technology tuning when introducing a new part into production.

- **Machine tool digital twin** is an effective instrument for predicting and optimizing the machining process
- Machine tool digital twin allows for calculating the real machining time, optimizing the CNC control and feed drive setting, optimizing the tool path and cutting process parameters or calculating the cutting forces during machining process
- **Workpiece digital twin** is a result of a complex simulation of the real machine – process interaction and its dynamic behavior



Energy Efficiency of Machine Tools and Manufacturing Systems

By increasing the energy efficiency of machine tools and production systems it is possible to reduce production costs. This can be achieved by reducing energy consumption, increasing productivity or complex solutions. Cost return of the proposed and implemented measures is usually up to 3 years.



Measurement of power supply



Optimization of fluid circuits (hydraulic, pneumatic)

Monitoring and energy balance:

- Monitoring the consumption of machines and equipment according to international standards (ISO 14955, VDMA 34179 and others) or by own procedures
- Determination of energy balance and efficiency of the tested device
- Development of specific measuring devices and software solutions
- Analysis of electrical, pneumatic and hydraulic energy use and their interconnection

Machine tool and equipment innovation:

- Proposals for machine tool and component modifications for increasing the energy efficiency
- Testing of components and systems and recommendations for components optimized selection
- Calculations of cost saving potential and time returns of proposed solutions

Optimization of production technology:

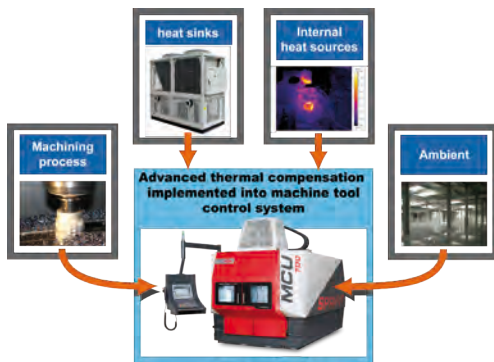
- Technology optimization for increasing the productivity – cutting tools, cutting conditions, NC programs, feed drive tuning, etc.
- Optimizing the correct supply of cooling media
- Testing of cutting tools including the lifetime
- Virtual machining simulations
- Proposals of other manufacturing technologies (e.g. lasers)

Productivity improvement



Advanced Compensation of Thermal Errors

Machine tool thermal deformations represent one of the major sources of machining inaccuracy and may contribute to total workpiece errors by up to 75 %. Reliable software compensations of thermal errors is an effective tool to increasing the machining accuracy.



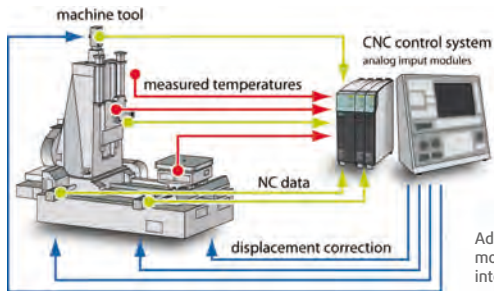
Advanced compensation models cover the effects of various sources

RCMT has developed an advanced software compensation method for minimization of machine tool thermal errors, based on transfer functions.

Main benefits of this method compared to common approaches include:

- Up to 10× higher machine tool accuracy in a wide range of working conditions
- High robustness and stability
- Simplicity – clear positioning of temperature sensors close to heat sources
- A cheap method with no further requirements on hardware
- Transferability to machine tools from the same production series

Number of successful applications has proven the priority of the RCMT solution compared to standard approaches based e.g. on linear regression models.

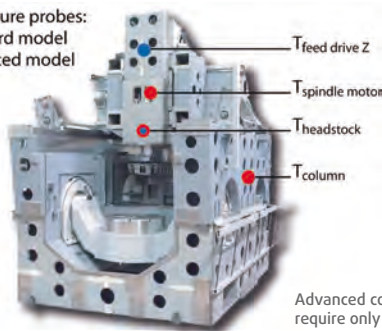


Advanced compensation models are implemented into CNC control system

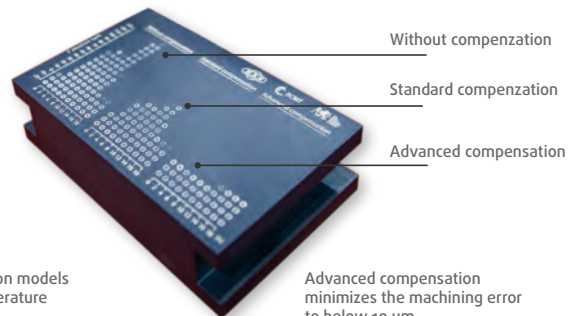


Temperature probes:

- Standard model
- Advanced model



Advanced compensation models require only few temperature sensors



Advanced compensation minimizes the machining error to below 10 μm

Machine Tool Structural Optimization

One of the main aims of machine tool design is to develop a structure which will represent an optimum solution with respect to various design and functional requirements. This is a highly complex task, which includes finding an optimum machine structural concept, material use in the machine design space and optimum dimensioning of the proposed structure.

RCMT has developed an advanced integrated design development strategy, including:

- **Conceptual topology optimization** for fast evaluation of various structural designs suited for machining the workpieces of defined size
- **Topology optimization** for finding the optimum material distribution in the defined design space fulfilling the given structural target criteria
- **Parametric optimization** for optimum structural dimensioning fulfilling the given structural target criteria
- **Final design check**

The RCMT approach allows for achieving substantial mass reduction of up to 50 % compared to conventional design or a significant increase of structural properties.

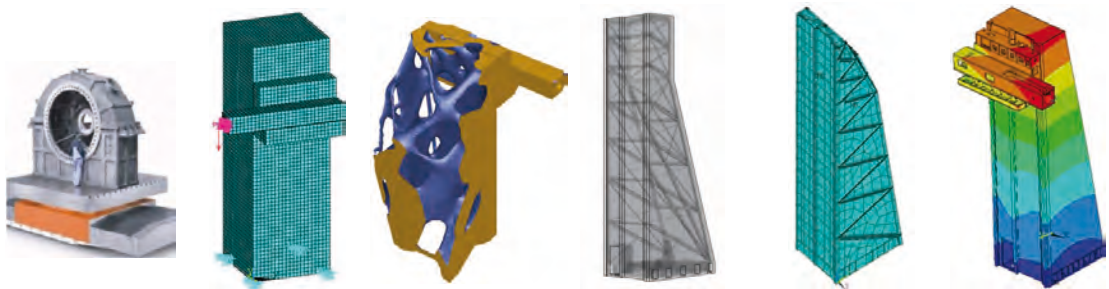


Up to
50 % mass
reduction

RCMT successfully collaborated on the design of a number of **Czech machine tools with higher precision and machining performance.**

Design input data:

machine kinematics, axis strokes, max. dimensions, material information

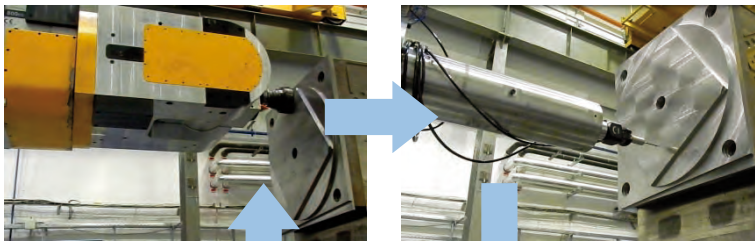


Functional demands:

static stiffness, modal properties, dynamic stiffness, feed drive bandwidth

Additional Measuring Systems And on-machine Measurement

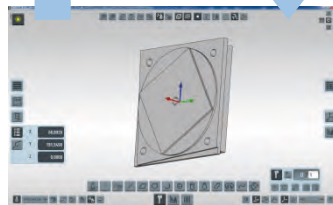
One of important sources of workpiece inaccuracy is the machine tool structural deformation due to own weight, process forces or temperature effects. Another sources of errors result from the common strategy of measuring the workpiece geometry outside of the machine tool in different conditions than during machining.



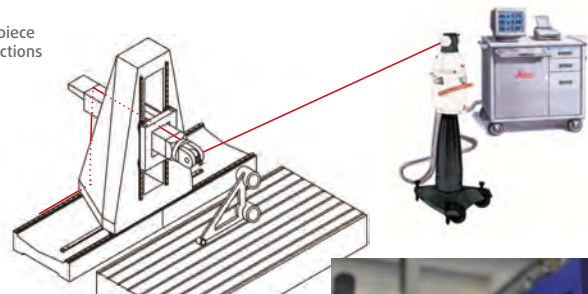
RCMT has developed several systems for calibrating the machine tool before the machining process, for monitoring its condition online or for direct evaluation of the workpiece errors on the machine and calculating the compensation needed.

Main benefits include:

- Improved static positioning accuracy
- Improved path control accuracy
- Significantly improved geometric and dimensional workpiece accuracy
- Ability to align several machines working on one workpiece and compensate for their error.



RCMT system of workpiece on-machine measurement allows evaluating the workpiece errors and calculating the machining corrections directly on the machine



The machine can be controlled by metrology software implemented in CNC as a coordinate measurement machine



Inbuilt RCMT measurement system / laser tracker for contactless position measurements and evaluation of the machine tool static errors

Optimization of Technology and Production Processes

The process that starts with a part drawing and ends with a finished product having the desired properties and reasonable manufacturing costs involves a number of demanding operations. Deciding on the right production technology is one of the most critical of these operations. By selecting the right machining strategies, cutting tools, tool holders, materials and entire production methods, it is possible to significantly influence product quality and manufacturing costs.



Optimization of process parameters – an example of critical chip formation

RCMT experts provide comprehensive technological support for any phase of the workpiece production process: design, selection of machining strategy, selection of tools, selection of machinery, etc.

We focus on production modeling and optimization as well.

The main benefits are:

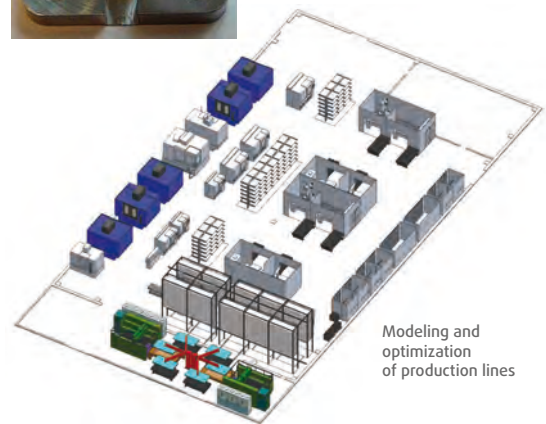
- Optimization of the pre-production phase
- Reduced machining and idle times
- Reduced manufacturing costs
- Higher quality
- Higher productivity
- Optimization production



Technology optimization of the specific part resulted in 5× higher productivity and better surface quality



RCMT offers advanced support in optimization of machining hard to machine materials



Modeling and optimization of production lines

Laser and Hybrid Technologies

Laser becomes a productive and cost-effective alternative to other additive or subtractive manufacturing processes. It is also one of methods for surface engineering. Laser engraving and texturing suits well especially for hard to machine materials. Laser cutting, welding and material cladding are effective and precise processes.



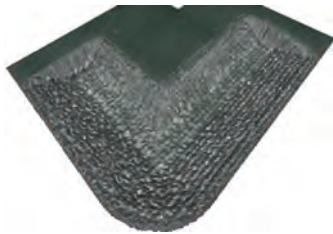
Laser texturing of the mold

Benefits from using laser for engraving and texturing applications:

- Similar precision compared to mechanical engraving
- Guaranteed engraving repeatability
- A contactless technology
- Applicability to difficult-to-cut processed materials
- Increased hardness of the engraved surface

Benefits from using laser for cutting, welding and hybrid additive manufacturing:

- Cutting and welding of thin parts from different materials (Ti, Ni, Mo, etc.)
- Generation of new structures and functional surfaces
- Effective and precise processes



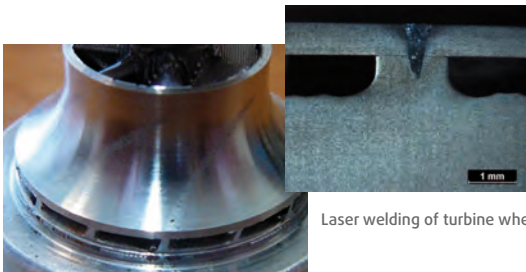
Laser engraving and texturing of the cutting insert



Additive manufacturing by laser cladding



QR code engraving



Laser welding of turbine wheel cover



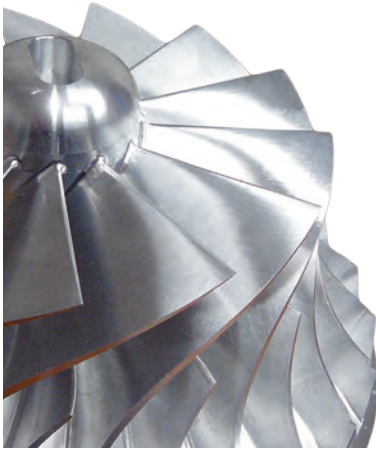
Holes by laser drilling

Complex Surface Machining

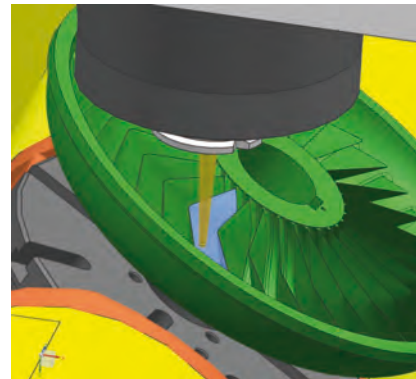
Complex surface machining places high demands on programming systems and the experience of CNC programmers, both for single-spot and meridian machining operations. Complex surface machining can be used efficiently to produce radial and axial compressors and turbines. RCMT experts offer proposing cost-effective production methods respecting the required dimensional accuracy and surface quality.

Machining of complex blade surfaces is characterised by extreme shape complexity and high accuracy requirements. RCMT offers:

- Technically viable and cost-effective solutions
- Selection of tool path strategies and tool geometries
- Optimization of cutting conditions
- Virtual check of NC codes using machine tool virtual models



Detail of blades of a compressor wheel



Simulations of complex 5-axis machining



A wax model of a gas microturbine and the resulting casting



Manufacturing of a radial compressor wheel

Postprocessors for Multi-Axis Machining Operations

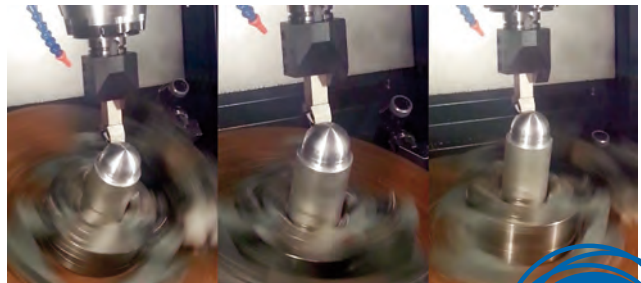
NC postprocessors for common machine tools are commonly prepared using a generator that is part of the CAM system "package".
RCMT offers development of postprocessors for multi-axis machine tools with advanced technology module.



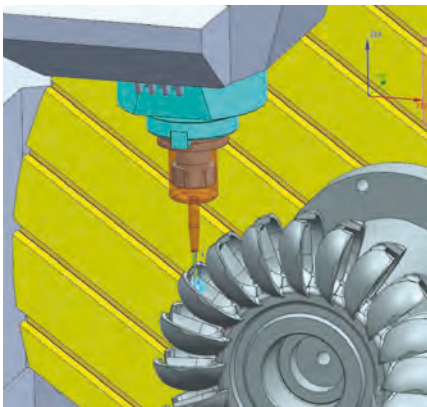
Postprocessors for multifunctional turning-milling centres

RCMT individual solutions offer the benefits:

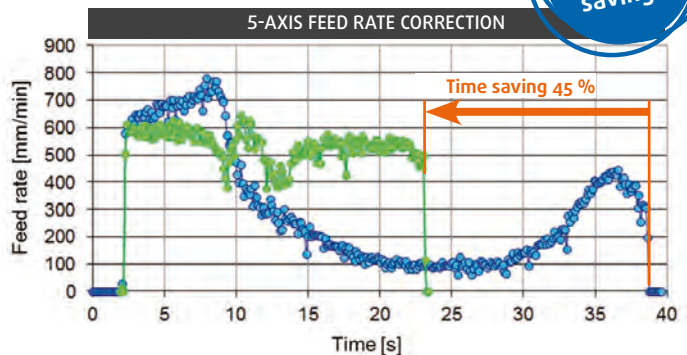
- Post-processors adapted to the user's specific needs and requirements
- The range of post-processing functions can be extended
- Independent of PC resources
- Ability to develop new post-processing functions in cooperation with the user
- Implementation of advanced technology module for feed rate recalculation in multi-axis machining
- Machine tool kinematic models including CNC controller emulator for simulations based on real NC program



Special functions for multifunctional centres, e.g. multi-axis turning



NC program collision check using a simulation model



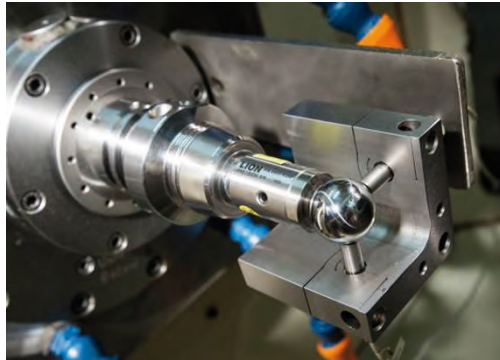
Feed rate correction in 5-axis machining by RCMT technology module brings substantial machining time savings

Accredited Testing Laboratory

In 2004 RCMT's Accredited Testing Laboratory adopted a quality management system in compliance with the ISO/IEC 17025 standard. The laboratory is accredited for all major machine tool tests under the ISO 230 standards. These include geometric accuracy, static and dynamic stiffness, thermal behaviour and noise. The laboratory also performs diagnostic machine tool measurements.



Machine tool analysis using thermo-vision



Spindle accuracy measurement



Diagonal displacement test

Thanks to many years of experience and an extensive theoretical basis, we are able to offer comprehensive solutions to issues concerning machines under test (geometry adjustment, non-invasive balancing, temperature compensation).

We offer:

- Measurements and analyses of machine tool condition in compliance with existing standards (ISO 230 series)
- Determining spindle operation accuracy, circular interpolation, accuracy of axial and diagonal positioning, geometric accuracy, machine static stiffness
- Vibration, sound pressure, sound power and sound intensity measurements, diagnostic measurements, thermal behaviour measurements
- Measurement and data analysis consultations
- Non-accredited measurements based on the client's needs



Volumetric accuracy measurement