From A to Z

Research at the Division of Industrial Production at LTH

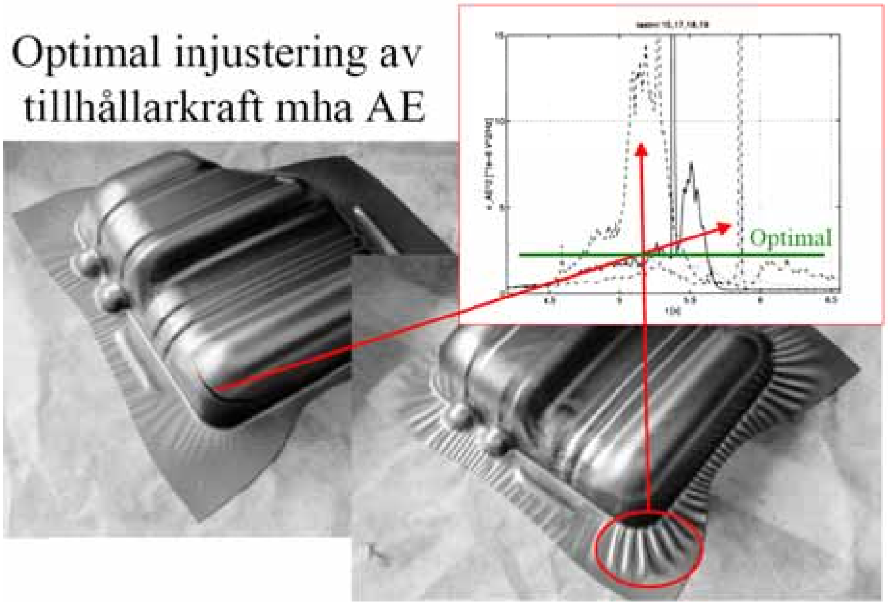
Lund University, Sweden

The person to contact for further **information** and regarding **picture rights** and other practical matters is **Jan-Eric Ståhl.** From A to Z describes current and earlier research, the research experience this has provided, and certain of the results. The photographs, diagrams and tables presented relate to research and developmental projects carried out at the Department as well as to industrial implementations or commercial applications of research results that have been obtained.

A

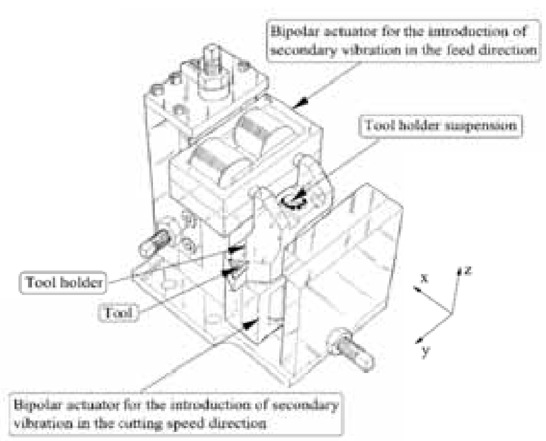
Acoustic emission

These are used in research for the monitoring of such machining processes as plate-metal manufacture, wire drawing, powder compaction and cutting processes. Work in this area is largely focused on the study and analysis of contact and friction behavior. A doctoral dissertation in the area has been presented.



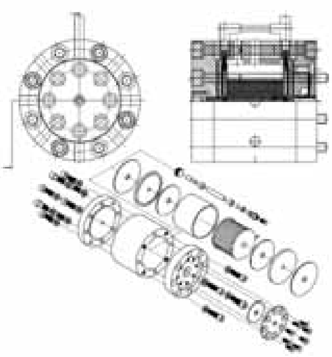
Active vibration damping

A unique research apparatus for producing active vibration damping in connection with metal-cutting processes has been developed at the Department. It involves use of adaptive vibration suppression produced by a bipolar magnetostrictive actuator. The apparatus controls the position of the cutting edge in real time in a manner that maximizes the damping effect through its reducing the extent to which undesired movements or vibrations occur. A doctoral dissertation within this area has been presented.



Actuators

Research on magnetostrictive materials and the development of linear actuators for use in different areas of application is being conducted. The actuators and actuator systems developed are capable of producing forces of up to about 150 kN. They have a region of application extending from about 200 Hz up to 30 kHz, the limits depending in the specific case upon the tasks involved. The types of manufacturing technologies in which actuators can be employed include vibration-assisted plastic forming, active vibration damping in cutting processes, ultrasound welding of polymers, vibration-assisted infiltration of melts, homogenization of material mixtures, cleaning tasks, killing of bacteria, and the creation of patterns aimed at in grinding and cutting processes.



Amorphous materials

Research in this area has involved primarily the development of new sensors, such as for contact-free torque measurement, and for measurement of forces, of accelerations, of acoustic emissions.

Applied materials technology
This is one of the major areas of research at the Department. The term "applied material technology" combines and integrates the areas of manufacturing technology, on the one hand, and material technology and production, on the other. The Department has research experience relative to this in the areas of metal-matrix composites (MMC), thermoplastic composites, hard-plastic composites, soft magnetic powder composites (SMC), magnetostrictive alloys, amorphous iron alloys and carbide-based tool materials, for example. These materials have been adapted to use in applications of the following types: protective materials and their use, light vehicle components, magnetic applications such as in induction heating, electric motors, fast relays and actuators, sensors for measuring torque, forces or accelerations, components exposed to hard abrasive wear, shearing tools, cutting tools, and inserts in forming tools.

B

Boring
Research concerned with boring processes is often carried out with the help of specially developed measurement technologies together with models of cutting processes. Workpieces having characteristics that have been specially developed are also used for the analysis and optimization of bore geometries.

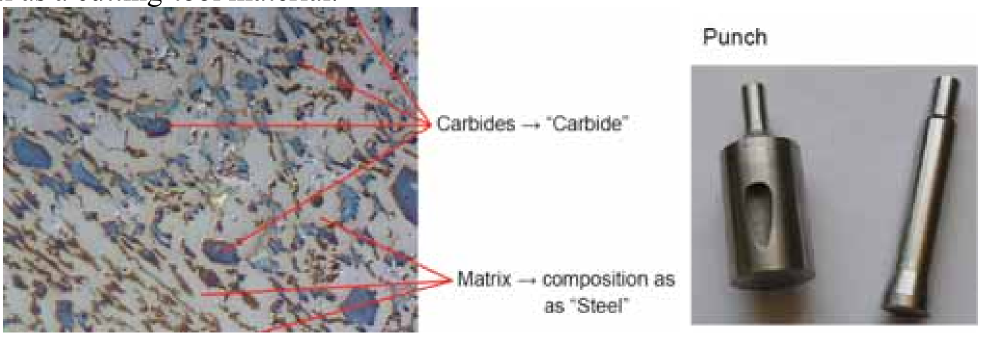
C

CADCAMCAE
The Department offers a course (7.5 points) in CI-programming within this area

CAM
No specific research within this area is being carried out, but research procedures that can contribute to the study both of load analyses of control strategies used in connection with milling processes are expected to be implemented in CAM-modules before long, for example for the selection and optimization of cutting data.

Carbide steel
This was introduced at the Department in 1994 as a castable tool material which is highly wear-resistant. Since then, processing methods and types of applications for which it is appropriate have been developed. Carbide steel contains an extremely high level of carbides in both primary and secondary form that are bound together in a matrix of either

austenite or martensite, which of these is involved depending upon the heat-treatment conditions employed. The material can be processed by means of lathing or of milling with use of CBN cutting tools. Its characteristics lie somewhere between those of high-speed steel and cemented carbide. It can be used to produce wear-parts and has high potential as a cutting-tool material.



Casting technologies

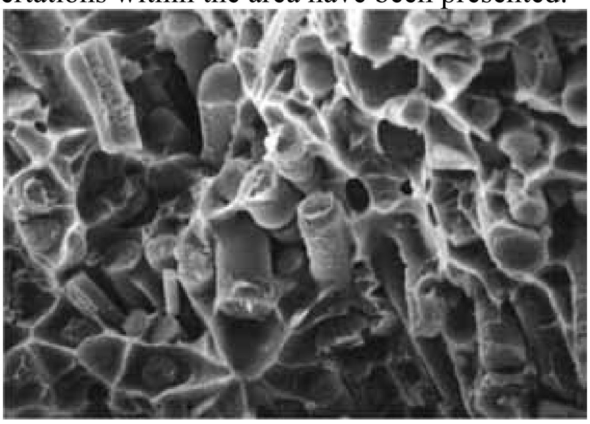
Research conducted here concerns casting of metal-matrix composites (MMC) and of carbide steel. A method of vibration-assisted casting termed VibroCast has been developed. A doctoral dissertation within this area has been presented. See also VibroCast. Casting methods are taken up in the course Manufacturing methods (7.5 points).

Cold forging

Analytical computational methods within this area have been developed. Empirical studies regarding it have been conducted at the undergraduate thesis level.

Composite materials

Research concerning the structure as well as the manufacture, use and reuse of composite materials has been carried on at the Department. The work conducted has dealt with a wide variety of areas of application. Research concerning the manufacture of metal-matrix composites (MMC) by use of VibroCast processes, the hot-pressing of fiber-reinforced thermoplastics (GMT), the use of soft magnetic powder composites (Permedyns) and of composite-based highly magnetostrictive materials (GMPC), and the recycling of high-performance carbon-fiber composites has attracted particular attention. Such matters are taken up in the Composite material course (7.5 points). Three doctoral dissertations within the area have been presented.



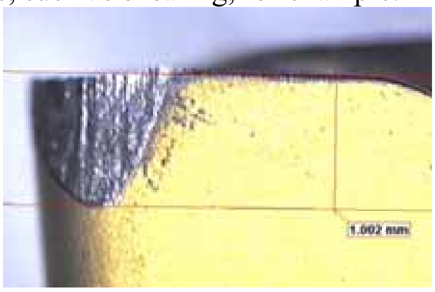
Cost derivatives
These are used for identifying those production-related developmental measures having the strongest effects on the costs of different parts. See Manufacturing-economic simulation.

D

Deep-drawing tools
See Forming technologies and Acoustic emission

Deterministic production development
This is synonymous with goal-oriented production development. See also Manufacturing systems.

Development of cutting tools
This is one of the specialties of the Department, where both modeling and theories pertaining to methods for testing cutting tools have been developed over a long period of time. In connection with this, methods of optimizing the microgeometry of cutting tools with regard to damping and stability, cutting-edge strength during processing, and balance between toughness and wear resistance have been studied, along with similar matters relating to other types of tooling processes, such as shearing, for example.



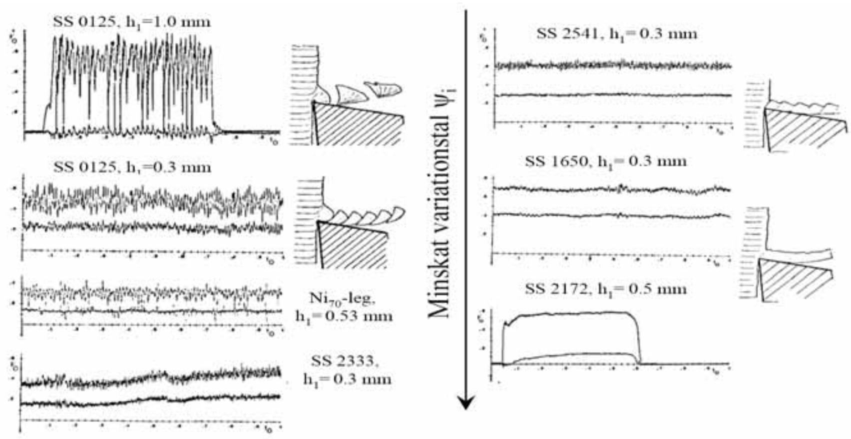
Disturbance analysis
See Downtime analysis.

Disturbance index and disturbance distribution
These are cutting-process concepts introduced at the Department for designating the number of disturbances of the cutting process that occur over a given distance that the cutting process covers and how these are distributed. The disturbance index multiplied by cutting speed yields the disturbance frequency. The inverted value of the disturbance index for segment formation is equal to the segment-formation distance.

Downtime analysis
This is a part of systematic production analysis (SPA), one concerned primarily with investigating the causes of downtimes, planned and unplanned ones usually being distinguished. Each of the factor groups A-H is associated, in a production performance matrix (PPM), with the corresponding downtime type. Data on downtimes enables the downtime ratio q_s for a given time period to be computed.

Dynamic cutting forces

The processing forces that cutting processes involve are often of dynamic character. This is linked with variations in energy transformation during chip generation (segmentation). It is usually only the static cutting forces that are reported. In order to describe the maximal cutting forces that develop and the forces acting on the cutting edge, measurement of the dynamic cutting forces that are present is needed. Measuring these in a reasonably correct manner requires that the force sensor have an eigenfrequency higher than the cutting-force frequency. The cutting-force sensor thus needs to be as stiff as possible (see Measurement technologies). The Department has long experience in the development and use of cutting-force sensors.



E

Electromagnetic forming

Certain pre-studies in this area have been carried out. A laboratory platform is in the process of being developed.

Environmental and recycling technology

See Recycling technology.

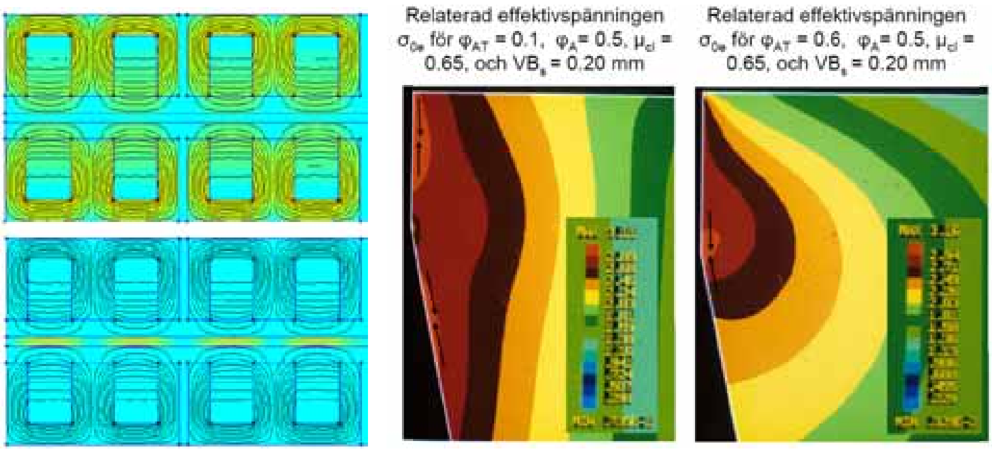
F

Factor groups

The factors which affect the result parameters in a cutting process or in a production line can be divided into groups A-H. Group A is “Cutting tools and cutting-tool systems”, Group B “Blanks and workpieces”, Group C “Processes”, Group D “Personnel and organization, including external logistics”, Group E “Wear and maintenance”, Group F “Special factors”, Group G “Peripheral equipment”, and Group H “Unknown factors”. These factor groups are employed, together with the different result parameters, for systematizing the causal relationships by means of a systematic production analysis (SPA). The SPA approach presently employed at the Department has been developed here successively.

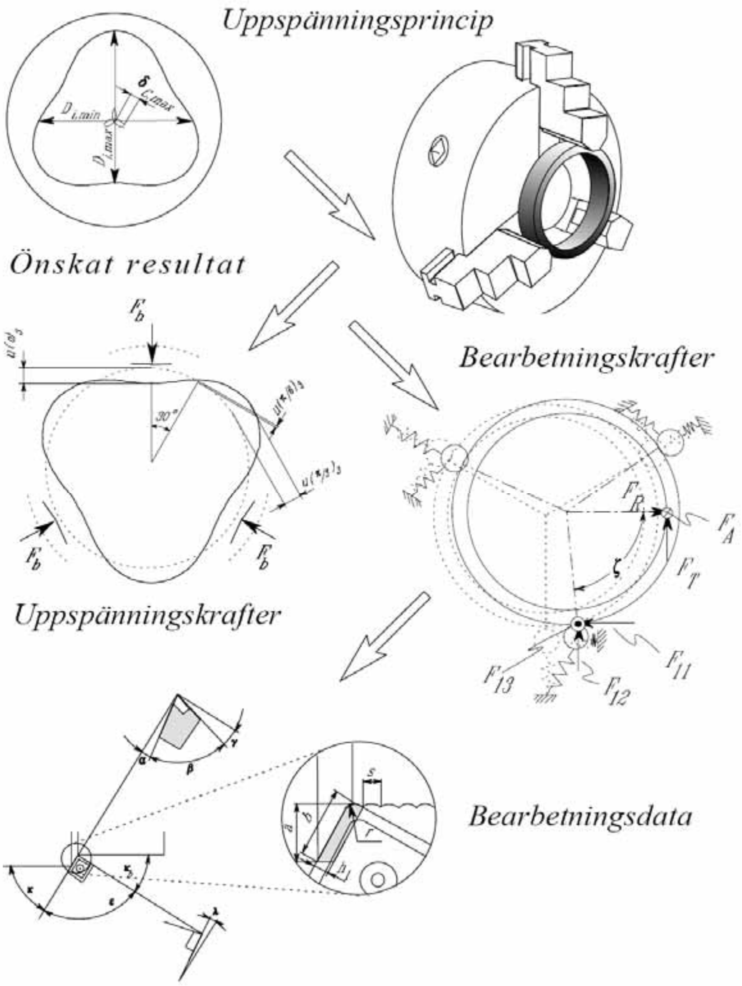
FEM

The Department offers a course in the use of FEM (7.5 points) within the framework of the CI-program. The practical examples taken up concern matters of manufacturing, use of machine tools and processing operations. Use is made of FEM within the Department in connection with most of the research projects being conducted, for example for computing the stresses to which tools are subjected, temperature fields and magnetic fields and strain.



Fixtures

The Department has research experience in connection with the attachment of workpieces in fixtures for machining centers and in rotating workpiece holders (chucks). Models and measurement methods and models have been developed for describing attachment forces, deformations and tolerances, as well as the clamping security of chucks.

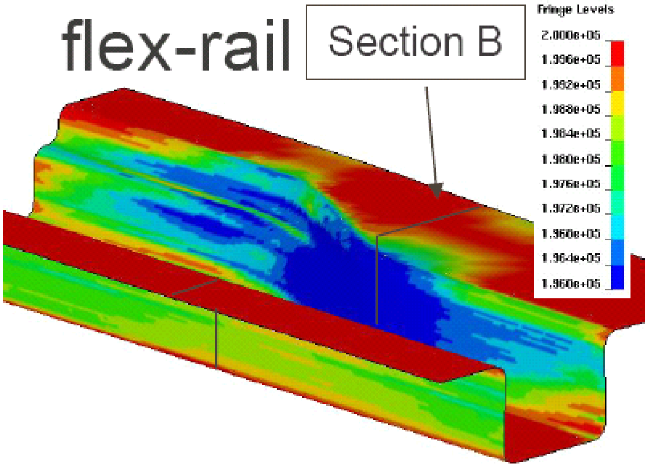


Forming simulation

A project is being conducted within this area. See Forming technologies.

Forming technologies

This represents one of the major areas of research in the Department. A modularized deep-drawing tool has been constructed, in collaboration with partners, within of one of the Department's projects. The tool is being used to demonstrate a variety of new technologies, such as integrative inductive heating, and monitoring of acoustic emissions, forces and surface-contact relationships. Beam-shaped parts of differing complexity can also be manufactured by this highly flexible tool. The types of parts produced can be selected so as to provide the basis for calibrations and for comparisons with the results of forming simulations. The tool also enables springback, fold and crack formation, as well as retraction to be studied. In addition, varying the stamp and die radii employed allows the formability of different materials to be assessed. These matters are dealt with in the Manufacturing methods course (7.5 points). Two doctoral dissertations within the area have been presented.

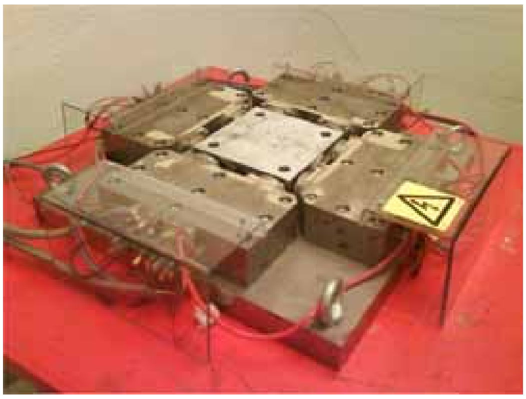


Functional materials
See Magnetic materials.

G

GMT
Glassfiber-reinforced thermoplast, GMT, is a material frequently used in constructing vehicles, allowing the weight of the vehicles and the number of parts needed to be kept at a minimum. Constructing the body of a vehicle of hot-pressed GMT makes it possible for a variety of functions to be performed by a given part of the vehicle body, to a greater extent than would be possible with use of other conventional body-plate types. Research has been carried out aimed at determining the optimal process data regarding pressure, temperature, holding times and form needed to produce the most desirable component characteristics. A doctoral dissertation in this area has been presented.

Grinding
Research is being conducted within the area of vibration-assisted grinding, which involves use of a magnetostrictively-based actuator for controlling a pattern created on a surface that is being processed. A prototype version of equipment designed to control the position of a workpiece on a plane in real time with a frequency of 2-3 kHz has been developed. The equipment is general in character in the sense that it can be used in a variety of different “dynamic applications”.



H

Hard machining

This term refers to cutting processes carried out on a material the final processing of which usually involves use of grinding and polishing methods. In research in this area, methods for the effective cutting of fully-hardened materials such as hardened steel and carbide steel as well as principles that apply to this, are being investigated. The methods being studied are primarily turning and milling, CBN serving as the tool material.

High-speed machining

The meaning of this term is rather diffuse. Machining in which high cutting speeds are employed differs neither theoretically nor in terms of the model that applies from processing at low cutting speeds. Cutting models that have been developed at the Department are applicable to cutting at both low and high speeds. The adiabatic effects of a cutting process increase, however, as the cutting speed becomes greater, leading to a more localized energy development in the deformation zones, to lower cutting forces and to higher process frequencies.

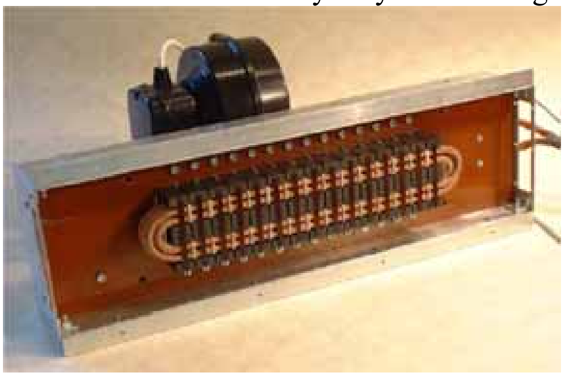
Hot-forming

Research on the hot-forming of sheet metal by use of induction techniques is being carried on at the Department.

I

Induction heating

Research conducted at the Department has led to the development of a new method for induction heating, one that makes use of the trans-flux principle. The method is very energy-effective and results in only very limited magnetic leak flux.



Injection moulding

Form-spraying processes have been developed for the manufacture of components and products made of SMC. The courses Manufacturing methods (7.5 points) and Recycling technologies (7.5 points) take up the methods involved here.

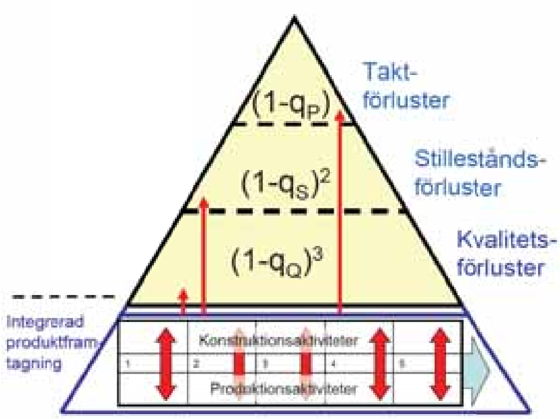
L

Lean production

The production philosophy this represents plays a central role in continual efforts that are being made to improve the functioning of manufacturing systems. Developmental measures of a Lean Production type are necessary in order to develop adequately a production system involving use of goal functions, or what is referred to as deterministic production development. A doctoral dissertation in this area was presented in 1997. Lean Production, or continual improvement work as it can also be called, is included in the Manufacturing systems course (7.5 points).

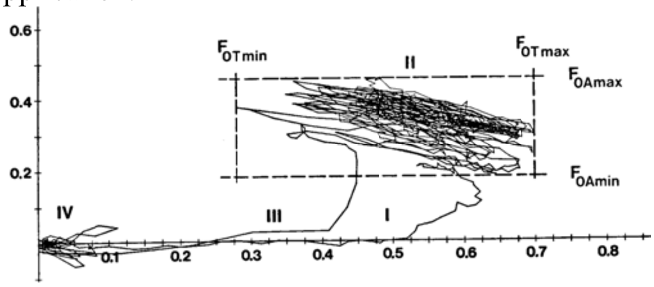
Lean triangle

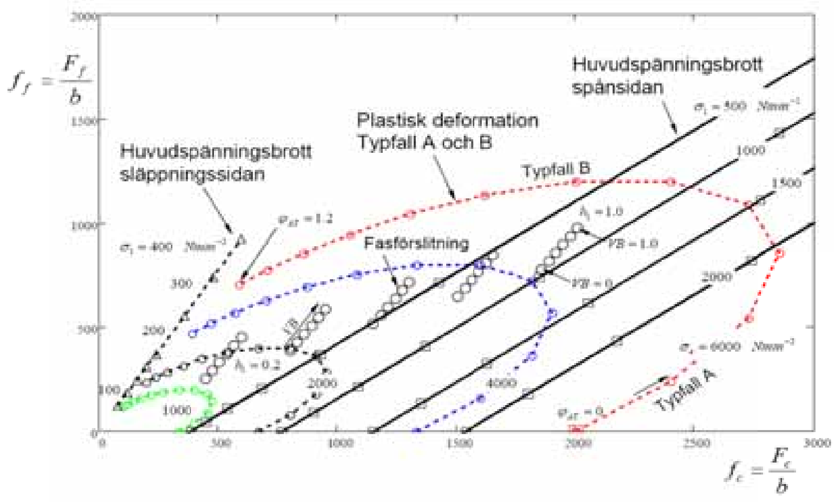
The principle behind this involves an order of priorities such that, first and foremost, quality is to be improved; secondly, improvements in use of time are to be made; and third, production speed or cycle-time is to be improved. This is to be achieved above all through active interaction between product development and production (integrated production of the product). The lean triangle principle provides a basis for research and development work at the Department within the area of manufacturing economic simulation (MES) .



Load diagrams

These provide a graphic presentation of how the pattern of forces (axial and tangential forces) on a cutting tool changes as a function of time, such as in the case of intermittent cutting processes. The borders shown within a load diagram are a basis for describing and studying different forms of non-wear-related deterioration of a cutting tool. Load diagrams are also used to study and to clarify the effects of different geometric characteristics of cutting tools. Since 1984, there has been a successive development of the use of load diagrams at the Department - for assessing the load situation, as well as wear and other forms of damage to the cutting tool. Through use of stress functions, a load diagram can be transformed into a stress diagram, such as for describing the relationship between the highest level of stress and the effective stress level. The information this provides can serve as the basis for selecting the optimal tool material for a particular cutting-tool geometry in a given application.





Load functions
The concept of load functions has been developed at the Department for describing the force and stress distributions that affect the active surfaces of the cutting tool. Load functions can also be useful when applied to other types of tools, such as shearing and punching tools.

M

Machinability
This is an important area of cutting process research. In research within the area, the Department has developed a method for obtaining a modularized machinability assessment of a work material. The method involves the creation of a polar diagram (material-characteristics diagram) to provide a general description of those characteristics of a work material that control the degree and type of machinability it possesses.

Magnetic materials
Such materials belong to the functional-material group. It possesses unique magnetic characteristics such as magnetic conduction and magnetostrictive properties for which technical applications can be found, in addition to such structural characteristics as that of its considerable load-bearing capacity. Research on the development and methods of

manufacture of magnetic flux conductors that are based primarily on iron-powder composites (SMC) is being carried on within the Department. See also Powder technologies.

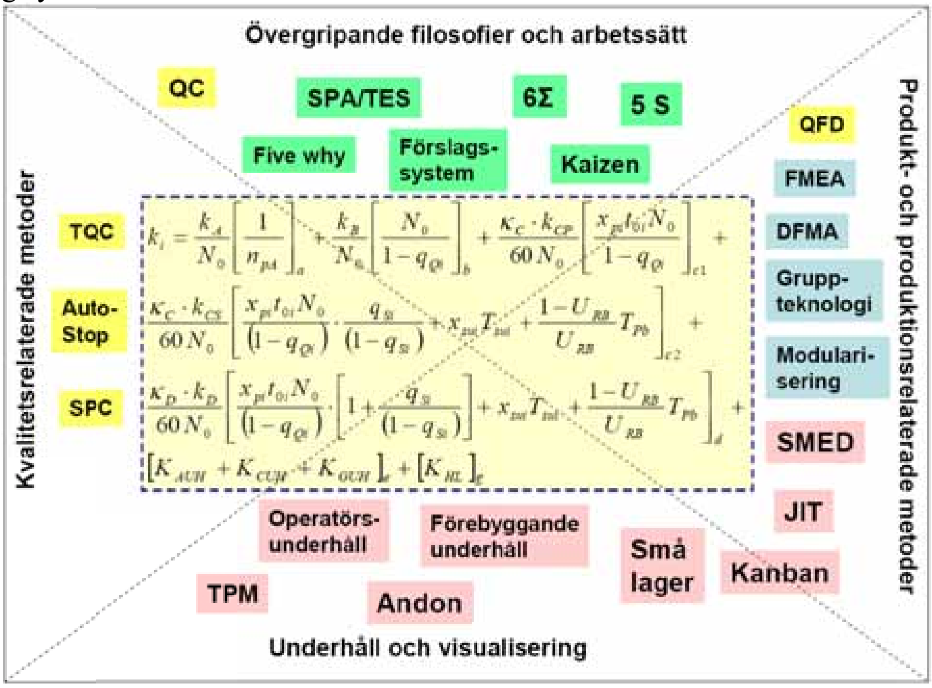
Magnetic forming
See Electromagnetic forming

Magnetostrictive materials
Material of this type belongs to the Functional material group. A magnetostrictive material increases in length when placed in a magnetic field. This increase in length, or striction, usually occurs without a loss of any sort, and generally takes place immediately. In contrast, eddy-current losses can occur in connection with the magnetization of rough-surfaced bodies, often ones that are rod-shaped. Magnetostrictive effects are reversible, their reflecting changes that take place at an atomic level in the energy balance between magnetic and mechanical energy. Even at room temperature, highly magnetostrictive materials, as their name implies, display a rather high degree of magnetostriction, a property based on the iron, terbium and in some cases dysprosium that they contain. Intermetallic material of this type is named Terfenol. Magnetostrictive material is usually produced in an actuator, the material in question being placed in a magnetic field there; for further details, see Actuators. A wide range of research concerned with the implementation of magnetostrictive materials and the function they can play in workshop applications has been conducted at the Department. Examples of their application include their use for controlling tool movements, in friction welding (ultrasound welding), in active vibration damping, in vibration assistance in processes such as powder compaction and plastic forming that involve considerable friction, in vibration-assisted casting and wetting (see VibroCast), in structural excitation, and in sensor applications of various types. A magnetostrictive composite based on Terfenol (GMPC), one that has very positive high-frequency characteristics, has been developed at the Department. It is being used primarily in connection with ultrasound. A doctoral dissertation in this area has been presented. Magnetostrictively-based actuators have also been used in a large number of studies at the Department. For further information, see Actuators.

Manufacturing Economics
This area, which can be seen as being a part of the broader area of production economics, deals primarily with costs linked directly with the processing of a product or part, which do not include certain costs for the manufacturing company as a whole. Manufacturing-economic models describe the effects of different factors on the part or product costs that accrue, such as rejection rates, downtime rates, cycle times and slowdowns, setup times, wage and salary costs, degree of utilization, and the like. Manufacturing-economic models are given a high priority within research at the Department concerned with manufacturing systems.

Manufacturing Economic Simulation, MES
The costs of a part can be simulated for a variety of different production-related scenarios, making use both of existing data and of a relevant manufacturing-economic model. This allows the cost effects of different directions that production development can take to be evaluated. A manufacturing-economic simulation, MES, can provide an answer to

the question of what developmental steps would result in the greatest reduction in costs. The cost derivatives that can be obtained describe the potential changes in cost associated with a given change, such as in rejection rates, downtime rates, cycle times and slowdowns, as well as setup times, wage and salary costs, and degree of utilization. In addition, it can enable the effects of different lean-production measures, such as QC, 5S, Five why, Kaizen, FMEA, TPM, Andon or SPC, to be assessed in manufacturing-economic terms. MES represents a cornerstone in research at the Department concerned with manufacturing systems.



Manufacturing Economic Effectiveness, TEE

This measure of effectiveness, η_E, describes how closely the manufacturing costs of a product or part are linked with the correct manufacture of it. This is computed as the ratio of the ideal costs to the actual costs. The ideal costs are the costs as they would exist if there were no rejects, losses in time in the form of downtimes, slowdowns, material waste, and the like. TEE can be regarded as a further development of OPE, one in which account is also taken of the cost distribution. The Department makes use of this index in research, in course work, and in work in collaboration with industry.

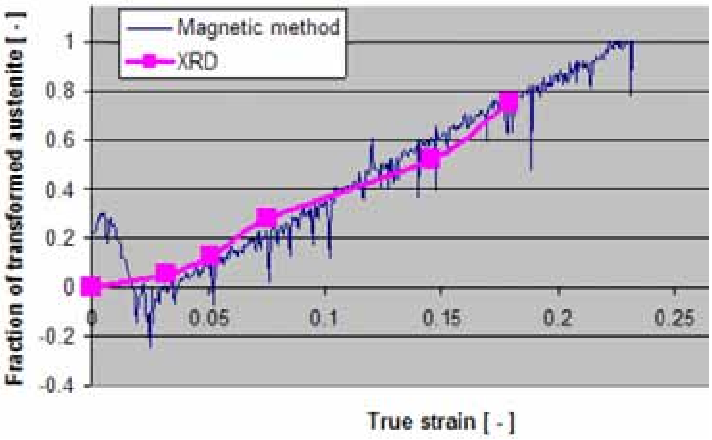
Manufacturing Methods

These can be classified in terms of 14 different categories, in which product assembly is included. The Department conducts basic process research within the areas of cutting processes, plastic processing (forming technologies), powder-compaction technologies and casting technology. Research regarding other types of methods can be subsumed under research on manufacturing systems.

Manufacturing Systems

Any such system consists of the methods and equipment, as well as the associated personnel and organizational entities, involved in manufacturing of some particular type within a manufacturing organization. A manufacturing system can also be centered on the use of some particular machine, or of some particular production line. One or more manufacturing systems in which storage and logistics functions are included can in turn represent a production system. Research on manufacturing systems concerned in particular with systematic production analysis and manufacturing-economic simulation represents a major area of research within the Department. It is directed in part at the effects of different technical and organizational changes on manufacturing costs and on competitiveness of the product and of the organization. It also deals with questions of whether a manufacturer should let its manufacturing, or some of it, be carried out in a country in which wages are lower (outsourcing). This is taken up in particular in the course Manufacturing systems (7.5 points) and in a corresponding course at the doctoral level held on a national basis.

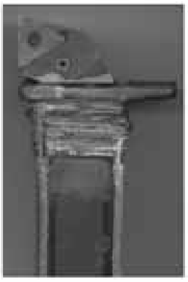
Material analysis
A method for assessing the extent to which an austenite-martensite transformation has occurred in connection with plastic deformation has been developed at the Department. The amounts of deformation-martensite present can also be analyzed in real time. The method for doing this involves measurement of the frequency-dependent magnetic characteristics of the material.



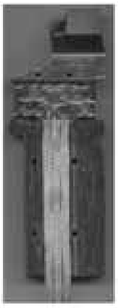
Material technology
See Applied material technology.

Measurement technologies
Research in this area at the Department is concerned largely with the measurement of process variables that apply to the manufacturing process, such as cutting forces, torque and temperature, and also measurement of the magnetic properties of the materials involved. Considerable work has been devoted to the development of sensors for measuring dynamic cutting forces. The advanced measurement technologies used have served as a basis for describing and modeling the dynamic load relationships and the accompanying transient stresses present during intermittent cutting processes. This enables theories concerning segment formation, for example, to be formulated and tested, variation indices

and disturbance indices to be obtained that apply to the work material, and damping of the cutting processes to be detected and described.



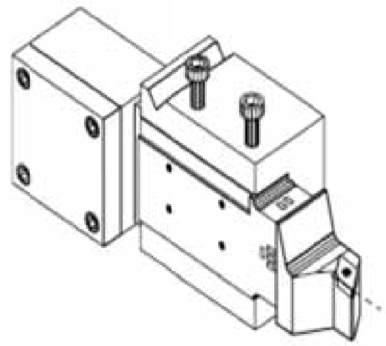
Force sensor 1985.

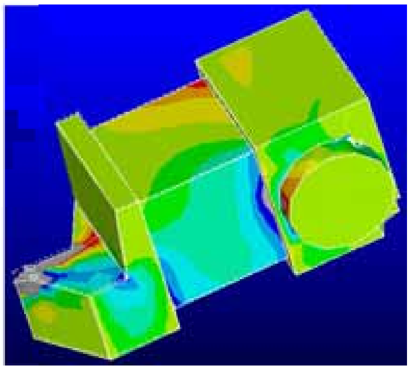


Force sensor for machinability Research, 1996.

VDI force sensor for precision machining (hard turning), 2001.

Covial AE sensor for Wear identification, 2002.



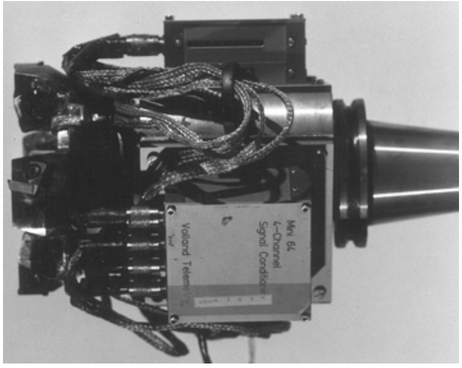


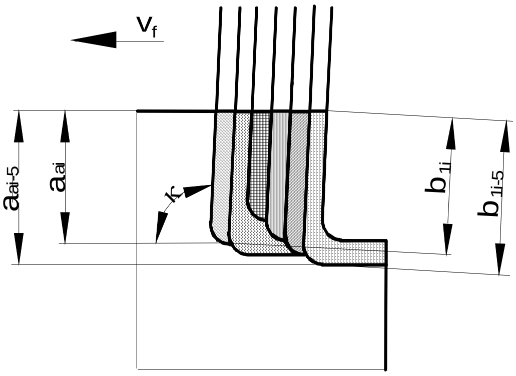
Mechanical analysis
This is an area in which the Department possesses specific competence, particularly in connection with cutting processes. Mechanical analysis is also being applied in Departmental research to shearing and to forming. It deals with the measurement, modeling, and simulation of various mechanically-caused deformations and the stresses accompanying them.

Metal cutting technology
This is one of major areas of research at the Department. Research experience has been gathered in each of the following areas: tool wear and tool failure, process monitoring, clamping devices, vibrations and cutting dynamics, measurement technologies, FE-simulation, mechanical-load analysis, thermal-load analysis, intermittent processing, burr formation in cutting processes, active vibration damping, hard machining in turning and milling, vibration-assisted cutting processes, and machinability and machinability analysis. Thus far, 10 doctoral dissertations in this area have been presented.

Milling
Research in this area conducted at the Department has been aimed primarily at describing and clarifying the load interference that takes place between the separate cutting edges of a milling cutter as wear progresses, warping occurs or the tolerances of the cutter become restricted. A unique measurement technology has been developed for measuring the cut-

ting forces acting on each of the edges of the milling cutter. A doctoral dissertation within this area has been presented.





MMC
See VibroCast and Composite materials.

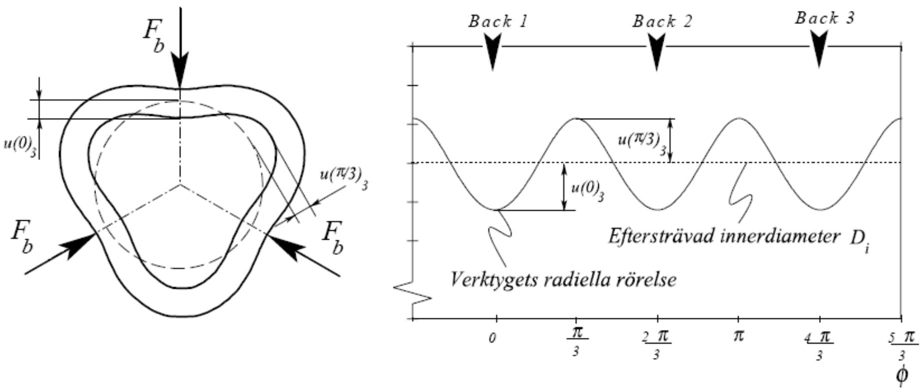
Mode locking in cutting processes
The dynamic movements of a cutting edge can both be partly controlled and be limited in a particular direction by its geometric form. How the edge behaves is related in part to the deformation damping that occurs during various portions of the vibration cycle. The extent of the vibration damping is strongly affected by the geometry of the cutting edge, the segmentation behavior of the work material, the cutting data selected, and the give (or the stiffness) of the system.

Monitoring
The Department has conducted research in this area for a long period of time, particularly in connection with cutting processes. Various studies in this area involving welding have also been carried out. A doctoral dissertation within the area has been presented.

N

NC
No specific research in this area is being conducted, although a considerable part of the Department's research on cutting processes is clearly relevant to the control of machining tools. The area is dealt with in many courses that the Department offers.

Non-round turning
Research in this area has also been conducted at the Department, concerned in particular with controlling of the position of the cutting tool in the radial direction, with the intention of compensating for elastic deformations caused by the processing and attachment forces involved, primarily in connection with attachments to rotating work holders (chucks) in turning. A doctoral dissertation and a licentiate thesis in the area have been presented.



Q

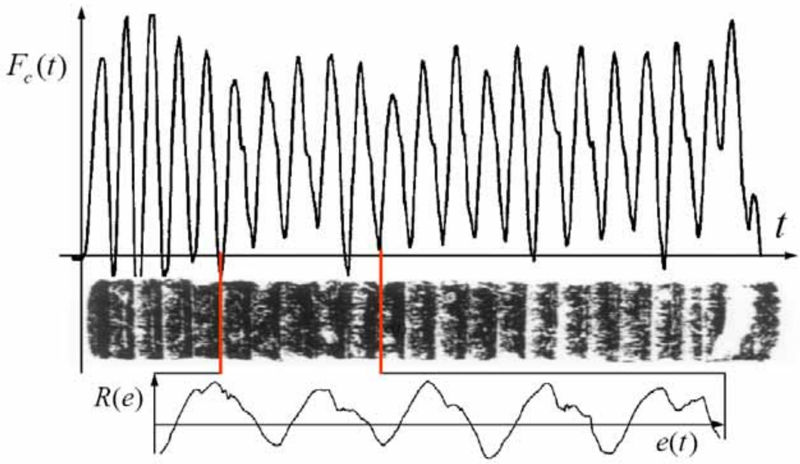
Quality technology

This is closely connected with the development, management and analysis of a manufacturing system. Questions of quality and maintenance are important in systematic production analysis (SPA). The Manufacturing systems course (7.5 points) deals in part with quality technology.

P

Pendulum hammer

These have been employed for providing well-defined cutting processes in research conducted here. The initial studies involving pendulum hammers (1983) concerned the relationship between dynamic cutting forces and the surface typography generated.



Powder technology

Research here concerns primarily the forming of soft magnetic powder material (SMC) and giving parts produced by it the characteristics desired. Material of this type is used for directing a magnetic field in a manner that results in a minimal loss of energy. It can be used, for example, in equipment for induction heating, in linear motors and actuators, and in sensors and inductors.

Production analysis
This is one of the major areas of research at the Department. Being able to analyze a production segment in a systematic manner is essential if a rational production development is to be carried out. In a systematic production analysis (SPA), factors of central importance for production are linked with result parameters in a production performance matrix (PPM). The major conclusions arrived in a PPM serve as the basis then for measures aimed at improvement. A PPM also enables certain key figures to be computed describing factors of direct relevance to production, such as the rejection ratio, the downtime ratio, the degree of speeding up or slowing down, and setup times. These key figures are needed for manufacturing-economic simulation (MES) to be carried out. Both the SPA and the MES approach have been developed further at the Department recently, providing a basis for assessing the effects of both continued development work (a Lean Production approach) and project-oriented, goal-oriented development (Deterministic production development).

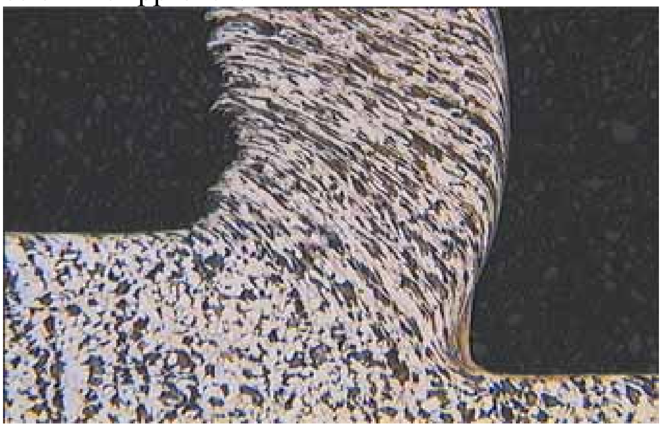
Faktorgrupper	Kvalitets-parametrar Q_1, Q_2...	Stillestånds-parametrar S_1, S_2...	Produktivitets-parametrar P_1, P_2...	Miljö- och Krets-loppsparametrar MK_1, MK_2...	Σ Faktorer
A. Verktyg					100
B. Arbetsmaterial					100
C. Process					300
D. Personal & Org.					100
E. Slitage & underhåll					100
F. Speciella faktorer					100
G. Kringutrustning					100
H: Okänt					0
Σ Resultatparametrar	200	400	200	100	

Production economics
See Manufacturing economics.

Q

Quick stop

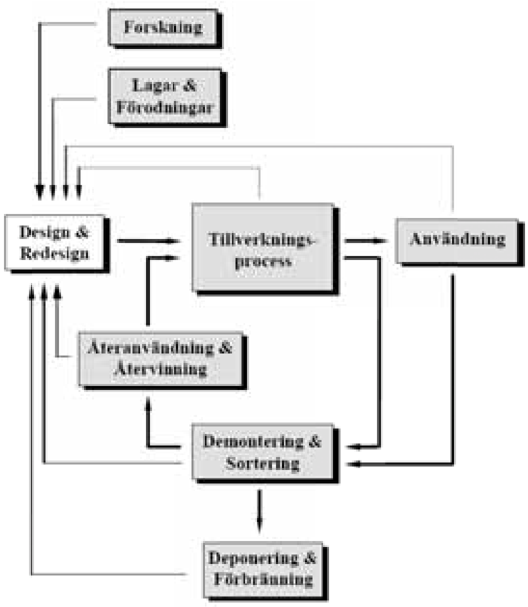
This is a method used for studying different segments of a cutting process and how these relate to each other. A photograph of what occurs at a particular instant in the course of a cutting process is obtained. This is possible by using a charge of explosives to shoot the cutting tool out of its attachment at a particular time. The method allows one to determine the size of the deformation zones, the position of the stagnation point and the form and breadth of the stagnation zone. Obtaining this information is essential for being able to model a cutting process in both a mechanical and a thermal sense. The Department has long experience in use of this approach.



R

Recycling technologies

Environmental and recycling technologies are major elements of the concept of sustainable development. The Department has conducted research on the reuse and recycling of advanced composite materials, carbon-fiber composites in particular, and energy recovery from them. The recycling of both production wastes and worn-out products has been studied in this connection. Environmental effects in terms of noise and dust formation, as well as tool wear, in the breaking up of composite materials in granulation machines have been investigated as well. A doctoral dissertation in this area has been presented.

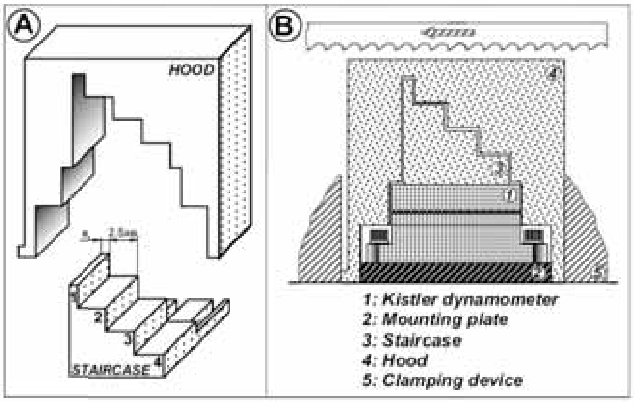


Result parameters
Production results can be described by use of the result parameters Q. Quality, S. Downtimes, P. Production speed, and MK. Environment and recycling. The result parameters are controlled by factors belonging to the factor groups A-H. The result parameters are used together with these factors for systematizing the causal relationships that a systematic production analysis (SPA) deals with. Practical applications of SPA have been developed continually at the Department.

RotoCast
This is a manufacturing method that the Department is in the process of developing. The method, makes use of centrifugal casting. It is intended for applications involving the forming and casting of magnetic flux conductors.

S

Sawing
This belongs to the group of multi-edge cutting methods. Measurement methods and theories for analyzing and describing such multi-edge cutting methods as sawing and milling have been developed at the Department. Different geometric forms for workpieces designed to isolate certain types of cutting behavior have been developed at the Department in collaboration with industry. A doctoral dissertation within the area has been presented.



Sensor technology
The Department has extensive experience in the development and adaptation of sensors for use in factory and workshop settings. For further details, see Measurement technologies.

Setup times and reduction in setup times
A reduction in setup times can often be achieved on the basis of conclusions drawn from results of a production analysis and a manufacturing-economic simulation (MES). A setup time can be regarded as a planned downtime, yet setup times sometimes vary to an unnecessary and undesirable extent. The occurrence of shorter production series leads to an increase in costs due to the many setup operations during the manufacturing that this requires. Each year, a developmental project is carried out at the Department aimed at reducing the time lost through setup times, SMED often being used to achieve a reduction in the number and length of setup times.

Shaping
The cutting method of shaping is used within a research context here to study transient load development during intermittent cutting processes. The well-defined conditions and linear cutting movements that shaping involves make it useful for studying the course of loading and unloading during successive engagement and disengagement of the cutting tool. The effects of different geometric parameters applying to the cutting tool and to the workpiece have been studied in this context. The results obtained have contributed to knowledge of the mathematical relationships involved and of models that can be used in describing intermittent processing, such as in the case of milling. The first force sensor used and developed here for measuring the dynamic cutting forces involved (1983) was designed for use in connection with shaping and cutting by means of a pendulum hammer. See Pendulum hammers.

Sheet metal forming
See Forming technology

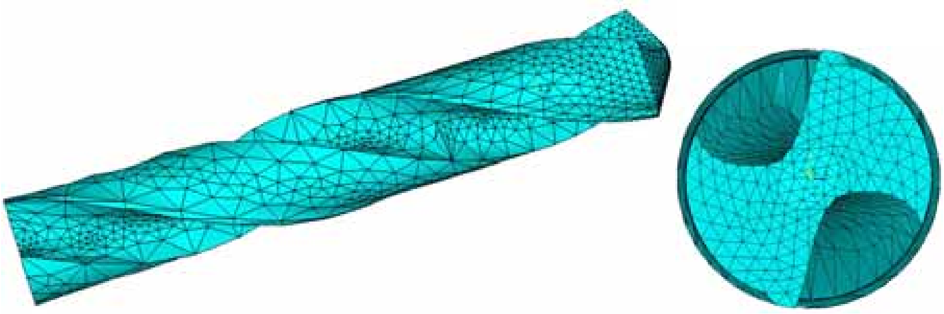
SMC
See Powder technology.

Soft magnetic material

See Magnetic materials.

Solid modeling

This is used in a research context for generating models, such as for FE-analysis. Modeling of this sort is also taken up in the course in CADCAMCAE (7.5 points) that the Department offers.

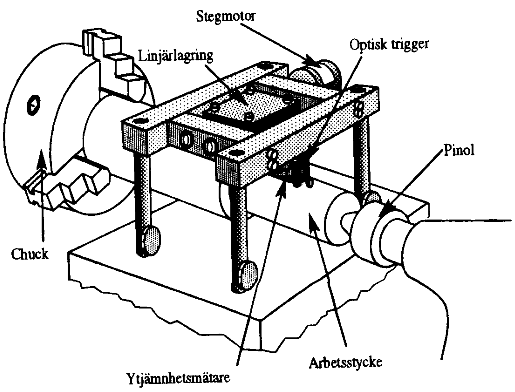


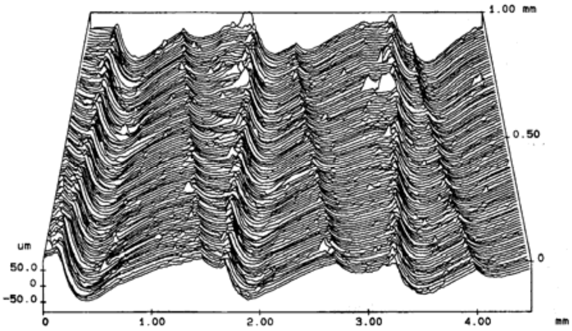
Stress diagrams

These describe the relationship between the highest stress level and the effective stress level in a cutting tool. This, in turn, can be viewed in relation to the load pattern involved. A stress diagram can indicate, for example, what cutting-tool characteristics are most appropriate for a given application. Consideration of both a stress diagram and a load diagram can be useful in connection with mechanically loaded tools of other types as well. Stresses of thermal origin can be dealt with in a corresponding way.

Surface roughness measurement

An apparatus for surface roughness measurement in 3 dimensions was developed very early at the Department. The apparatus is portable and is able to measure the typography of the surface of a workpiece mounted in a machine tool. It has been used primarily for studying cut surfaces after cutting processes have been carried out. The apparatus has been highly useful in connection with the formulation of a theory concerning the functioning of the microgeometry of a cutting edge. Use of this apparatus has been gradually replaced by use of apparatus of other kinds that has become available commercially.





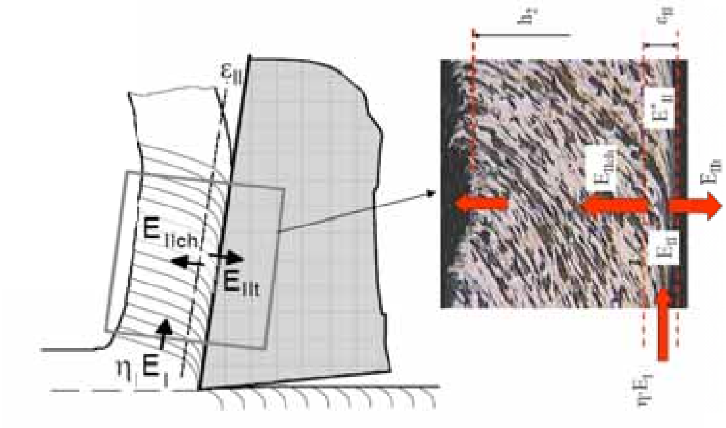
Sustainable development

See Recycling technologies.

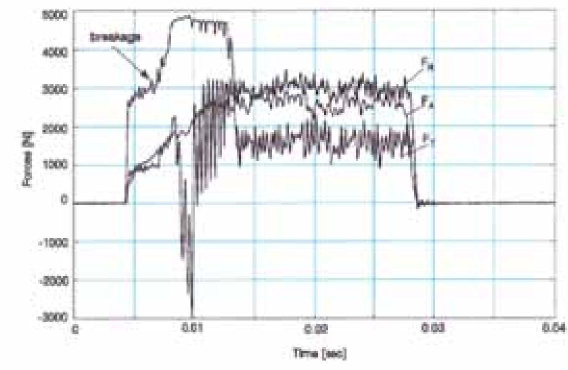
Systematic Production Analysis, SPA
See Production analysis.

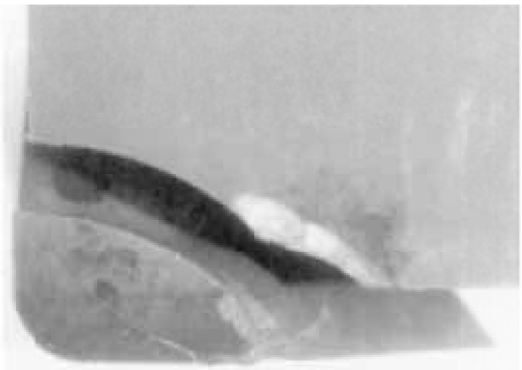
T

Thermal analysis
This is an area cutting-process research in which the department has special competence. Measurement technologies and analytical models have been developed for computations and simulations of temperature levels (composite temperatures) in cutting processes. The models can be used in conducting sensitivity analyses concerning the different parameters that control temperature developments in the course of cutting processes.



Tool failure
This is a matter of the non-wear-related breakdown of cutting tools. The Department has long experience with the analysis and modeling of tool failure. Many of the doctoral dissertations have dealt in some way with tool failure.



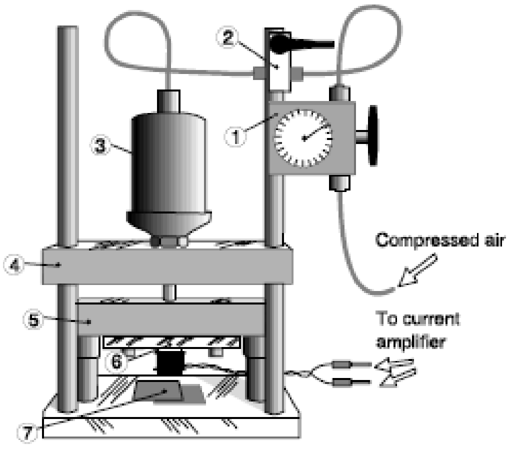


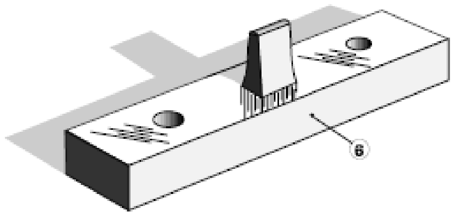
Tool material
The development of cutting-tool material at the Department has been concerned above all with material for forming-type tools, such as reinforced short-series tools. See also Carbide steel.

U

Ultrasonic welding

Equipment for ultrasonic welding of thermoplastics has been developed at the Department. The equipment involves use of a resonance horn of highly magnetostrictive material (GMPC) about 20 mm in height.





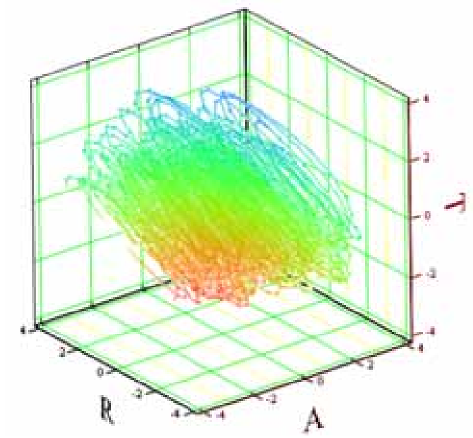
V

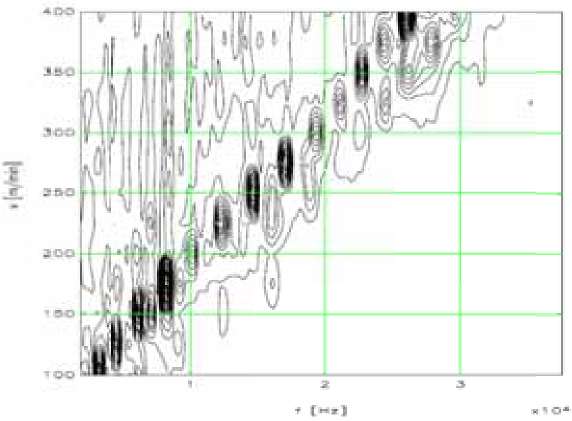
Variation index and variation distribution

These are concepts, developed at the Department, concerned with the dynamics of cutting forces.

Vibrations

Movements and vibrations caused by cutting forces were studied in a series of projects at the Department at the beginning of the 80s, in which the movements and dynamics of cutting processes were measured by an accelerometer, by laser and by an inductive sensor. See also Mode locking and Measurement technologies.



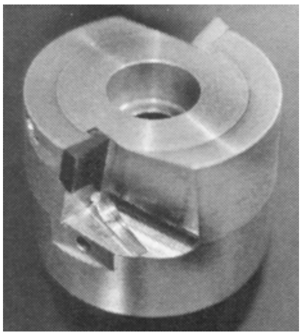


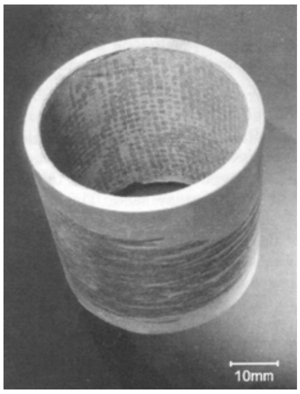
Vibration damping in cutting processes

See Vibrations, Dynamic cutting forces and mode locking.

VibroCast

This is a casting method developed at the Department in which the melt is provided with vibrations of high energy content. The vibrations can be supplied by means of either vibration-dip coating or form vibration. Many different factors can be affected in this way. The vibration energy can increase the wetting that occurs between the different components or types of material within the system. The major wetting effect can be attributed to the dynamic wetting angles that develop on the basis of the cyclic pressure which is created. Also such not very readily wetted material systems as those of aluminum oxide and of melted aluminum alloys can be wetted in this way. A strong capillary effect allows composites with a high volume fraction of reinforcing material to be poured by use of a VibroCast-process system. This can be done without use of a high pouring pressure, one that usually results in serious damage to the reinforcement structure (preforming). Metal-matrix composites (MMC) containing > 90 % aluminum oxide have been poured by use of this method. The vibration energy can also lead to a reduction in the size of the primary precipitated phases and to an increase in the number of nucleation points that are operational, resulting in a decrease in grain size. A structural change of this sort provides better material characteristics in the form of greater strength, ductility and impact strength. The method has proved to be successful in connection with the pouring of grey cast iron and of cast aluminum, marked changes in the structure of the material producing greater strength, being noted in both cases.





Vibration-assisted processing

Losses that friction in the course of a cutting process brings about can be reduced by use of high-frequency vibrations. A variety of models have been advanced for explaining the positive effects on a contact surface subjected to a moving load that providing it with vibrations can produce. At the Department, use has been made of a magnetostrictive-based actuator to provide surfaces on which deep drawing or wire drawing, in particular, can be carried out with vibrations of this sort.

W

Wear

The processing of work materials leads to continual tool wear. Research regarding it is concerned with modeling, measuring, assessing and explaining such wear, as a step in efforts to bring about improvements in the tools involved and in their use. Studies of different types of tool wear that have been carried out at the Department include studies of cutting processes, plastic forming, shearing and granulation machining.

Welding

Earlier, this was one of the major areas of research within the Department. A part of this research concerned the weldability of particularly strong types of steel. The Department has also had considerable experience in regard to the welding of grey cast iron. The welding research conducted has followed to a considerable extent developments that have occurred within the Swedish wharf industry. Matters of automation in connection with welding have been taken up in recent years in particular. The Department also has research experience concerning metallographic aspects of welding. A total of 5 doctoral dissertations pertaining to welding have been presented.