The name »Advancer« conveys a sense of foresight, progress and benefit. Ceramics manufacturers and users find in it their »Advanced Ceramics« - materials holding great promise for the future. Advancer presents innovative applications for high-performance ceramics: systems solutions with »Ceramics inside« for today and tomorrow.

»Advancer«

The demonstration center has taken shape at all locations of the seven participating Institutes. At the Dresden location, »Advancer« joint developments are already on display.

News from IZD: On June 3, 2004 a ceremony was held to celebrate completion of expansion work at FEP, IFAM-IPW, IWS and IKTS. Visit Dresden and visit »Advancer«!

Fraunhofer meets NASA: As a contribution to the nationwide "Technology Day" in the "Year of Technology," Fraunhofer IKTS held a seminar on June 18, 2004 on adaptive structures. The 60 guests were introduced to one of the Fraunhofer-Gesellschaft's 12 leading-edge innovations.

W. K. Wilkie and R. G. Bryant, leading developers at NASA Langley Research Center (R.G. Bryant, middle, with Dr. Schönecker from IKTS), reported on the origins and developmental results of "Macro Fiber Technology," which arose to provide a solution for active control of lightweight structures using piezocomposites.

Dresden is worth visiting anytime. Now that the renovation of the Frauenkirche church has been completed, another highlight has been added to the skyline of the old city centre.
Featured overview:
Fine finishing of high-performance ceramics (Part 1)

Components made of high-performance ceramics have been increasingly used in engine manufacturing, mechanical and plant engineering and medical engineering over the last few years. The specific advantages of these materials are their outstanding strength and wear behavior, high-temperature and structural stability and chemical inertness. High-performance ceramic materials are already being mass-produced for rolling and sliding bearings, brake disks in vehicles and medical implants. The high cost of ceramic components can be traced back to complex and time-consuming post-machining, which is currently done by using fine machining processes such as grinding, honing, polishing and lapping. Current efforts of the AdvanCer team in the area of fine machining are aimed at developing or optimizing machining technologies to expand the application field for high-performance ceramics.

Making life easier: Alumina washers for single-handle faucets – mass-produced with high-tech finishing.

Fine machining
Grinding, honing and lapping are the processes used for fine machining of high-performance ceramics. Because of their high hardness and wear resistance, these materials can only be machined using tools with diamond or boron carbide grains. For generation or finishing of functional surfaces on components, a variety of technologies are employed. Besides surface, cylindrical and profile grinding of ceramic materials, surface grinding with planetary heads, double-disk lapping, ultrasonically assisted grinding, abrasive-flow machining and honing are subjects of R&D projects currently underway at AdvanCer.

Surface grinding with planetary heads and double-disk lapping
Surface grinding using planetary heads and double-disk lapping result in highly accurate coplanar functional surfaces. These processes possess the same kinematics but differ in the type of tool they use. For surface grinding with planetary heads, diamond grains are fixed on the grinding wheel; for lapping, loose grains are used. Boron carbide grains are used for lapping to make the process more economical. In these processes, ceramic workpieces are placed in toothed wheels and simultaneously passed between the faces of an upper and a lower grinding or lapping wheel. The resultant functional surfaces are characterized by an extremely high surface quality. Whereas lapped surfaces exhibit the crater structures typical for this process, surfaces ground using planetary motion have randomly oriented scratches forming crisscross patterns. Both processes are used in the industrial production of a variety of sealing disks and regulating wheels, rolling bearings and tools. Double-disk lapping of silicon nitride produced $R_a$ roughness values on the scale of 0.05 µm. Similar levels were achieved with surface grinding using planetary heads and bound abrasive grains.

Ultrasonically assisted grinding
In ultrasonically assisted grinding, a longitudinal oscillating motion is superimposed on the conventional grinding motion. The frequency of alternation is ca. 22 kHz; usually it is the tool that executes the motions. This superimposition of ultrasonic oscillations on conventional grinding motions significantly reduces the grinding forces, which are quasi-stationary over the duration of the machining process and enable high machining volumes to be achieved. For ceramics, the advantages of this process can be exploited in the production of complex contours such as those of drill holes, grooves, spherical surfaces and freeform surfaces. This process has already found its way into such industrial applications as the production of medical implants made of high-performance ceramics.

Abrasive-flow machining
Abrasive-flow machining is used on components made of high-strength materials with inaccessible, complicated geometries to replace productivity-hindering manual deburring and polishing operations. The machining effect is achieved by a polymer fluid in which abrasive particles are bound. Boron carbide or diamond is used as the grinding medium. The fluid is made to move in alternating cycles over the contour of the workpiece. This motion, in combination with the abrasion caused by the grinding media, leads to material detachment. Results depend on grain size, viscosity and composition of the grinding medium as well as operating pressure and the number of cycles. With abrasive-flow grinding, the surfaces of ceramic components can be reproducibly and accurately formed. Internal geometries benefit especially from the advantages of this process, which is currently being used for finishing nozzles with complex geometries and thread guides made of high-performance ceramics. Abrasive-flow grinding of silicon nitride produced $R_a$ roughness values of less than 0.01 µm.

Honing
Long-stroke internal cylindrical honing can be used for machining of internal ceramic components subjected to extreme tribological conditions. Surfaces with high degrees of contacting profiles can be produced using this process. Honed surfaces exhibit crisscross scratch patterns, which facilitate lubricant absorption and thereby result in surfaces with outstanding tribological properties in sliding conditions. Long-stroke internal cylindrical honing can be used to achieve high machining volumes and is thus more economical than internal cylindrical grinding is. Thus far its potential for producing internal contours has been utilized industrially in machining of ceramic cylinder barrels for high-performance engines and in production of ceramic sliding bearing races.
To experience the flexibility and performance capabilities of the CT-Mini firsthand, visit AdvanCer at Materialica on September 28-30, 2004 in Munich. You will find us at Stand 109 in Hall C1 (joint stand with TASK). We will also present at Euromold on December 1-4, 2004 at the Fraunhofer Alliance for Rapid Prototyping joint stand (Stands N112 to L115 in Hall 8).

Using results of investigations performed on the tribological system consisting of a ceramic, a lubricant and a sheet material, suitable drawing die and sheet materials were selected for deep-drawing. Friction and wear in this system depend not only on the material pairs used but also on the surface structures and internal stress states of the active surfaces created by machining.

The service lifetime of ceramic drawing dies used in three stages was 100% greater than that of coated hardmetal drawing dies in application conditions during ironing of sleeves made of CrNi steel sheet. Results of fractography indicate potential for further improvements in tool quality.

Optimized tools guarantee:
- higher service capacities
- lower forming forces
- better product quality

In shearing tests with a closed cutting curve (hole diameter: 8 mm), ceramic cutting punches produced a 10-20% improvement in amount of smooth cut and an improvement in surface quality over HSS and hardmetal cutting punches during punching of steel and nonferrous sheet metal. Hardmetal tools are required for shearing high-strength sheet steel (TRIP, dual-phase or complex-phase steel). Here, research is aimed at optimizing hardness, strength and cutting geometry, as well as at developing suitable lubricants and determining conditions in which a film of lubricant exists continuously in the gap between the punch and the die.

Visit AdvanCer at Euroblech on October 26-30, 2004 in Hannover. At the joint Fraunhofer stand (Stand G14 in Hall 11), you can meet representatives from IKTS, IPT, IWM and IZFP as well as from the ZEUS demonstration centre.

Thread guides for the textile industry possess complex functional surfaces that need to meet demanding requirements.

2004 trade show highlights:
CT-Mini at Materialica and Euromold

For industrial applications, 3D X-ray computer tomography has an advantage over other testing methods in that it delivers information about spatial relationships between internal structures of an object without damaging the specimen or being geometry-dependant. Despite its unique features and undisputed advantages for detecting internal defects and checking assembly of complexly constructed parts, the 3D CT system is not yet being widely used as an on-site analysis system in industrial environments, since many potential users are deterred by the high price of a large stationary universal CT system.

The CT-Mini, developed jointly by Fraunhofer scientists and the company Procon, fulfills all requirements of an industrial 3D X-ray computer tomography system.

The CT-Mini is delivered as a complete, ready-to-use compact system. After being connected to a power supply and to a local computer network, the CT-Mini must be adjusted once - then it is ready for use. Hardware and software were coordinated to enable many important parameters to be optimized automatically, making the system extremely user-friendly.

Ceramic forming tools at Euroblech

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Success stories: High-performance ceramics in forming technology

Whether in your car, PC or household appliances, components made using ceramic tools from BeaTec are probably part of your daily life. BeaTec GmbH, established in 1999, has had great success in producing ceramic forming tools, thanks in part to experiences gained via the Fraunhofer-Gesellschaft. BeaTec tools are now being used successfully in countless forming operations for sheet, pipe and bulk materials. Continuous development, including cooperative efforts with various Fraunhofer institutes, has pushed BeaTec into a leading market position.

Ceramic forming tools have the fundamental advantage of possessing excellent tribological properties. They offer lower frictional forces and better wear resistance than conventional tool materials such as steel or hardmetals do. These advantages are particularly useful for the increasingly common application of shaping parts made of hard-to-form multiphase and stainless steels. For instance, deep-drawing of austenitic sheet materials using a ceramic tool resulted in a significantly lower tendency for welding, and thereby a better product surface. In some cases, ceramic tools eliminated the need for chlorine-containing oils or reduced the need for lubricants – important results in the light of ever-stricter environmental regulations.

Application-based knowledge was used to develop appropriate tool designs to address the problem of high mechanical loads generated in the forming process. Using this know-how, BeaTec produces customized ready-to-install ceramic tools: These tools can usually just be installed in place of the old tools, with no changes to the process or the machine being necessary.

With respect to the cost-benefit ratio, previous experience has shown that for ceramic tools in comparison with hardmetal tools, slightly higher procurement costs are more than compensated for by a longer service lifetime and higher product quality. This especially applies to tools for mass production, in which a long service lifetime and the ability to make use of new technological possibilities play major roles in ensuring competitiveness.

Production of ceramic rolling tools

When it comes to making ceramics, manufacturers are no longer thinking small. Advances in shaping technologies and material quality have increasingly made production of large parts possible. Hard machining of these parts now poses new problems: Not only must the respective machines be optimized but also the machining processes themselves must sometimes be optimized. In grinding of ceramic rolling tools, for example, despite the fact that parts have relatively large dimensions, they still must meet close shape tolerances and high standards for surface quality.

Recently hard machining of rollers was accomplished for the manufacture of highly alloyed high-grade steel wire. Grinding must produce high-quality rollers without compromising surface quality. At TE-KO-WE, a new grinding process called “stepwise grinding” has been developed to accomplish this.

Profiling is no longer done using a profiled tool in which the entire profile of the grinding wheel is used at once; now sideways motions are made along the part by a smaller tool to produce the desired profile. This results in significantly less damage in near-surface regions of the workpiece and thereby allows the part’s original material strength to be retained. An important side effect of the use of this grinding process is a considerable increase in service lifetime and process reliability, which also results from the fact that cooling is facilitated on account of a smaller contact zone. Rollers manufactured using this process are currently being used by Böhler Edelstahl.

The successful example of ceramic rollers shows that continuous user-oriented development of individual processes creates great potential for optimization of ceramic manufacturing processes - and ultimately for application of ceramics.