Efficient and Durable in Harsh Environments

Tools in metalworking must meet a variety of requirements. They must be particularly robust and wear-resistant even under the harshest conditions in order to be used in machining processes. Advanced ceramics from CeramTec not only meet the required standards, they are also economical thanks to their long service life.

Fig. 1
Tool holder and cutting inserts for turning, made from different ceramic grades

Their properties make it possible to use advanced ceramics from CeramTec in a wide variety of metalworking processes. The advantages of the materials are used for example in the forming, welding or machining of metal, in working with molten metals, in electroplating and even in the sintering process of metal injection molding components. Technical ceramics play an important role in each of these areas to make manufacturing processes efficient or to machine metals even under the most extreme conditions. Even piezo-ceramic actuators are used in metalworking.

Keywords
cutting tools, ceramics tools for forming and drawing, welding tools, piezoceramic actuators, salt-based cores, porous galvanic diaphragm cells, setter plates

Cutting tools made of technical ceramics

More product variants, shorter product cycles and increasing productivity as well as cost pressure: The technological and economic demands in metal machining are constantly growing.

In response to these requirements, CeramTec offers a variety of high-performance cutting materials made from ceramic, PCBN and cermet, matching tooling systems for machining applications and a wide range of engineering services to cover the entire spectrum of machining. This portfolio ensures efficient machining processes with high productivity, quality and maximum reliability. The result is a significant reduction in machining costs per part while at the same time ensuring that the component meets the customer's quality standards. Cutting materials and tool systems are used in a number of industries in different machining processes for turning, hard turning, grooving, milling and boring components made of cast iron, hardened steel and steel components and materials used in aviation engine manufacturing.

Inserts from the SiAlON cutting ceramics family are designed specifically for high-performance machining of cast iron materials and Ni-based alloys. These cutting ceramics give the insert an exceptionally hard and extremely wear-resistant surface with a very tough core to achieve the highest cutting data and long tool life. Coated or uncoated inserts made of SiAlON ceramics are adapted to various cast iron materials.

Inserts made of silicon nitride ceramics represent a performance standard for efficient machining. Uncoated, they are ideally suited for machining of gray cast iron parts with high cutting data.

Mixed ceramics are used for fine and hard machining. In this case, as a composite

CeramTec GmbH
CeramTec-Platz 1-9
73207 Plochingen
Germany

www.ceramtec.com

made of alumina (Al_2O_3) and titanium materials (TiCN). They have exceptional edge stability and wear resistance. Their excellent hot hardness makes them ideal for hard precision turning of hardened steels, hard machining of rolls and precision finishing of gray cast iron workpieces.

Oxide ceramics from CeramTec are suitable as inserts to machine not interrupted cuts in grooving, roughing and finishing of workpieces made from gray cast iron and alloyed cast iron. Oxide ceramics enable dry cutting machining of cast iron materials. Also applied are indexable inserts made of polycrystalline cubic boron nitride (PcBN), which is said to be the second hardest material in the world next to diamond. They are predestined for efficient machining of cast iron materials and sintered metals when turning, milling, boring and grooving. Due to their excellent wear characteristics they set new standards in continuous and intermittent cutting operations. Additionally, they offer unparalleled performance in terms of hot hardness, toughness and chemical stability.

Cermets are cutting materials made of ceramic materials in a metal matrix that are characterized by their very high hardness and wear resistance. They are used in all kinds of applications that require finishing or semi-finishing machining in continuous cutting or slightly interrupted cutting. Grooving and turning of steel parts are additional areas of application.

Cutting materials, inserts and tooling systems for high-performance hard turning applications complete the portfolio. The cutting materials for hard turning feature superior edge stability, the highest level of crater and flank wear resistance to ensure high process stability and to achieve excellent surface qualities and dimensional accurancies of the workpiece (Fig. 1–3).

Fig. 2 Range of cutting tools for turning and milling

Wear-optimized solutions for forming and wire drawing

When forming metals – in either casting, rolling, drawing, bending or widening – the tools that are used are subject to extreme stress and high wear. The robust and wear-resistant ceramic tools from CeramTec deliver enhanced performance and increased economy in every step of the metal forming process.

Machines and wires are subject to extremely powerful forces whenever copper and aluminum wire is drawn. The surfaces of the tools used, e.g. forming rolls and drawing cones, must be perfectly adapted to the wire's requirements in order to ensure that the surface of the wire does not suffer any permanent damage. Over the years CeramTec has continued to develop

Fig. 3
Cutting inserts made from SiAlON

Fig. 4
Tools for wire drawing

Fig. 5
Forming tools for bending, widening, drawing and rolling

Fig. 6
Components for welding process, e.g. welding pins, welding rollers and gas nozzels

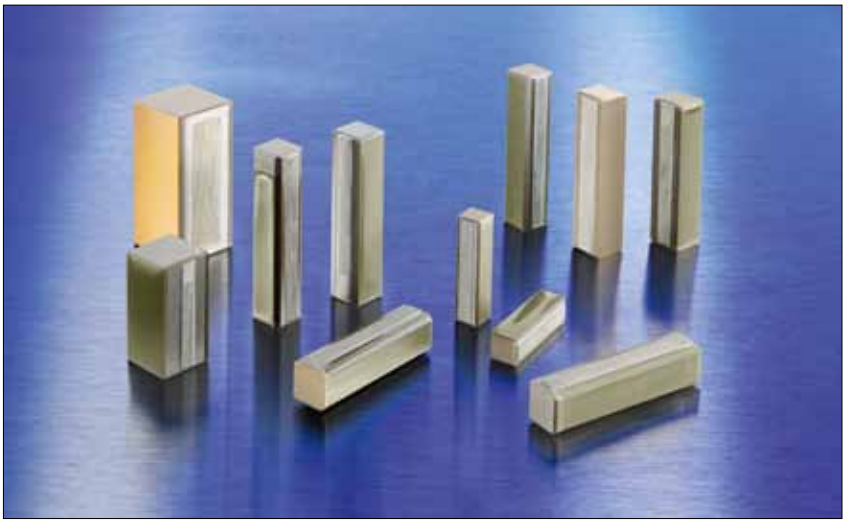

Fig. 7
Plezoceramic actuators actively influence the deep-drawing process

and optimize the ceramic surfaces of the drawing tools it manufactures. This has enabled CeramTec to precisely define the particle size of the zirconia and alumina materials used, because this is a decisive factor in the surface quality and roughness that can be achieved in the drawing tools.
Using ceramic tools in wire drawing noticeably improves the surface of the wire, because it prevents possible corrosion damage to coated wires and ensures consistent wire thickness.
This results in fewer wire breaks and associated maintenance costs. In turn, the increased machine running times lead to a reduction in the total setup times, resulting in maximum process reliability and increased product quality.
The thermal and mechanical forces exerted when forming, bending and widening tubes push forming tools to their performance limits. Tube forming tools made of zirconia and silicon nitride are extremely resistant to these mechanical and thermal stresses. Their strengths lie in the uniform grain-size distribution, optimum surface roughness, superior fracture toughness and low tendancy to buildup welding. Their performance and dimensional accuracy sets standards. Service life is also vastly extended compared to conventional tools. The low diffusion and adhesion of the materials prevent cold welds, and the hot hardness and temperature strength reduce the likelihood of plastic deformation. The chemical and thermal resistance of the forming tools also makes them suitable for use in aggressive environments, like molten metals, acids and lyes. Additional fields of applications for silicon nitride ceramics include joining and welding of pipes and tubes (Fig. 4–5).

Ceramic tools for the welding process
Silicon nitride ceramics from CeramTec create added value in welding processes: The advanced ceramics minimize wear, which has a positive effect on machine running times. This increases tool life while significantly reducing total setup times, thus making the welding process more economical. The quality of the final product also increases.
Compared to other ceramic materials, silicon nitride is clearly the better choice overall for the extreme demands in the welding process. CeramTec develops silicon nitride welding tools such as welding rollers for the production of longitudinally welded pipes and tubes.
Silicon nitride ceramics are also used to make welding pins, which ensure a perfect fit for sheet metal and nuts in projection welding, or gas nozzles for MIG/MAG welding. This material is characterized by its extreme hardness, flexural strength and wear resistance, thermal shock resistance and chemical resistance. The ceramic material is electrically insulating and features superior toughness and compressive strength (Fig. 6).

Actuators in the forming process
Integrated process monitoring sensors and actuators based on piezoceramic technology are used to improve component manufacturing in the production of car body parts. They open up entirely new possibilities for quality assurance. Intelligent deep-drawing tools include process monitoring sensors in conjunction with piezoelectric actuators to control the deep-drawing process. Piezoceramic actuators are piezoceramic components that can generate very high forces (in the kN range).
Movement is in the 1 – 100 µm range and can be controlled with micrometer accuracy. Using piezoelectric actuators makes it possible to actively influence the forming process (Fig. 7).

High performance for foundry and temperature measurement technology

Aluminum titanate (ALUTIT) from CeramTec effortlessly masters challenging conditions in the non-ferrous molten metals industry. This advanced ceramic material can be used even in aggressive melting processes, at maximum temperatures of 1000 °C and with temperature differences of several hundred degrees.

ALUTIT cannot be wetted by liquid aluminum and is especially known for its excellent resistance to thermal shock. This makes the material suitable for use in aluminum foundries for components subject to high thermal stress levels such as risers for low-pressure die casting and tubes for dosing furnaces. Intake pipes, fill tubes, break rings, nozzles, stoppers and closing plates are also made of this material and used in industrial applications. Its low thermal conductivity saves energy and its outstanding chemical and abrasive resistance ensures high melt purity (Fig. 8).

Technical ceramics are also the first choice for devices used to measure and control temperatures. Protection tubes, thermocouple tubes designed for use with thermocouple wires, and RTD elements (resistance temperature detector) made of alumina can safely and stably withstand aggressive atmospheres and conditions with temperatures up to 1700 °C. They are characterized by excellent electrical insulation and high mechanical strength.

Cores made of water-soluble materials

Manufacturers across the globe also use advanced materials from CeramTec for the manufacturing of media channels and cavities in the casting process. Water-soluble, salt-based cores are used to produce complex casting components in foundry technology, e.g. for piston casting. Applications range from gravity and low-pressure die casting to high-pressure die casting. The cores are used as placeholders for the cavities in the casting and offer numerous advantages compared to conventional sand cores. They are very resistant and dimensionally stable, create very smooth casting surfaces and, thanks to their water solubility, can be completely washed out from the mold without leaving any residue. This helps prevent casting failures due to core gases. The core application properties make it possible to increase part quality through an optimized casting process. There are no harmful emissions during casting and core removal. In addition to classic pressing processes to produce water-soluble, salt-based cores in the shape of a ring, core shooting is applied to realize complex geometries and sophisticated designs. CeramTec also offers a large number of different ceramic materials for cores used in fine casting to produce complex components made of various metal alloys (Fig. 9).

Fig. 8
Aluminium titanate components for aluminium casting

Ceramic components for use in galvanic applications

Porous advanced ceramics are also suitable for use in galvanic applications. CeramTec offers porous galvanic diaphragm cells and plates for the diaphragm process in galvanic baths – in chrome plating for instance. This is a process chiefly used in electrolysis and redox reactions (in galvanic elements) and is based on the

Fig. 9
Cores for manufacturing complex media channels in foundry technology

Fig. 10
Porous ceramic components for galvanics

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Fig. 11
Energy-efficient setter plates for MIM, CIM and LTTC production

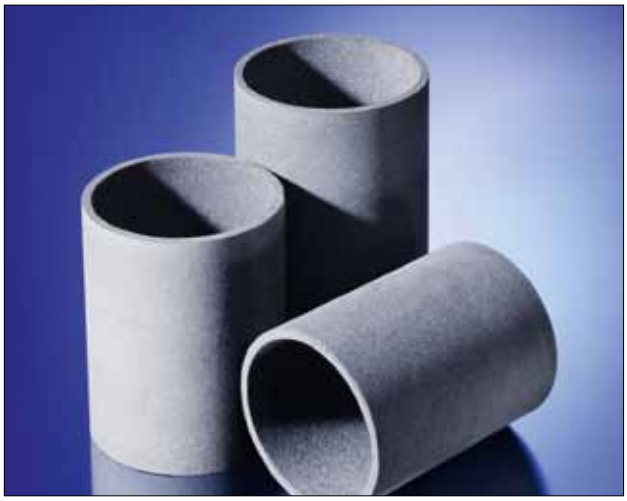

Fig. 12
Metal matrix composites for weight reduction and material reinforcement

separation of both electrodes and their ion solutions by a porous wall, the diaphragm. Thanks to its excellent chemical resistance, the 80% alumina is able to stand up to even aggressive chromic-sulfuric acid in chrome plating. Sulfuric acid is used in electroplating, so plant operators need a resistant ceramic that must also be able to allow chromium ions to pass. Metallic impurities can be prevented with the aid of a permeable medium such as this (Fig. 10).

Setter plates for ceramic injection molding (CIM), metal injection molding (MIM) and low temperature co-fired ceramics (LTCC)

Alumina and aluminum nitride ceramics from CeramTec make it possible to create setter plates in customer-specific designs and qualities. They ensure energy-efficient and precise process control in the sintering process. In addition, the material properties of the advanced ceramics guarantee shape accuracy when debindering and sintering the products while also ensuring energy-efficient firing processes.

Releasing agents or protective layers such as coatings are no longer needed since there are no contact reactions with metals due to the inertness of the ceramic surfaces. This gives the setter plates a very long service life without the need for reconditioning. They can be used in ceramic injection molding (CIM), metal injection molding (MIM) and the production of low temperature co-fired ceramics (LTCCs).

Weight reduction and material reinforcement thanks to composites

CeramTec delivers key benefits for lightweight construction thanks to Metal Matrix Composites (MMCs). Ceramic preforms are infiltrated with aluminum to not only reduce weight but also increase component strength.

This is conceivable for various components such as bearing blocks or similar applications. MMCs are also used locally to reinforce aluminum casting. The ceramic substrate consisting of hardening particles seamlessly combines the light weight of the metal with the stability of ceramics. This combination is used, for example, to reinforce cylinder walls in different Porsche models.

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