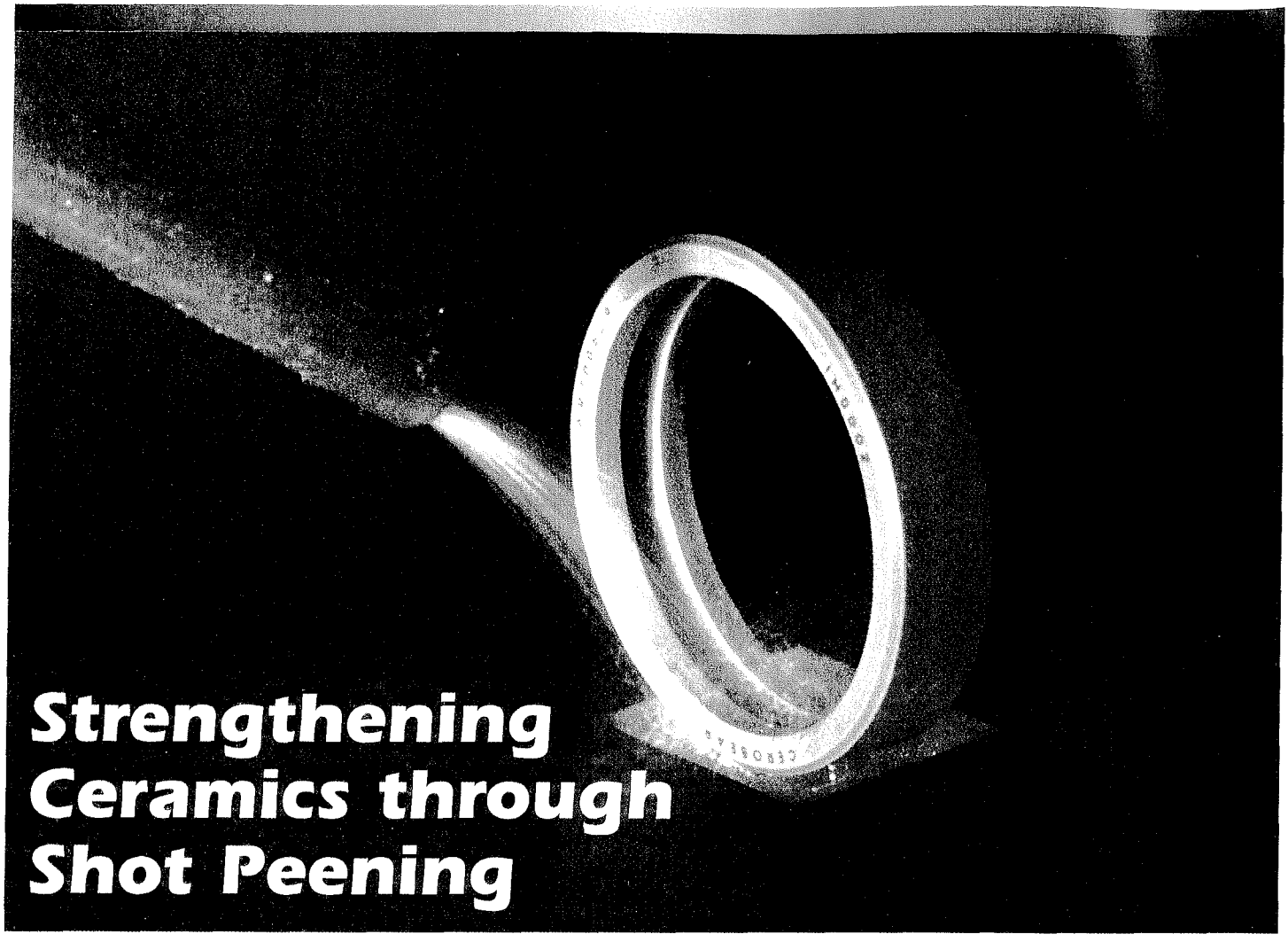

Strengthening Ceramics through Shot Peening

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Lift off! When a space shuttle takes off, high-pressure turbo-pumps funnel over seventy kilograms of liquid hydrogen and almost half a ton of liquid oxygen per second into each of the three main engines. At a temperature of -250 °C, the metallic parts in contact with the hydrogen fuel are subjected to extremely stressful conditions. Until now, it was necessary to dismantle and service the pump bearings after every single flight. But this is changing – the new parts are expected to survive at least twelve launches before they need servicing. Why? Because components consist of a hard ceramic material, silicon nitride.

As researchers at the Fraunhofer Institute for Mechanics of Materials (IWM) in Freiburg, Germany have discovered, it is now possible to improve the strength properties of ceramic materials through "shot peening", a traditional metalworking technique. Similar to sandblasting, bombarding a metal surface with tiny metal balls causes it to become more dense and resistant – whereas ceramics subjected to the same treatment crack or fracture. For this reason, neither shot peening nor rolling are normally used on materials in this category.

The researchers made systematic investigations of how the surface of ceramics changes during shot peening. Numerous variable factors had to be considered, from the size and the material of the balls to their velocity and the duration of treatment. Dr. Wulf Pfeiffer, one of the researchers on the project, explains the advantages of the technique: "When ceramics have been treated under optimal conditions, their surface is capable of withstanding stresses up to fifty percent greater than before, without fracturing. Not even the tiniest crack appears. A bearing that has undergone surface hardening in this way lasts up to two-and-a-half times longer."

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>
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The process is now being refined in collaboration with the industrial manufacturer CEROBEAR with the aim to integrate the hardening of high-performance silicon-nitride bearings in a production line.

Ceramic bearings have no need of lubrication in many applications. They run completely "dry" in compressors, for example, to keep the gases free of oil. In the food and beverage industry, the fluid being pumped acts as its own lubricant. In the space shuttle, it's the liquid hydrogen that performs the same function.

Photo: Increasing the load capacity of full ceramic roller bearings by shot peening. Photo source: Fraunhofer IWM.

More on the shot peening of ceramics on page 6