Peen Forming of Ceramics—A New Chipless Shaping Technique

DR. WULF PFEIFFER, the head of the business unit and a researcher with Fraunhofer IWM, presented his latest research on the shot peening of ceramics at the 38th International Conference and Exposition on Advanced Ceramics and Composites in Daytona Beach, Florida in January.

The mission statement of Fraunhofer IWM states that the research company characterizes, simulates and evaluates the behavior of materials, components and systems under the influence of external forces in different environments. They work with companies and public agencies to develop solutions that improve the safety, reliability, durability and functionality of technical components and systems, thus making them more cost-effective, energy-efficient, and economical with natural resources. Given these goals, we asked Dr. Pfeiffer about his work.

The Shot Peener: First of all, congratulations on the opportunity to present your research at the conference. We know this research is a continuation of your work on ceramics. Why are you studying this material?

Dr. Wulf Pfeiffer: High-strength ceramics provide benefits metals cannot provide. Unfortunately, ceramic components often cannot compete with metal components due to their brittleness and costly manufacturing procedures. Our research focuses on manufacturing processes which reduce the cost of hard machining and simultaneously overcome the limitations of brittleness. Shot peening may be such a fabrication procedure and it is fascinating to apply it to materials which have been thought to be unsuitable.

The Shot Peener: We reviewed the conference program and didn't see research other than yours on the shot peening of ceramics. Why do you think that is?

Dr. Wulf Pfeiffer: Shot peening is still thought to not work on ceramics although we have been continuously reporting about successful applications for more than 15 years. People from the ceramics industry are just not used to thinking like people from the metal world. Nevertheless, ceramics are non-forgiving materials when it comes to the effects of single cracks and local stress peaks. Thus, the selection and control of peening parameters are more demanding for ceramics.

The Shot Peener: How was your paper received at the conference?

Dr. Wulf Pfeiffer: After the technical session, we had a workshop on root technologies for ceramics. Within that workshop it was stated that unconventional thinking is needed to reduce manufacturing costs and establish new products made of ceramics. Shot peening and peen forming may be the offbeat technologies needed to extend the market for ceramic components.

The Shot Peener: Can you tell us about your upcoming research?

Dr. Wulf Pfeiffer: The next step will be to establish projects with industry to explore how the results of our research may be transferred into production processes. To promote the use of shot peening in industry we peen formed a leaf spring and a concave mirror made of silicon nitride. These demonstrators should illustrate the possibilities of chipless forming of ceramics by shot peening.

The Shot Peener: Thank you for your time, Dr. Pfeiffer. We look forward to reading about your continued work on ceramics and shot peening.

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ABSTRACT*
Thin ceramic components are often distorted during production due to anisotropic shrinkage and/or residual stresses due to machining. If unwanted distortion is detected in a component in its final shape, the distortion cannot be eliminated by additional material removal. Such ceramic components are usually discarded since their brittleness does not permit further flattening. Ceramic parts with complex shapes must be fabricated by, for example, sintering close to the desired shape followed by a costly 3D machining process.

This paper describes the first successful experiments aimed at shaping ceramic specimens using shot peening. Strips of different thicknesses made of silicon nitride ceramic were shot-peened using different shot peening parameters. The residual stress-depth distributions were determined using X-ray diffraction. Based on the experimentally determined stress states, the curvatures of the strips were determined analytically and using Finite Element (FE) calculations. Silicon nitride flat springs and a concave mirror could be peenformed without the need of additional hard machining. FE calculations demonstrated the capability of designing peen forming processes on basis of experimentally determined peening stresses.