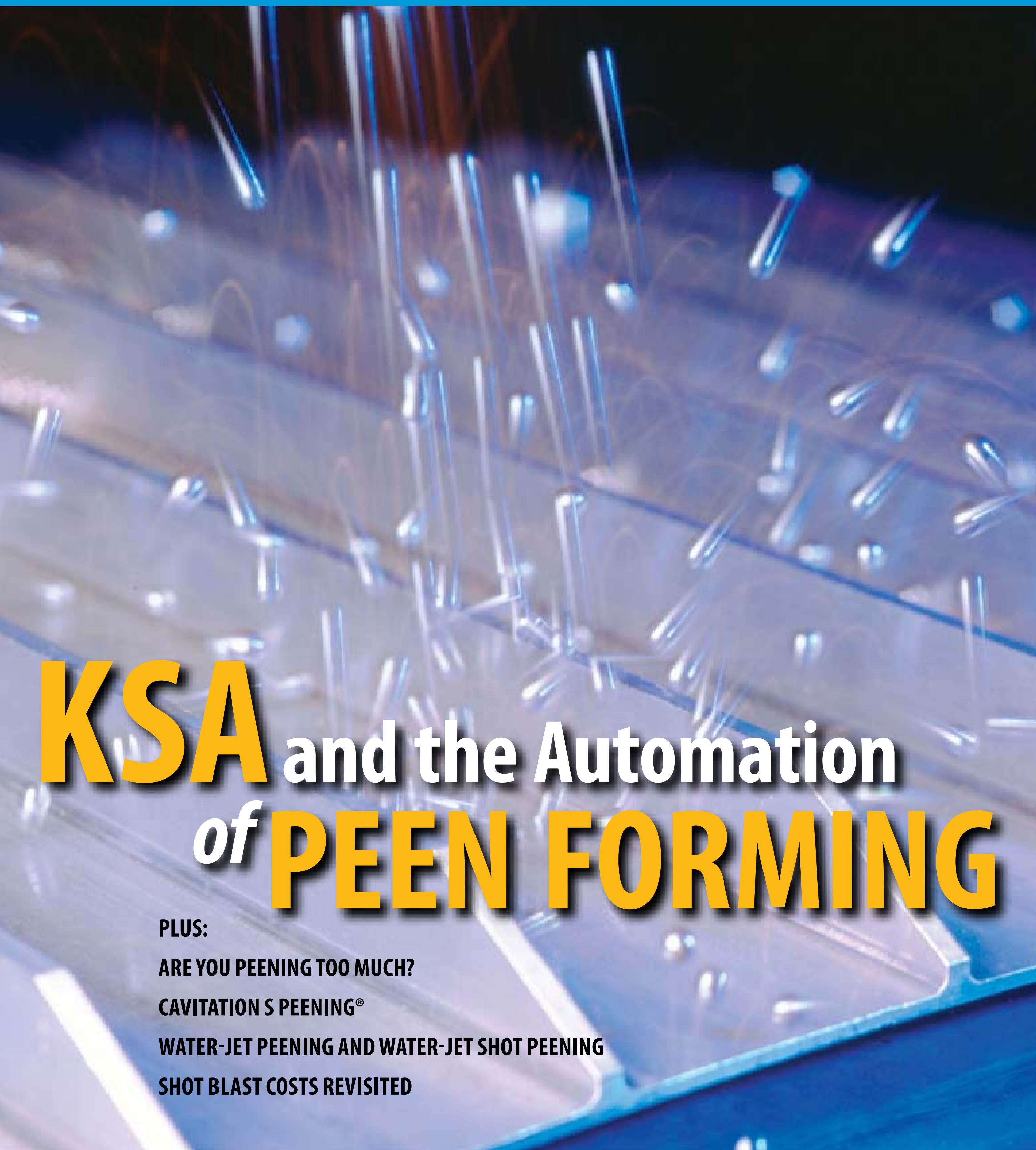
Summer 2014
Volume 28, Issue 3 | ISSN 1069-2010

The Shot Peener

Sharing Information and Expanding Global Markets for Shot Peening and Blast Cleaning Industries



KSA and the Automation of PEEN FORMING

PLUS:

ARE YOU PEENING TOO MUCH?

CAVITATION S PEENING®

WATER-JET PEENING AND WATER-JET SHOT PEENING

SHOT BLAST COSTS REVISITED

Dr. Carolyn Kenny | Executive Assistant | KSA Kugelstrahlzentrum Aachen GmbH

Shaping Parts with Shot Peen Forming

AS IS WELL KNOWN to *The Shot Peener* readers, shot peening is widely used in the aerospace and automotive industries as a process for improving fatigue resistance. The compressive residual stresses induced in the cross-section of the component and the hardening of the surface layer of the material strengthens its resistance to cracks or corrosion.

Shot peen forming can be regarded as a specialized application of shot peening. Rather than focusing on increased fatigue strength, shot peen forming makes use of the fact that the transfer of kinetic energy from the shot media to the component generates material flow in all directions. From a certain peening intensity onwards, this material flow and the residual stresses induced by peen forming result in a permanent curvature of the component due to the balance of forces and movements induced in the part. The objective of shot peen forming is to control this change and to form the component into a previously defined curvature.

If only a small percentage of the component's cross-section is "plastified" by the shot media, the material flow and residual stresses result in a convex curvature. If the cross-section is plastified as far as the centre, the result is merely a stretching of the part. The part then "grows" without any curvature. If the kinetic energy of the shot is increased to such an extent that the part is plastified throughout its cross-section, the result is a concave curvature.

Intensity, peening time and pre-stressing are the three most significant control values of peen forming. Further important peening parameters include shot type, size and velocity and, of course, shot coverage. The properties of the component to be peened obviously also play a significant role. These include factors such as material hardness and thickness, thickened edges with transitions, the presence or absence of integral stringers and residual stresses induced in the part by machining.

Successful peen forming requires extensive knowledge of the interaction of all these variables as well as expertise on material flow and behaviour. Too great a shot velocity, for example, can result in irreparable damage to the piece. Peening which does not take sufficient account of the variations in the growth and stretching of the metal due to various thicknesses can induce non-correctable waves or bulges in the component. Because principles of both plasticity and elasticity play a role in determining how the part will change shape, shot peen forming is particularly difficult to predict and control.

Generally, peen forming is carried out on a manual or semi-automated basis by skilled technicians whose experience and know-how enables them to predict the growth factor of the component in question. In the case of new parts, a small number of attempts at achieving the required result may be

Peen forming of a tank bulkhead segment for Ariane 5.

KSA's peen forming processes are fully automated.

necessary before an accurate prediction of the component's behaviour can be made and the peen forming process can be "frozen."

Peen forming is frequently used in the aerospace industry to form large panels such as wing skins and fuselage shells. While the complexity of the process means that it is extremely difficult to automate, this is not impossible. In fact, KSA Kugelstrahlzentrum Aachen GmbH of Germany succeeded in introducing Automated Peen Forming (APF) for parts for the Ariane 5 space launcher more than two decades ago, including spherical tank bulkhead segments as well as cylindrical and conical panels. More recently, KSA successfully used APF to peen form elliptical panels and even orthogrid structures. (In an orthogrid panel, the stringers run at right angles to each other, making these panels a huge challenge to peen form as the stiffeners resist the material flow in both directions.)

Thousands of parts have been produced for Ariane to date using this fully automated, "frozen" closed-loop process and KSA expects to continue to implement this successful peen forming technology in ambitious launcher programmes in the future.

Shot Peen Re-Shaping

The correction of distortions which have occurred due to residual stresses induced in the material during an earlier process such as milling or welding is a further application of peen forming. This corrective process is often described as shot peen straightening or rectification. A combination of relaxation peening and high-precision peen forming is required to "re-shape" the distorted part and to bring it to within its defined tolerance range. With increasingly strict specifications in aircraft manufacturing and the introduction of new, more complex designs and materials, this process has become more relevant than ever.

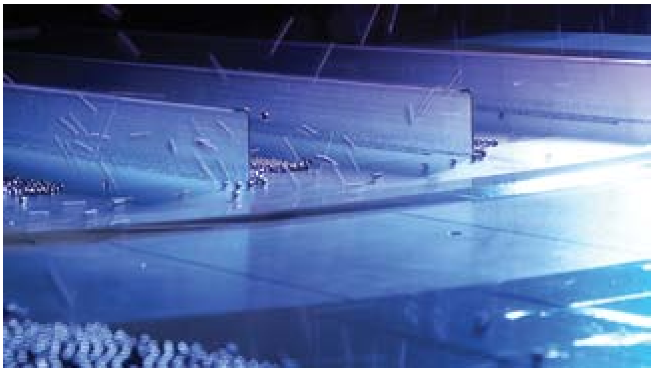
As in all peen forming, the process involves the application of both plasticity and elasticity principles and is therefore particularly challenging. KSA first automated its re-shaping process successfully at Airbus in 2003 with the introduction of an integrated on-site machine for re-shaping laser-beam-welded fuselage shells for a wide range of aircraft. A key customer requirement was to eliminate all manual intervention from peen forming and to implement it as a state-of-the-art process. As the focus was on achieving a previously defined final curvature in a fully automated controlled process, the term "re-shaping" rather than straightening or rectification was used.

More recently, KSA has applied its Automated Peen Re-shaping (APR) to a wide range of complex structural components for a leading European manufacturer of aircraft parts. These include ribs, spars, beams and frames. In each case, an individual peening "recipe" has been developed for the part in question and the corresponding software written. The initial investment in process development has had a disproportionately high pay-off in terms of reduced throughput times, excellent results and process reliability. A further advantage is that the APR software generates the required compliance documentation for the components automatically. Thousands of components have now been re-shaped automatically by KSA in accordance with the quality standard QSF-A. This is proof that APR is an excellent alternative to manual rectification.

Future Potential

Process automation is especially valuable where large numbers of components of the same geometry need to be formed. Repeatability, reliability and consistently high quality then become absolutely essential. While fully automated peen forming is not widely used in the aerospace industry today, there is obviously huge potential here; for example, in the peen forming of wing panels. Considering the constant drive to reduce costs and to use resources as efficiently as possible in today's competitive manufacturing environment, more widespread application of this fully automated industrialized process would surely be a useful development.

Automated peen re-shaping of a fueslage shell.



KSA creates individual peen forming "recipes." The recipes and software can be developed off-line if required and subsequently transferred to the customer's site for series production.