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Current Applications of Advanced Peen Forming Implementation

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1 Introduction

Shot peen forming is above all carried out in the aeronautic and aerospace industry for the production of complex integral structures in fuselage and wing components (= *Partial Forging Process / Shot as a Tool*).

Particularly in the aeronautics industry, development engineers and designers intensively work on complex, single-axis or multiple-axis curved geometries, varying panel thicknesses and/or stringer stiffenings. The aim here is to optimize weight and hence to save on aircraft operating costs, as well as to optimize production processes (= *Design for Manufacturing Feasibility*).

A further important customer requirement comes from production managers: completely controlled, documented and reproducible processes with practical flexibility in design are a prerequisite for the industrial series production of carrier rocket structures or airplane components such as fuselage and wing panels (= *State-of-the-art Industrial Processes*).

Appropriate documentation for today's market should include the component data and the influences of forming on the material as well as all process data relevant to the customer (= *Complete Transparency and Constant Quality Control*).

The *KSA – Kugelstrahlzentrum Aachen GmbH* (Aachen Shot Peening Centre) uses modern modelling and facility technologies which facilitate controlled shot peening with complete process control and automation (= *KSA – Controlled Shot Peening*).

The following describes the procedure for implementing controlled shot peening. We will use examples from our current work to show that this highly-automated process can be employed both for producing components on a contract basis as well as for series production at the customer's own plant.

2 Project Planning and Implementation

Clear project structuring is necessary before peening applications can be controlled and automated. This is the only way in which complex matters can be described, simplified and automated.

The *KSA – Kugelstrahlzentrum Aachen* has an open policy in this respect, because we believe that the customer has the right to receive documentation covering all the information relevant to the component and process (= *Maximum Transparency*).

First the project and customer needs are analyzed and studied with regard to their practicability. To do this we feed in CAD data, analyze the specifications of the process and the project conditions and discuss the necessary production and measuring toolings with the customer.

We proceed as follows for new projects (Fig. 1):

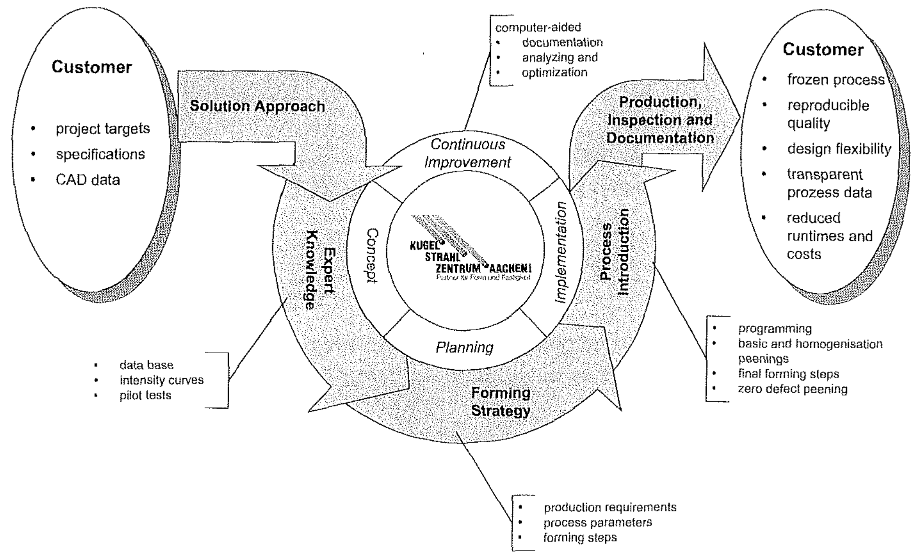

Figure 1: Shot peening process automation by KSA

After adopting joint project planning (= *Milestone Planning*), we work out a possible solution, define a forming strategy and produce a first qualification specimen. For this we use our know-how regarding the process, our existing data sheets on peening process parameters and on projects (= *Expertise / Data Library*) and/or our evaluation of smaller previously-defined samples which have been subjected to shot peening treatment (Fig.2).

The latter, which are often described as intensity curve samples having the same material and thickness, enable us to determine how to approach the project without processing or losing an original component.

Programming of the peen forming strategy takes place off-line. We log, control and finally regulate production of our first specimen with our models for on-line acquisition, control and documentation of the peening process parameters.

In addition to conventional machine information such as the current axis position, peening pressure, shot dosing or nozzle velocity over the component, essential process information is logged and presented in visual form on-line.

This includes the *number of registered particles* per second and their *normal distribution* (= *Mass per Surface*) as well as *shot velocity* and *shot coverage* on the component surface itself as a function of the time and place of peening [1].

This means an end to the trial and error approach to shot peening for the first time and facilitates clear description of the influences of forming on the material.

Our integrated 3D contour measuring with on-line evaluation and representation of contour lines enables our facilities to actually program themselves to attain the target contour. Our CNC-/robot-aided nozzle movements and positioning provide an additional guarantee of high precision, process reliability and control (= *State-of-the-Art Shot Peening Facilities*). This procedure means that regularly our qualification components can be used later as series parts (Fig. 3).

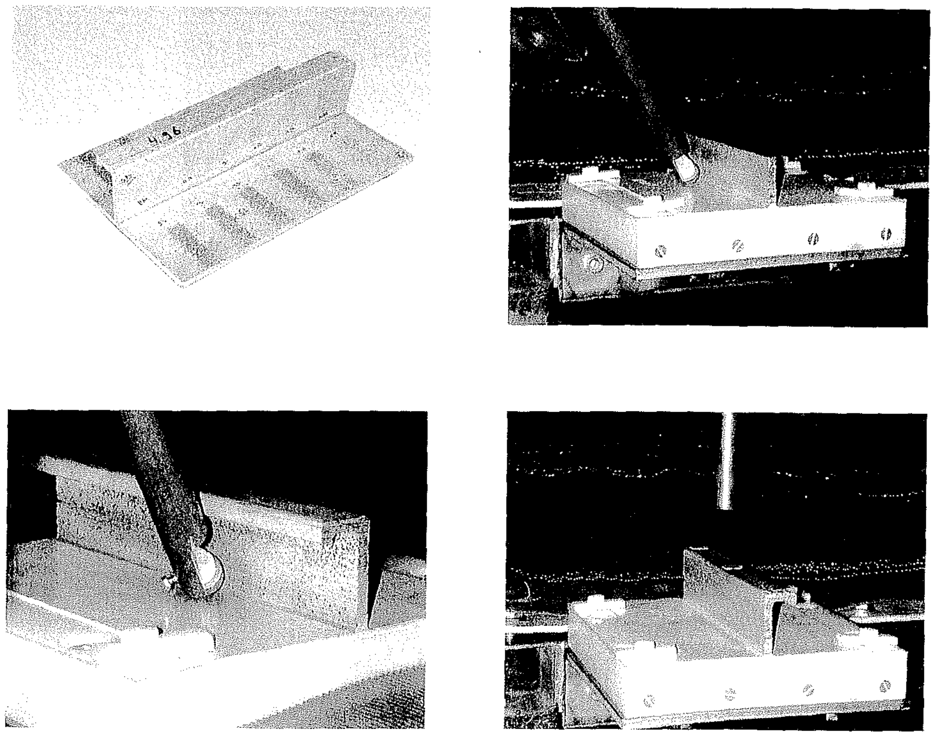

Figure 2: Determination of intensity curves and forming parameters

Our model and facility technology and its facilitation of the exact depiction and documentation of the process allow us to further optimize and automate the forming process (= *Reduction of Sequence Steps and Run Times*). Hence, after treating the fourth component we have as a rule already reached a point at which series production is stable, so that we can achieve the same peening result as with the first specimen, but with the additional advantage of optimized run times and sequence steps (= *Learning Curve*).

Finally, the peening process runs on a controlled and automated basis and can be reproduced exactly with a high level of process reliability and precision (= *Frozen Process*). Manual intervention in the peening sequence is neither possible nor necessary.

Despite the large number of applications, there has not been one case in our company's history where a component from series production has been rejected because of imperfect shot peening treatment (= *High Process Reliability*).

We would like to illustrate the procedure and quality of our controlled shot peening with various examples from our current production.

Our reference [2] already describes the automated production of ? dome bulkheads for Ariane 5 with shot peening.

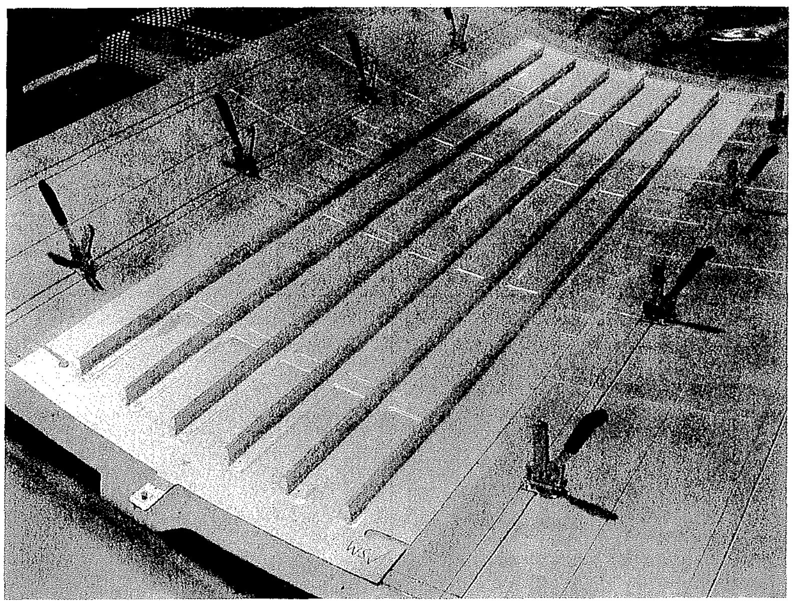

Figure 3: Forming example Airbus A380: qualification panel with precise contours

3 Re-shaping of Laser-welded Fuselage Skin Panels for Airbus A380

Our latest project deals with the re-shaping laser-welded fuselage panels for Airbus A380 [3,4] (Fig 4).

The components are between 2,700 and 10,500 mm long and have varying sheet thicknesses, the stringers and skin panels also having varying geometric profiles. The thickness of the material ranges from 1.6 mm to 5.8 mm, the material used being various, aluminium alloys for panels and stringers (= *High Design Flexibility*).

As a result of the heat applied during the previous laser welding process, the components are warped along both their length and breadth.

Therefore, the components have to be re-shaped in a controlled and automated way. To achieve this, defined shot peening treatment is applied to the area of the fuselage skin panels on the inside of the component which was initially influenced by the heat.

The qualification work which is necessary for the later re-shaping shot peening process is currently carried out successfully in Aachen on our two 7-axis CNC-/robot-controlled shot peening facilities for *Airbus Deutschland GmbH* [4].

It is intended that the re-shaping of the skin panels will finally take place at the Airbus plant itself with a new, corresponding facility for maximum dimensions of 11,600 × 3,000 × 750 mm (L × B × H), featuring high process reliability.

Being the systems supplier, this will be our responsibility (= *Open Policy, Shot Peening Systems Integration*).

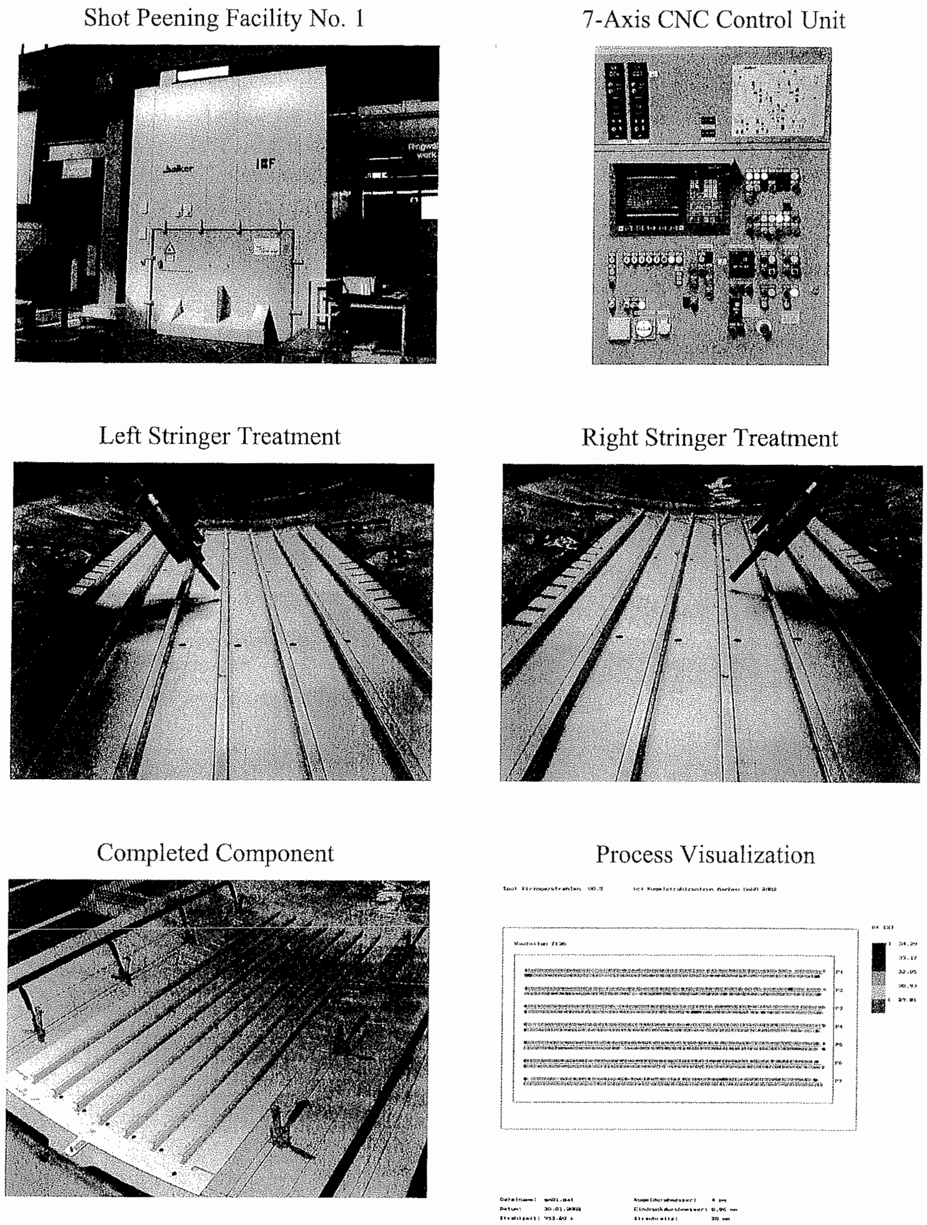

Figure 4: Controlled re-shaping of laser-welded skin panels for Airbus A380

4 Production of Conical Segments of Power Module Frame for Ariane 5 using Shot Peening

We use controlled shot peening to make various extremely complex panels for the frame of the Ariane 5 power module (Fig. 5).

The components consist of large flat segments measuring approximately 1 m^2 (Box Cone Panel) to 2,5 m^2 (Cone Panel) with varying sheet thicknesses, stringer stiffening and cut-outs. They have to be converted into a conical contour with radii of about 900 to 2,700 mm by means of controlled and automated shot peening.

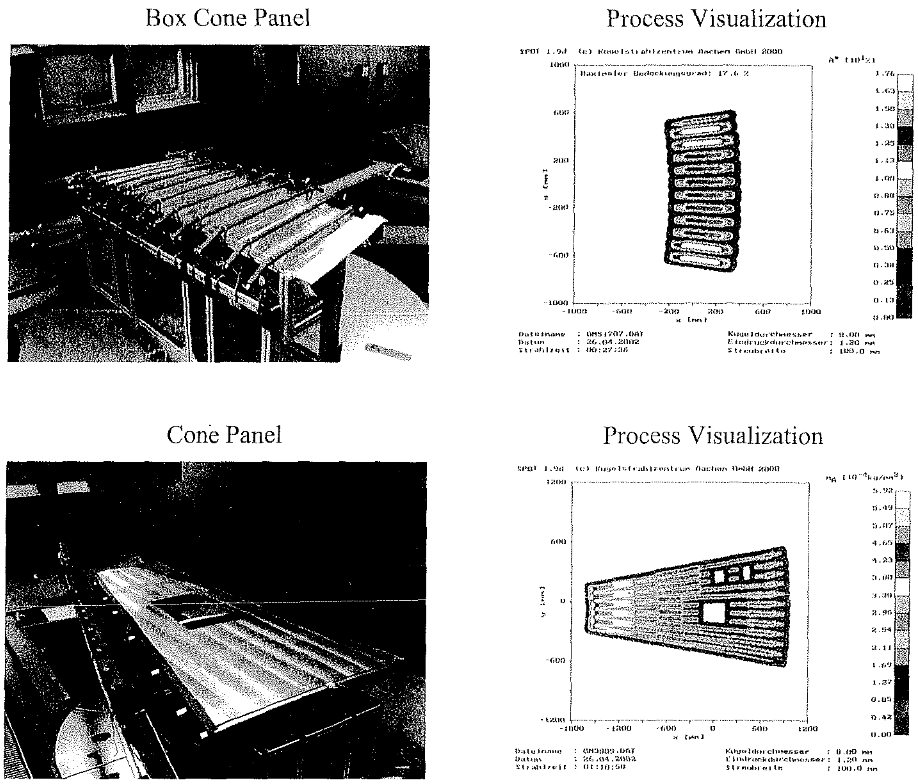

Figure 5: Segments of power module frame of the european rocket Ariane 5

There is a total of 12 different geometric profiles within the required 24 panels per carrier rocket. The components are made of reinforced aluminium alloys for panels and stringers, the thickness of the material ranging from about 2.3 mm to 8 mm (= *Design Flexibility*).

The panels are formed by shot peening both sides simultaneously with shot of a diameter of 8 mm. The production process can be reproduced exactly with high reliability (= *KSA -Controlled Shot Peening*).

Compared to conventional hand peening work, we carry out the forming process in a fraction of the time which would otherwise be required (= *Process Automation / Reduction of Sequence Steps and Run Times*).

Furthermore, possible changes in design can be incorporated into our modelling and NC peening programs quickly and flexibly.

A significant innovation is that our customer, *Dutch Space B.V.*, receives complete documentation of what happened on the surface of the component (= *Open Policy*).

5 Production of Spherically Curved ¼ Dome Bulkheads for Ariane 5 using Shot Peen Forming

A further very recent project is the production of ¼ dome tank bulkheads for European space launcher Ariane 5 (Fig. 6).

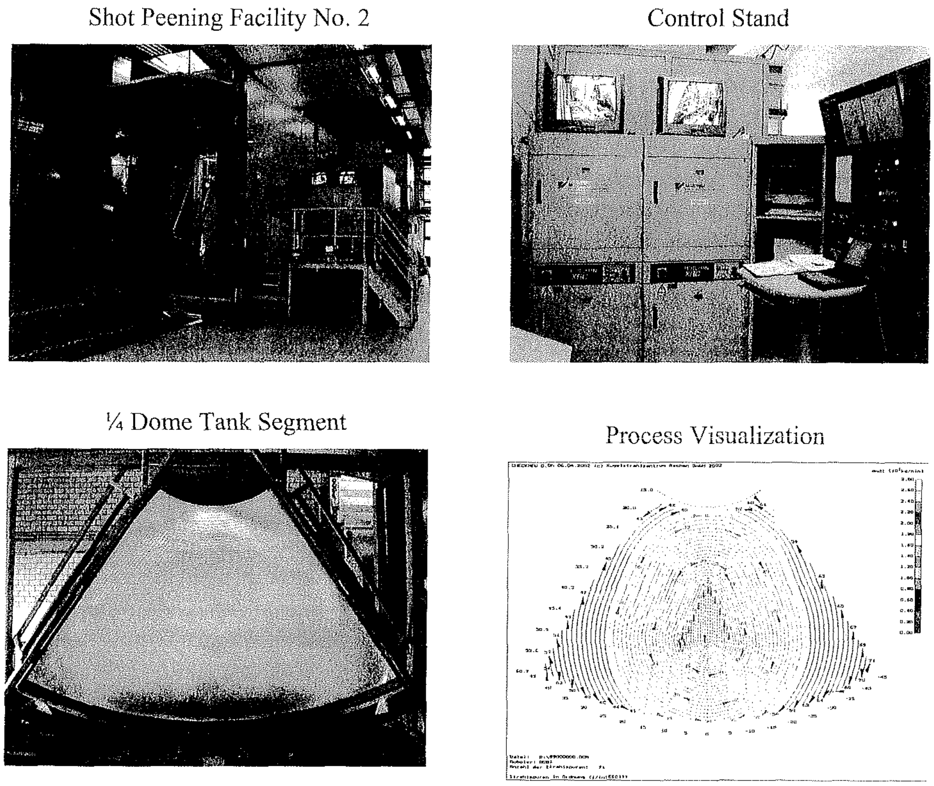

Figure 6: ¼ dome tank bulkheads for the european space launcher Ariane 5

These components consist of segments of approximately 8 m^2 which have to be converted by shot peening into a spherical contour with a constant radius of approximately 3,000 mm.

There are five tank floors for each Ariane 5 carrier rocket with four different geometric profiles and varying sheet thicknesses of 1.6 mm to 3.5 mm in the panel.

The panel thickness widens in stages up to a maximum of 6.4 mm at the edge of the component (= *Integral Structure / High Design Flexibility*).

The segments are peened simultaneously on both sides on our new 7-axis robot-aided shot peening facility using two articulated industrial robots. In comparison to our usual ? dome segment production [5,6], this results in a considerable reduction in run times and costs for our customer *MAN Technologie AG* (= *Customer's Competitive Advantages*).

The only sequence steps now required in the process are the basic peening and the final forming steps. The contour which was achieved is electronically logged using integrated 3D laser measurement, any deviations being represented in the form of contour lines with the same deviation from the target contour. Finally, our control software programs the remaining necessary forming steps fully automatically. Manual intervention in the production sequence of peening technology is neither possible nor necessary.

6 Customer Benefits

KSA – Controlled Shot Peening fulfils the customer requirements of design flexibility combined with the highest level of process control and automation as well as complete documentation and transparency (= *State-of-the-art Industrial Processes / Open Policy*).

Proven process and model technologies provide the customer with shorter development times and facilitate changes in design during production (= *Simultaneous Engineering, 'Time to Market'*) without losing an original component (= *Reduced Pre-run and Adjustment Costs*).

All data on the component and the process parameters are recorded in the data library and can be accessed by the customer at any time (= *Development and Production Partnership*).

Our modern, new-generation peening facilities feature central control units which facilitate off-line programming as well as on-line logging, evaluation and documentation of the essential peening process parameters (= *High Process Reliability*).

The production process is fully computer-controlled, which eliminates any errors in processing the component (= *Process Automation*).

In order to give all our customers this advantage, whether they prefer peening on a contract basis or in-house production, KSA devises a customized package for each case (= *Customized Automation Solutions*).

Our support service for the customer during the implementation of highly-automated shot peening processes can include engineering work for the development and qualification phase, contract peening and the supply of control systems and complete facilities with process introduction at the customer's plant (= *Systems Integration*).

Peening work on a contract basis is carried out on our highly-automated facilities (= *High Productivity / Short Run Times*), providing the highest quality and reliability regarding delivery.

Our high-end shot peening capacity can also be used to cover customers' peak demand (= *Back-up Production*).

7 Summary

Controlled and automated peening processes have brought about an end to the trial and error approach to the shot peening process and facilitate clear description of the influences of forming on the material.

We view ourselves as a partner for implementing actually entitled KSA – Controlled Shot Peening with the aim of supporting the customer to develop the potential for increased quality and economic efficiency.

All our processes, facilities and models completely fulfil the requirements of DIN ISO 9001 - 2000.

KSA's shot peening automation technology can, in principle, be applied to all peening processes on the market and can be transferred to surface hardening peening and other applications.

8 References

[1] F. Wüstefeld, Metal Finishing News 2000, December Issue, page 9–10, Shot Peening: Process Automation for the Aircraft Industry

[2] F. Wüstefeld, ICSP 8 2002, Towards Peen Forming Process Automation

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[4] F. Wüstefeld, Metal Finishing News 2001, August Issue, page 12, Successful Shot Peening Tests for Airbus A380 Fuselage Shells

[5] F. Wüstefeld, Metal Finishing News 2001, November Issue, page 18–19, Shot Peening Forming of new ¼ - Dome Tank Segments for Ariane 5

[6] R. Kopp, J. Schulz, ICSP 8 2002, Optimising the Double-sided Simultaneous Shot Peen Forming