IMPLEMENTING ON-LINE PROCESS CONTROL FOR SHOT PEENING

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ABSTRACT

Rolls-Royce Deutschland (RRD) is germans aeroengine manufacturer with the complete responsibility for design, manufacturing, validation and in-service support for engines. Within component manufacturing beside complex machining operations a series of special processes such as controlled shot peening are applied. Benefit of improved process control will be improved quality (less process failures) and reduced time and cost for process control. Standard control method for shot peening based actually on Almenstrip peening and measure the bending of the strip as measure of the "Almen-Intensity" prior to the peen the part. Here a reduction of almenstrip peening will deliver benefits in terms of lead time for components and will reduce the resource (e.g. machine capacity, operators) needed for process control work.

An optical measurement system has been modified for shot peening application delivering the distribution of the velocity for typically used peen media and manufacturing equipment. It has been demonstrated that the system is feasible to determine peen intensities at least comparable to Almen tests.

SUBJECT INDEX

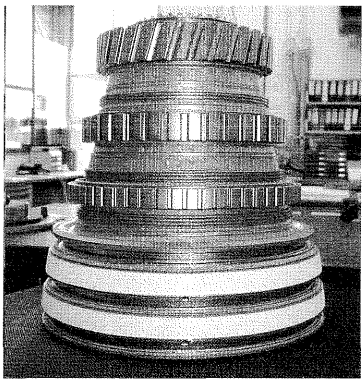
Process Control, On-Line Diagnostic, Aeroengines, Cost Reduction

INTRODUCTION

Rolls-Royce Deutschland (RRD) is germans aeroengine manufacturer with the complete responsibility for design, manufacturing, validation and in-service support for engines. Within the Rolls-Royce group RRD is the center of competence for 2 shaft engines, BR710 series engine has been selected to equip the corporate jets Gulfstream V and Bombardier Global Express, BR715 engines exclusively equip the Boing 717-200. In the aeronautical industry competition is driven by cost, lead time and quality. Cost reduction demands or other improvements concern the complete supply chain from airlines to aircraft manufacturer to aeroengine manufacturer to suppliers. Additionally flexibility and short development cycles for new products are required.

At the manufacturing site in Oberursel components such as compressor disks and drums, casings, turbine disks, rings and seals are manufactured for BR700, V2500, CFM-56 and other projects. Repair and overhaul is performed for BR700 components, small engines and helicopter engines for civil and military applications. Within component manufacturing beside complex machining operations a series of special processes are applied ranging from electron beam welding, NDT techniques, thermal spraying to controlled shot peening. Special processes typically require time-consuming process control methods because the quality of the processes often can't be measured on the component directly. E.g. the residual stresses introduced by means of shot peening are typically validated by correlating Almen intensities to residual stresses, but not measured continuously for each component in serial production. In serial production process control based on Almen tests and detailed visual inspection of the peened surface.

Controlled shot peening is applied mainly at critical rotating parts (see fig 1) to introduce compressive residual stresses at the surface to obtain increased life of the component (König, 2002). Basic process parameters that determine the residual stresses achieved are the shot mass, velocity and the coverage. Standard process control today is to peen a test piece (Almenstrip) and measure the bending of the strip as measure of the Almen-intensity.
Objective of the work described here is to improve and implement an on-line process control tool able to measure the shot velocity distribution and correlate measurements to Almen-intensities. Development of the system is described in Wüstefeld 2005 (this proceedings). Using an on-line control system the use of Almenstrips can be reduced generating cost and lead time improvements.



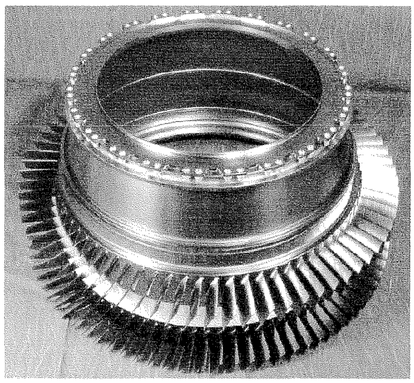


Fig 1: a) BR710 HPC front drum **b) BR715 LPC blisk**

METHODS

Controlled shot peening is applied mainly at critical parts (see fig 1) for life improvement of the component. Drawing requirements are detailed as Almen intensities (eg. A 0,15 – 0,25mm or N 0,1 – 0,35mm), areas to be peened and coverage to be achieved. The Almen intensities need to be controlled with an accuracy of e.g. 0,02 mmA. Basic process parameters that determine the residual stresses achieved are the shot mass, velocity and the coverage. Standard process control today comprise peening a test piece (Almenstrip) and measure the bending of the strip as measure of the "Almen-Intensity" prior to peen the part. The Almenstrip is used to control the stability and reproducibility of the equipment in serial production or after changing peening medium and set ups. Process time for peening the Almenstrips is often comparable to the time to peen the component. As batch sizes are small in aeroengine manufacturing the peening of almenstrips covers a significant amount of machine capacitiy.

Implementation of an on-line process control tool that delivers comparable information as Almen strips will have – depending on the control tool costs - a potential for cost saving. RRD chose to start collaboration with KSA Aachen using the velocity measurement system developed there (Wüstefeld 2002). This system has been set up for peen forming applications. Here a modification for the use for controlled shot peening is presented. Modification has been necessary to enable the detection of the peen medium (typically steel, S70 – S170) with different size and amount compared to peen forming. Details of the measurement system are described elsewhere in this proceeding (Wüstefeld, 2005).

To implement the new process control method a step-to-step approach has been chosen. In a first step the measurement system has been modified for shot peening application at RRD. In a second step the stability of the measurement system need to be demonstrated in manufacturing environment. Third step is to demonstrate the comparability of the measured values to Almen intensities and to prove that specification limits can be detected and discerned. Final step is to generate a database of measurements and Almen intensities to statistically prove the comparability of results leading to a reduction of almen strip peening and measuring for serial production. This paper gives a status of work performed yet.

RESULTS

In a first step the measurement system has been modified for shot peening application at RRD. Fig 2 exhibits a velocity distribution measured for S170H at a RRD production equipment. The experiment demonstrated that the modified system is able to determine mean velocities and velocity distributions with peen medium used at RRD.

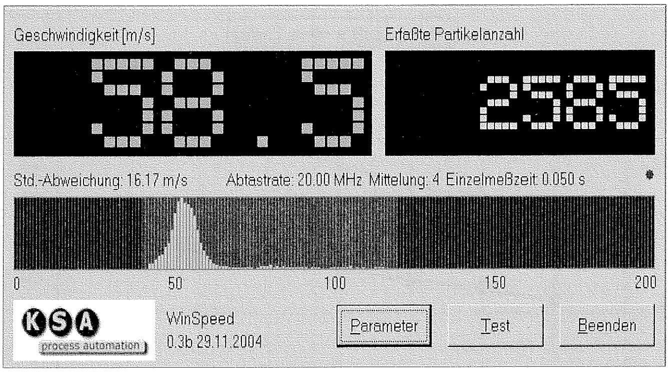


Fig 2 : screenshot of a velocity distribution measurement for S170H

The second test for feasibility of the measurement system was performed wi variation of peen medium mass flow and pressure. Results indicates as shown in f that the velocity measurement is able to distinct peening parameters.

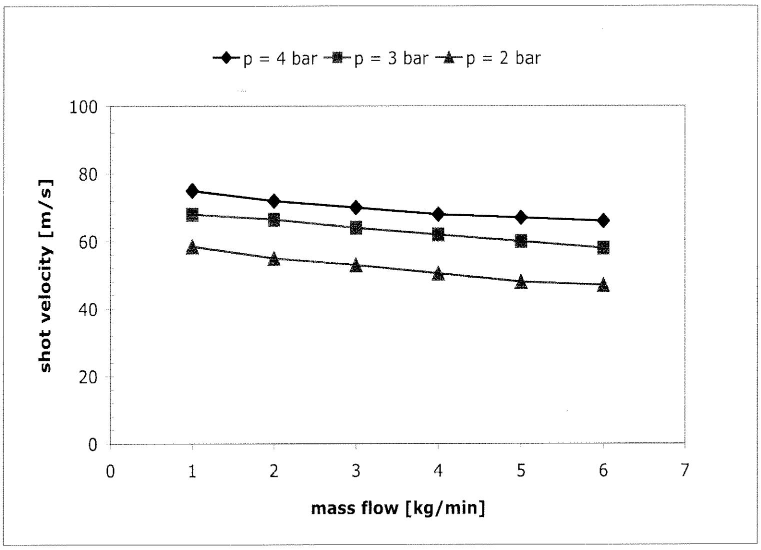


Fig 3 : shot velocity as function of mass flow and pressure

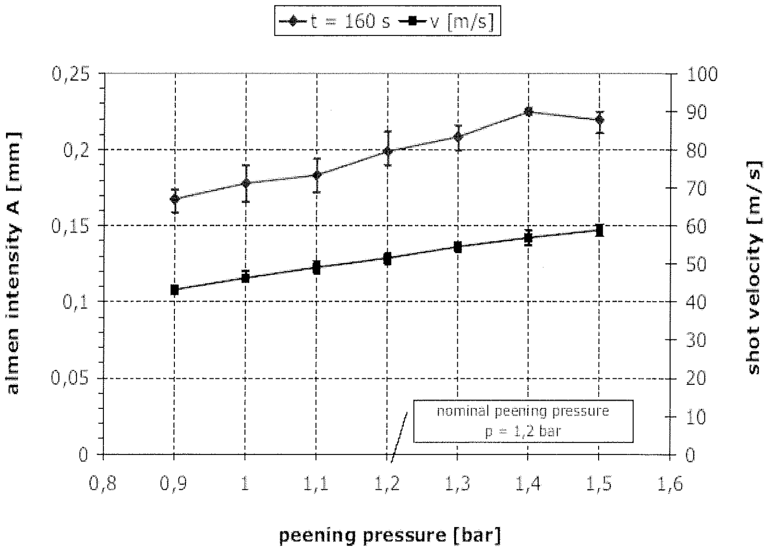


Fig 4 : velocity and almen intensity as function of pressure

Further experiments have shown that the accuracy of velocity measurements is at least comparable to almen tests, the required 0,02 mmA difference in Almen intensity could be detected (see fig 4).

Additionally the position of the sensor to the nozzle has been investigated to determine the sensitivity of the results to positioning in the peen flow. It could be shown that the velocity of the peen medium is relatively insensitive to the position in the beam. All measurements has been performed on production equipment indicating that the sensor system is able to work in manufacturing environment. Long time experience is not yet available.

Next step planned is demonstrate the comparability of the measured values to Almen intenstities under serial production conditions to prove that specification limits can be detected and discerned reproducable. If this correlation is achieved a reduction of almen strip peening and measuring will be possible.

DISCUSSION

The measurement system has been modified for shot peening application at RRD. The experiments demonstrated that the modified system is able to determine mean velocities and velocity distributions with peen media used at RRD. Accuracy of the measurements has been acceptable for discerning Almen intensities as typically required for aeroengine components.

All measurements has been performed on production equipment indicating that the sensor system is able to work in manufacturing environment. Long time experience is not yet available. To validate the on-line diagnostic system a statistical prove of repeatabilty and reproducability of the correlation between measurement and Almen intenstites need to be shown.

CONCLUSION AND IMPLICATIONS

It has been shown that the use of on-line diagnostic tools can significantly improve the matter of manufacturing process control. Effort that is put on process control has very often a significant impact on costs and lead-time in manufacturing. Benefit of advanced process control can be improved quality (less process failures) and reduced time and cost for process control. Here a reduction of almenstrip peening will deliver benefits in terms of lead time for components and will reduce the resource (e.g. machine capacity, operators) needed for process control.

REFERENCES

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