Application of Shot Peening and Blasting Methods in the Aircraft Industry

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ABSTRACTS

In the aircraft industry exist a lot of applications for shot peening and blasting. Forming of aircraft wing sections is a well known procedure. Shot peening of forgings manufactured from Al and Ti is necessary before the parts will be installed into the airframe. During overhaul a great number of high heat treated steel parts will shot peened for bettering the fatigue life and for corrosion prevention.

Nearly all parts of the undercarriages of the aircrafts are chrome-plated in areas of high stresses. Before crome-plating the parts must be shot peened to compensate the tensile stress of the chrome deposits by producing compressive stresses. Turbine blades and vanes will be peened by glass-beads to get better fatigue life. Many aircraft parts from the airframe from undercarriages and from the engines will be overhauled by application of plating deposits. To get a good adhesion between base material and the layer, the parts will be blasted for activation by Al-Oxid. All peening and blasting procedures must be carried out accurately with reliable and repeatable processes.

INTRODUCTION

In the aircraft exists a great concentration of different parts and different materials. These parts and materials must be constructed and chosen in such a way that an optimum for aircraft reliability and safety is present. All peening and blasting procedures are in connection with the surface conditions of these parts and the materials of the parts. As the good surface conditions guarantee a reliable aircraft operation it is consequent that peening and blasting procedure give their part for good shape of the aircraft operation.

From outside looking, everybody is convinced that an aircraft exists mainly from Al- and Mg-alloys and in near future from GFK and CFK. The stress enforced areas of the **airframe** are constructed from high heat treated steel parts with tensile strength up to 2000 Megapascal. The parts are normally forgings.

All parts of the **undercarriages** are also from HHT-steel, beginning from the simple bolts up to drop forging trucks.

A lot of different parts with different materials are positioned in the **engines** of the aircraft. There are existing simple carbon steels, high alloy steels and nickel- and cobalt-base alloys for protection against high temperatures.

These examples give an impression of a great number of various parts and materials in the structure of the aircraft in the components and in the engines.

A great percentage of all these parts must be peened and blasted during the manufacturing process and during overhaul of the aircraft. In the next chapters the special application of peening and blasting processes will be shown.

PEEN-FORMING ON AIRFRAME PARTS DURING MANUFACTURING

This process is well known from the early fifties in combination with the manufacturing of the wings of the Lockheed Super Constellation. At Lufthansa, we had great experience in servicing this plane. After introduction of jets like Boeing 707, we used this plane as short range service, that means routes from Hamburg to Frankfurt, Düsseldorf and Munich. Due to the great number of landings, the wings were affected by a higher interaction between tensile and compressive stresses so that cracks occured also in the peened areas and the whole fleet had to be taken out of service after the short range shuttle operation.

Later on, Vickers Armstrong applied these processes for peen-forming also for the wings of Vanguard and VC10. In a Chicago-Meeting in 1984 was reported about details of the process and especially about the peen-forming of an Airbus A310 side panel was given a slide.

All these parts must be peen-formed with high accuracy, reliability and repeatability. Today, these qualities can be ensured by application of computerized numerical control machines. Human errors should be eliminated by using these machines and carrying out periodical test inspections.

After these parts, such as wings or side panels are installed into the frame structure, it is impossible to make stress corrections. These parts and their stress configuration are installed for the whole aircraft life as these construction elements are not or very seldom removable.

Everybody of the manufacturing people has to take this in account.

In contradiction to the above mentioned facts, parts which will be overhauled can be treated during every overhaul process.

SHOT PEENING OF STRUCTURE PARTS DURING AIRFRAME OVERHAUL

The modern methods of investigations of crack-detection, of process-development and the application of modern procedures should bring the aircraft manufacturer in the position to sell an aircraft which should fly for more than 20 years without any rejection. The detailed knowledge of stress contribution in the aircraft parts allow the aircraft manufacturers to strengthen the areas were stress risers will occur.

After delivering of the aircraft to the airlines, all problems of the aircraft must be handled by the airlines. But there exists a very good information system so that every fault or construction error will be reported from the airlines to the manufacturers.

So it happened from time to time that during a routine overhaul a beam, a stringer or a spant must be removed or cold worked for prevention of crack propagation.

During overhaul of a Boeing 727 aircraft it happened that during crack detection by ultrasonic- and eddy-current inspection a stress corrosion crack was identified. It was impossible to remove or to reinstall the part due to the very complex construction. The crack was removed by milling. Now it was necessary to carry out peen-forming on the installed part.

There is another example for peen-forming during overhaul: on the head of the cylinder of the A300 main landing gear, there exist a spheric bearing. In the bearing area a corrosion attack took place and were identified during overhaul of the complete landing gear. The corroded material was removed by grinding. The material was high heat treated steel with tensile strength up to 300.000 psi. The specification of the steel is SAE 4340 modified. After grinding the part must be shot peened for getting better life time conditions. The peening procedure was carried out by using special shots fixed in a plastic sheet which was rotating round an axle.

The reason for using such a complicated peening procedure were the geometrical conditions of the spheric bearing. No blasting or wheel-equipment could be used. However, the peening process was satisfied regarding the surface-stresses, which were brought into the material.

SHOT PEENING BEFORE CHROME PLATING

As mentioned before, nearly all parts of the undercarriages of jet airplanes are high heat treated steel parts. Special areas of these parts are very hard effected by wear. The surfaces of these areas will be chrome-plated. For example: the brake collar area of the main landing gear axles of the jet aircrafts are chrome-plated up to 0.5mm thickness chromium (~ 0,02 inch). During the chrome-plating process, the surface of the steel will be affected by tensile stresses due to tensile stresses in the chromium deposit. It is well known that tensile stresses decrease the fatique life of material rapidly.

For compensating these tensile stresses by application of compressive stresses, the parts must be shot peened very correctly. As the process must be repeatable and reliable, all facts and parameters for the shot peening process must be fixed:

- parameters of the peening material
- parameters of the peened material
- parameters of the equipment
- parameters of the peening process.

There are two detailed facts which must be very exact. One of these is the coverage of the peened surface. If the coverage is lower than 100% hazard of uncontrolled stress rises will occur. As the material of landing gear parts is high heat treated up to 300.000 psi, it is very sensitive regarding cracks or stress concentrations.

The second detailed fact is the necessity to have the correct relation between the shot size and the pressure. Looking at the electron-microscope picture a too high pressure will produce uncorrect activation of the surface by the balls and these areas are sensitive for micro-cracks and lead later on to faults in the base material too.

The mainly used shot size is SAE S20 and the used pressure 2 bar.

During the overhaul process a heat treatment for stress relieve or baking to prevent hydrogen embrittlement will be carried out. In that case the temperatur must be below under a certain threshold, otherwise the affect of shot peening -that means compressive stresses- will be eliminated by the heat treatment.

BLASTING WITH GLASS BEADS DURING ENGINE OVERHAUL

The intensity of the blasting process will be measured by using ALMEN-Gauges.
Different thicknesses of the ALMEN-Gauges will be applied, the N-Gauge with 0,8 mm thickness, the A-Gauge with 1,3 mm thickness and the C-Gauge with 2,4 mm thickness.

The N-Gauge is necessary to test the process of using glass beads. The diameters of the glass beads differ between 0,05 to 0,2 mm and the intensity of ALMEN N-Gauge must be 0,1 to 0,3 mm. The coverage should be not smaller than 120%.

Compressor discs and vanes and blades of jet engines will be blasted by glass beads to increase the fatigue resistance.

The applied material of the compressor parts consists of Nickel- and Titan-alloys.

In the jet engine there are a lot of parts which must be peened by glass beads regarding their small thickness and diameters. The surface roughness must be improved by using glass beads so that the parts get better fatigue life and fatigue resistance. The process must be controlled and be repeatable and it is very useful to check the diameters of the glass beads in the same way like the shot peen balls by a continuous screening process.

GRIT BLASTING IN CONNECTION WITH THE PLATING PROCESSES DURING OVERHAUL OF AIRFRAME AND LANDING GEAR PARTS

This chapter is a little bit away from shot peening but the process is similar. Instead of steel balls or glass beads the material for blasting is grit made from Al_2O_3 (Korund). The following grit sizes will applied in the aircraft overhaul: mesh 320, mesh 230, mesh 120 and mesh 36.

There are different tasks for using grit blasting. One task is to clean surfaces from dust, oil, paint and other layers. Another task is to remove very thin layers of base material from the surface. A third task is to activate the surface to get better adhesion between a galvanic layer and the base material. This surface activation is the reason for an electron flow at the surface so that a good bonding effect between Kationen and Anionen during the plating process occur. This procedure as a preparation of the plating process is substituting the dip of the part into an acid solution.

If the grit blasting will be used there is no hydrogen attack in comparison to the acid dip. All high heat treated steel parts above 180.000 psi will be grit blasted instead of dipping into hydrogenic acid, sulphuric acid or nitrofluric acid. Landing gear parts and steel parts of airframe like beams, brackets and screw shafts will be treated never with acids.

There exist some investigations about influence of surface roughness by grit blasting at the pick-up of hydrogen during plating processes.

In the same way as the shot peening process needs correct facts for being repeatable and reliable, the grit blasting processes are working correctly if exact parameters for the process are available.

Distance between nozzle and material surface, pressure, grain size, angle between nozzle and suface and the blasting time (coverage) must be known exactly. A continuous screening to eliminate the broken parts of the grit must be serviceable during the process.

A microscopic test of the grit and the surface is useful to carry out from time to time.

CONCLUSION

The process dates and the theoretical aspects of shot peening are well known and were reported in the past congresses.

This paper shows samples of the application of shot peening in the aircraft industry as well in manufacturing area as in the airline business, especially overhaul of civil jet aircrafts.

Additional to the shot peening process the application of grit blasting by using Al_2O_3 (Korund) was presented.

This grit blasting process is similar to the shot peening process.

It is usefull to carry out further experiments of the application of shot peening and grit blasting.