



**Shot Peening  
Aerospace Solutions**

**FerroECOBlast®**  
EUROPE

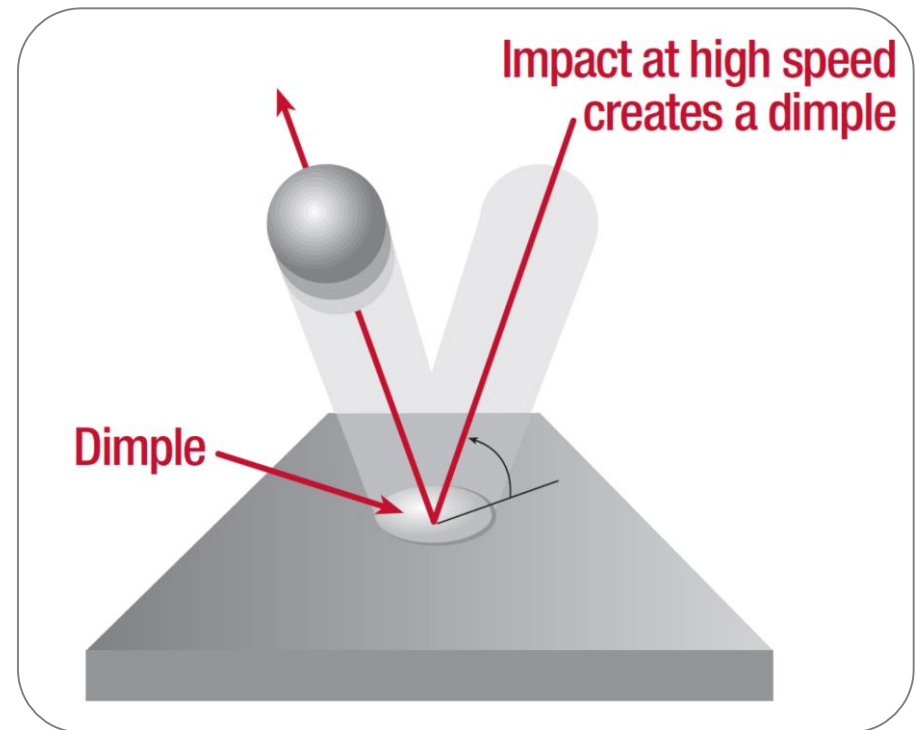
**Shot peening** is a cold working process in which the surface of a part is bombarded with small spherical media called shot. Each piece of shot striking the metal acts as a tiny peening hammer imparting a small indentation or dimple on the surface. In order for the dimple to be created, the surface layer of the metal must yield in tension.

Below the surface, the compressed grains try to restore the surface to its original shape producing a hemisphere of cold-worked metal highly stressed in compression. Overlapping dimples develop a uniform layer of residual compressive stress.

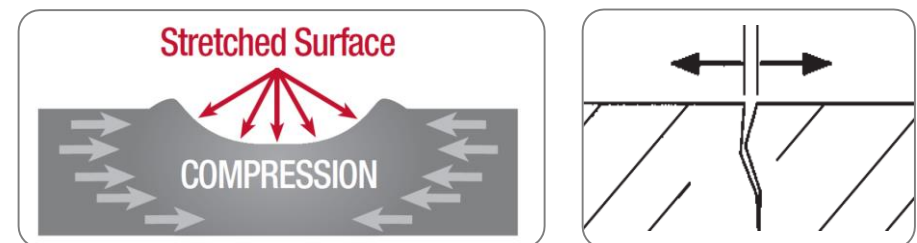
It is well known that cracks will not initiate nor propagate in a compressively stressed zone. Because nearly all fatigue and stress corrosion failures originate at or near the surface of a part, compressive stresses induced by shot peening provide significant increases in part life. The magnitude of residual compressive stress produced by shot peening is at least as great as half the tensile strength of the material being peened.

In most modes of long term failure the common denominator is tensile stress. These stresses can result from externally applied loads or be residual stresses from manufacturing processes such as welding, grinding or machining. Tensile stresses attempt to stretch or pull the surface apart and may eventually lead to crack initiation.

Because crack growth is slowed significantly in a compressive layer, increasing the depth of this layer increases crack resistance. **Shot peening is the most economical and practical method of ensuring surface residual compressive stresses.**



**FIGURE:** *Mechanical Yielding at Point of Impact*



**FIGURE:** *Compression Resists Fatigue Cracking & Crack Initiation and Growth Through Tensile Stress*

## Where Is This Surface Treatment Applicable?

- Shot peening is used on gear parts, cams and camshafts, clutch springs, coil springs, connecting rods, crankshafts, gearwheels, leaf and suspension springs, rock drills, and turbine blades.
- Shot peening is a crucial process in spring making.
- Shot peening may be used for cosmetic effect - overlapping dimples causes light to scatter upon reflection
- Shot peening can apply materials on metal surfaces – peen plating. When the shot or grit particles are blasted through a powder or liquid containing the desired surface coating, the impact plates or coats the workpiece surface.



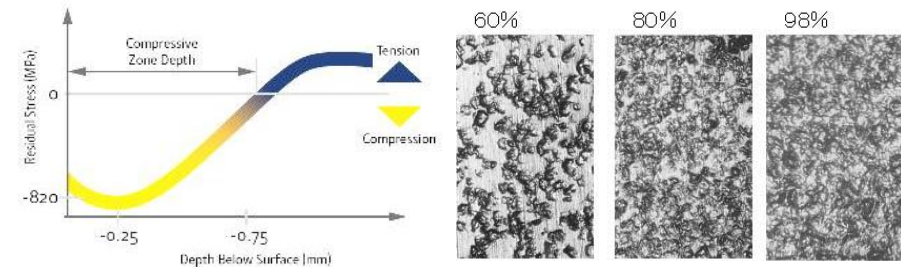
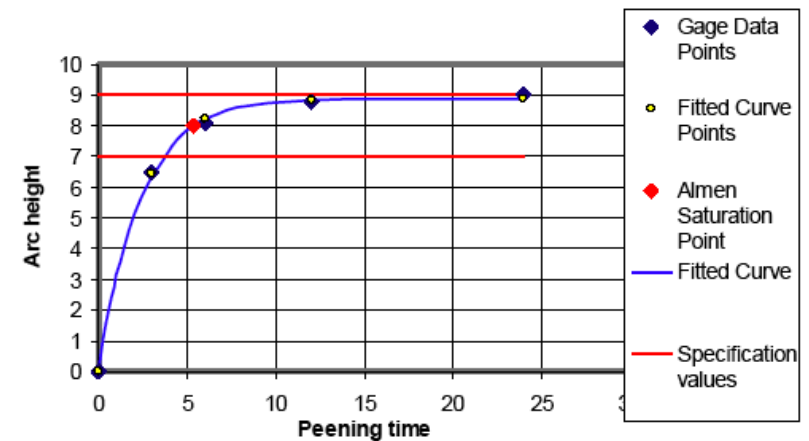
## Importance of process control and verification

Unlike abrasive blasting, the shot peening is highly controlled process with sharp requirements on:

- Process Repeatability
- Process Regulation
- Peening Effect Control
- Process History Recording ...
- .

## Peening Intensity & Coverage

- Intensity: Magnitude of compressive stresses indented by plastically deforming the surface
- Coverage: Ratio of indented surface area to the total surface area



The overhaul maintenance cleaning of jet engines and their components is scheduled to allow inspection and preparation for additional work by removing scale, soil and dirt build-up.

This scheduled maintenance is a crucial factor for safe and reliable operation of aircrafts. Once an engine is dismantled with view to begin the inspection phase, cleaning and surface treating of engine parts are recommended.





Following careful disassembly and cleaning every vital engine part is thoroughly inspected and treated if necessary. In case of microscopic cracking a process of shot peening is being performed. It is one of the most critical processes in overhaul of a jet engine and its components.

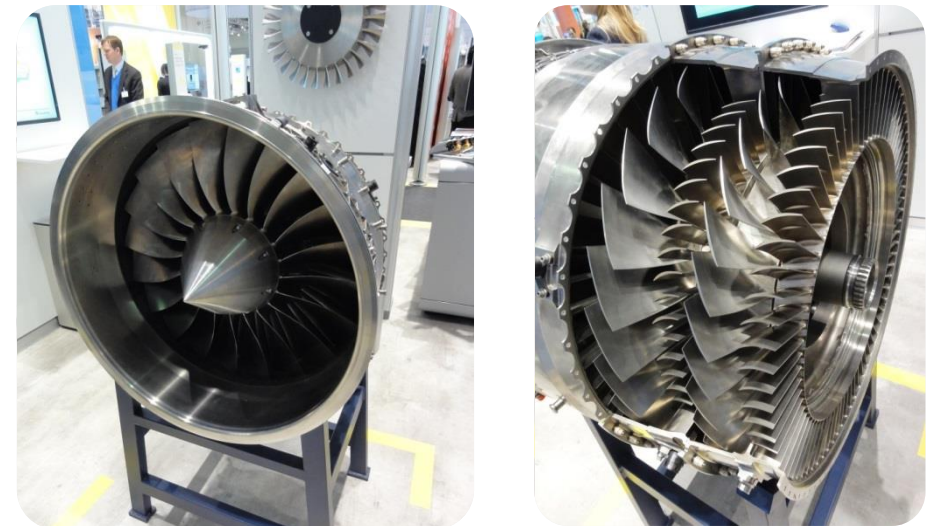
Customers long time experience in their engine production and overhauling facilities worldwide and extensive testing has showed that the process of engine overhaul treatment of larger components with jet of glass beads and with controlled jet of peening shots offers an adequate result.

In addition to the above this technologies of surface treatment are also used in the production of new engines and other versatile aircraft components which are exposed to substantial dynamic loads.



Property of Pratt & Whitney company

**FIGURE:** *Jet engine overhaul facility*

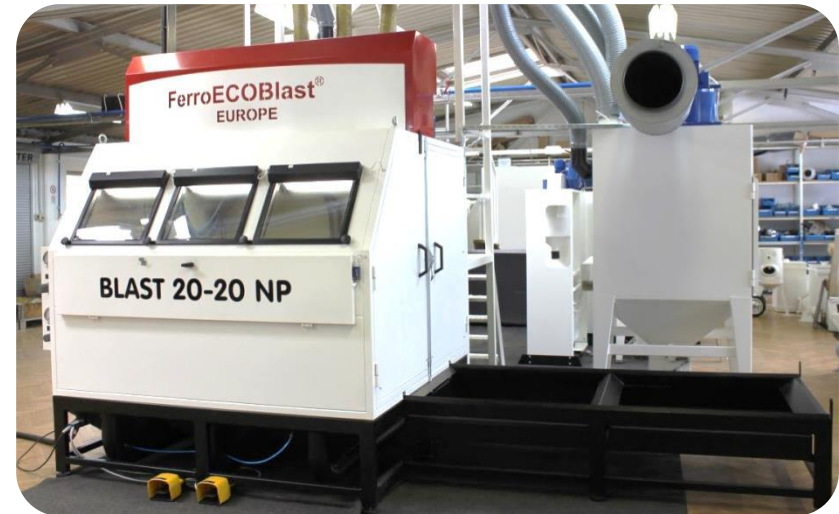
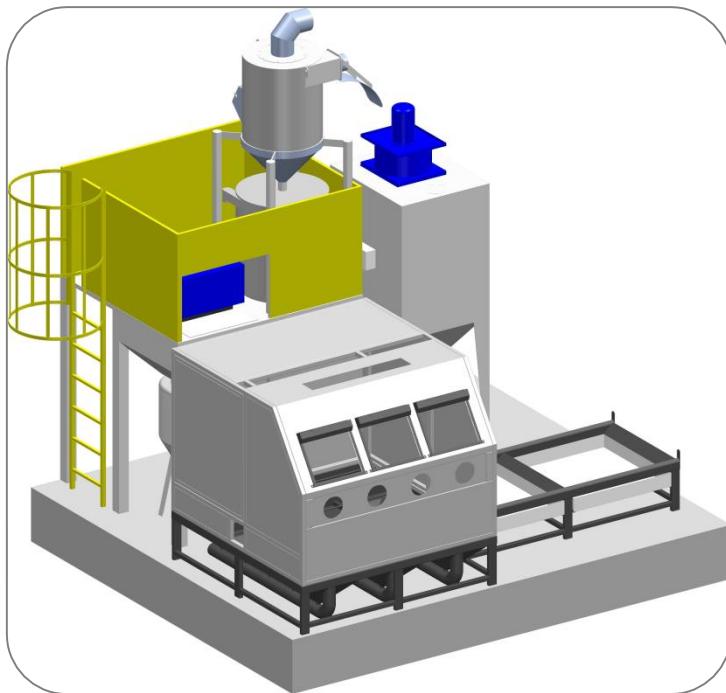


**FIGURE:** *Typical jet engine appearance and cross section*

Based on 50 years of experience in designing and manufacturing of special automatic shot blasting systems, latest Blasting/Peening machine “BLAST 20-20 ECO-NP” has been developed in particular for cleaning and shot treating of different engine parts.

## Blasting /Peening machine “BLAST 20-20 ECO-NP”

This machine provides cleaning and surface treating of all kind of metal or alloy parts with high abrasive or peening jet, using light blasting/peening abrasives like glass beads, ceramic shot, aluminum oxide (corundum), i.e. materials with lower specific weight.



**FIGURE:** “BLAST 20-20 ECO-NP”  
in production (top) & 3D model (left)



## Machine and Working Process Description

A complete machine solution based on the standard type of industrial FerroČrtalič blasting cabinets and type of “BLAST 20-20 ECO-NP” is upgraded with several modifications.

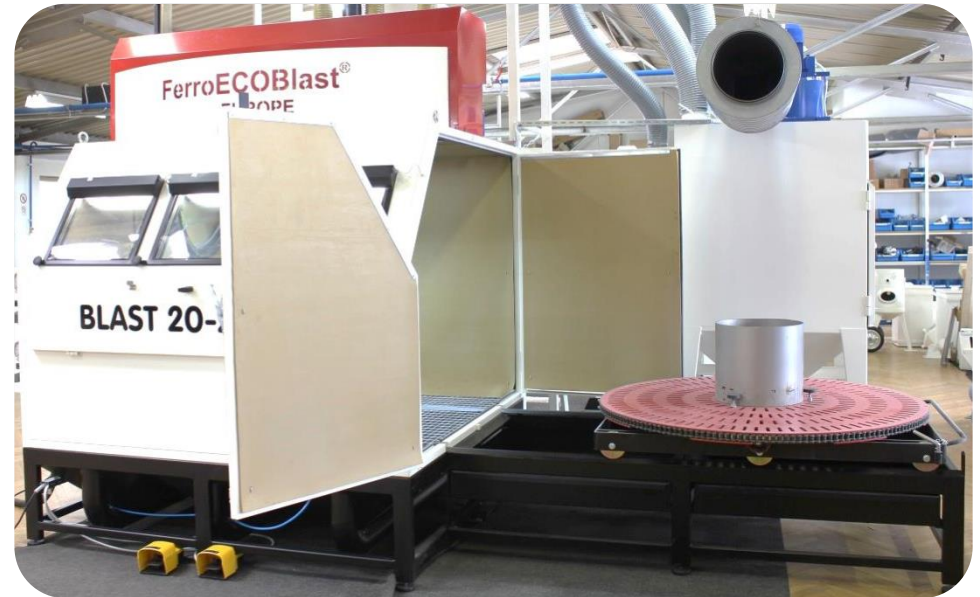
At the right side of the blasting cabinet there is a transport line with a mobile carrier, which is equipped with a rotating turntable for fixing, loading and further manipulation of work parts (WP). The carrier with WPs is manually pushed through double winged door into a working space of cabinet and fixed on the position, where the motor-powered rotator is connected on.

After closing double-wing door, operator can initiate an automatic blast sequence according to preset programs or choose manual manipulation of provided blasting gun.

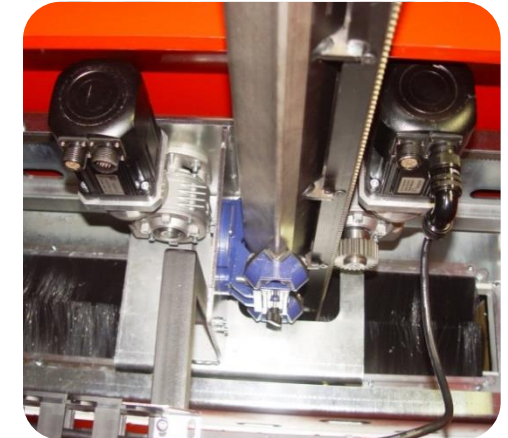
## Automatic Blasting or Peening mode

This machine is equipped with a control system, providing settings for X,Z axis movement and speed of turntable rotation. PLC unit is controlling and storing a large number of operations together with full machine diagnostic.

In the automatic mode the blasting process is done by means of two blasting guns mounted on two-axis manipulator driven by two linear motors. Manipulator drive mechanism and motors are installed on the outer top side of cabinet, in this way providing a good protection from abrasive contamination .



**FIGURE:** *Loading of Workpiece*

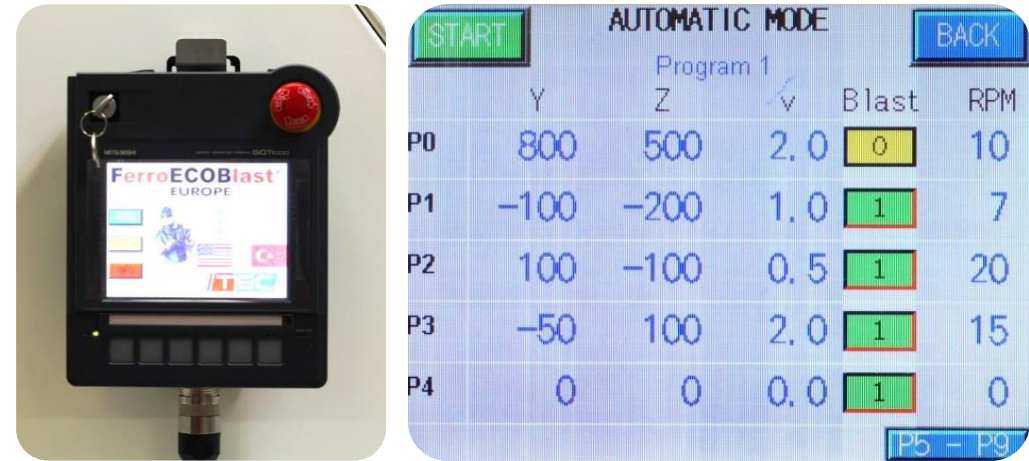


**FIGURE:** *Blasting System and Manipulation Drive*

## Mobile HMI Panel for Optimal Working Ergonomics

Machine is equipped with Detachable HMI mobile display which is enabling selection of working modes and complete machine configuration for both manual and automatic mode.

This range of the control equipment provides an easy access and maintenance as well as an ergonomic approach to the management and programming, and furthermore emergency stopping of machine at any time with installed STOP pushbutton.



**FIGURE:** Detachable HMI panel & Programming interface

## Manual Blasting Mode

When Manual working mode is needed a desired mode is selected, protection cover opened, operator is standing in front of the machine pushing his hands into the working space through special in-built gloves and blasting manually by means of foot pedal controls.

For manual blasting operator is using an additional manual injector gun (type FC POWERGUN) with boron carbide nozzle. After finishing the blasting process, pieces are cleaned with blowing gun with compressed air.



**FIGURE:** Hand openings with in-built gloves & foot pedals



## Soundproofing for Safe Environment

A special attention was taken for soundproofing blasting cabinet using sound insulating windows and sound absorbing anti-abrasive materials inside the cabinet, with the objective to meet strict EU protection regulations.



**FIGURE:** *Sound Insulating Windows & SPL Measurements*

## Blasting Media Reclaim System

Abrasive media is collected in specially designed hoppers under gratings and PNEUMATICALLY transported from the cabinet trough the FULL RECOVERY SYSTEM back again into the blasting process.

A special Vibration sieve unit with standard size meshes for media classification, additionally supported by a magnetic filter, is installed for a good media separation.

Dust and removed oxide are collected in the box below filter unit, which is strong enough for a perfect ventilation and pneumatic transport of light abrasives.

Pneumatic components are important part of this machine and have a place in separate pneumatic control box thus enabling a separate blasting pressure adjustment for manual and automatic mode.



**FIGURE:** *Media Reclaim System*

## FAT protocols and Instalation

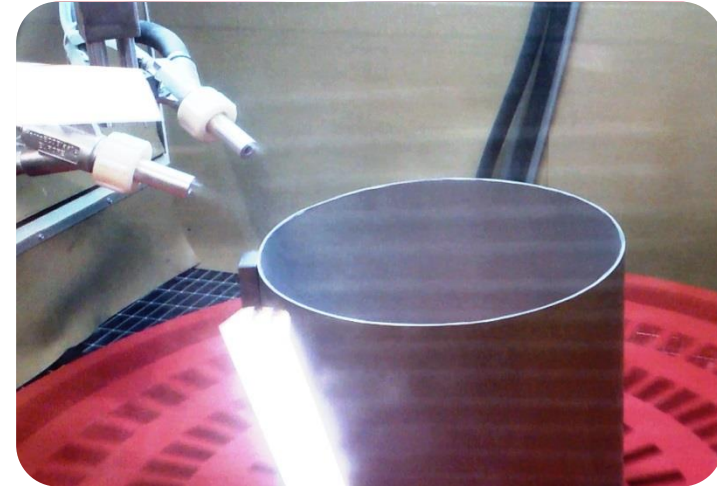
Each produced machine is assembled and finished in our company with FAT and acceptance tests carried out before delivery. During FAT protocol all parameters are measured and recorded, so every machine is provided with its own "Personal Card".

All our machines are designed, engineered and manufactured in compliance with all applicable European standards and directives. They are equipped with Quality control marking, "CE" marking and declaration of conformity.

After testing machine operation special shot blasting intensity tests (ALMEN) are performed at FerroČrtalič facilities to confirm if the machine meets the customer's requirements.

After all criteria of surface treatment have been met and machine fully complies with strict electrical, mechanical and safety requirements of a client's company, machines are transported to the customer's location where technical and SAT acceptance of the machine takes place.

Machine final user is provided with more effective and reliable engine overhauling method with completely controlled working process, what at the end mean safe and reliable air transport of passengers worldwide.



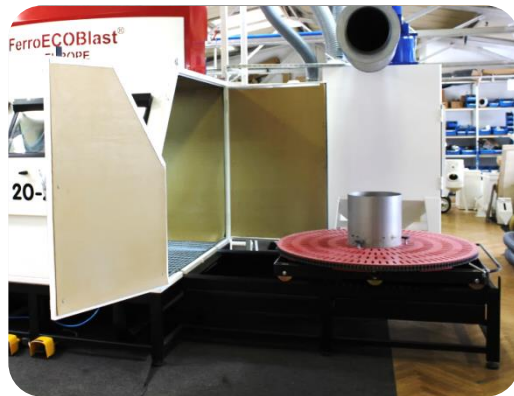
**FIGURE:** *ALMEN testing*



**FIGURE:** *BLAST 20-20 NP on location*

## ADVANCED AUTOMATED PEENING

- Touchscreen HMI
- PLC Control
- SCADA integration
- Servo Driven Turntable
- Linear 2 axis Nozzle Manipulation
- Batch Printout Reports
- Media flow control
- Media Classification
- Media Reclaim System wit
- Dust Filtration

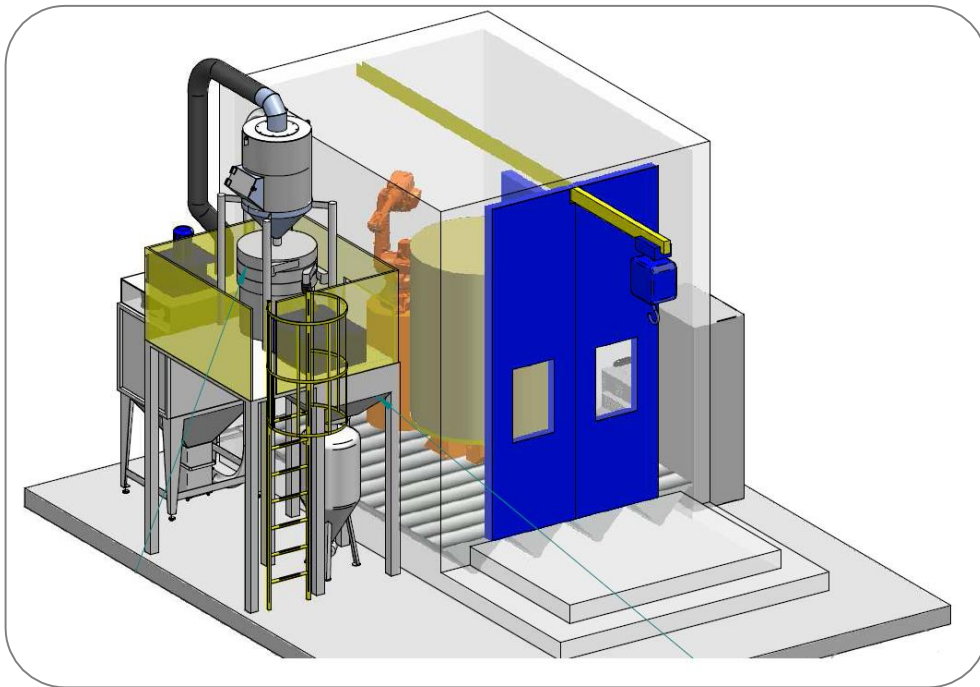




For the purpose of treating large jet engine parts during overhaul process a special robotic shot peening system “ASP-1500 ECO” is being specially developed.

### Robotic Full Shot Peening Cell “ASP-1500 ECO”

This machine provides controlled and repeatable shot peening of different kind of metal or alloy engines parts with two different peening media sizes, with regular blasting head and special rotary lance head.



**FIGURE:** “ASP-1500 ECO”  
*During assembly (top) & 3D model (left)*

### Machine and Working Process Description

Complete machine type “ASP-1500 ECO” solution is based on the custom made blasting chamber designed specially to achieve ideal working conditions for shot peening process.

Blasting chamber is designed and constructed with sound absorbing materials taking under consideration strict health regulations and providing safe working environment for operators.

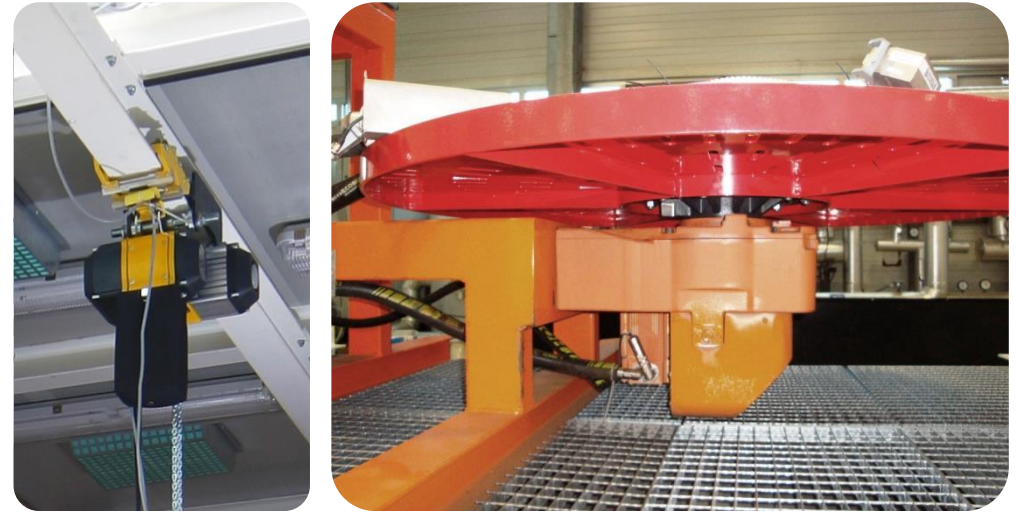
Machine is equipped with its own electrically driven winch hoist which is designed for loading of heavy pieces on the servo driven rotary table.

After closing double-wing door, operator can initiate an automatic blast sequence according to preset programs stored in central supervision system.

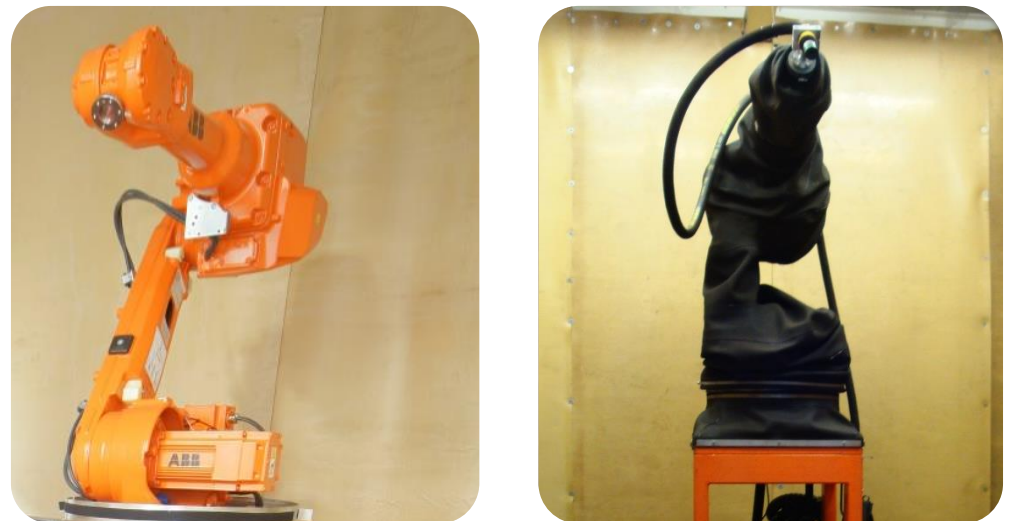
### Automatic Peening mode

For high precision manipulation of blasting head a modern 6 axis robot manipulator installed, which is completely protected against abrasive effects of the process by special custom fit shield.

All working movements and parameters are fully controllable and repeatable suitable for shot peening process and providing the ability to create reports for particular jobs from abrasive contamination .



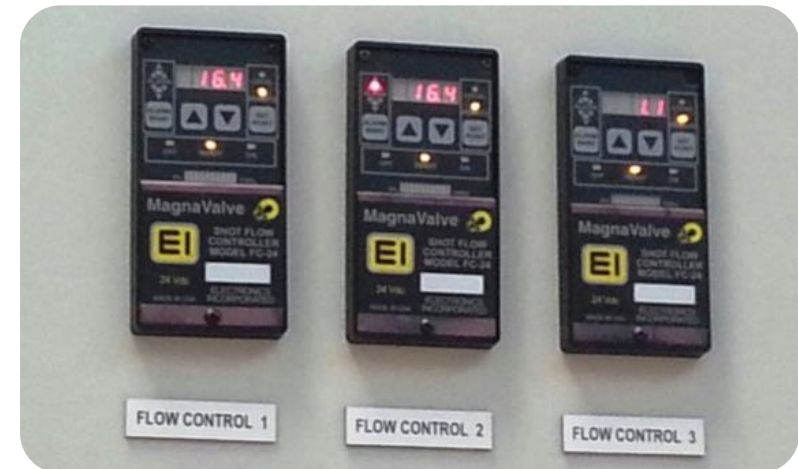
**FIGURE:** *Electrically driven Winch Hoist  
& Servo Driven Rotary Table*



**FIGURE:** *6-Axis robot for Nozzle Manipulation*

### Media Flow Regulation

For precise dosing of peening media MagnaValve magnetic valves with closed loop regulation are being used. The MagnaValve provides reliable, repetitive, and consistent shot peening and blast cleaning process with confidence of proper media flow rate at all time.



**FIGURE:** *Media Flow Regulation Valves*

### Special Peening Features

Shot peening of small features such as slots, bolt holes, deep pockets is very critical since the complexity of these features makes it impossible for traditional nozzle peening to be effective. For this reason special rotary lance shot peening equipment and nozzles were developed. This equipment can be mounted on the manipulation robot and it is fully interchangeable with traditional nozzle.

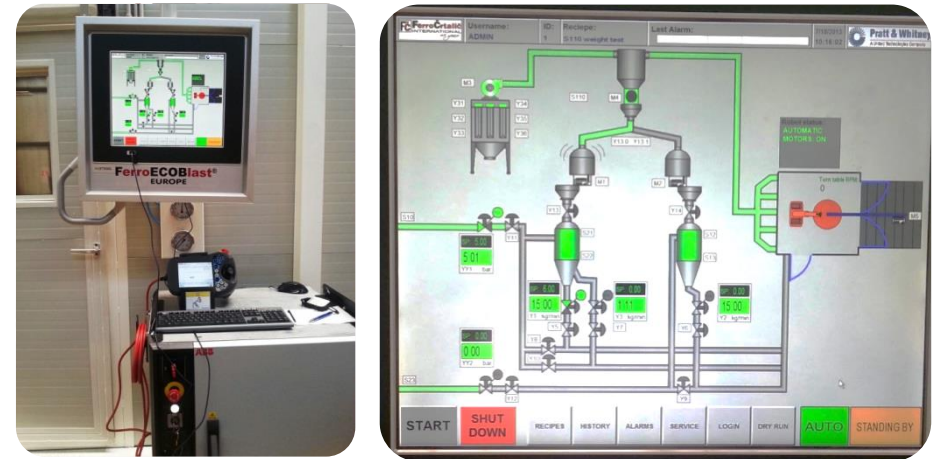


**FIGURE:** *Rotary Peening Head*



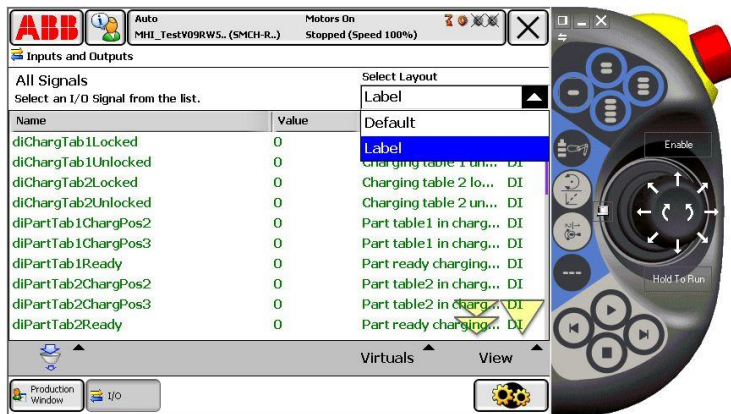
## Process Management

Supervision and management of the complete system and process functions are performed via a SCADA control system, which is closely linked to inbuilt industrial PLC unit. This type of process management is providing possibility for creation of reports with all technical parameters for particular job or batch of workpieces. This feature is absolutely necessary when dealing with aerospace industry.



**FIGURE:** SCADA Control System

Programming robotic modules and manual handling are executed through FlexPendant mobile HMI with all inbuilt features for safe operation during manual programming and service actions.



**FIGURE:** Robot Controller Unit (top) & Mobile HMI (left)

### Media Reclaim System

Special two way media system was installed providing possibility of working with two different media sizes with ability for fast automatic interchange between them without means of manual operation.

Twin media reclaim system is additionally supported by air wash and magnetic separator installed prior to vibrational sieve units. Vibrational sieves are equipped with standard size meshes for precise media classification.

Dust and removed particles are collected in the box below filter unit, which is strong enough for a perfect ventilation and pneumatic transport of heavy abrasives collected at the bottom of blasting cabinet.



**FIGURE:** *Twin Media Reclaim System*



### FAT protocols and Installation

Each produced machine is assembled and finished in our company with FAT and acceptance tests carried out before delivery. For personnel of the end users thorough training of machine operation is provided.

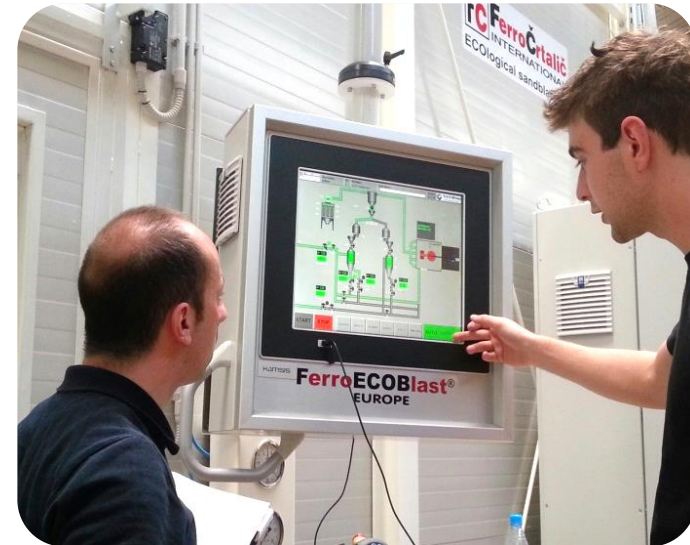
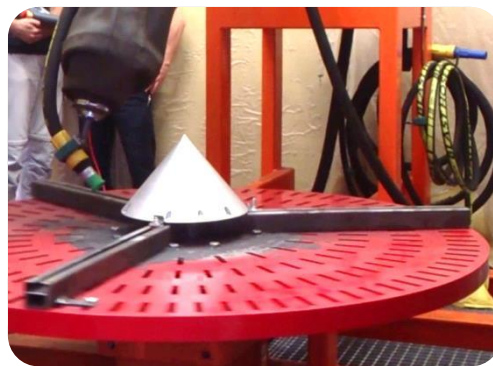
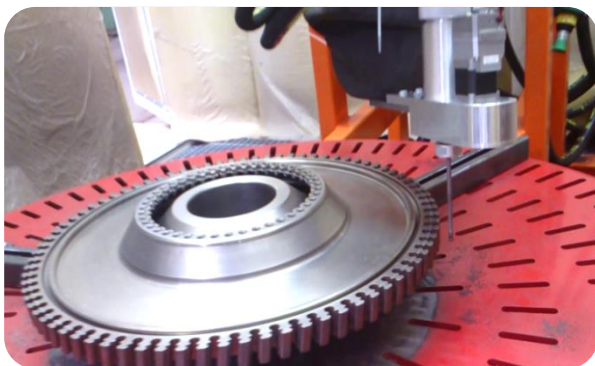
During FAT protocol all parameters are measured and recorded, so every machine is provided with its own “Personal Card”.

After testing system functionality special shot peening intensity (ALMEN), catch tests and other specific trials were run at FerroČrtalič facilities to confirm if the machine meets the customer's requirements.

Passengers worldwide.

On the customer's request we can also provide NADCAP accreditation for our shot peening systems as well

In this way effective and reliable engine overhaul is provided with completely controlled working process, consequently meaning safe and reliable air transport of passengers world-wide.



**FIGURE:** *Training of Customers Personnel*

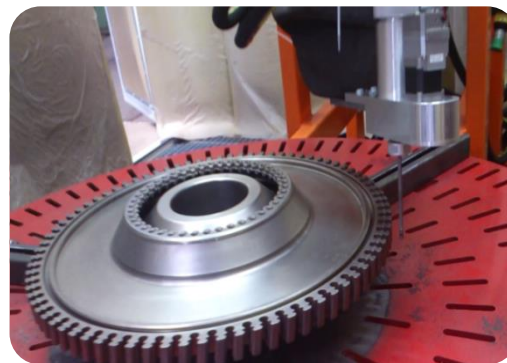


**FIGURE:** *Machine testing (left) & (top)*



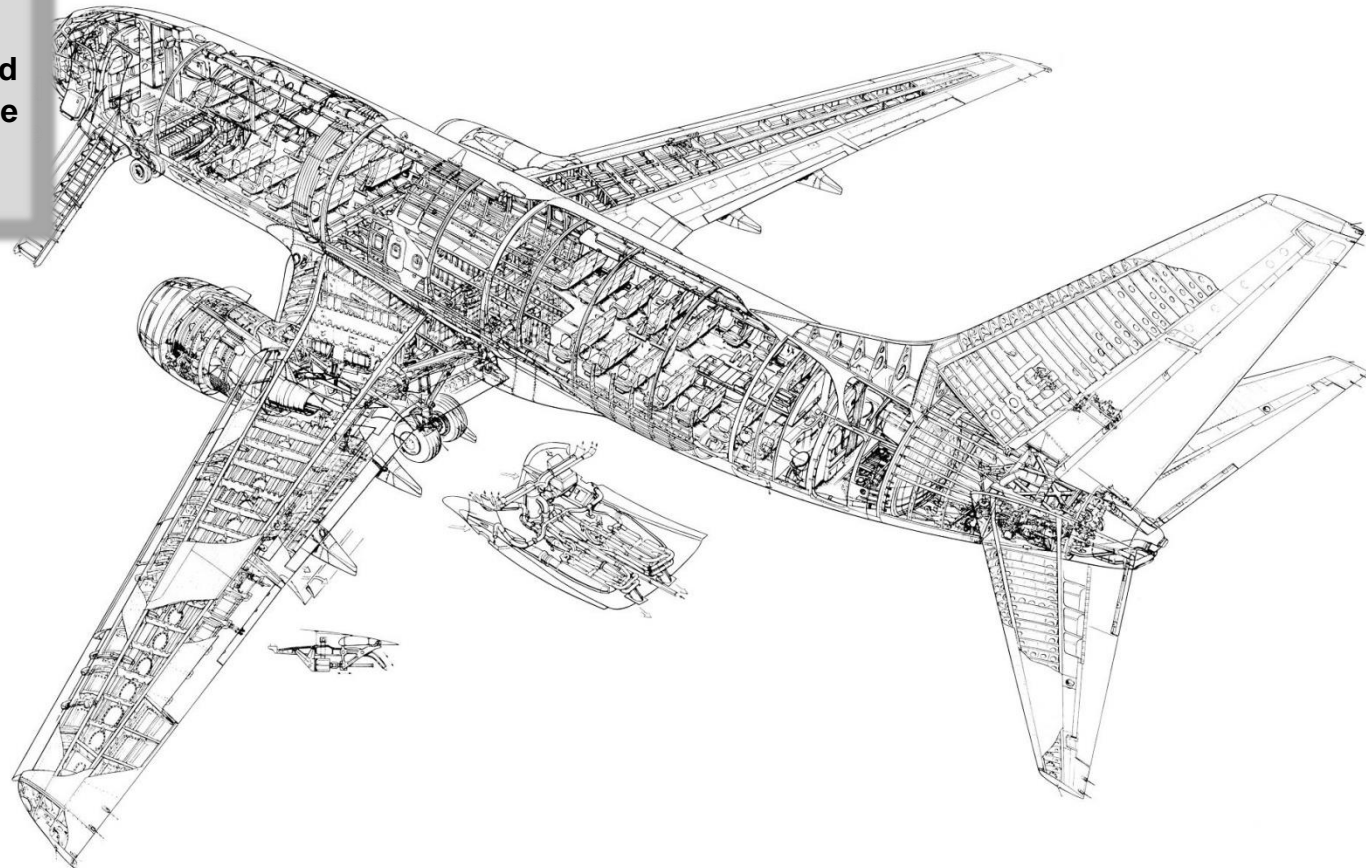
## SUPERIOR ROBOTIC PEENING

- PLC Control
- SCADA integration
- Industrial grade PC
- Servo Driven Turntable
- Rotating Penning Lance
- 6 axis Robotic Nozzle Manipulation
- Batch Printout Reports
- Media Separation & Classification
- Closed Loop Media Flow Regulation
- Closed Loop Air Pressure Control
- Media Reclaim System



Manufacturing processes have significant effects on fatigue properties of metal parts. The effects can be either detrimental or beneficial. Detrimental processes include welding, grinding, abusive machining, metal forming, etc. These processes leave the surface in residual tension.

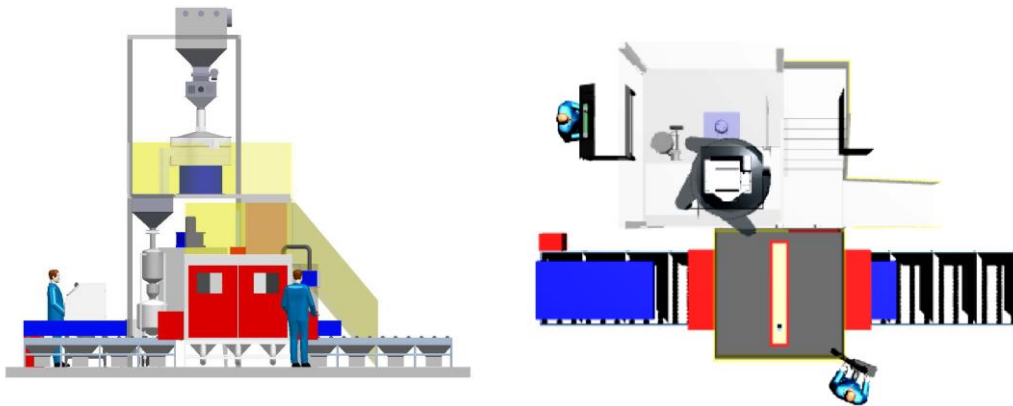
The summation of residual tensile stress and applied loading stress accelerates fatigue failure.



For the purpose of releasing surface tensile forces induced by machining process we developed specialized through feed shot peening system for processing of larger aerospace components.

## Automatic Shot Peening Machine “ASP PEENLINE 4/1000 ECO”

This machine provides controlled and repeatable shot peening of various metal or alloy machined structural components with high efficiency cutwire media, with four adjustable nozzles attacking workpieces from 4 different angles



**FIGURE:** “ASP PEENLINE 4/1000 ECO” During assembly (top) & design model (left)



## Machine working description

Unlike previously mentioned solutions where workpieces are fixed on indexing turntable for high precision positioning and accurate processing, machine ASP PEENLINE 4/1000 ECO is designed as a through feed system with heavy duty transport line for workpieces manipulation.

Transport line is feeding objects into the peening cabinet in controlled manner where travel liner speed is controlled via PLC and SCAD.

Machine is enabling workpieces manipulation in directions, these allowing operators to flip or reposition object after one side (surface) has been processed.

Special care was taken in design of technological openings for parts exit and entrance to cabinet in order to prevent escape of reflected peening media.

## Automatic nozzle manipulation

Differing from systems with turntable where workpieces are peened by one nozzle, here the peening process is performed with set of 4 nozzles geometrically positioned in rectangular pattern aiming horizontal surface at the angle of 45°.

Complete nozzle fixture is servo driven in horizontal plane perpendicular to the transport line.

The height of nozzle fixture is adjustable through SCADA system with fixture also having provision for manual fine adjustment of each nozzle pitch and yaw. This kind of configuration is providing fully configurable peening system capable of achieving requested repeatable intensity and coverage on workpieces of irregular geometry.



**FIGURE:** *Heavy duty rubberized transport line*



**FIGURE:** *1 axis Servo driven nozzle manipulator*

## Machine Process Control Systems

Machine is equipped with standard components for process control with overall machine performance meeting full requirements of standard SAE AMS-2432.

Among the components we emphasize set of MAGNAVALVES for closed loop regulation of media mass flow of each nozzle. In addition to the mass flow control elements there is installed system for closed loop regulation of compressed air work pressure.

Supervision and management of the complete peening system and process functions are performed via customized SCADA control system, which is closely linked to inbuilt industrial PLC unit.

## Double Pressure Vessel

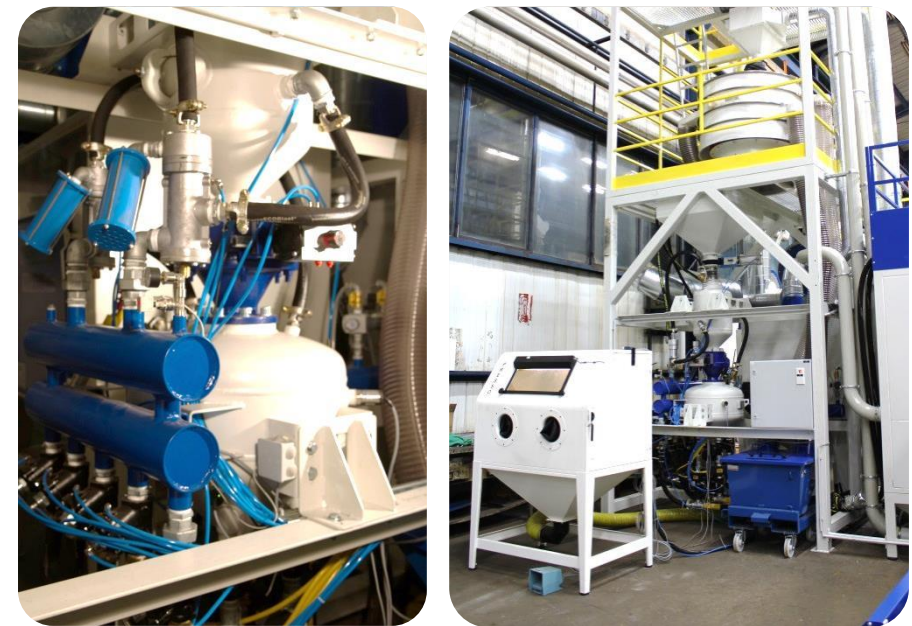
As the peening of larger structural components must be performed in continuous manner for longer time periods a special double pressure vessel was developed and installed that provides a constant refilling and uninterrupted peening process

## OPTIONAL: Manual peening mode

Outstanding feature of peening system is an additional manual peening cabinet supplied for post processing and treatment of smaller objects with reservation that only highly skilled personnel can perform such actions. Manual blasting cabinet is fed by all highly controlled systems of main machine (media, air, suction) offering controlled and repeatable parameters to manual operator.



**FIGURE:** Set of MagnaValve controllers



**FIGURE:** Double pressure vessel (left) & Manual peening cabinet (right)



## Media Management System

Media is collected from bottom hoppers of machine and transported 6 meters high into reclaim unit with pneumatic transport system. Strong dust collector unit is producing enough suction power to cope with amount of media delivered through 4 pressurized blast nozzles.

Installed media reclaim system is additionally supported by air wash unit installed prior to 42” vibrational sieve unit. High performance vibrational sieve suitable for large volumes of peening media is equipped with standard size meshes for precise media classification.



**FIGURE:** *Pneumatic driven reclaim unit (above)  
& high capacity Sweco (left)*



## ▶ CONTROLLED THROUGH FEED PEENING

- Suitable for Larger Structural Parts
- PLC Control
- SCADA integration
- Frequency Controlled Conveyer Speed
- Linear 1 axis Nozzle Manipulation
- Batch Printout Reports
- Media Separation & Classification
- Closed Loop Media Flow Control
- Media Reclaim System with Dust Filtration



The landing gear is one of the most critical and strained components of the aircraft, often withstanding asymmetrical loads and heavy impacts during landing procedure in non-perfect conditions.

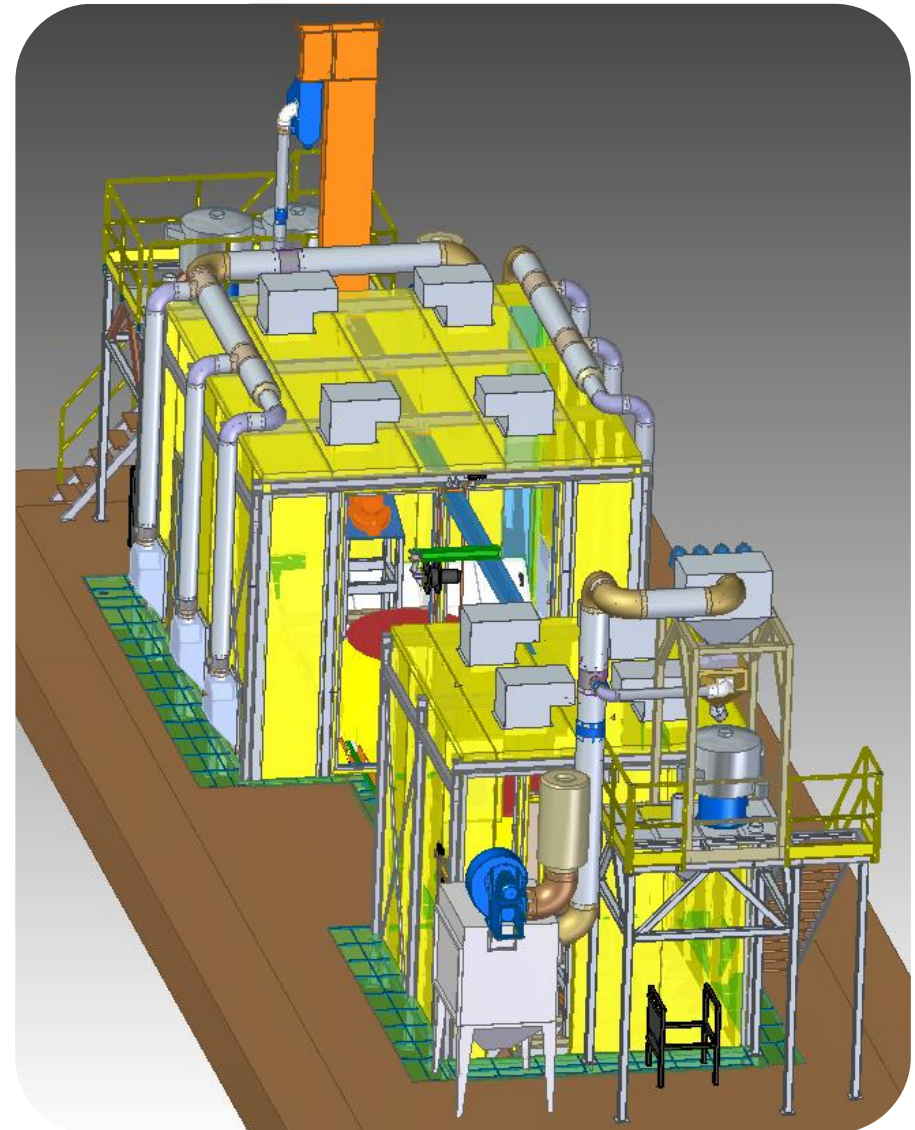
Therefore Shot Peening is standard regular maintenance operation for these complicated and geometrically challenging assemblies.



For the purpose of performing regular maintenance shot peening of landing gear and solving difficult problem of challenging geometry with different intensity requirements we developed versatile and flexible two interconnected robotic chambers system.

## ARSP +ARGB system

This large robotic shot peen system with two separate chambers (ARSP&ARGB) is designed to peen the ID and OD surfaces of a range of landing gear components. The parts are loaded and manipulated using an integral machine mounted hoist connecting both chambers and can be rotated or indexed on the precise servo turntables.



**FIGURE:** 3D model of ARSP +ARGB system



## Two Chamber Design

As landing gear components come in different sizes, materials and therefore different requirements for peening results that exceed the capabilities of a single machine a double robotic chamber was adopted as a complete solution.

## N strip chamber (ARGB)

One chamber is equipped with peening system suitable for achieving results in range of Almen N-Strip using glass peening media. Commonly for lightweight media is the pneumatic media collecting and transport system used also benefiting in low maintenance while less mechanical components are being used as in mechanical systems.

For media mass control all new MAGNAVALVES for non-ferrous media are installed thus solving long time problem of regulating Glass media flow. Two Magnavalves are working in combination with double pressure vessel and feeding two robotic manipulated nozzles, one standard and one rotating lance for ID.



**FIGURE:** *N strip chamber (ARGB)*



**FIGURE:** *Double pressure vessel (left) & Magnavalves for nonferrous media (right)*

## A strip chamber (ARSP)

Second chamber is optimized for achieving intensities of Almen A-Strip range using two different sizes of highly effective SCCW media.

A-Strip chamber is equipped with standard components for process control such as Magnavalves, proportional air pressure controller and SCADA along with industrial robotic manipulator.

For achieving wide range of intensities throughout A-Strip range system for two different media sizes was integrated with ability for fast automatic interchange between them without means of manual operation.

As a standard solution for heavy media collection and transport a mechanical system containing full floor scrapping unit, screw transporter and bucket elevator was adopted.



**FIGURE:** *A strip chamber (ARSP)*



**FIGURE:** *Bucket elevator with Airwash unit (left) & two media recycling system (right)*



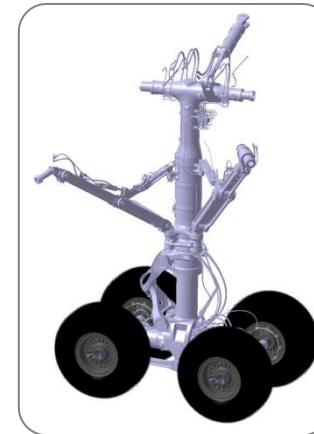
## Challenging Geometry

Keeping in mind challenging geometries of typical landing gear components a customized multiple tooling systems was developed.

For smallest and most precise ID a robotic manipulated rotating lance was installed. Lance design incorporates servo mechanism always driving small lance with stable preset value of RPM. This combining with accurate indexing table presents ideal solution not only for landing gear ID but also for other aerospace components such as LPTs or other objects containing small sized grooves and apertures.

A large automatic horizontal rotating lance is programmed topeen the ID surfaces of largest parts

Inside tilt mounted and additionally protected ABB industrial robot manipulates a direct pressure nozzle or rotating lance drive to peen all outside surfaces providing large flexibility of functions and programing to operating engineers.



**FIGURE:** Typical main landing gear assembly



**FIGURE:** ABB Robotic industrial robot with rotating lance for smallest IDs (above) & Horizontal rotating lance assembly (left)



## Work object manipulation and system flexibility

Complete system design was performed with special care for manipulation of components between both chambers. The idea was to provide possibility of object loading, unloading and cross transfer with little manipulation as possible and without necessity for external crane or hoist.

Both chambers are interconnected with clever manipulation transport line consisting of rails for precise guidance and positioning of two trolleys and connecting hoist for object lifting.

Special attention was given to the design of each transport trolley. Trolleys are equipped with indexing turntables and powered through flexible power lines. Therefore complete trolley housing is also acting as anitabrasive protection for all integrated turntable systems and installations below.



**FIGURE:** *Transport trolley on rails (above)  
& precise drive mechanism (left)*

## FAT protocols and Installation

Each produced machine is assembled and finished in our company with FAT and acceptance tests carried out before delivery.

For final customer we are providing system solutions such as: tooling and fixtures, basic machine programming, SCADA customization measurements and process verifications – Almen saturation curves .

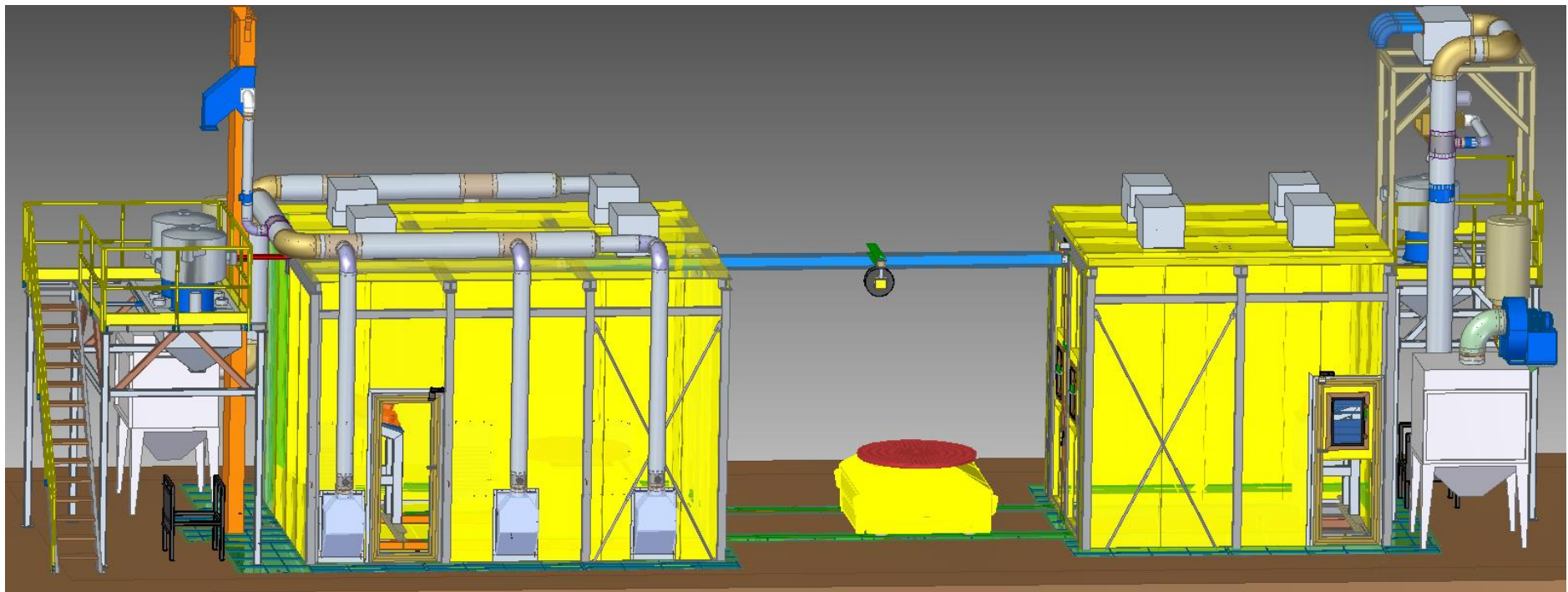
On the customer's request we can also provide NADCAP accreditation for our shot peening systems as well





## TWO ROBOTIC CHAMBER SYSTEM

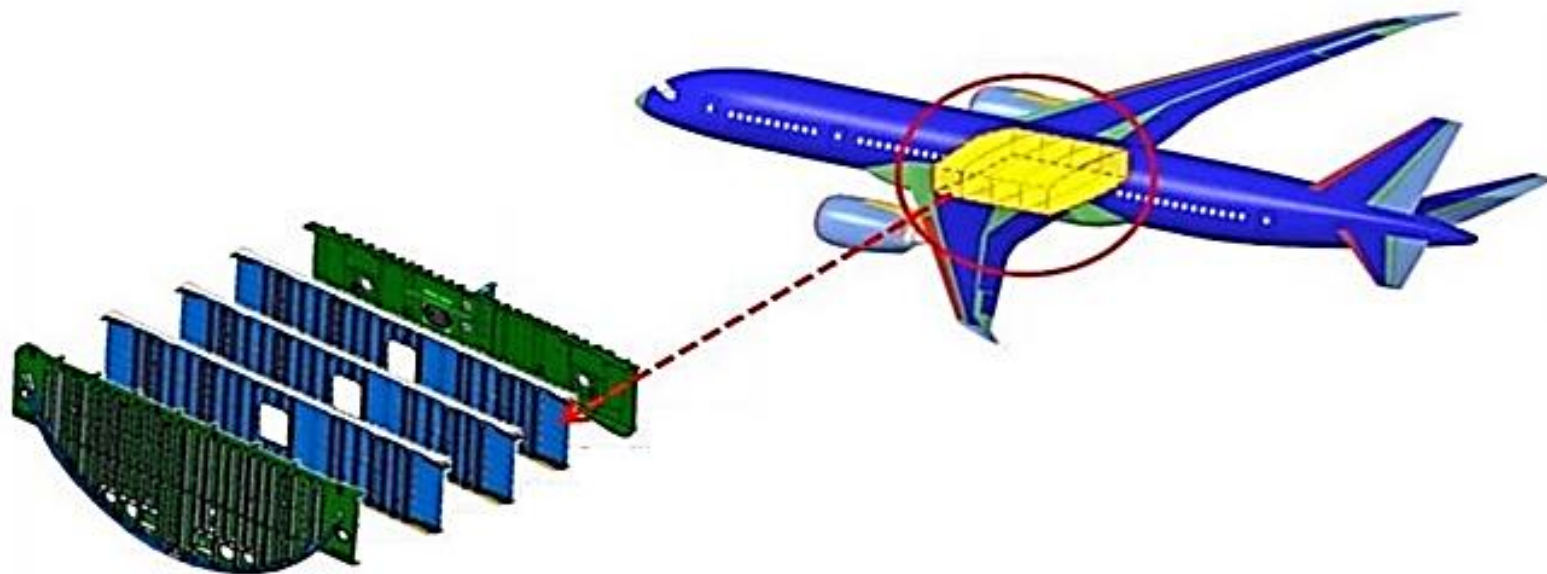
- Robotic functionality
- Multi tooling
- Workflow Flexibility
- Customized loading unloading
- Dual SCADA control
- Interconnecting crane and transport line





During full scale fatigue tests of airplanes with decade or more of continuous service, some cracks can be detected on major fuselage structural components.

To avoid possible crack initiation and subsequent extensive repair on the structure, introduction of shot peening in the radius of critical area is recommended.

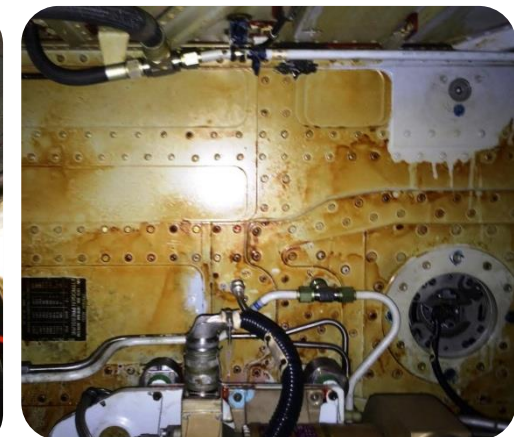


During regular maintenance operations on aircraft, fuselage skin panels are removed and critical areas of airframe structure exposed.

## Airframe Preparation

Prior to performing on-site shot peening service an inspection of work area and all prior preparation activities is necessary. Preparation is done strictly in accordance with technical maintenance manual and documentation.

All vital electrical and hydraulic equipment should be removed and well protected. Existing coating of the areas to be peened should be stripped and subsequently polished leaving fully exposed metal surface.





## Determining Process Parameters

Just as important as the preparation of the fuselage working environment is the preparation and determination of all relevant Shot Peening parameters process.

Maintenance technical specifications are defining required intensity and coverage that must be achieved for requested results.

Skilled certified shot peening operator is therefore performing series of **Almen intensity** and **Coverage** measurements with subsequent fine adjustments of peening equipment in order to achieve and validate necessary parameters.

All measuring and blasting equipment used in process is in accordance with relevant aerospace shop peening standards (SAE AMS).



Almen test: (mm)  
Required intensity: 0,130 - 0,160 mm

Before	After	Final	Pass
-0,012	0,242	0,130	1 X (15)
-0,008			2 X (25)
-0,010			3 X

Two metal test coupons are placed on the table, one above the other. They have handwritten markings and numbers, including 'E1 L01000010-2000-4' and 'E1 L01000010-2000-1'. The coupons are positioned over the 'After' and 'Final' columns of the Almen test table.



## Protection

For the reasons of field on-site peening application only mobile peening machine can be used. Doing so there is no closed cabinet to retain all dust and left over peening media.

Due to sensitivity of airplane equipment to external influences and dust the actual work area is localized and well protected. Mobile filtration unit is introduced to the localized area for ventilation and used media suction.

Eventually, controlled peening operation is performed by skilled operator inside the area of protective curtain. Operator is well protected and equipped with breathing apparatus.

Finally peened surface can then be recoated and all removed avionic equipment reinstalled.

## Peening operation results

These preventive maintenance service actions and periodic inspections are enabling safe operation and longer life expectancy even of older aircraft in the fleet flying worldwide for almost 20 years or more.

