Shot peening treatment.

Characterization, NDT & predictive tool

Ruth González Fernández – EIDEIC 2019

Proyecto cofinanciado por **fondos FEDER**

GOBIERNO de CANTABRIA
CONSEJERÍA INNOVACIÓN, INDUSTRIA, TURISMO Y COMERCIO

UNIÓN EUROPEA
Fondo Europeo de Desarrollo Regional

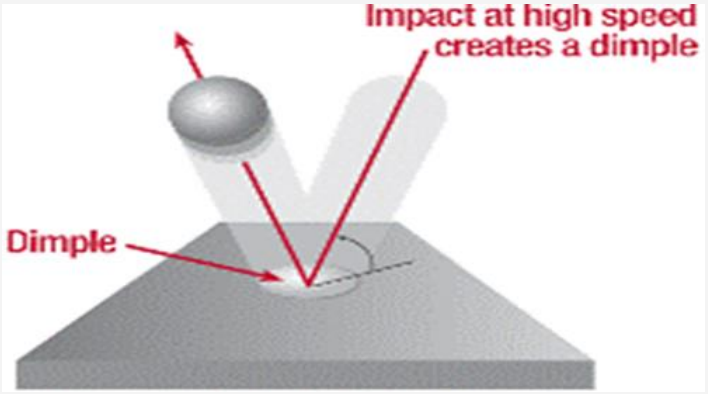
- Index
- Shot Peening Process
- PhD & Project Objectives
- Results
- Other results

- Index
- Shot Peening Process
- PhD & Project Objectives
- Results
- Other results

Process description

Process consisting in shooting particles on a surface at high speed
Traditionally used to homogenize surface residual tensions under a uniform compressive stress to fight fatigue.
Shot peening induces residual compressive stresses by deforming the material surface with media impacts

Goal: improve the steam oxidation resistance on the ID of austenitic tubes to avoid exfoliation by improving Cr2O3 layer scale recover. Requested often for CodeCase 2328



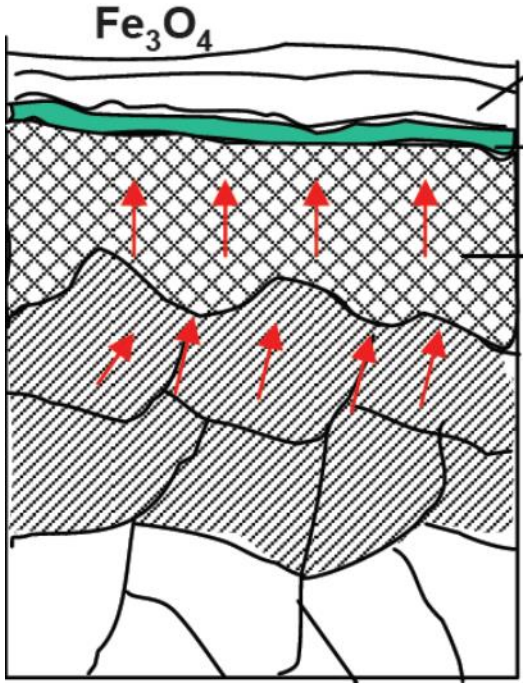
Higher energy transfer results in deeper compressive stresses into the material

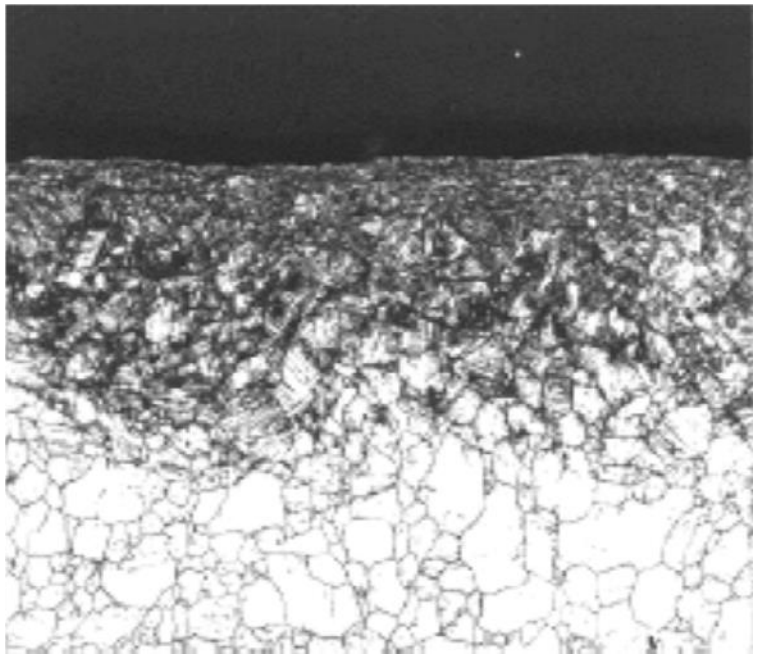
Process description

During shot peening a layer of ~100µm of the ID is plasticized, creating a structure with a high density of grain and twin boundaries close to the surface.

The Cr diffusion to the surface is accelerated and the **oxidation resistance behavior is improved**.

Shot peening promotes the **rapid apparition** of a slow growing, dense, single-layered scale **of Cr_2O_3**





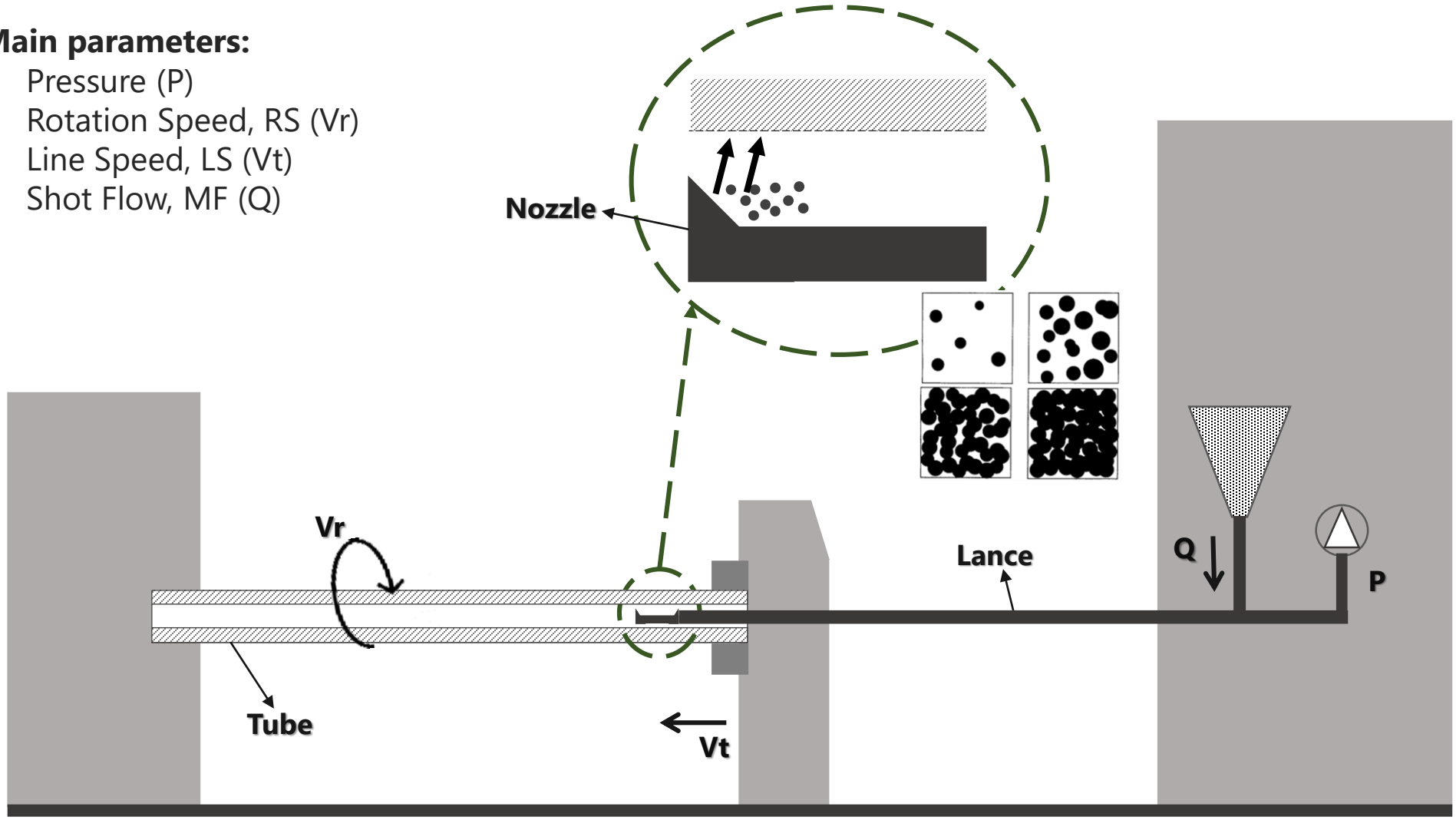
TUBACEX SERVICES

TUBACEX GROUP

Process description

Main parameters:

- Pressure (P)
- Rotation Speed, RS (Vr)
- Line Speed, LS (Vt)
- Shot Flow, MF (Q)



SWOT analysis

Strengths:
International market.
Innova program support

Weaknesses:
Process application: stainless steell tubes interior, Length ≈ 12 meters
The details of the mechanism are not yet clear
Quality assurance based on **random destructive testing**
No Non-Destructive Test Available To Verify That Shot Peening has been done correctly
- Positive Control Of The Process is essential to ensure repeatability and reliability of the product.

Opportunities:
Develop a new, on-line system
Further to process control, use **micro-hardness** measurements and Almen test for product certification
- Excellent **opportunity** to develop know-how, a new product. Patent

Threats:
Lack of unified specifications & quality controls.
High risk and uncertainty

- Index
- Shot Peening Process
- PhD & Project Objectives
- Results
- Other results

Project Objectives

Process characterization
Data analysis
Microhardness measurements, data relations
NDT method

Main variables

Hardness increase

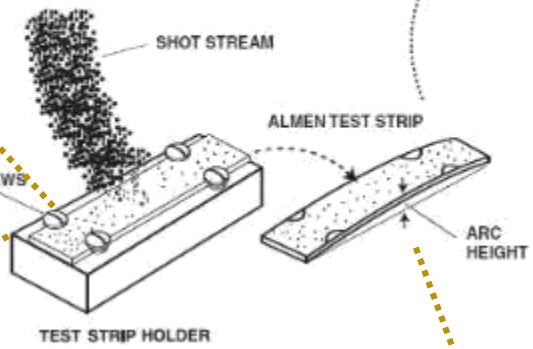
Cold wordek layer depth

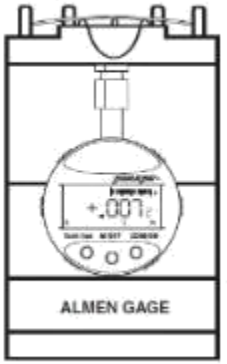
Homogeneous coverage level(CL)

SP Process indirect control: Almen Strip Test

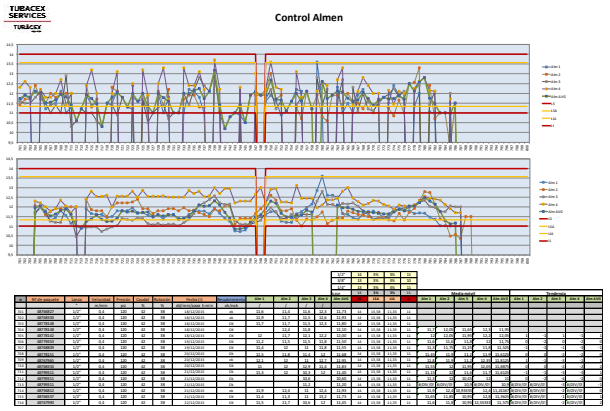
Procedure performed every shift or every time a relevant change in the machine occurs to measure the Intensity of the Shot Peening process.

SAE J442
SAE J443





Arc Height Data

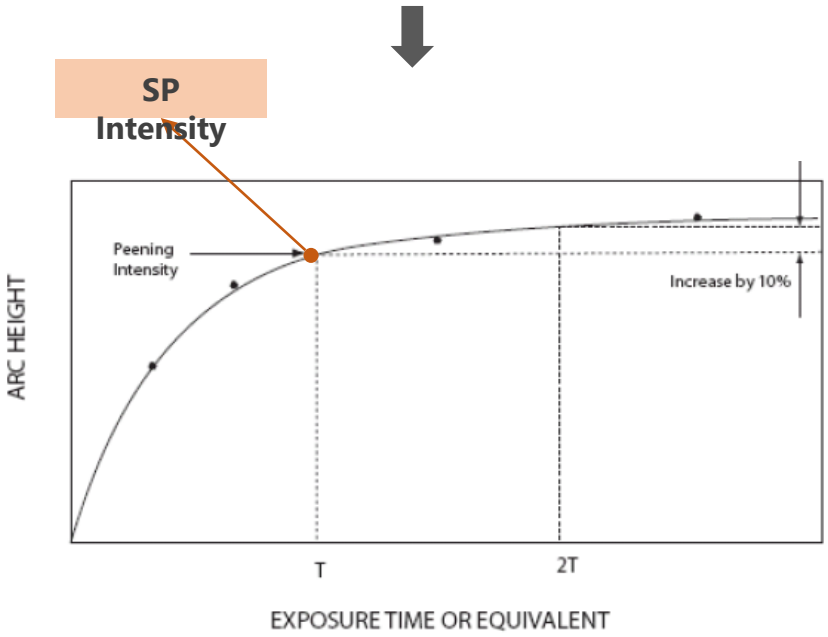


Additional Technique to measure the Coverage developed

SP Process: Almen Strip Test

Saturation Curve

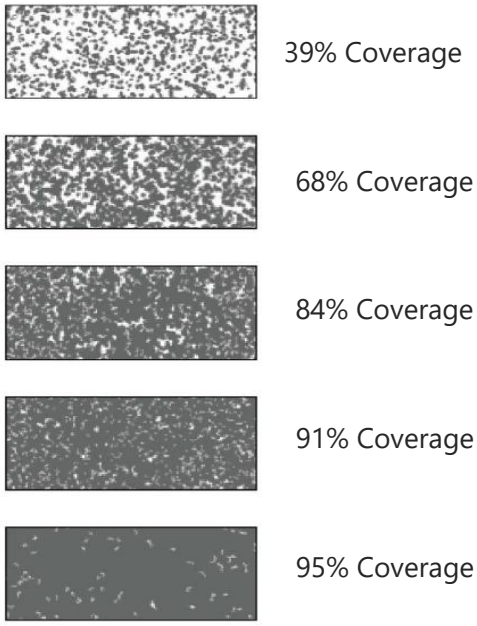
Arc Height Data

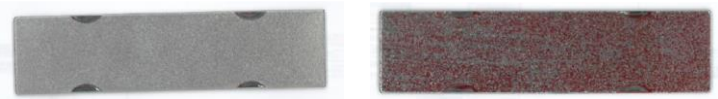


The point on the curve where the arc height increases by 10% when the exposure time is doubled is declared to be the intensity.

Coverage

% of a surface that has been dented at least once by the peening media





OK NO OK

Validation Tests

SP process acceptance

- **Test methods**

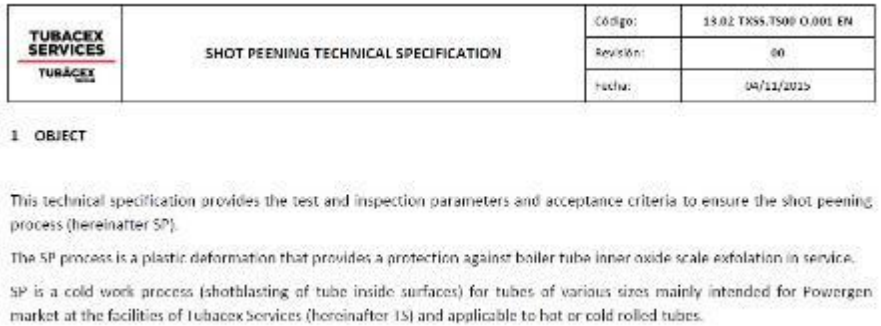
TS Acceptance criteria

Avg. Hv 0,1 (40 µm – bulk) ≥ 100

Depth of shotpeened area ≥ 60µm

- **Scope of inspection**

Per each ID/WT/Material combination, TS quantifies the SP process based on the used machine settings (peening parameters) by performing hardness and microexamination test on one sample cut at sections from the start, middle and end of a tube.



TUBACEX SERVICES	SHOT PEENING TECHNICAL SPECIFICATION	Código:	18.02 TXSS.TS00 0.001 EN
		Revisión:	00
		Fecha:	04/11/2019

1 OBJECT

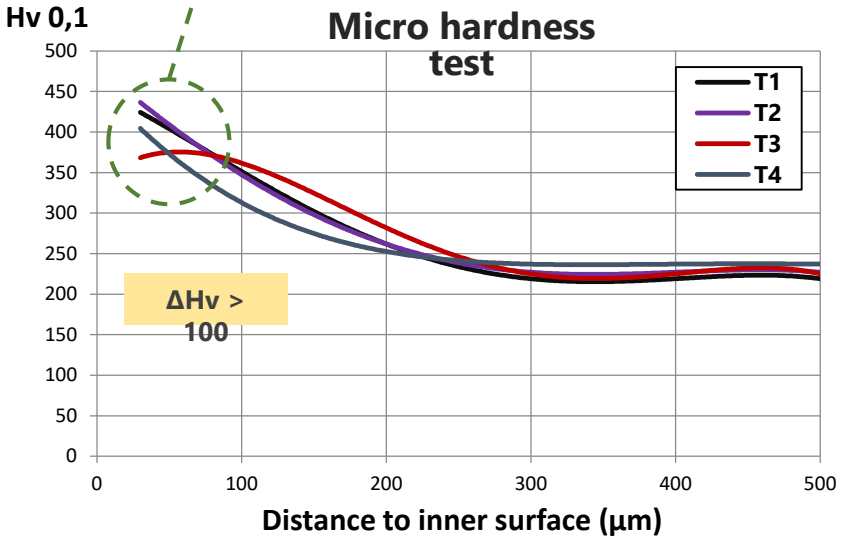
This technical specification provides the test and inspection parameters and acceptance criteria to ensure the shot peening process (hereinafter SP).

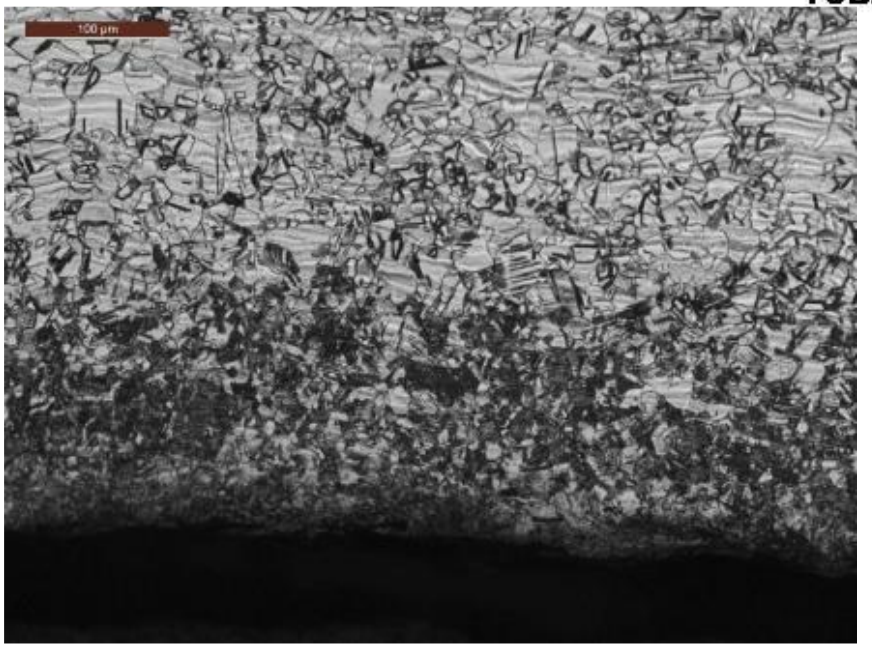
The SP process is a plastic deformation that provides a protection against boiler tube inner oxide scale exfolation in service.

SP is a cold work process (shotblasting of tube inside surfaces) for tubes of various sizes mainly intended for Powergen market at the facilities of Tubacex Services (hereinafter TS) and applicable to hot or cold rolled tubes.

Number of pcs per ID/WT/Material	Sample cut frequency
From 1 to 1000	1 per each 300
From 1001 to 2000	1 per each 400
From 2001 to 4000	1 per each 500

Validation Tests





X200

- Micrographic results per section and microhardness evolution in different dimensions demonstrate TS Shot peening process capability to achieve a homogeneus cold worked layer

Results on TUBACEX trials show a cold worked layer after the shotpeening process matching this information.

- Index
- Shot Peening Process
- PhD & Project Objectives
- Results
- Other results

TUBACEX SERVICES

TUBACEX GROUP

Current Results

Thorough characterization of the properties of the material used by TS in the production process (stainless steel super 304, denomination UNS S30432). In particular, the final level of coverage (coverage level) and the hardening experienced by the material as a consequence of the blasting treatment have been studied.

The following milestones have been reached:
A technique based on the analysis of images obtained by optical microscopy that allows to **obtain experimentally the coverage level** reached

An analytical formula, validated from the experimental results derived from the experimental Works of the Project, to determine the **coverage level** from the process parameters.

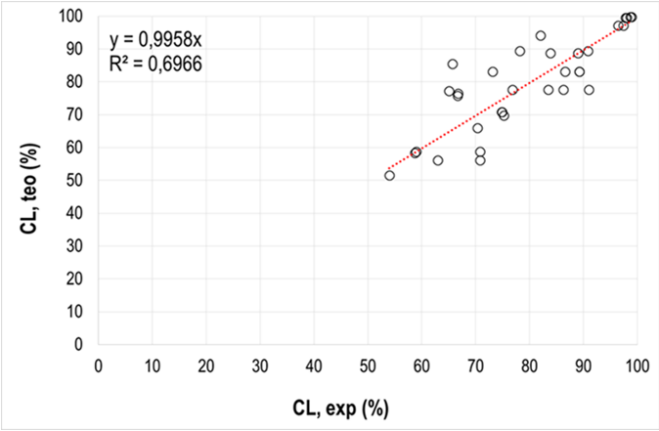
A computational tool, based on the **neural network** method, which, based on the process parameters, results in the distribution function of the material hardness after shot-peening treatment.

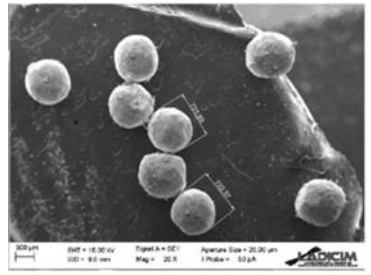
Current Results

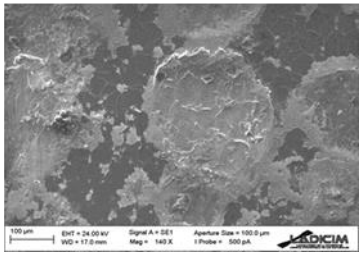
Determination of coverage level through the análisis of images obtained by optical microscopy.

Figure 1: Almen strip aspecto, previously painted, after shot-peening treatment.

Development and experimental validation of a predictive formula for the determination of the **coverage level** according to the process parameters.

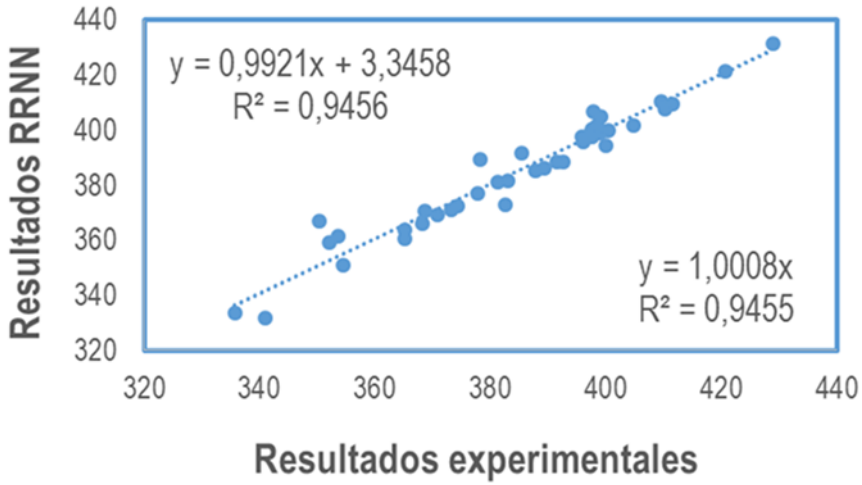






Current Results

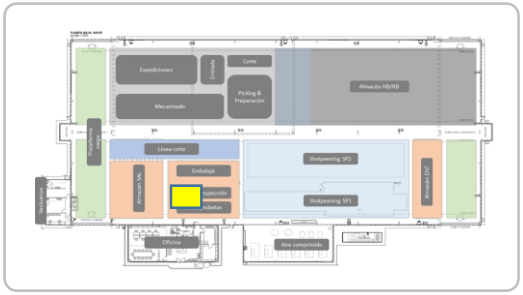
Development and experimental validation of a predictive tool, a neural network, for the prediction of **hardness distributions** according to the process parameters.



For each combination of available process parameters, the average value of experimental hardness (at a certain depth) has been compared with the predictions obtained with excellent results.

Figure 2: Comparison between experimental values and obtained through neural networks.

Current Results



- Index
- Shot Peening Process
- PhD & Project Objectives
- Results
- Other results

Other Results. Conferences, Papers, patent, mentions.

- ✓ *13th International **Conference** on Shot Peening (ICSP-13)* http://www.polymtl.ca/icsp13/en/

Montreal, Canada, 18-21st, 2017. Book of abstracts, pg. 108

- ✓ *Investigation through Artificial Neural Networks on the influence of the shot peening parameters on the hardness of ASTM TX304HB stainless steel.* ASTM Journal of Testing and evaluation.

- ✓ *Measurement of hardness increase for shot-peened austenitic TX304HB stainless steel with electromagnetic Non-destructive Testing*. Revista MEASUREMENT, MEAS-D-18-01291R1

MENTIONS: within the INNOVA program call, this project has been selected as a good practice on Cantabria part to present the action to the Directorate General of European Funds of the Ministry of Finance and Public Function.

Proyecto cofinanciado por **fondos FEDER**

GOBIERNO de CANTABRIA
CONSEJERÍA INNOVACIÓN, INDUSTRIA, TURISMO Y COMERCIO

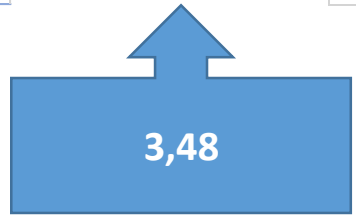
UNIÓN EUROPEA
Fondo Europeo de Desarrollo Regional

Competences assesment; compliance degree

- ✓ Positive annual evaluation, dated march, 15th 2019.
- ✓ *13th International* ***Conference*** *on Shot Peening (ICSP-13)* *http://www.polymtl.ca/icsp13/en/* . Montreal, Canada, 18-21st, 2017
- ✓ Regarding basic skills defined in assesment guide, my self-evaluation (scale 1 to 5) is:

BASIC SKILL	-AVERAGE
CB11	3,67
CB12	4,33
CB13	5,00
CB14	4,00
CB15	3,00
CB16	3,50

CAPAB. & PE	
CA01	3,33333333
CA02	3
CA03	4
CA04	2
CA05	3
CA06	3



THANK YOU!

uc1062@alumnos.unican.es