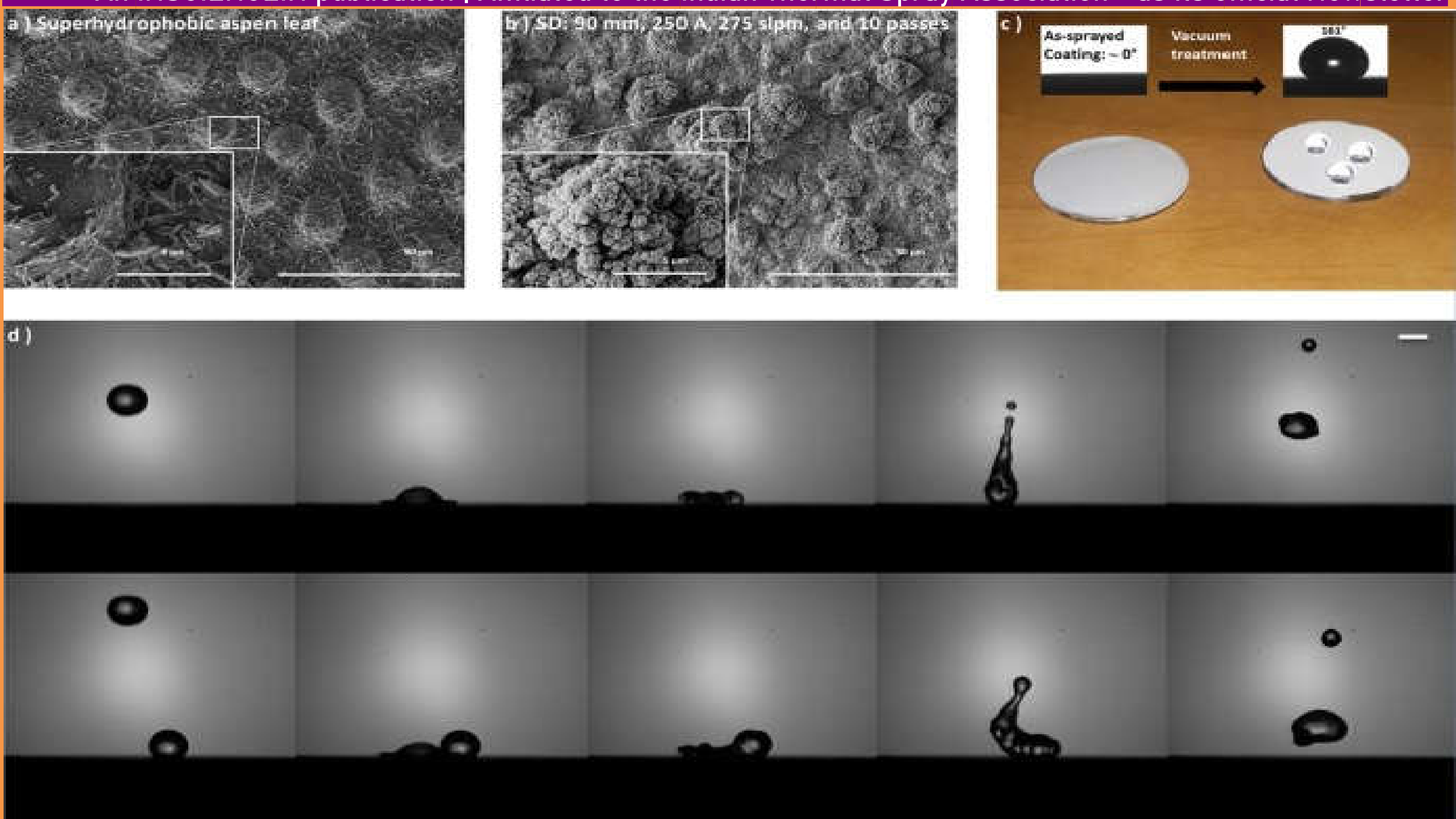
iTSA
Indian Thermal Spray Association®

Dec. 2021| Vol. 1|Issue 4

SPRAYTODAY™

An INSCIENCEIN publication | Affiliated to the Indian Thermal Spray Association® as its official Newsletter



Issue Highlights

- Featured Article: Best Practice for Cylinder Block 3500 Salvage, Pitting and Corrosion in the Surface Top Deck, Water Holes and Bottom Seal Places
- Technical Note: Superhydrophobicity by Thermal Spray Processing
- Industrial: M/s MECPL has launched CNC Automatic External & Internal Dry Shot Peening Machine
- Academia Research: Simulation of Residual Stress due to Shot Peening in AISI 4340 Landing Gear Steel

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Mission: Our mission is to deliver the most recent thermal spray industry news and keep up to date to thermal spray community by providing company, event, people, product, research, and membership news of interest to industrial leaders, engineers, researchers, scholars, policymakers, and the public thermal spray community.

SPRAYTODAY™ is a quarterly publication of the INSCIENCEIN Publishing, affiliated to the Indian Thermal Spray Association® [iTSA] as its official newsletter. Published and distributed digitally INSCIENCEIN Publishing.

A subscription to **SPRAYTODAY™** is free for individuals interested in the thermal spray and coatings industry.
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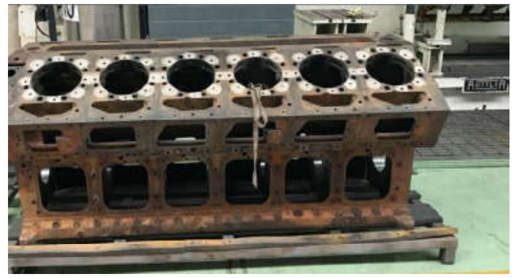

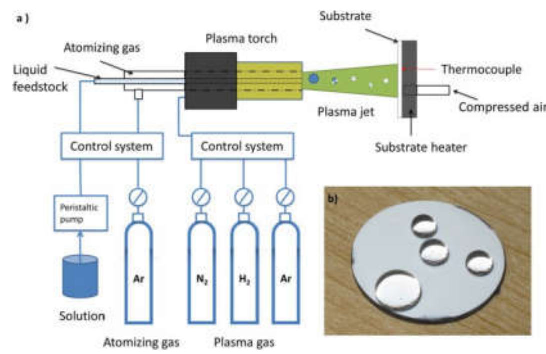

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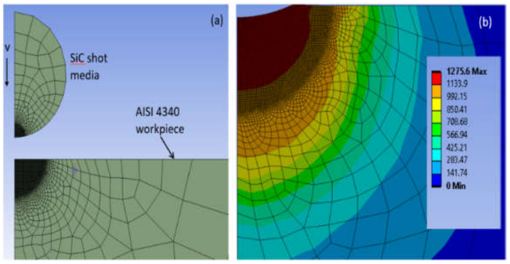

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ABOUT THE COVER

Super Hydrophobic ceramic coating developed by Solution Precursor Plasma Spray

Editor's Note

Dear Readers,

We have been battling Corona for the last two years and Corona has affected everyone's business a lot. The coating industries have also been particularly affected by thermal spray system production and their delivery. Meanwhile, with the opening of the market, a new variant of Corona "Omicron" has knocked. We all still have to take care and follow the corona protocol. Hopefully, in the New Year, we will bravely tackle this new variant as well.

Many foreign automobile and aviation companies are investing in India and it will play an important role in the growth of the Indian economy in the coming decade. This will also increase the demand for thermal spray coating market as different types of thermal spray coatings are being done on the automobile and aviation parts.

On the other hand, thermal spray for remanufacturing and salvage is also being considered and many scrap parts are being remanufactured and salvaged using thermal spraying, which is a cost saving factor. The cost of manufacturing a new part is very high and time consuming, while remanufacturing and salvage the part with thermal spray coating technology can easily cut costs and keep the repaired part as new as possible with the performance. Cylinder heads, engine blocks, compressor housings, crank shafts, rollers, wire drums and many other valuable parts are being rebuilt and salvaged using thermal spray technology. Many parts are also being 3D printed and repaired with cold spray.

I am particularly pleased to be allowed to recommend to you the latest issue of the **SPRAYTODAY**. This issue includes invited innovative featured articles on Practice for Cylinder Block Salvage using thermal spraying, Superhydrophobicity by Thermal Spray Processing, Simulation of Residual Stress due to Shot Peening in AISI 4340 Landing Gear Steel and Automatic External & Internal Dry Shot Peening Machine received from industry and academia experts that illustrate research trends in thermal spray development.

Looking at the future of thermal spray in India, it will be pleasing if SPRAYTODAY can also inspire the spirit of thermal spray research in the country by providing the latest information on thermal spray technology.

Be healthy, active and curious.

Merry Christmas And Happy New Year 2022

Best Regards,

(Dr. Satish Tailor)

Pioneers In Material Science

Kymera International

ADVANCED METALLIC COMPOSITE NIOBIUM CARBIDE CLADDING

US Patent Application No: 63/248,885 (patent pending)

20% More Erosion Resistant Than Other Competitor Products
Extend Service Life by 20%
12X Better (Sulfidation Resistant) Than Uncoated Carbon Steel

COMPOSITE CORED WIRE CLADDING CONTAINING HARD NIOBIUM CARBIDE (NC100 CLADDING)

KEY FEATURES OF THIS NEW INNOVATIVE CLADDING

- > Corrosion & Erosion Resistant
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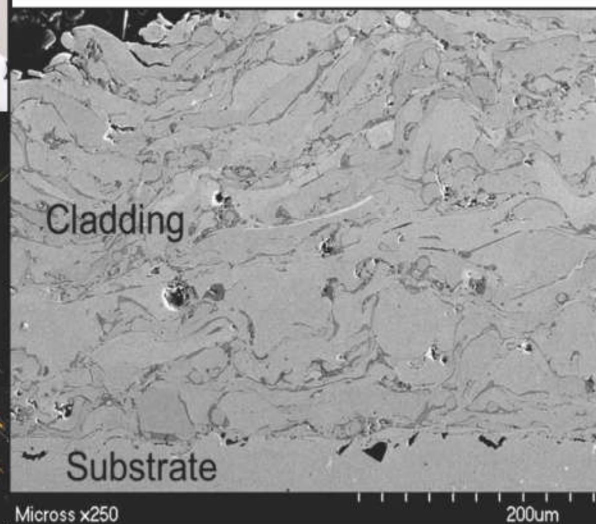
- > High Bond Strength: > 4000 PSI
- > Easily Repairable
- > Porosity: < 4%
- > Total Oxide Content: < 3%
- > Hardness: Average 56 HRC
- > Deposition Efficiency: 68%
- > Cladding Thickness Typically Between 6 mils To 125 mils.

Innovative Wire Feed Stock



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NC100 CLADDING – EROSION RESISTANCE

20% More Erosion Resistant Than Competitor Products in the Market

Best Practice for Cylinder Block 3500 Salvage, Pitting and Corrosion in the Surface Top Deck, Water Holes and Bottom Seal Places

*By **Jimmy Castro**, Director & Founder, C&A 6 Sigma Corp en C&A 6Sigma corp. Rionegro, Antioquia, Colombia.*
Email: jcastro@cya6sigma.com

Cat 785/789/793 OHT are some of the trucks more common in the Mining Industry worldwide. The engines life is affected by corrosion, pitting and wear that occur to the engine block during its operation, it represents the main cost of the parts that are required to repair and get a new life. Today and thanks to the Arc Spray technology, the Cat Dealers has developed the procedures to recover this Part. Just in Latin America is running more than 6.000 OHT. Other Equipment could reach more than 20.000 units.

Figure 1: An engine

Main problems: The engines blocks present the following problems during its operation:- Corrosion, Pitting Wear, Wear, Previous Repairing Issues, leaks, Blowby as shown in Fig 2.

Figure 2: Main problems in engine blocks

Procedure

It must be well defined, step by step, with Points of Quality Control. Figure 3 presents a step by step guide. The very first step is cleaning and washing at the time of reception. Before any further processing, evaluation is a very necessary step. In evaluation the things need to checked are any damage site, dimensions, identify the coating area, area for masking etc. According to the report, the planning is needed. Next step is pre-machining followed by grit blasting (Table 1) on the area where coating is required. Now the job is ready for coating. Arc spray system to be used for coating deposition. Spray parameters are listed in Table 3. Only recommended wire should be used for salvaging (Table 2). After coating the next step is machining or grinding. The final step involves cleaning, dimension check and packing. Coating operator and machining operator should be trained.

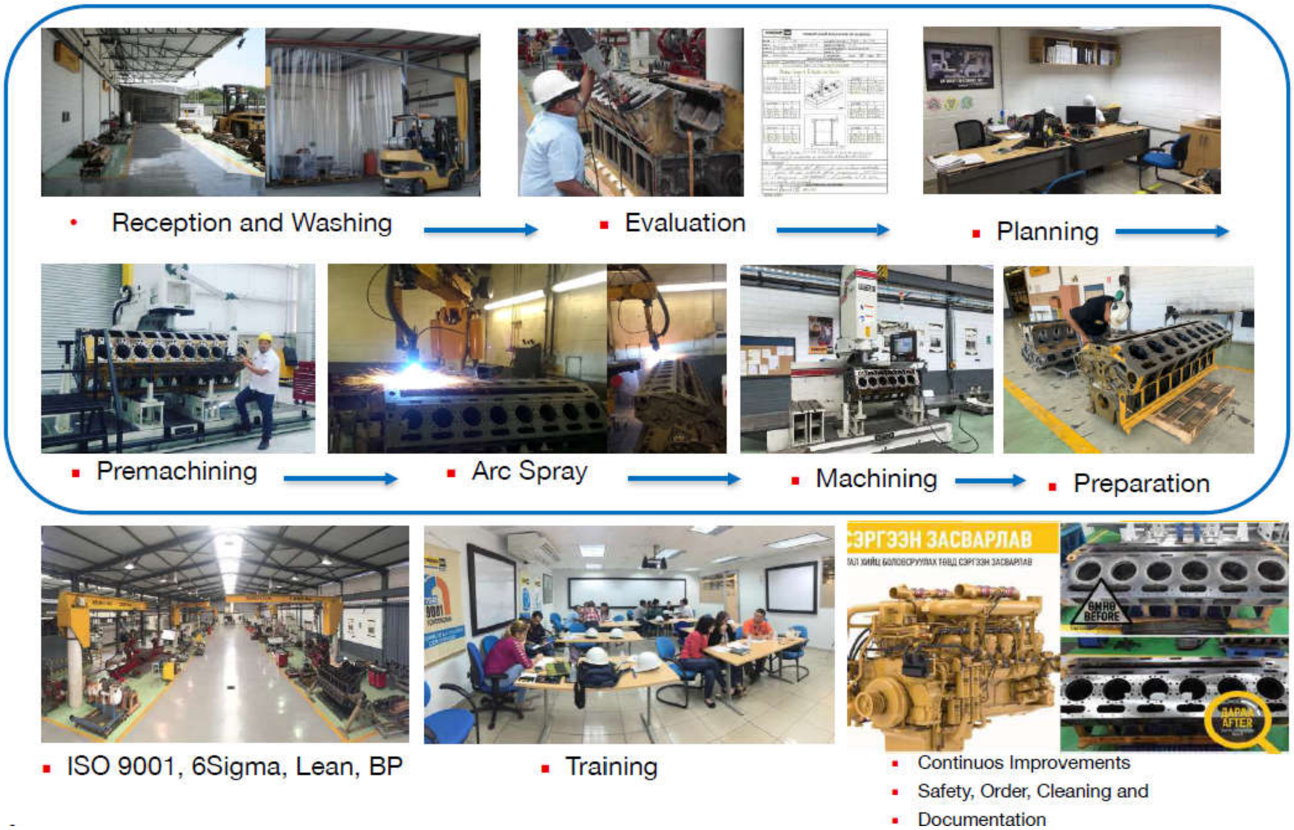

Figure 3: Procedure guideline flow chart

Table 1: Grit blasting parameters

Pressure	100 PSI
Distance	7-8"
Material	Metcolite C 400

Table 2: Material

REF	SM8400
DIAMETER	1/16"
Net WT	26 lbs.
Kgs.	11.79

Table 3: Spray parameters

Variable	Operation Range
Voltage	30V
Current	130 Amp
Pressure	60 PSI
Distance between gun and workpiece	5" (127 mm)
Velocity	150 mm/sec
Thickness Layer (I & F)	0.039"- (1 mm)
Temperature	100-130°C

Coating steps

a: Arc Spray with Robotic Arm and 8400 Wire

b: As sprayed job

c: Machine D Shape for the Seal

d: Machining to final Dimension in a Rottler EM104 or 105 Machine

e: Perform the Leak Test

Figure 4: Coating procedure steps

Resources Required

Fully integrated, self-contained coating facility with a Smart Arc Advanced Electric Wire Arc Thermal Spray System. The leading-edge gun head is integrated to a Robot arm and a Workpiece Manipulator (Turntable). The system produces highly reliable electric wire arc spray coatings for wear protection, restoration of component dimension and corrosion protection.

a) Arc Spray System
b) Robot
c) Training
d) Rottler CNS Grinding

Benefits

1. Improve the Quality of the Deposits
2. Reduce the Process Time. (50%)
3. Reduce the Costs and allow the effective control costs. (43%)
4. Increase the useful life of the block. (+3 Times)
5. Guarantee the optimal operation without probability of leakage from the cooling system in the area
6. Eliminates the use of a sleeve top and in the bottom of the liner

Statistics: +650 Engines Blocks has been salvaged with this new procedure, no Redo, Life has reach more that 25.000 hrs (Up to 45% better than before)

Successful Stories: Matco, Wagner, Venequip, Relianz, Ferreyros, Finning.

Figure 5: Another Parts of Engine and other Components that can be salvaged: +60.000 parts salvaged by Arc Spray at VMS.

Previous Caterpillat Salvaging

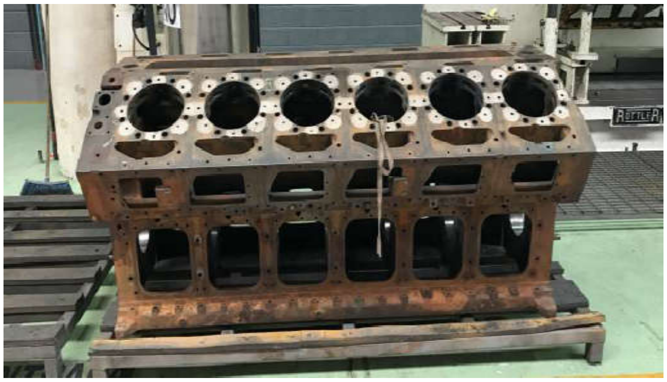

Figure 6: Insert with SS, CI or Brass. For recover the surface already used: Arc Spray + 8400 wire.

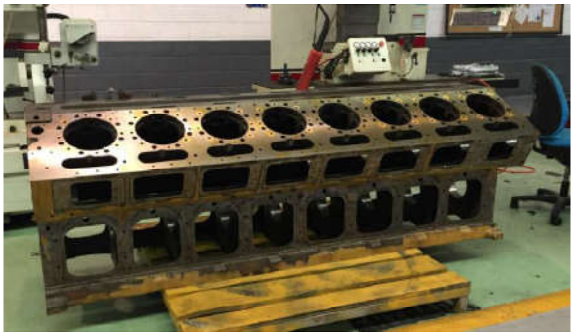

Figure 7: Dealers development 2012: Spot Face to fill up the water holes and liner seat. Using Smart Arc + 8400 Wire

Figure 8: Dealers development 2017: fill up the water holes, liner seat and Surface. Using Smart Arc System + 8400 Wire, Optional 8293 Wire

Recommendations: Motivate and work with Customers to Develop the Best Practice

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Best Master Thesis and PhD Thesis Award in Thermal Spray (Annually)

An initiative has been taken to promote thermal spray research and its application in India by the Indian Thermal Spray Association-iTSA.
Nominations are invited for Best Master Thesis and PhD Thesis, work done in the field of thermal spray in India. Please send your entries to iTSA office info@indtsa.org with following details

- Scholar Name and Email address
- Supervisor Name
- Supervisor's Institute and email address
- Supervisor's Contact number
- Thesis Title
- Year of completion
- Brief summary of PhD thesis, including novelty of the work (max two pages) and highlight the potential applications.
- A recommendation letter from supervisor on letterhead
- A list of published research papers based on the work

Judges from Prime Educational institutes/ National Labs/Industries will evaluate the work potential and its application. Based on the evaluation report, winners will be announced.

Superhydrophobicity by Thermal Spray Processing

By **Mehdi Khodaei**, *K.N. Toosi University of Technology, Tehran, Iran. Email: khodaei@kntu.ac.ir*
Hua Li; *Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo, China. Email: lihua@nimte.ac.cn*

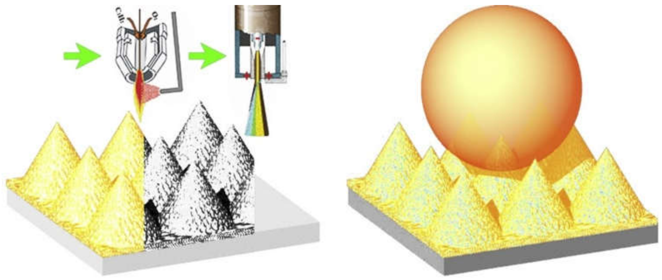
Thermal spray coating methods are one of the widely used and versatilemethods of fabrication of functional coatings. Superhydrophobicity is one the interesting and unique functions that can be achieved using thermal spray methods. The coatings should have two main properties in order to become superhydrophobic; a hierarchical micro and nanoscale roughness should be fabricated and the surface energy should be lower than water. In that case, the water contact angle (WCA) will rise to higher values than 150° and the Sliding angle and contact angle hysteresis (CAH) will be less than 10°. Hence, the such coatings have a unique behavior against water droplets which results in new applications including self-cleaning, anti-icing, anti-fouling and anti-bacterial, drag reducing, oil-water separation, enhanced corrosion resistance [1]. In case of thermal spray coatings, there are various approaches that have been taken to achieve superhydrophobic properties. Prof. Hua Li's group at Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences[2] worked on three kinds of coatings using three different thermal spray methods. They used a high velocity arc spray system in order to deposit Al coating, flame spray to deposit Cu coating, and atmospheric plasma spray to deposit NiCrBSi. All the coatings were hydrophilic after the coating, and they used a 5% PTFE solution and put samples inside it for one hour at room temperature, and then cured them for 2 hours.

Table 1: WCA and sliding angle measurements of the thermal sprayed coatings before and after the surface modification by PTFE[2]

Samples	Water Contact Angle°	Sliding Angle°
Al coating	0	NM
Al coating – PTFE	152.5	3.5
Cu coating	62	NM
Cu coating – PTFE	151	7
NiCrBSi coating	26	NM
NiCrBSicoating – PTFE	150	8.5

After this process, a thin layer of PTFE was made on the thermal sprayed coatings and led to a rapid increase in WCA, and as a result of that, superhydrophobic properties were achieved. In Table 1, WCA and Sliding angle measurements before and after surface modification with PTFE coating are reported.

In another study at Prof. Hua Li's group[3], a novel superhydrophobic coating was fabricated completely by thermal spraying in which they used atmospheric plasma spray and flame spray method for deposition. At first, they deposited Titania coating on stainless steel substrate, which was covered by a stainless steel mesh in order to make a micro pattern on the substrate. Three different sizes of meshes with pore sizes of (74µm, 173µm, and 125µm were used. After making the micro pattern, PTFE and nano Cu mixture with PTFE was coated on the sample by flame spray method. The combination of micro structure on the substrate by the plasma sprayed Titania followed by Cu nanoparticles and PTFE low surface energy led to superhydrophobicity.The micro structure made by the Titania plasma spray coating did not have any obvious effect on the WCA, but they showed that this unique structure would improve the mechanical stability of the superhydrophobic coating in Fig.1 schematic of the surface structure and SEM images of the surface after each coating step are provided.They showed that this micro pattern structure that had been made by the plasma spray of Titania helped to improve mechanical properties and stability of the superhydrophobic properties.



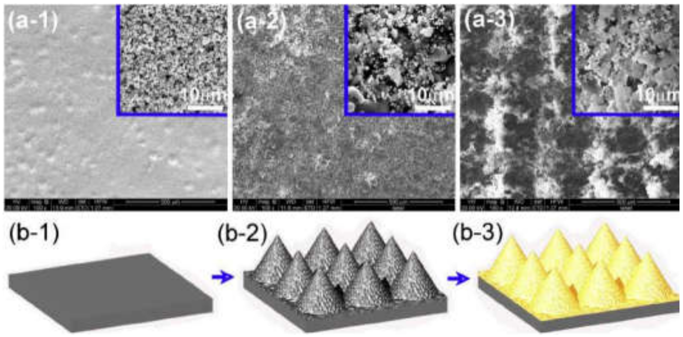


Figure 1: Schematic of coating processes and SEM image and schematic of the sample before coating (a-1, b-1), after Titania plasma spray coating (a-2, b-2), and final superhydrophobic coating after deposition of PTFE-nano Cu coating (a-3, b-3)[2].

As mentioned before, low surface energy hydrocarbons are usually used in order to fabricate superhydrophobic coatings. These polymeric modifiers are not stable in harsh environments,and as a matter of fact, the superhydrophobicity of the coating will not last. So in order to reach stable superhydrophobic properties, there is a need for robust inherently hydrophobic materials.

In 2013 for the first time, Azimi et al.[4] discovered that Rare Earth Oxides(REOs) from Ceria to Lutecia are hydrophobic in nature. On the other hand, most ceramics are hydrophilic due to their high surface energy. The unique electronic structure of REOs limits the polar interactions, and it is not possible for water molecules to make hydrogen bonding to the surface. This will result in the hydrophobicity of the REOs. The question here is how the electronic structure of REOs caused the hydrophobicity of these ceramics or not?. To answer this question, the electronic structure of these ceramics should be described. As shown in Fig.2, the full octet layer of 5s2p6 has covered the unfilled 4f orbitals, so it will be like a barrier for these unfilled orbitals, and this will decrease the chance of Hydrogen bonding formation with the water molecules to its minimum and leads to the hydrophobicity of the REOs. On the other hand, for Al2O3 and almost all other ceramics, there is no barrier that limits the hydrogen bonding, and as a result, water will spread all over the surface of the ceramic, which indicates their hydrophilicity.

Azimi et al. [4] did extensive research on all REOs and measured their surface energy and WCA. That research approved the intrinsic hydrophobic nature of REOs.Although it was mentioned that these ceramics are intrinsically hydrophobic, but the presence of excess oxygen on the surface of these ceramics will produce a perfect place for Hydrogen bonding and will result in a reduction in WCA and hydrophilic behavior.

This is a problem that can hinder the hydrophobic nature of the REOs, So if the excessive oxygen gets removed from the surface, then these ceramics can show their hydrophobic nature.

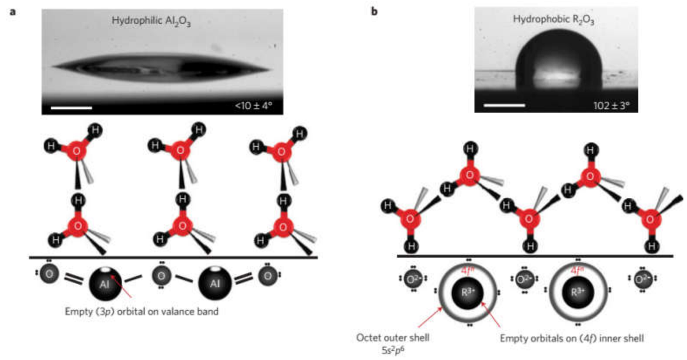


Figure 2: comparison of the unique electronic structure of REOs and Al2O3, which leads to different wetting behavior against water[4].

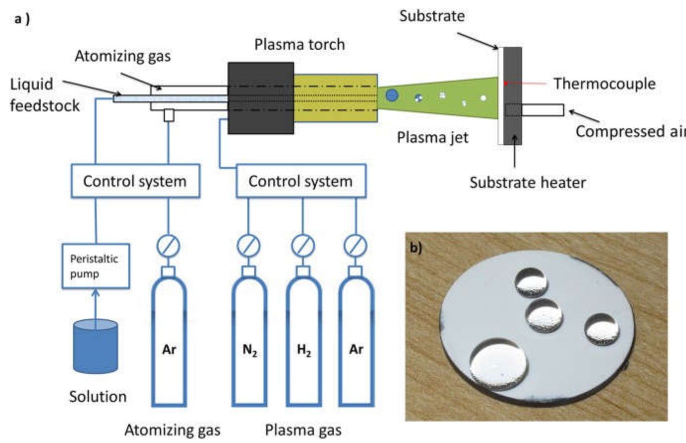


Figure 3: (a) Schematic of the SPPS deposition system. (b) Water droplets of different sizes on the coated surface [5].

At Department of Mechanical and Industrial Engineering in University of Toronto, Prof. Mostaghimi's group introduced superhydrophobic Yb2O3 coating by the SPPS method for the first timein 2016. As mentioned before, rare earth oxides were found out to be intrinsically hydrophobic in 2013. By understanding REOs hydrophobicity, they deposited this hydrophobic ceramic (Yb2O3) on the substrate by the SPPS method in order to achieve robust superhydrophobic coating. But the main problem with the SPPS method is that the optimum parameters are usually very challenging to find. The feedstock was 1molar Ytterbium Nitrate in 50%wt water and 50%wt ethanol solution. There are many parameters such as plasma power, feed rate, plasma velocity, number of passes, solvent, and many other tiny details can such as needle size, feedstock injection mode (radial, axial), space between needle and plasma plume and etc. which all can directly affect the coating microstructure and therefore its wettability properties. So they studied

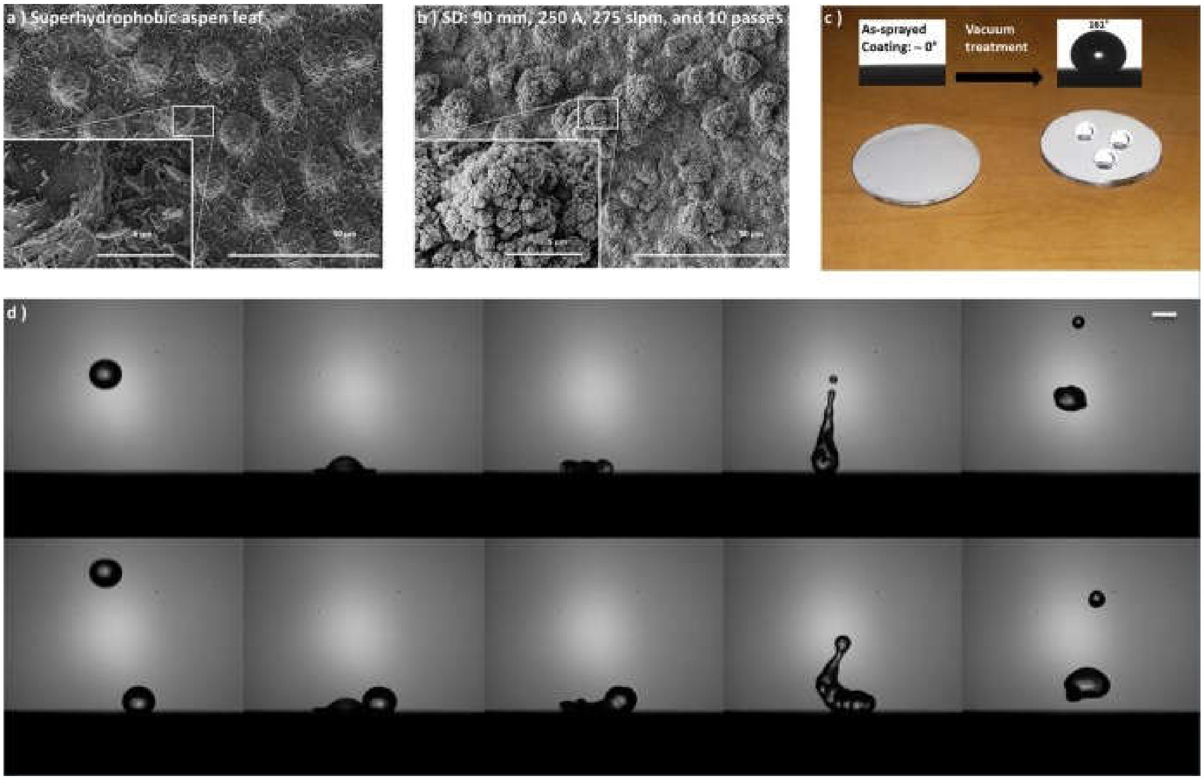


Figure 4: Topography and dynamic impacts of water droplets on the coated surface. (a) SEM image of the surface of a superhydrophobic quaking aspen leaf shows a hierarchically structured surface. (b) SEM image of the surface of a coating. (c) Change in wetting behaviors of the coating under various conditions (vacuum treatment). Sample size is 25.4□mm in diameter. (d) Dynamic impact of a single water droplet (top panel) and coalescence of 2 droplets (bottom panel) on the coated surface [5].

the effect of different parameters such as standoff distance, plasma power, number of passes, solvent, and plasma velocity in order to find optimum conditions.

It is worth to mention that there is several scientific reports on fabrication of superhydrophobic coatings by thermal spraying process in the last decade, which can be introduced to the industries.

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M/s MECPL has launched CNC Automatic External & Internal Dry Shot Peening Machine

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Shot peening is a cold working process, surface of the part/job is treated by striking the spherical media called shots (round metallic, glass or ceramic particles). These shots after striking on metal, creates dimple or small indentation on the surface with force sufficient to create plastic deformation. It is a process used to produce a compressive residual stress layer and modify mechanical properties of metals.

Shot peening is often called for in aircraft repairs to relieve tensile stresses built up in the grinding process and replace them with beneficial compressive stresses. Depending on the part geometry, part material, shot material, shot quality, shot intensity, shot coverage, shot peening can increase fatigue life from 0%-1000%.

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. Shot peening is the most economical and practical method of ensuring surface residual compressive stresses.

Some of the applications where shot peening are used:

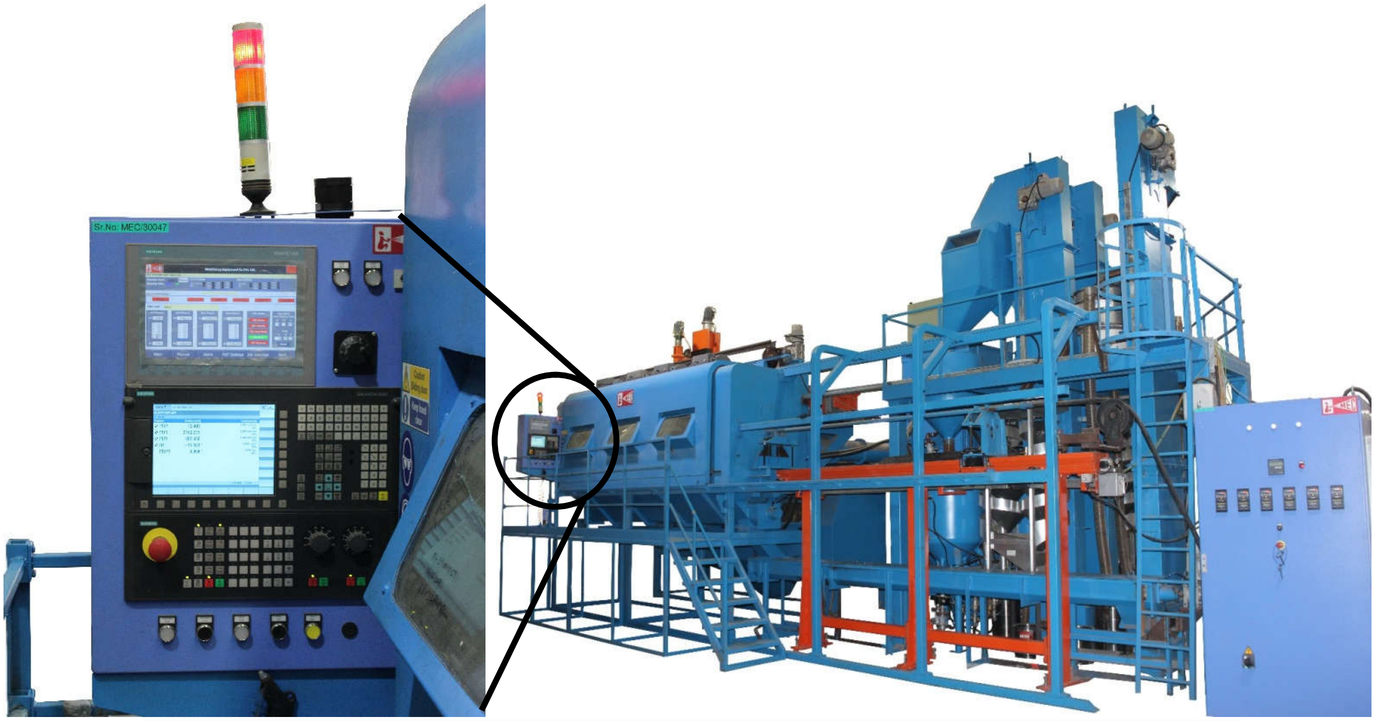
- Gear parts
- Cams and camshafts.
- Connecting rods.
- Gearwheels, leaf and suspension springs and rock drills
- Turbine blades, landing gears and engine shafts

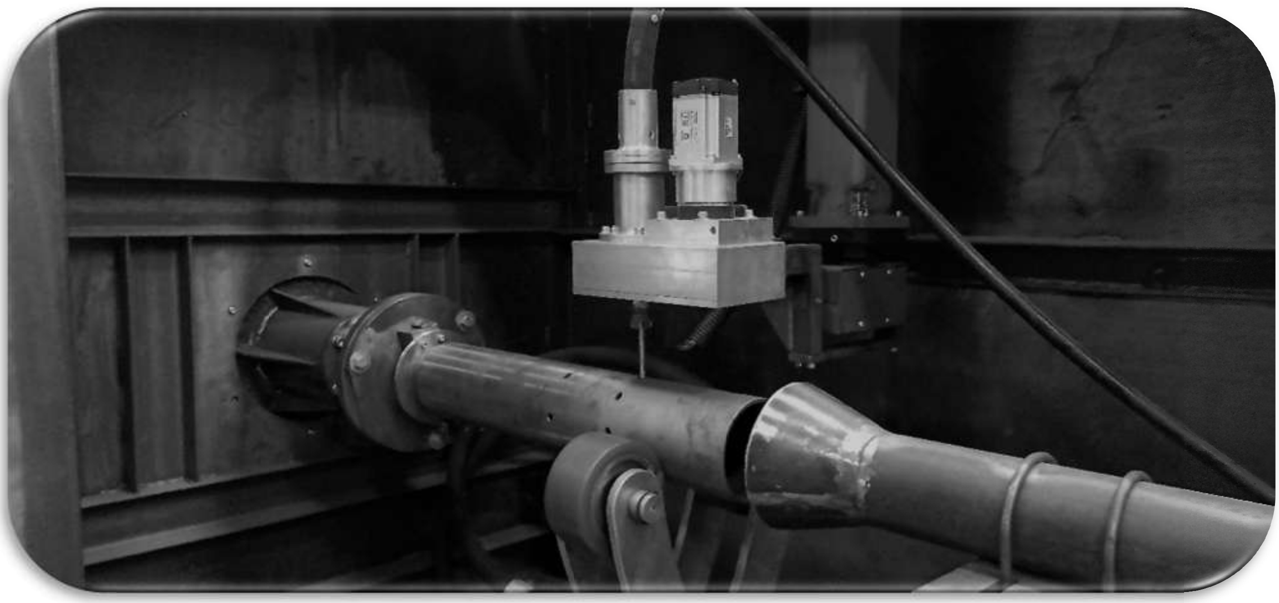
In INDIA, MEC develops and manufactures customized automated machines for surface treatment processes; shot peening included.

MEC provides consultation, specific solution for any of the industry-whether specialized in engines, landing gear, engine components and structural components.

MEC has launched CNC Automatic External & Internal Dry Shot Peening Machine, Model: PB-451214 for the Aerospace Industry. Machine is developed for shot peening on engine shafts and components with process repeatability. The technical design is developed in cooperation with the customer, to meet their requirement in term of machine capability, part processing and repeatability.

Machine and Working Description:
Complete machine is customized and designed specially to achieve ideal working conditions for shot peening process. Peening chamber is designed and constructed with sound absorbing materials taking under consideration strict health regulations and providing safe working environment for operators. After placing the job, operator will close the sliding door and start an automatic Peening cycle according to pre-set programs stored in PLC controller. Nozzle movement during the peening is controlled by CNC controller. One can perform CNC programming or use post-Processor for motion programming.





Some of the machine features are:

- Automatic peening mode: For precision manipulation of peening nozzle, PLC with CNC controller is installed to control the movements, parameters are fully controllable and repeatable suitable for shot peening process and further provides ability to create reports for particular jobs.
- Media flow control through magna valve: For precise flow of peening media, magnetic valves with closed loop regulation are being used. The Magna Valve provides reliable, repetitive, and consistent shot peening process with confidence of proper media flow rate at all time. In case of difference in flow rate, magna valve will generate alarm
- Air flow control through close loop air pressure regulator: For precise flow of air, closed loop air pressure regulators are being used. In case of difference in air pressure, machine will generate alarm and shown on HMI screen
- Vibratory classifier for size segregation
- Spiral shot separator for shape segregation
- Rotating lance nozzle
- ID peening nozzle for long shafts upto 3500 mm.

Simulation of Residual Stress due to Shot Peening in AISI 4340 Landing Gear Steel

*By **Abir Bhattacharyya** and **Aman Bansa***
Department of Metallurgical & Materials Engineering, IIT Jodhpur
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Investigation of Structural and surface integrity requires understanding the effects of manufacturing and surface processes (e.g., machining, forming, shot peening, and laser-shock peening) on residual stress, surface roughness and cold work of the surface and subsurface layers of the processed material, including the effect of these alterations on the surface-related physical and mechanical properties. Anyone who is not closely familiar with the challenges of maintaining the safety and integrity of commercial, military, corporate and private aircrafts, may wonder what is Shot Peening! This article is primarily targeted to delineate the role of shot-peening to induce residual stresses, which improves life of aircraft landing gear steels [1].

Shot Peening is a cold process which uses tiny spheres of steel, glass or ceramic (in the order of over 0.5-1.5 mm in diameter) impacting on to the surface of metallic components. These spheres are propelled at about 50-70 m/s on to the surfaces of metal parts to permanently deform the surface, and create dimples (Fig. 1(a), and (b)). The multiple indentations subject the material subsurface and surface to plastic loading due to progressive shot effects. The outer layers are subjected to an in-plane stretch, whereas the elastic region surrounding the subsurface plastic-zone tries to retain its original shape during unloading [2]. However, continuity conditions between the elastic and the plastic zones do not allow for this to occur. Consequently, a compressive residual stress field is developed in the near-surface layer of the structural component, to maintain equilibrium in the peened component, a tensile residual stress field is developed through the depth of the component. This compressive residual stress induced by shot peening reduces the effective applied stresses of the component during application, resulting in delayed crack initiation and retarded crack propagation from the surface. Shot-peening is therefore an effective method widely used in the industry, which can considerably improve the fatigue strength and life of cyclically loaded metallic components by inducing compressive residual stress and work-hardening into the surface region [3].

There are several parameters involved in shot peening which need to be regulated in order to tailor compressive residual stress distribution within the component. These parameters can be sorted into three groups relating to the shot, the workpiece and the process. In order to control the resulting residual stress pattern in a peened part, it would be highly desirable to determine quantitative relationships between these parameters and residual stress characteristics. The evaluations of the shot peening mechanism are largely

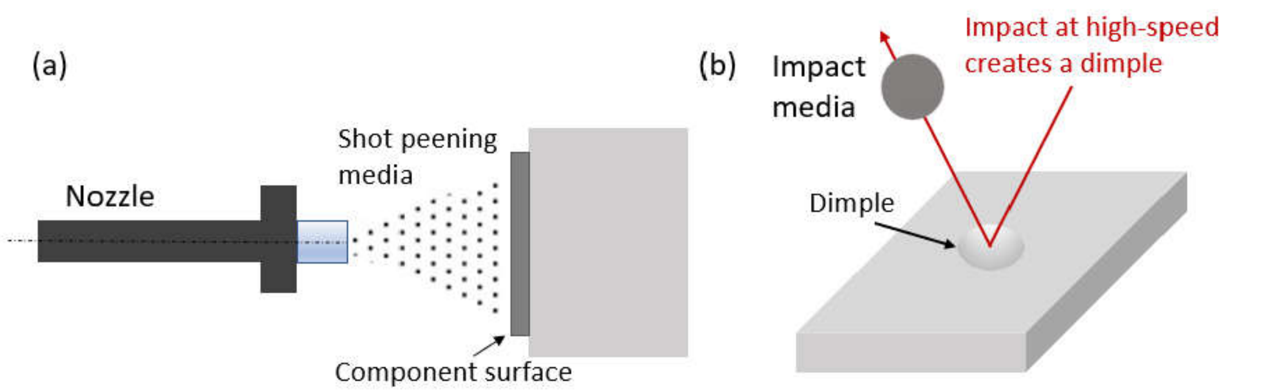

Figure 1: (a) Schematic showing shot peening of a component surface by impact of shot peening media (b) demonstration of a dimple on the surface of the component.

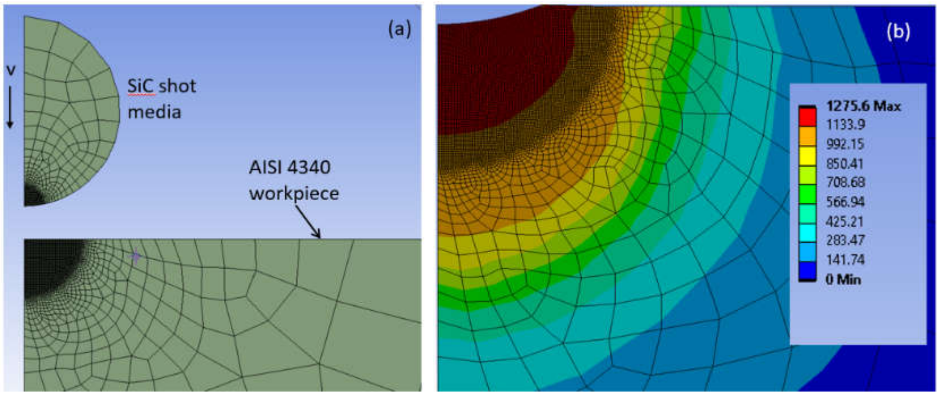

Figure 2: (a) Meshed SiC shot media and AISI 4340 workpiece. (b) Dimple formed on surface during to impact at a velocity, and the associated equivalent stress profile during loading at a velocity of 50 m/s

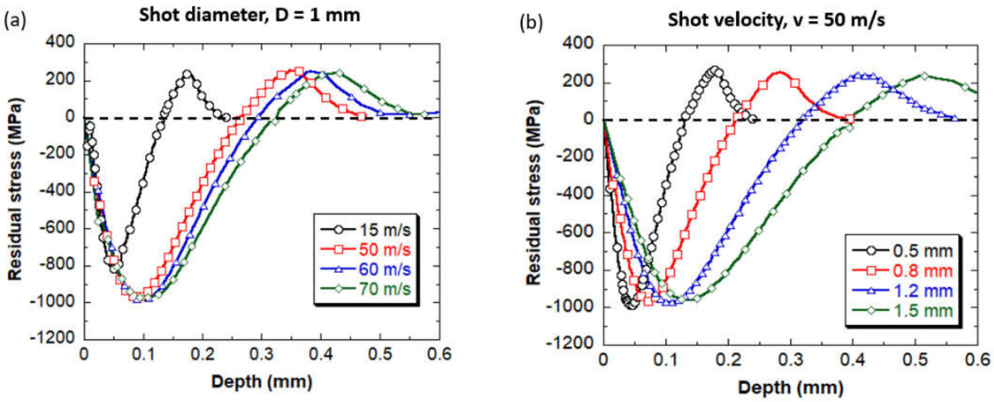

Figure 3: Residual stress profile after unloading as a function of depth from impact surface for (a) D = 1 mm at different impact velocities, (b) v = 50 m/s for different shot diameters

based on experimental work that is very difficult, tedious, costly and time consuming. The availability of powerful finite element codes, such as ANSYS, LSDYNA, ABAQUS, etc. allow simulation of dynamic processes. Modeling and numerical simulations can also provide as insight into the spatial and temporal evolution of deformation and stresses during the impact of shot on the target material.

In the current article, we present how finite element analysis of ceramic shots impacting on metallic target plates can be used to understand the effect of shot velocity and shot size on the compressive residual stress. To carry out simulation of shot-peening process, explicit dynamics tool of Finite Element Package, ANSYS R19 has been used. The ANSYS explicit dynamics suite enables to capture the physics of short-duration events for products that undergo highly nonlinear, transient dynamic forces.

A 2-Dimensional (2D) axisymmetric Finite Element model with half symmetry is developed to simulate the perpendicular impact of a single elastic sphere on an elastic-plastic workpiece. The main model consists of two parts that involved a deformable 2D equivalent of a 40 mm thick and 100 mm wide plate (workpiece) made of AISI 4340 steel, and a ball made of Silicon Carbide ceramic. Figure 2(a) shows the 2D Finite element model that was used to simulate the single shot impact on the workpiece. The geometry of the workpiece is kept constant in all analysis. The boundary condition on the workpiece was bottom end fixed, and the far end was kept free. The contact surface of the workpiece was kept free. The meshing was done using four-node quadrilateral element. Very fine mesh size of 5 micron was used in the vicinity of contact between the ball and the workpiece to capture the nonlinear force displacement behavior that is typical of a contact problem. The Johnson-Cook [4] material model was chosen as the constitutive model and the material model parameters of AISI 4340 steel already incorporated within ANSYS database were used to carry out the simulation.

The effects of key parameters, such as, shot velocity and shot size, on the mechanical response of the workpiece were examined. In all of these models the workpiece was assumed to be an elastic-plastic with isotropic hardening material. Unlike the experimental process, the results of the simulation are independent of distance between centre shot and workpiece surface. Therefore, this distance is assumed to be 1 mm for quick running of the model. The velocity of SiC shot is assumed to be in the vertical direction and applied to the body as an initial condition. All results were obtained from a variation of residual stress along the path that is created by selecting nodes along the central axis in target plate.

Effect of shot velocity: The single shot finite element analysis is performed to investigate the influence of shot velocity. Five different impact velocities were used with rigid shot with diameter D = 1 mm. Figure 3(a) shows the variation of residual equivalent von Mises stress along the depth after unloading, for the five impact speeds selected. Figure 3(a) shows that an increase in the velocity of shot results in an increase in magnitude of the maximum residual stress at lower velocities of impact, but the maximum residual stress for the three velocities 50 m/s, 60 m/s, and 70 m/s are very close to each other. However, an increase in the velocity of shot results in an increase in the of depth of the compressive residual stress meaning more volume of material in the subsurface is subjected to compressive residual stress.

Effect of shot size: The effect of shot size (diameter of impacting sphere) on the residual stress distribution is shown in Fig. 3(b). The impact velocity of each shot media was kept constant at 50 m/s. An increase in the size of the shot media results in decrease in magnitude of the maximum compressive residual stress created in the target plate surface, and an increased depth of the compressed residual stress. Therefore, more volume of subsurface materials is subjected to compressive residual stress

Summary: A 2D finite element dynamic analysis with consideration of the unloading effect was conducted to simulate the shot peening process and to predict the residual stress distribution within AISI 4340 steel. The effects of shot velocity, shot size upon the variation of residual stress after unloading have been examined and discussed. The results reveal that increase in shot velocity largely increases the magnitude and depth of the residual stress field created in target plate. However, the increase in the shot size results in decreased magnitude of the residual stress field although the depth of maximum von Mises stress increases and the compressive stressed volume increases.

The present work also indicates that the proposed finite element analysis is useful for the investigation of the influence of various parameters on the shot peening process. This process can be simulated by finite element analysis and can be potentially adopted to design the shot-peening process parameters for achieving desired residual stress distribution within subsurface of aircraft components to improve fatigue life of landing gears.

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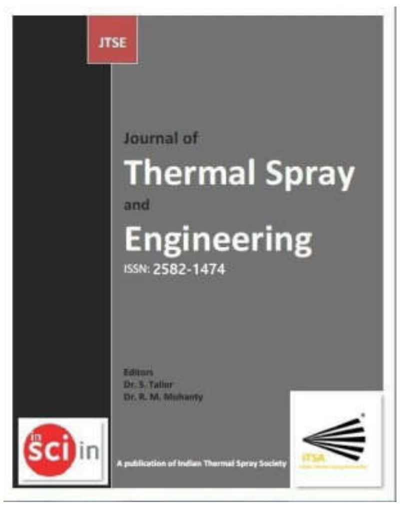

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