TENSIONED WIRE BLASTING – FUNDAMENTALS, ADVANTAGES AND APPLICATIONS

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Abstract

Plant owner's and grid operator's key concern is the question of how long protective coating systems will last in corrosive environments. For these systems is a proper surface preparation of paramount importance. Regardless of whether initial installation or maintenance carried out in difficult to access areas can be up to 20 times more expensive than performed in the shop. This holds especially true where abrasive blasting with respect to surface preparation standards according to SSPC-SP 10/NACE No. 2 or SSPC-SP 5/NACE No. 1 is not possible.

The Tensioned Wire Blasting technology (also known as Bristle Blasting) meets both, the required surface preparation conditions and the cost- and time-efficiency. By providing a cleanliness of SSPC-SP 10/NACE No. 2 at the very least with an anchor pattern with roughness profile R_z between 60 and 120 µm (2.3 – 4.7 mils), the technology is able to solve many construction site related issues. Besides versatility due to handheld operation, health and safety aspects (e.g., eco-friendly, dustless, low-vibration) are satisfied as well as the approval for operating in potentially explosive atmospheres and areas.

Introduction

Remedial coating systems protect against corrosive environments, but what if these systems aren't intact and have to be fixed? Maintenance carried out in areas which are difficult to access, especially where wet and abrasive blasting with respect to SSPC's surface condition SP 10 or SP 5 is not possible, can be up to 20 times more expensive than the maintenance carried out in the shop.[1] The following article will, hence, reflect several key elements of the Bristle Blasting technology in terms of the surface condition, residual stresses created on the surface as well as health and safety aspects.

Coating Adhesion and Cyclic Corrosion Tests

Surface preparation tools like power wire brushes, grinders or needle scalers are capable of realizing SP 11. However, these surface conditions ultimately lead to adhesion failure of the coating system by generating poor anchor profiles. In contrast, the Bristle Blasting process removes coatings and affords an anchor pattern giving surface profiles that are similar to grit blasting. The main difference between traditional wire brushing and the Bristle Blasting surface treatment is that score markings and striations are eliminated, because bristle tips retract immediately after impacting on the target surface.[2]

Performance tests comparing the chosen surface preparation methods were carried out on carbon steel with rust grades A and D, respectively. In both rust grade cases, roughness values R_z were much higher for Bristle Blasting than for standard power tooling techniques. Moreover, the recorded values are similar to those of grit blasting.[3]

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[1] Wilds, N.: "Bristle Blasting Surface Preparation Method for Maintenance". In NACE Corrosion Conference 2009, Atlanta, Paper no. 09004, p. 1

[2] Ibid., p. 2

[3] Ibid., p. 3

Cyclic corrosion tests according to ISO 20340 were made under laboratory conditions after applying different coating systems on test specimens simulating Korean shipyard conditions. Pull-off tests show an improved corrosion resistance for Bristle Blasting due to higher adhesion of coating systems to substrates. Substrates being machined by the power wire brushing method were still corroded and therefore unstable due to disbondment. That is, Bristle Blasting clearly outperforms conventional power tool techniques, and is at least equivalent to and even can exceed the cleaning that is achieved by white metal blast cleaning SP 5 (see Figure 1).[4, 5]

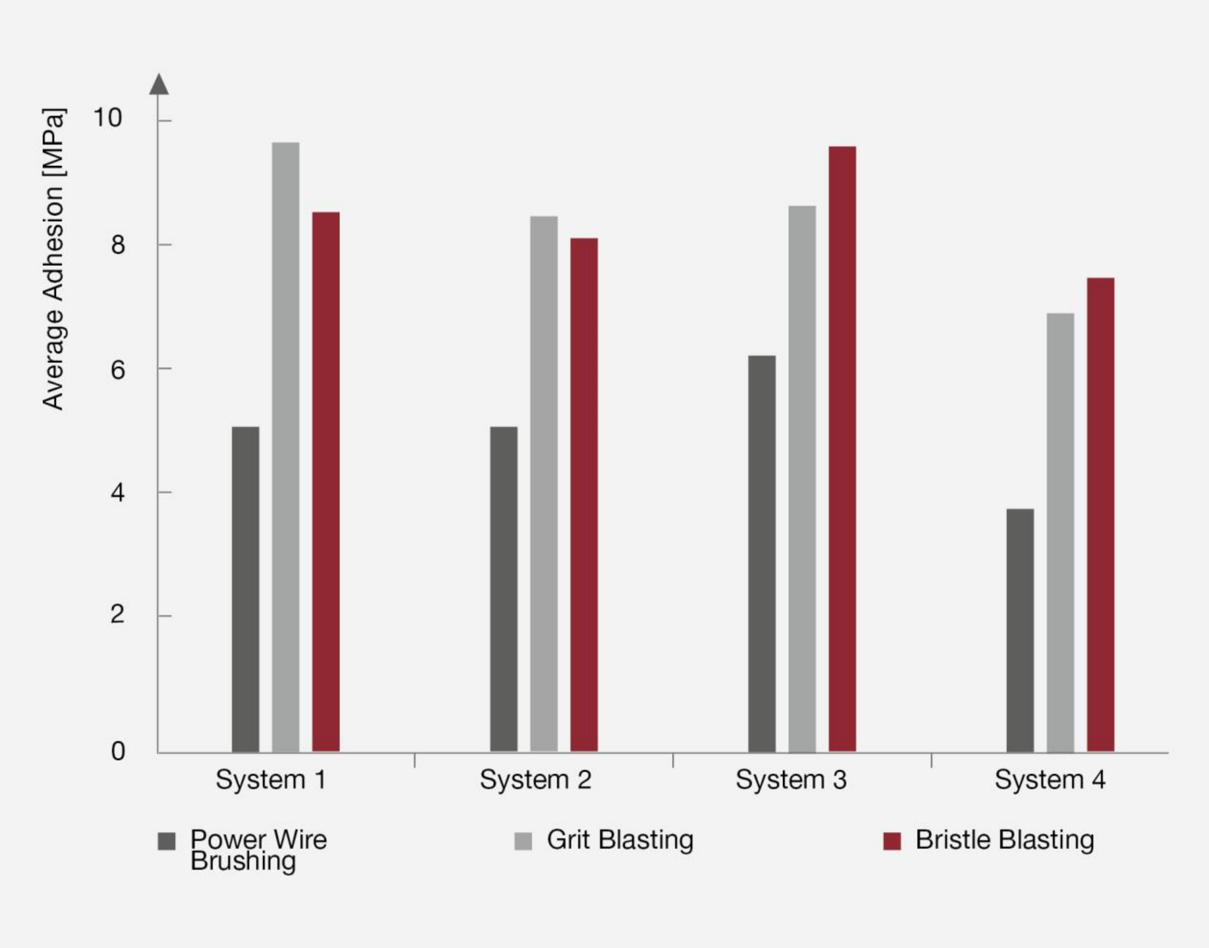

Figure 1: Average Adhesion Test Values[6]

Fundamentals of the Bristle Blasting Process

Conventional brushing processes are characterized by a continuous tool-workpiece contact (Figure 2a). Thus, a surface texture is generated that consists of grooves, as shown in Figure 2c. In contrast, the Bristle Blasting process generates surfaces by high-speed direct impact between bristle tips and the steel surface. This is achieved by using an Accelerator Bar which temporarily halts, and subsequently accelerates each bristle thereafter (Figure 2b).

Moreover, high speed photographic recordings of the bristles have proven that the tip hits the surface with a single strike and leaves a shoveled impact crater that resembles grit blasted surfaces. Thus, the

[4] Wilds, N.: “Bristle Blasting Surface Preparation Method for Maintenance”. In NACE Corrosion Conference 2009, Atlanta, Paper no. 09004, p. 7
[5] Ibid., p. 6
[6] Ibid., p. 6

Bristle Blasting tool creates countless impact craters that are closely related to grit and/or shot blasting processes.[7]

Scientific evaluations have demonstrated that a conventional standard bristle motion without acceleration and a tool spindle speed of approximately 2600 rpm equates to a grit velocity of 35 m/s for grit type G16[8]. With the same parameters, the Bristle Blasting process, as shown in Figure 2d, can realize an equivalent grit velocity of 79 m/s – an enhancement of 125%.[9]

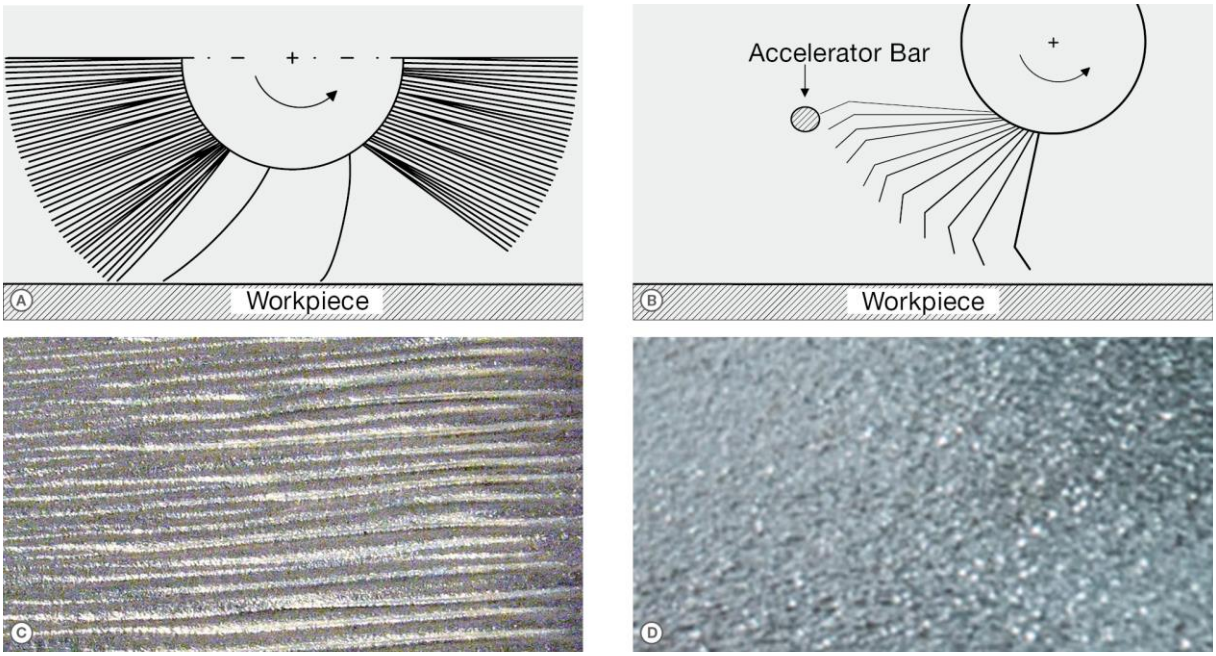

Figure 2: Comparison between Conventional Brushing (A, C) and the Bristle Blasting Process (B, D)[10, 11, 12]

To investigate the surface morphology and cleanliness created by the Bristle Blasting tool, a corroded API 5L pipe with a SSPC Condition D (100% rust with pits) was taken as test specimen. A close look at the resultant surfaces has shown that they exceed the cleanliness and texture expectations of power tool cleaning to bare metal (SP 11), which encompasses both impact and profile producing media as well as surface cleaning media. That is, the surfaces are comparable to near-white blast cleaning (SP 10) or even white metal blast cleaning (SP 5).[13]

[7] Stango, R.J. and Khullar, P.: "Fundamentals of Bristle Blasting Process for Removing Corrosive Layer". In NACE Corrosion Conference 2009, Atlanta, Paper no. 09191, p. 12
[8] Stango, R.J. and Khullar, P.: "Fundamentals of Bristle Blasting Process for Removing Corrosive Layer". In NACE Corrosion Conference 2009, Atlanta, Paper no. 09191, p. 8
[9] Ibid., p. 9
[10] Ibid., p. 4
[11] Ibid., p. 7
[12] Ibid., p. 9
[13] Ibid., p. 7

Finally, the results indicate that no corrosive pits remain after bristle blasting, and that the treated surface has a texture/profile that varies from 63 to 85 μm throughout the course of tool life (

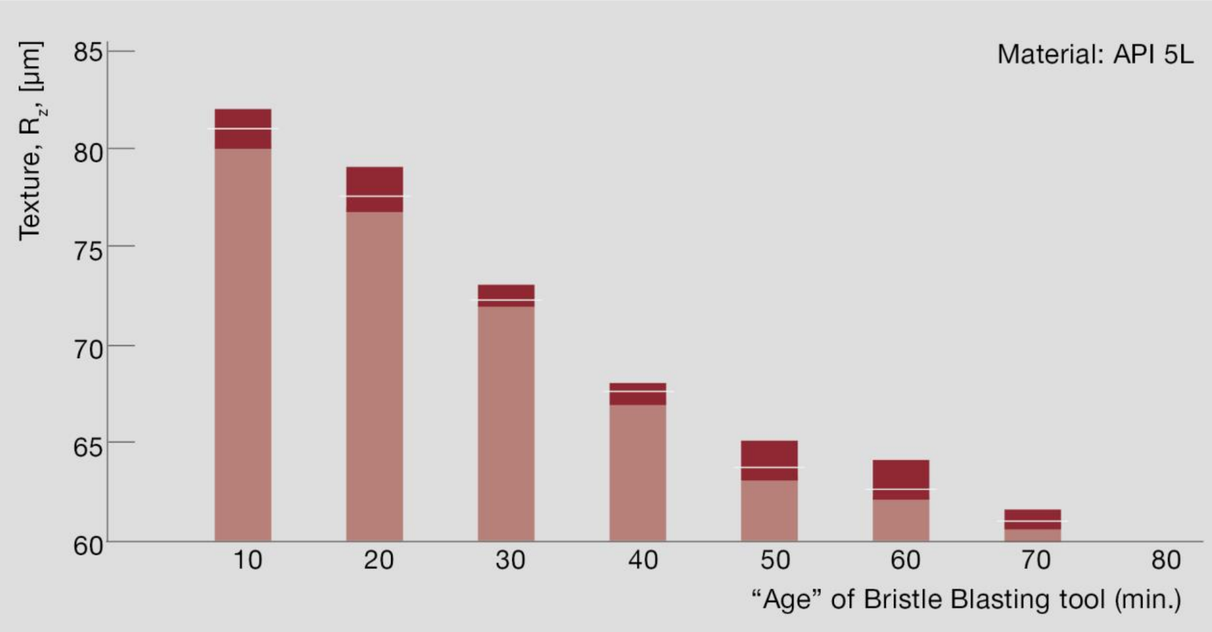

Figure 3).[14]

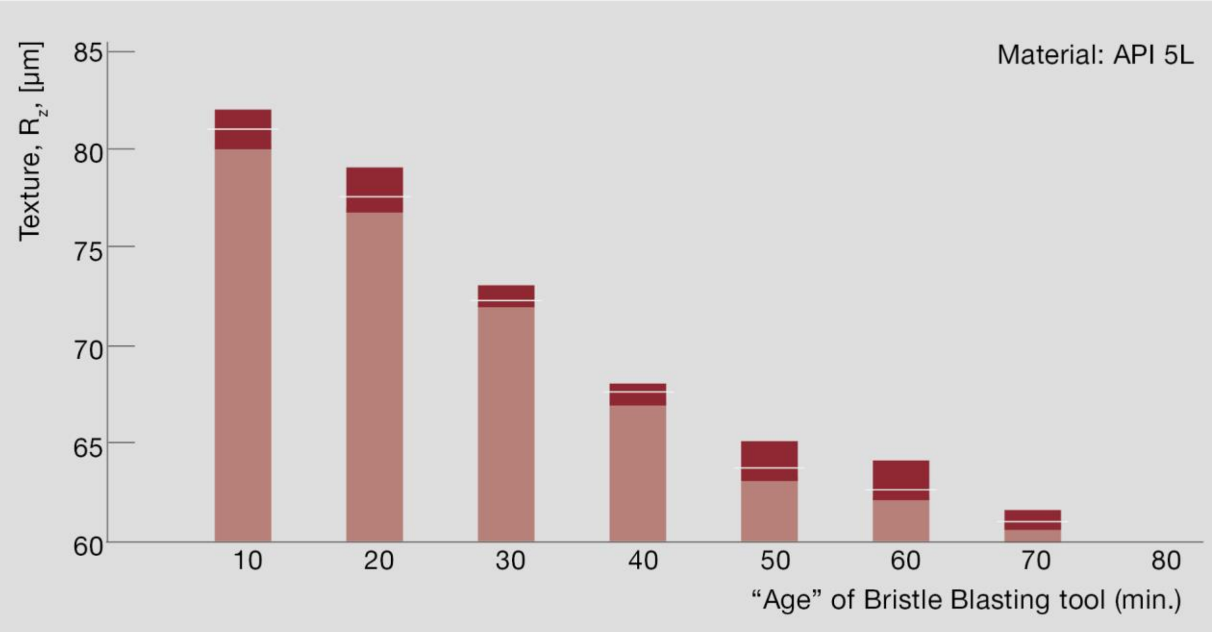

Figure 3: Anchor Profile Generated by the Bristle Blasting Process[15]

Compressive Residual Stress with Implication upon Stress Corrosion Cracking

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[14] Ibid., p. 7

[15] Stango, R.J. and Khullar, P.: "Fundamentals of Bristle Blasting Process for Removing Corrosive Layer". In NACE Corrosion Conference 2009, Atlanta, Paper no. 09191, p. 11

Striation-based surface preparation is characterized by score markings due to extended sliding contact duration between abrasive media and metallic surface. Thus, workpiece surfaces are subjected to greater material removal rates and frictional heating.

Excessive temperature can even lead to burn marks, also referred to as grinding burn, and is known to create extreme tensile residual stress that reduces the component life and increases susceptibility to stress corrosion cracking (ssc).[16] [12]

In contrast, crater-based processes generate minimal frictional heat, and create anchor profiles that are deemed essential for the subsequent adhesion and stability of applied protective coatings. Surface fragmentation provides the basis for rust removal and exposure of subsequent base-metal. That is, as a result of these micro-indentations, surfaces are cleaned and profiled simultaneously. Moreover, the appealed compressive residual stress in the workpiece is verifiable to a significant subsurface depth (

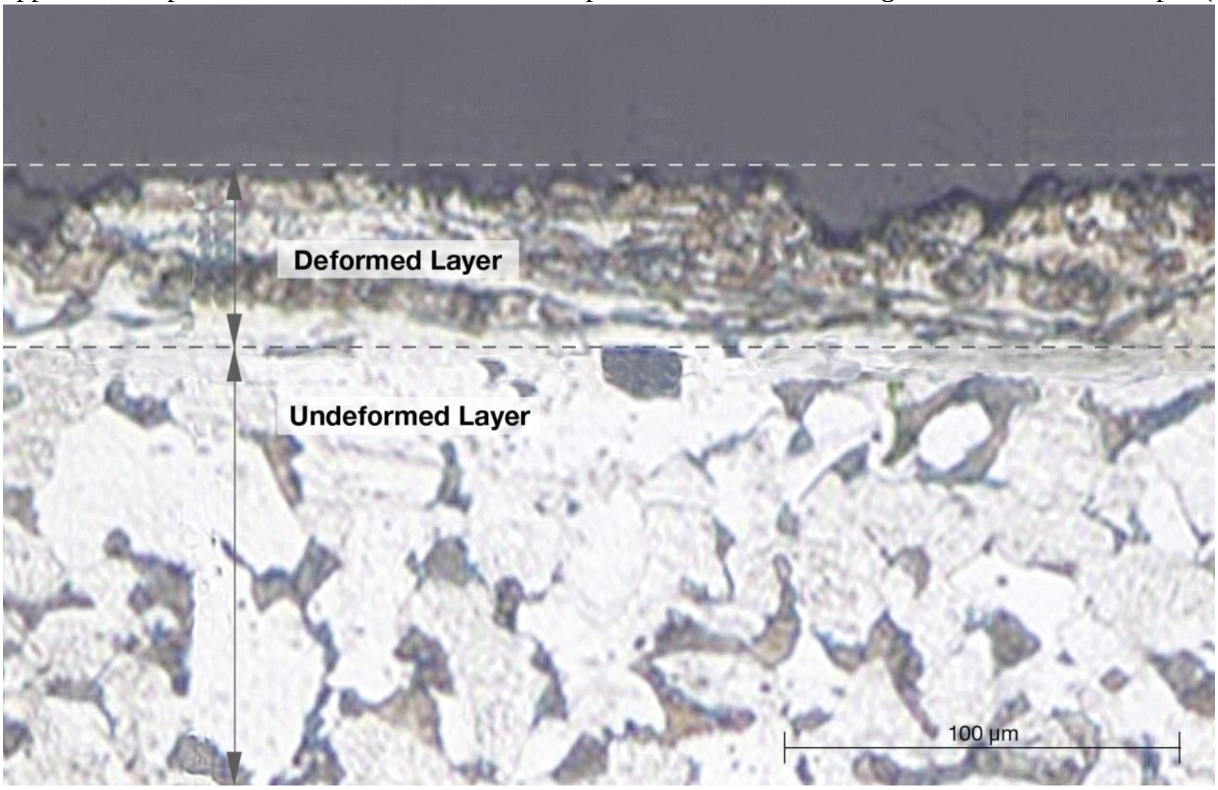

Figure 4).[17]

[16] Stango, R.J.: "Compressive Residual Stress Generated by Bristle Blasting Process with Implication upon SCC". In NACE Corrosion Conference 2014, San Antonio, Paper no. C2014-5152, p. 2
[17] Ibid., p. 2

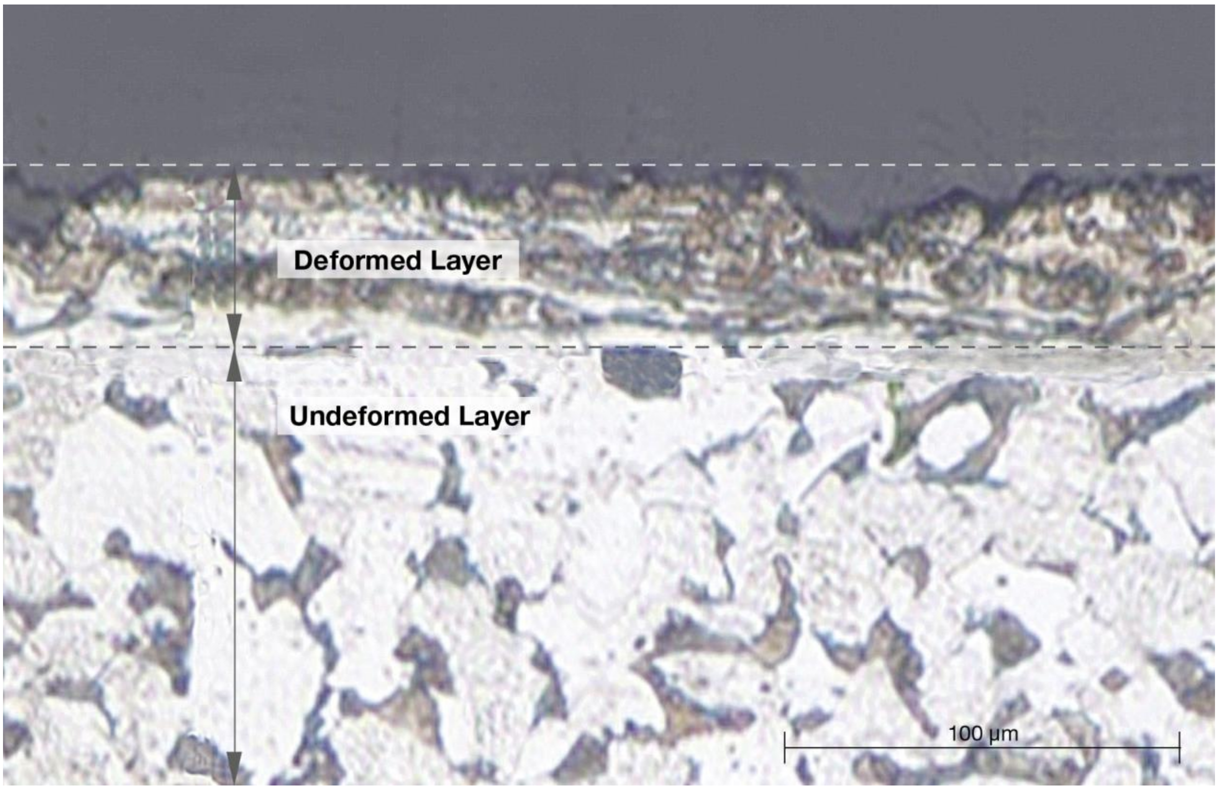

Figure 4: Cross Sectional Micrograph Depicting Worked Layer and Undisturbed Substrate of a Bristle Blasted Surface (ABS-A Steel)[18]

Machining a common ship construction steel (ABS-A) by using the Bristle Blasting process and investigating thoroughly the developing longitudinal and transverse stress, respectively, via x-ray diffraction shows a similar pattern for both – the greatest compressive residual stress is reached within

[18] Stango, R.J.: "Compressive Residual Stress Generated by Bristle Blasting Process with Implication upon SCC". In NACE Corrosion Conference 2014, San Antonio, Paper no. C2014-5152, p. 5

the vicinity of vicinity of 30 – 50 µm.

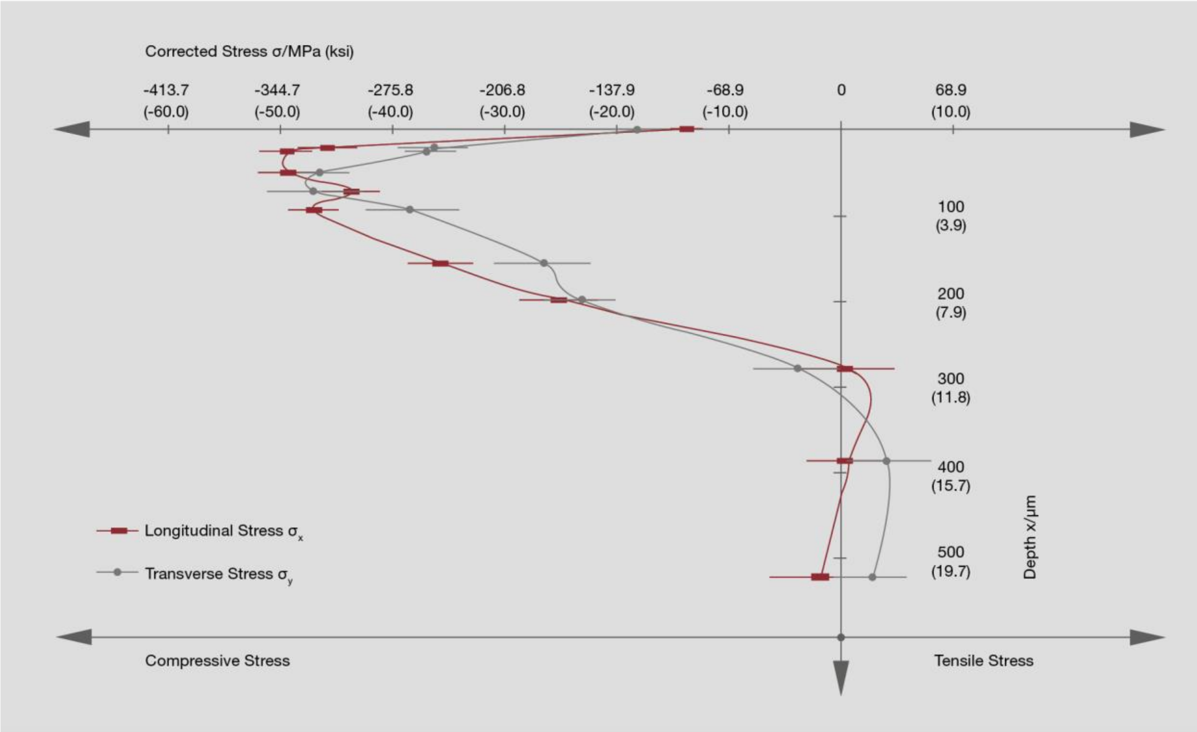

Figure 5 illustrates that compressive residual stress is measurable to a depth of ~300 µm before normalization. From this one can infer an enhancement of component life because of improved resistance to crack growth as well as delaying the onset of stress corrosion cracking.[19]

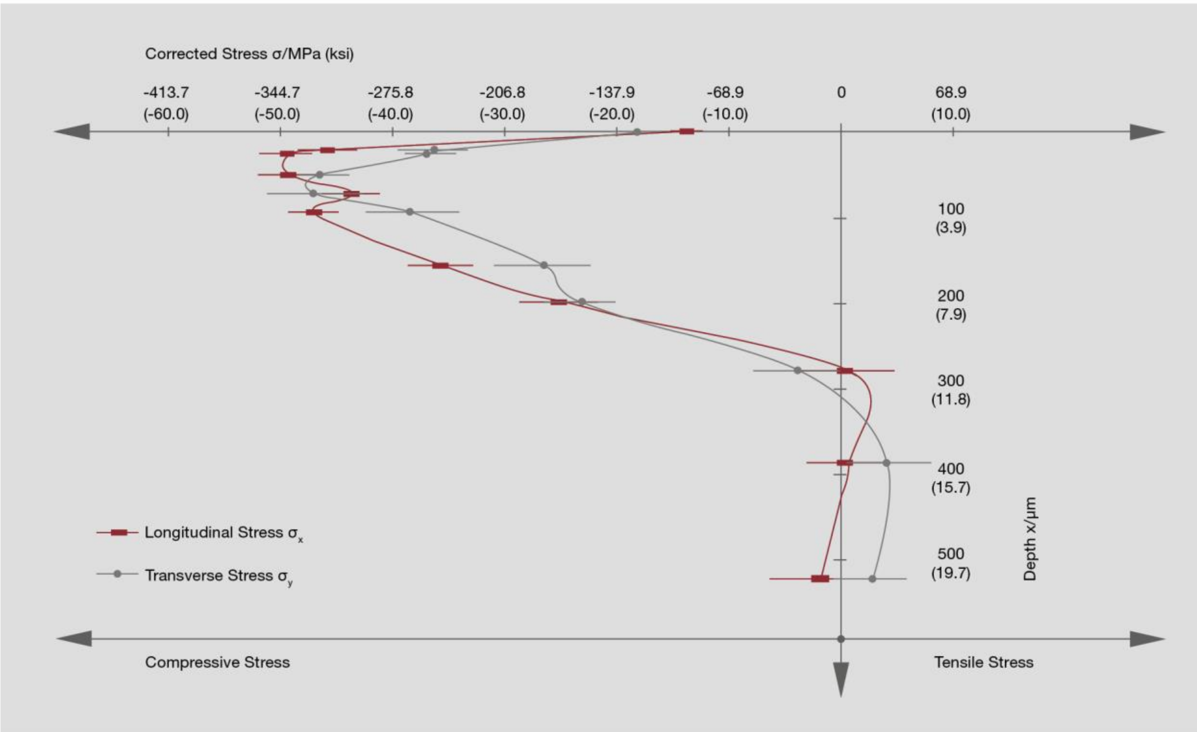

Figure 5: Residual Stresses Measured Using X-Ray Diffraction for a Bristle Blasted Surface (ABS-A Steel)[20]

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[19] Ibid., p. 8

[20] Stango, R.J.: "Compressive Residual Stress Generated by Bristle Blasting Process with Implication upon SCC". In NACE Corrosion Conference 2014, San Antonio, Paper no. C2014-5152, p. 5

Environmental Contamination and Health/Safety Management

Looking from an occupational safety and health perspective, the Bristle Blasting process will be compared to the grit blasting process and needle scalers. All three of these processes are capable of simultaneously removing surface contamination, exposing base metal and generating appropriate surface profiles for subsequently applied coatings.[21]

Needle scalers – also known as needle guns – are percussive power hand-tools with rapidly vibrating small diameter rods. The tool oscillates with frequencies ranging from 2,700 to 4,500 strikes per minute and reaches a noise level of 109 dB(A), which is well above the OSHA threshold level of 85 dB(A) requiring protection for the user and the workers nearby area. Mean forces exerted by the operator-tool system can rise up to 75 N (17 lb). Moreover, the power tool induced vibrations range between 10.9 and 28.7 m/s^2, which can lead to serious health disorders associated with the hand-arm vibration syndrome (HAVS).[22, 23]

Grit blasting processes are characterized by a high-speed particle stream of granular media (i.e., steel, coal slag, etc.) that repeatedly impacts and erodes the target surface. However, grit blasting processes produce hazardous dust and residues, which demand considerable personal protective equipment such as encapsulated control-suits, dust-filtering devices as well as fresh air that must be supplied from a remote source. Throughout the cleaning operation, workers have to sustain a steady reaction force of approximately 88 N (20 lb) that results in operator fatigue. In addition, noise levels up to 119 dB(A) are often encountered, which necessitate the use of ear protection.[24, 25]

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[21] Stango, R.J.: "Bristle-Blast Surface Preparation Process for Reduced Environmental Contamination and Improved Health/Safety Management". In OSEA International Oil and Gas Industry Conference 2010, Singapore, p. 16

[22] Stango, R.J.: "Bristle-Blast Surface Preparation Process for Reduced Environmental Contamination and Improved Health/Safety Management". In OSEA International Oil and Gas Industry Conference 2010, Singapore, p. 6

[23] Ibid., p. 7

[24] Ibid., p. 3

[25] Ibid., p. 4

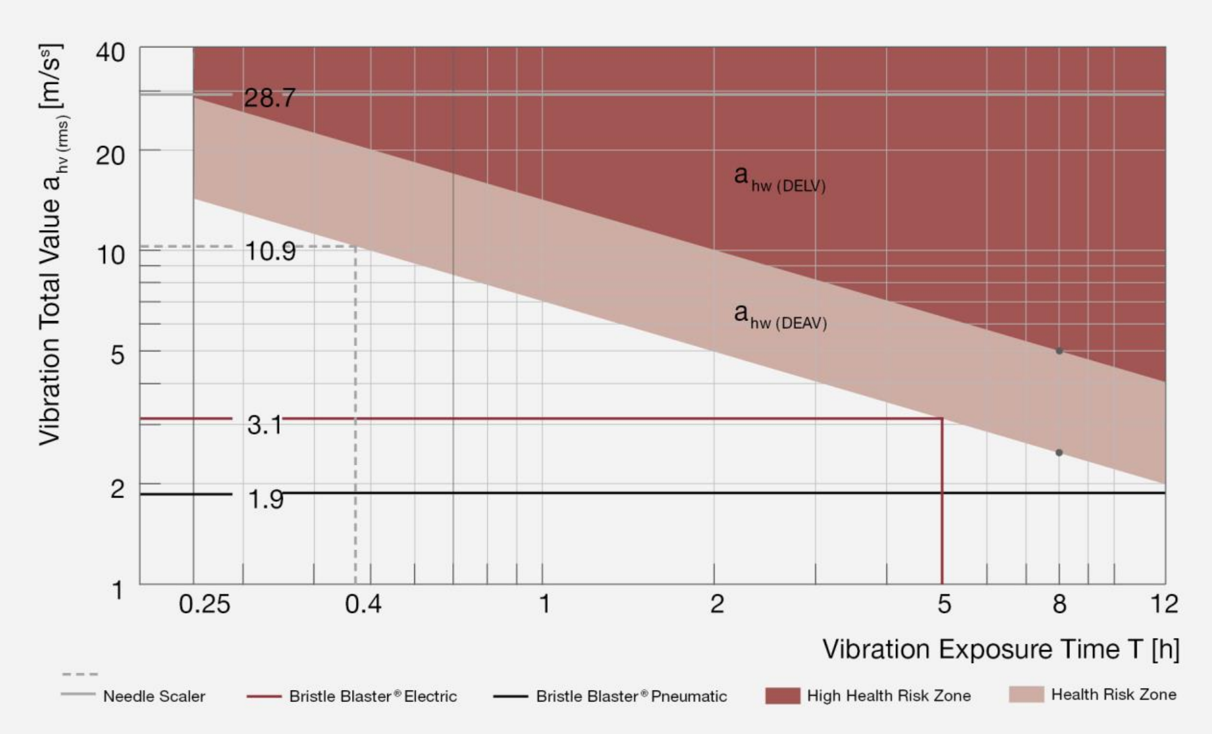

Figure 6: Relationship between the Magnitude of Tool Vibratory Acceleration and the Worker's Exposure Time[26]

The Bristle Blasting process generates crater-like micro-indentations showing results of surface conditions meeting SSPC's cleanliness standard SP 5 (white metal) with anchor profiles up to 84 µm. In contrast to needle scalers and grit blasting processes, noise levels emitted during Bristle Blasting processes are below OSHA's threshold level – approx. 83.5 dB(A) – with mean operating forces of 20 N (4.5 lb). While the electric power tool issues an acceleration of 3.1 m/s², the acceleration of the pneumatically powered tool is 1.9 m/s². Consequently, the latter does not pose a health risk to the user for any period of use according to the standard published by ANSI. Figure 6 shows the relationship between the magnitude of tool vibratory acceleration and the worker's exposure time.

In the best case, onset of health risk for needle scalers occurs within ½ hour of daily use, whereas electric driven Bristle Blasters® can be used for up to 5 hours of continuous use without the risk of injury.[27, 28]

Conclusion

In conclusion, the Bristle Blasting process generates a cleaned and profiled surface simultaneously. The surface condition, in terms of cleanliness and roughness, as well as corrosion resistance is equivalent to grit blasting. The cleanliness itself is comparable to ISO's Sa 2½ (SSPC-SP 10/NACE No. 2) or even Sa 3 (SSPC-SP 5/NACE No. 1), whereas the roughness R_z is at least 85 µm along the tool life cycle. Due to compressive residual stress and its improved resistance to crack growth the component life time is prolonged extensively. Focusing on health and safety aspects, the Bristle Blasting process has a noise emission below threshold level, enables a low-fatigue work relative to operating forces and the least exposure to harmful vibration with minimal health risk.

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[26] Ibid., p. 11
[27] Stango, R.J.: "Bristle-Blast Surface Preparation Process for Reduced Environmental Contamination and Improved Health/Safety Management". In OSEA International Oil and Gas Industry Conference 2010, Singapore, p. 8
[28] Ibid., p. 11

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Wilds, N.: "Bristle Blasting Surface Preparation Method for Maintenance". In NACE Corrosion Conference 2009, Atlanta, Paper no. 09004

Curriculum Vitae

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Professional Experience

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