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INFLUENCE OF PARAMETERS OF GRIT BLASTING CONDUCTED DYMET® DEVICE 412K TO OBTAIN ROUGHNESS

Mirosław Szyfelbain, Adam Charchalis, Robert Starosta

Gdynia Maritime University
Faculty of Marine Engineering
Morska Street 81-87, 81-225 Gdynia, Poland
tel.: +48 58 5586432, fax +48 58 5586399
e-mail: szyfelbainmiroslaw@gmail.com
a.charchalis@wm.am.gdynia.pl, starosta@am.gdynia.pl

Abstract

There are several fundamental steps for the technological preparation, which are required to optimize the thermal spray coatings. In order to ensure proper bonding of the coating, important is properly preparation of substrate. The surface of the substrate has to be clean and should have a suitable roughness after previously performed treatment. Knowledge about the effects of process parameters allows designing the coatings obtained with an optimal adherence. Only when all the components of the spraying coating process are used correctly there is possible properly design the technology. The article describes the impact of technological parameters of grit blasting to obtain the roughness of the steel substrate (steel S185) to the process of metallic coatings by cold gas dynamic spraying. Research was carried out by using the Dymet® 412K appliance, designed for applying metal coatings and substrate surface cleaning. Grit blasting is a mechanical method of surface preparation of metal parts. It allows obtaining a high degree of surface cleanliness and a determined roughness. The authors took into account parameters such as operational pressure, spray angle (incidence) of abrasive grit blasting in the axis of the stream and feed rate of used abrasive particles (Al_2O_3) passed to the nozzle of spray gun. Carried out the multiple regression analysis of the roughness parameters results. It revealed the existence of certain influences and changes of process parameters, which affect on the surface quality. Carried out calculations by using a multiple regression showed that the greatest correlation is between the required roughness and the feed rate of used abrasive particles. The studied roughness was described by the parameters: Ra, Rz, Rt and RSm. Stepped growth (from 0.1 to 0.8 g/s) of abrasive particles feed rate caused a decline of all of the roughness parameters. It has been found that the values of the roughness in the least depend on the operational pressure.

Keywords: *roughness, blasting, Dymet® 412K gun, alumina*

1. Introduction

There are many methods of thermal spraying which are using heated, melted or molten particles to apply on properly prepared surface. The gas-dynamic spraying method makes it possible to obtain coatings with good bonding to the substrate without the heat impact on the particles or the substrate. Consequently, properties of the substrate and the applied layer are not affected by the adverse effects of high temperature. Cold spray method can be divided into two methods:

– Low Pressure Gas Dynamic Spray – LPGDS, where the gas pressure is less than 3 MPa, and sprayed coatings is obtain from powders which particles have a diameter less than 50 μm.
– High Pressure Gas Dynamic Spray – HPGDS, where the powder particles have a diameter greater than 50 μm, and operating pressure has a higher value [9].

In the gas-dynamic spraying method, the powder particles are accelerated to the supersonic speed by the gas stream. As a result of the particles collision with the substrate follows it connection with the substrate. This method is the only one that allows makes coating by using the particles, which remain solid during the process [1, 5].

Thermal spraying has become competitive in relation to all known coatings preparation processes. The largest field of application is regeneration of weared surfaces of machines and equipment parts. Thus, obtained coatings protect components against the abrasion and the corrosion impact. Achieving the appropriate the coatings properties is possible by selecting the appropriate coating materials, methods and spraying parameters. The quality of the sprayed coatings depends on many factors, which include [6]:

– proper preparation of the surface associated with removal of impurities, degreasing and grit blasting of the surface in order to increase roughness,
– spraying the bond coating (backing),
– spraying a multilayer coating,
– finishing machining (turning or grinding).

Surfaces destined for metallization spraying should be degreased and deprived of oxides. They should have also the required roughness. Grit blasting belongs to the methods of mechanical surface preparation of metal parts and allows obtain the highest degree of surface cleanliness and its proper roughness. After such carried out treatment is possible to reach clean of the metallic surfaces and free of any solid pollutants i.e. oxides, residues of varnish, paint, etc [3]. The principle of this cleaning method consists in that the abrasive grains are carried in the high velocity air stream and they are directed at the surface to be purified. Grit blasting is widely used in cases of surface preparation for corrosion protection [2, 7].

Technological parameters of the surface treatment by using metallic powders depends on the physicochemical properties of abrasive material (size and weight), the parameters of the abrasive carrier (air operational pressure, air speed which flow from the nozzle, the distance from the nozzle to the treated surface, the angle of the spraying) and the physicomechanical properties of the workpiece. One of the factors influencing on the treatment process parameters is the concentration of the air-abrasive mixture, i.e. the ratio of the mass of air flowing through the nozzle per unit time to the mass of the abrasive ejected through the nozzle at the same time. The largest of the metal singular machinability is achieved by high concentrations of abrasive in the stream [8].

Grit blasting methods cause surface roughness and simultaneously its significant increasing. It is caused by the abrasive particles which fly with a high speed and strike on the workpiece surface generate it abrasion and cut out the small particles from it which forming the prominences and depressions [4].

2. Research methodology

Figure 1 show the pneumatic-abrasive stand for treatment of the workpieces made up of the following elements: (1) – air preparation system (pressure control unit, drainage and oil removal unit), (2) – spray gun, (3) – control unit and (4) – powder storage container. The operation principle of stream apparatus relies on conversion of the compressed air energy into the kinetic energy of the abrasive particles stream.

For the purposes of carried out studies the device DYMET® model 412K was used. Normally it is used in production, reparation and regeneration proceses of parts. This device was designed and manufactured for applying metallic coatings on manufactured parts by using metal powders, which are spraying on the substrate, by using compressed air. This device is also used for cleaning the surface by using abrasive grit blasting. DYMET® 412K was designed for operation by using the powders consisting of metal and ceramic particles. The maximum size of the powders particle used in the process has not exceed 200 microns. Parameters of compressed air in spray gun amount to:

– operating pressure – 0.5-0.9 MPa,
– operating temperature – 400-500°C,
– the mean powder consumption – 0.1-0.8 g/s.

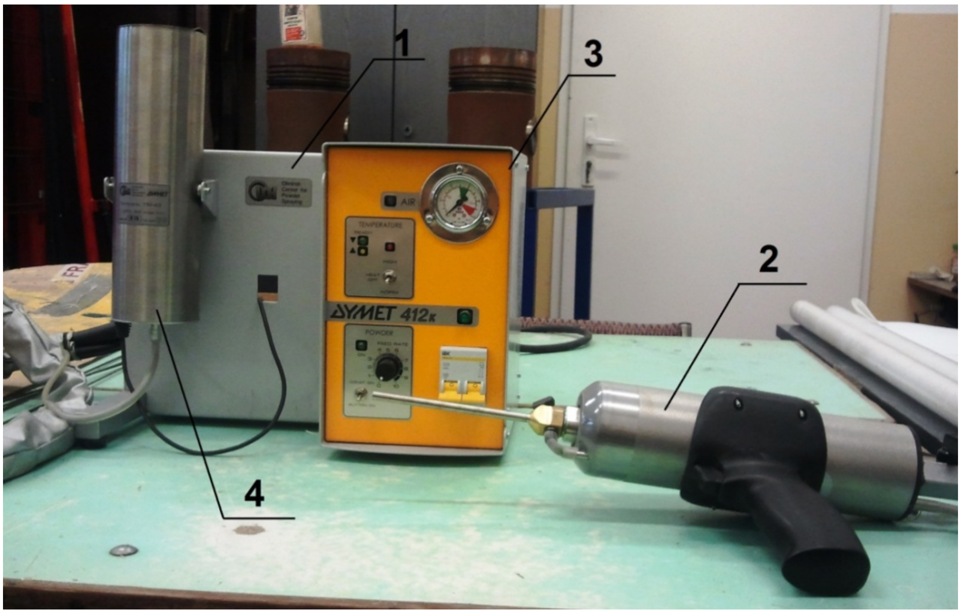

Fig. 1. General view of the device DYMET® model 412K

The powders used in the process have a different looseness. It means that the amount of the powder fed into the process from a storage container per unit of time via the transmission hose into the nozzle should be adjusted individually for each type of the powder. For abrasive grit, blasting used the powder of alumina (Al_2O_3) with a purity about 99.4%. The size of the powder's single particles does not exceed of 0.2 mm. The alumina is used for the grit blasting carried out in both sealed cabins as open structures. The alumina weight is slightly more than half of the chilled cast iron weight. From that reason, this type of abrasive material could be easily fed to the machine and could be effectively accelerated in the nozzle during the process. The alumina grains are also used to treatment of hard surfaces (> 45 HRC) and non-ferrous materials, because sedimentation of the steel grains which could lead to the corrosion.

3. Research results

Assumptions of the research included the analysis of the technological parameters impact in the grit blasting process, such as operating pressure; spray angle (falling angle) abrasive grains in the axis of the stream and feed rate of abrasive particles used. The distance between the end of device nozzle and the workpiece was constant and amounted to 15 mm. The research was conducted at five tests in which was set different parameters of the process (Tab. 1). The grit blasting was carried out in a perpendicular direction (or at the specified angle) to the steel substrate made from steel S185.

Calculating of grit blasting statistics was carried out at the significance level of 0.1%. Calculations carried out by using multiple regression showed that the greatest correlation is between the required roughness and the feed rate of used abrasive particles (Tab. 2). Adjusting of the feed rate significantly influences on the surface roughness. The lower fed rate ratio, the higher the Ra parameter (Fig. 2) [4]. In addition, it was found that:

– with a decrease of the spraying angle the Ra parameter also decreased,
– with an increase of the operational pressure the Ra parameter increased.

At this stage of the research about the impact of grit blasting technological parameters on obtained roughness, the main attention was directed to determine the dependence and predict the direction of changes (Fig. 3 and 4). Carried out analysis allow to stated that the greatest influence on the obtainable surface roughness have adjusts of the abrasive fed amount to the DYMET® device.

Tab. 1. Process parameters and the result of surface roughness

	Pressure [MPa]	Angle [°]	Feed rate	Ra [μm]
1	0.4	90	3	7.06
2	0.4	90	3	5.22
3	0.65	90	3	6.34
4	0.65	90	3	5.96
5	0.74	90	3	7.41
6	0.74	90	3	6.63
7	0.45	75	2	6.26
8	0.45	75	2	5.8
9	0.45	90	2	7.52
10	0.45	90	2	6.67
11	0.45	90	2	7.83

Tab. 2. Summary of the dependent variable regression

N=11	BETA	Error standardization BETA	B	Error standardization B	T(7)	The significance level
P [MPa]	0.34	0.33	0.2	0.19	1.03	0.33
Angle [°]	0.66	0.32	0.008	0.004	2.05	0.08
Feed rate	–0.78	0.37	–0.12	0.06	–2.1	0.07

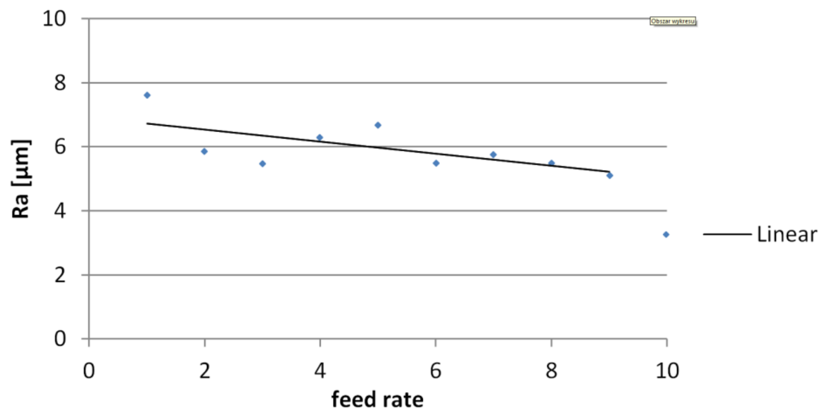

Fig. 2. The dependence of the influence between the feed rate and the Ra parameter

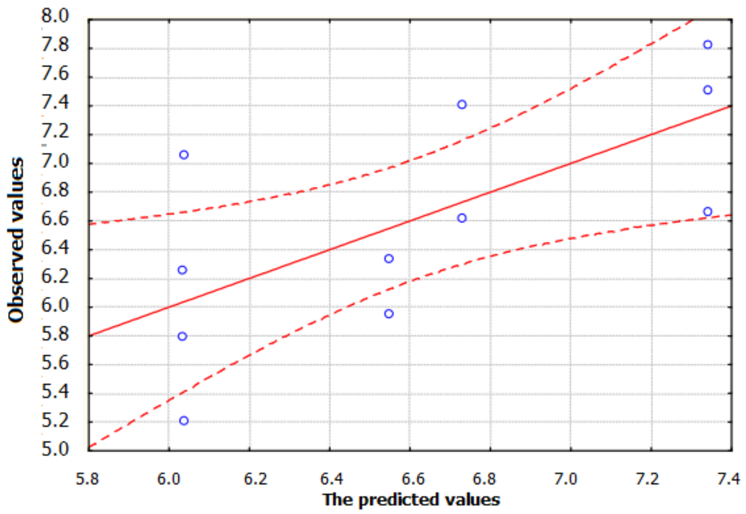

Fig. 3. Predicted values in relative to observed dependent variable Ra

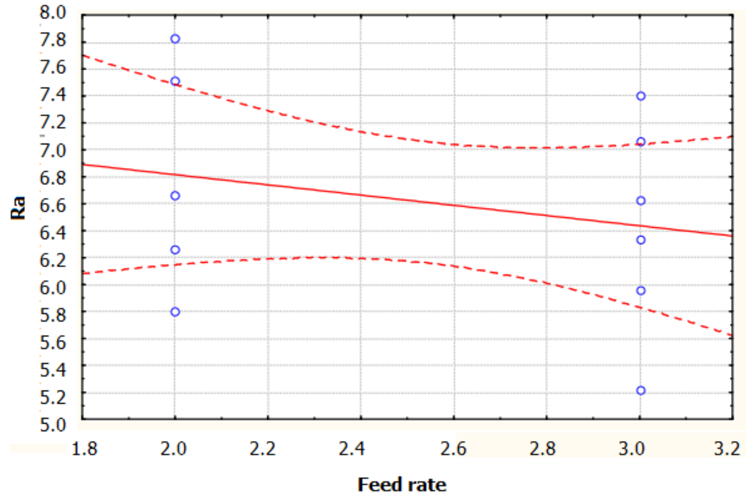

Fig. 4. Diagram of dispersion Ra parameter dependent from feed rate

Properly cleaned and rough surfaces provides a critical points, where could be settle the first layer of the spray coating. Properly prepared surface has the following attributes:

– the purity of the substrate surface provides better metallic contact between the phases and increase the adhesion forces (Van der Waals forces),
– increase of the roughness provides a significant contact between the particle and the substrate surface.

In addition, the possibility of mechanical jamming of the material in the roughness of the substrate. This relationship illustrate Fig. 5 and 6.

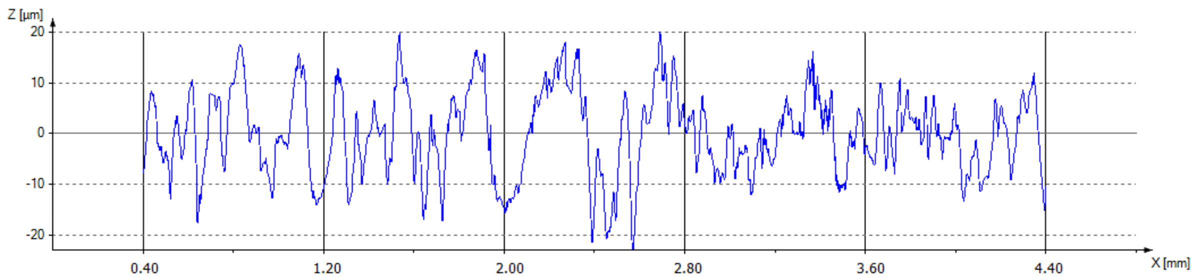

Fig. 5. The roughness profile diagram after the grit blasting with settings: the feed rate = 1, the operational pressure = 0.5 MPa, the angle = 90°, the distance between nozzle and surface = 10 mm, Ra = 7.6 µm

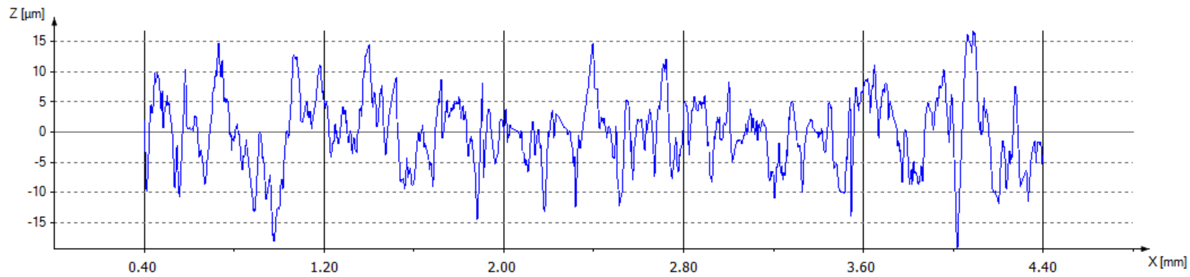

Fig. 6. The roughness profile diagram after the grit blasting with settings: the feed rate = 9, the operational pressure = 0.5 MPa, the angle = 90°, the distance between nozzle and surface = 10 mm, Ra = 5.1 µm

4. Summary

Conducted grit blasting with using dry abrasive powders is a technique frequently used in order to obtain surface roughness. The abrasive particles are propelled towards the substrate surface with relatively high speeds.

While hitting on the ground, sharp, angular particles preserve as abrasive and form fine irregularities on the surface. Carried out research provided the following conclusions:

- Adjusting of the feed rate significantly affect to the surface roughness.
- With a decrease of the spraying angle, the Ra parameter also decreased.
- With an increase of the operational pressure, the Ra parameter increased.

References

[1] Ambroziak, A., Maev, R., Leshchynsky, V., Kocimski, J., *Natryskiwanie powłok nisko-ciśnieniową metodą gazodynamiczną (cold spray)*, Przegląd Spawalnictwa, pp. 27-31, 5, 2009.

[2] Charchalis, A., Starosta, R., *Effect of finishing on the corrosion properties of flame sprayed Ni-5%Al and Ni-5%Al-Al_2O_3 coatings*, Journal of KONES Powertrain and Transport, Vol. 21, No 4, pp. 29-36, 2014.

[3] Mohamed, D., Eddine, B. N., Nacer, D., *Effect of Substrate Preheating, Roughness and Particles Size on Splat Morphology of Thermal Sprayed Coatings*, International Journal of Computational a Experimental Science and Engineering, Vol. 1, No. 1, pp. 16-18, Isparta 2015.

[4] Morel, S., *Powłoki natryskiwane cieplnie*, Monografie nr 48, pp. 107-115, Wydawnictwo Politechniki Częstochowskiej, Częstochowa 1997.

[5] Starosta, R., *Effect of burnishing on the contact fatigue of regenerative thermally sprayed coatings*, Journal of KONES Powertrain and Transport, Vol. 20, pp 309-315, 2013.

[6] Starosta, R., *Podstawy wytwarzania i obróbki powłok kompozytowych w procesach regeneracji elementów maszyn i urządzeń eksploatowanych w środowisku wody morskiej*, Prace naukowe Akademii Morskiej w Gdyni, pp. 13-15, Gdynia 2013.

[7] Tkaczyk, S., Walczak, K., Balcerowska, B., Ozgowicz, W., Rydarowski H., Szota, J., *Powłoki ochronne*, Wydawnictwo Politechniki Śląskiej, pp. 37-42, Gliwice 1997.

[8] Tucker, R. C., *Introduction to Coating. Design and Processing,* ASM Handbook, Volume 5A, Thermal Spray Technology, pp. 1-6, 2013.

[9] Yang, K., Liu, M., Zhou, K., Deng, Ch., *Recent developments in the research of splat formation process in thermal spraying*, Hindwai Publishing Corporation, Journal of Materials, Volume 2013, pp. 2-7, Guangdong, China 2012.