THE INFLUENCE OF THE PARAMETERS OF THE THIN WALLED METAL SHEETS SHOT PEENING ON THE TECHNOLOGICAL QUALITY OF WORK SURFACES

Jakub Lewiński, Czesław Niżankowski

Politechnika Krakowska, Faculty of Mechanical Engineering, al. Jana Pawła II, 30-001 Kraków, Poland

Abstract

Abrasive blasting is a surface processing method which uses loose abradant with certain kinetic energy capable of cutting. The abradant can be transported by liquid (usually water) or by gas (compressed air). This work focuses on the dry method of blasting. The factors which infuence the quality of the processed surface are geometrical parameters of the jet – blast angle, attack angle and distance between nozzle and workpiece. The next parameters which have an effect on the surface conditions are the properties of the abrasive – type of abrasive and granularity. Energetic factors are the mass of abrasive and pressure in the system.

Measuring technique of properties which was examined in this dissertation such, as surface roughness, waviness and deflection were thoroughly explained. Independent research was the next stage. Investigation scheme was introduced and factors having inflence on the test explainder. Research was carried out in accordance Hartley's plan. Test stand where the experiment had been realized, its construction and principle of the test were introduced. Hartley's plan requires eleven repetitions for three variables, there was: blast angle, distance between nozzle and workpiece and pressure.

For each test measurements of roughness and deflection were made. For sheet metal which was the most proper when it comes to the assumptions, that is the one with the least deflection and the smallest roughness, the material ratio (Abbot-Firestone curve) was additionally performed . Results were showed on graphs in connection to distance, pressure and roughness in constant blast angle.

Keywords: Sandblasting, blasting, shot peening, sand blaster, Hartley's plan

1. Introduction

The goal of application of sandblasting is achieving required quality of surface by removing a small quantity of material from a processed object. According to the purpose of the object, it is required to set optimal parameters of sandblasting: roughness, waviness, dimension tolerance and condition of the surface (removal of lacquer, rust). The essence of sandblasting is adjusting parameters, which are at disposal: distance of the nozzle, the angle of the tilt, pressure etc.) to make the process as efficient as possible and to achieve purpose in short time. The layer of removed material must not be substantial so as not to risk damaging or destroying of the processed element.

1.1. Sandblasting techniques classification

Among various different sorts of sandblasting machines, it is possible to classify them according to their purpose and size of objects which we want to process.

- **Very small objects** may be processed in sandblaster with rotary drum. In tumble belt batch machine with high efficiency and the possibility of automatized production, Through-line cleaners can be used.
- **Small and medium objects** are usually cleaned in cabinet sandblaster, where the operator controls the nozzle and positions the object cleaned in the cabin.
- **Big objects** are cleaned in large size sandblasters and in blast rooms.
- **Automatic sandblasting machines** – vary in construction depending on their purpose.
- **Elevations and constructions** are cleaned with a portable blaster which allow the operator to change the position. Such a blaster consists of a compressor, a container and abrasive and a pipe with a nozzle.

Filtering and dedusting systems are used to dedust the air and clear it of any pollution after the treatment. The effectiveness of dedusting reaches up to 99%. Abrasive is recovered in devices called separators or cyclones.

1.2. Types of medias applied in sand blasting.

There are two types of medias used in sandblasting: carrier and abrasive. Higher velocity is achieved in a stream of fluid. Examinations showed that abrasive achieves 96% of the velocity of water, but approximately only 24% in case of air. However, because of practical reasons, it is hard to achieve a high velocity of fluids, it is uneconomical because of quick deterioration of ducts through which the abrasive is transported. This is why the application of air medium is much more common.

Another type of medium is abrasive, whose purpose is to remove the layer of material of processed object. There are also many different types of abrasives, they have different granulations, shapes, sizes and hardness.

Among others are shot steel and iron, non-corrosive abrasive, silicon carbide (carborundum), quartz sand, different types of electro-corundum, glass microsphere, ceramic sphere, dry ice and natural abrasive.

1.3. Examples of items treated with sandblasting

Sandblasting treatment has very wide application. It is possible to treat materials like wood, glass, stone, brick and metal. The most common application of sandblasting is a treatment of metal, which allows to remove protective layers like lacquers, paint, glue and later to prepare the material for new coating. Sandblasting may be used for renovating plasters and elevations. It can be also applied in order to renovate and give wood specific appearance, also for artistic purposes.

1.4. Factors which influence the technological quality of surfaces after blasting.

There are many various parameters which influence the treated surface. The process considerably depends on geometrical characteristics of the stream, its energy, and type of abrasive (see Fig. 1). Those parameters may be modified and choose in order to achieve high efficiency and low cost.

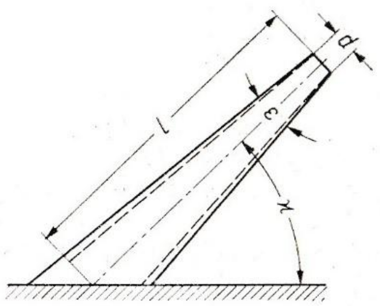

Figure. 1 Geometrical characteristic of the stream[2]

- **Angle of spraying ϰ –** varies between 0* and 90*
- **Angle of opening ε** depends on pressure of spray of the abrasive, construction and distance from the material
- **Distance between the nozzle and the material**
- **Type of abrasive**
- **Graininess**
- **Energy factor -** consists of factors such as mass of the grain, pressure of air, and mass of fluid

2. Own research

2.1. Research metodology

The research was carried out in accordance with Hartley's plan for three initial sizes.

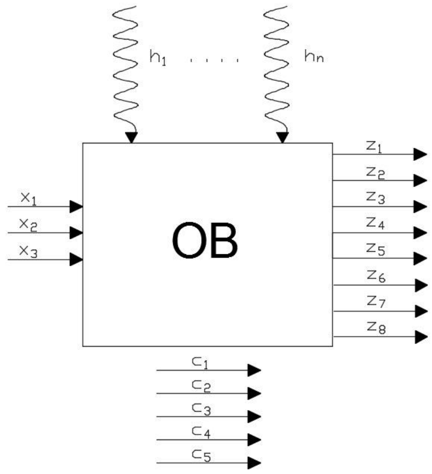

Figure 2 Scheme of the experiment

In examination three parameters were adopted as variables:

x_1 – Pressure 3, 5, 7 [bar]
x_2 – Distance between the nozzle and the treated object 15, 20, 25 [cm]
x_3 – Angle of blasting 30^{O},45^{O},60^{O}

The following parameters remained constant:

c_1 – Sheet thickness**:** 0,5 [mm]
c_2 – Type of abrasive: glass sphere
c_3 – Granulation: 40-70 [μm]
c_4 – Feed rate: constant ~1300 [mm/min]
c_5 – Sandblaster**:** SANT-TECH PKC-140

Researched initial parameters were: Ra -arithmetic mean, Rq - root-mean-square, Ry - maximum height, Rz - ten-point height of irregularities.

Imprecisions which may appear during the examination may be for instance: inaccuracies of reading the value of feed rate, fluctuations in the exhaust system, dispersion of glass granule's size.

2.2. Examination techniques

Abrasive sandblasting was carried out on equipment made available by SANT-TECH sp z.o.o. in Cracow.

Figure 3 Examination station on which eperiment was carried out

The set consisted of shot peening machine PKC-140, dedusting system ZO-150P, and Walter Kompressortechnik Polska compressor (see Fig 3). For the time of shot peening, an arm was fastened to the cabinet, thanks to which it was possible to manipulate the nozzle (see Fig. 4). The metal sheet was fastened to a cart which could move on a rail.

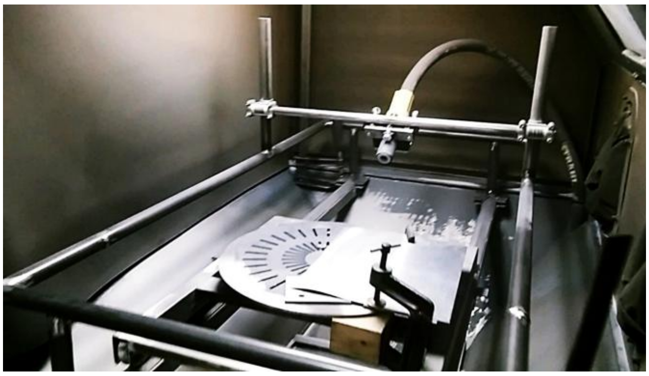

Figure 4 Examination position with fastened frame, nozzle, and cart

After 11 peening tests, the roughness of the metal sheet was tested with Mitutoyo SJ-201P device and bending degree was tested with height setting micrometer with height setting micrometer. For the metal sheet which had the best parameters, additional test of waviness was carried out with stationary profilografometer Form Talysurf 50.

2.3. Experiment results

The results were analyzed accordingly to Hartley's plan. Regression coefficient was calculated basing on *Hartley's plan*:

b0=5.5805
b1=0.7742   b2=-0.5079   b3=0.7583
b11=0.3895   b22=-0.2943   b33=-1.4357
b12=0.2837   b13=-0.6850   b23=0.1900

Test of Repeatability was calculated (Cochran's statistic)
coefficient G=0.2753
materiality level alfa=0.050
number of degree of freedom f1=11
number of degree of freedom f2=3
coefficient Gkr=0.3498
G < Gkr => Test of Repeatability was satisfied
Regression equasion:

$$y = b0 + b1 * x1 + b2 * x2 + b3 * x3 + b33 * x3^2 + b13 * x1 * x3 \quad (1)$$

$$y = 5{,}5805 + 0{,}7742 * x1 + 0{,}5079 * x2 + 0{,}7583 * x3 - 1{,}4357 * x3^2 - 0{,}6850 * x1 * x3 \quad (2)$$

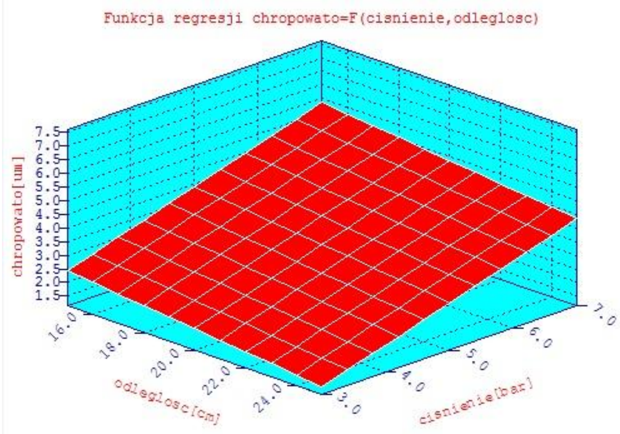

Figure 5 Roughness of the surface depending on the distance of nozzle and pressure for angle of 30^O

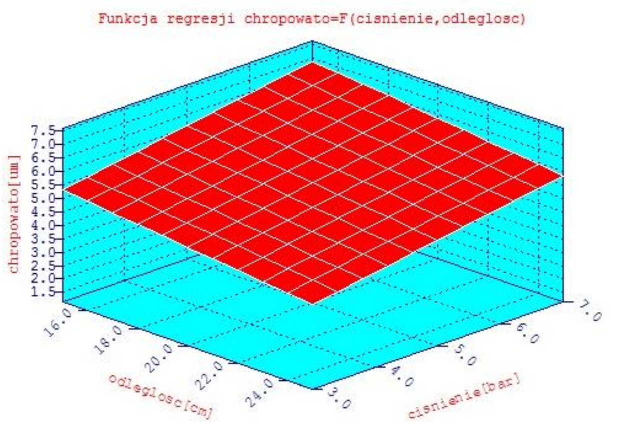

Figure 6 Roughness of the surface depending on the distance of nozzle and pressure for angle of 45^O

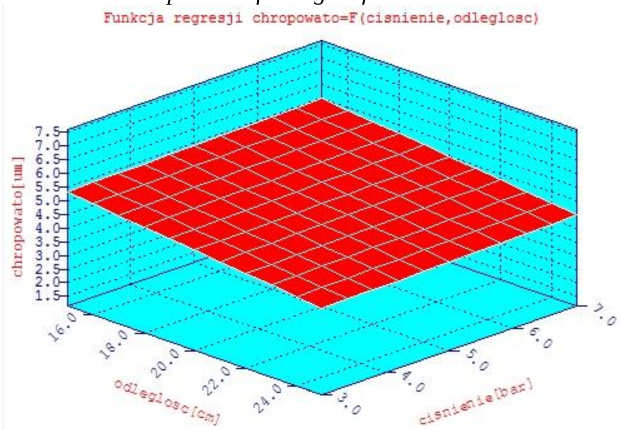

Figure 7 Roughness of the surface depending on the distance of nozzle and pressure for angle of 60^O

For the metal sheet which demonstrated the required properties, that is the lowest degree of bending and the lowest roughness, waviness and material rate was determined.

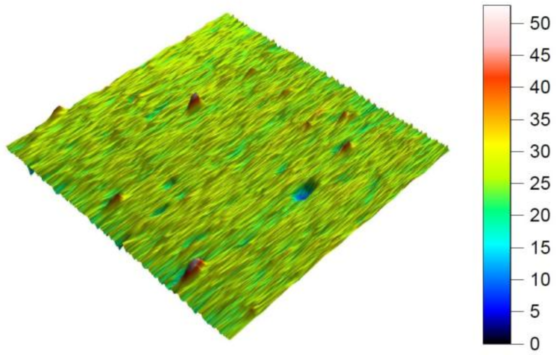

Figure 8 3D image of the roughness of the surface

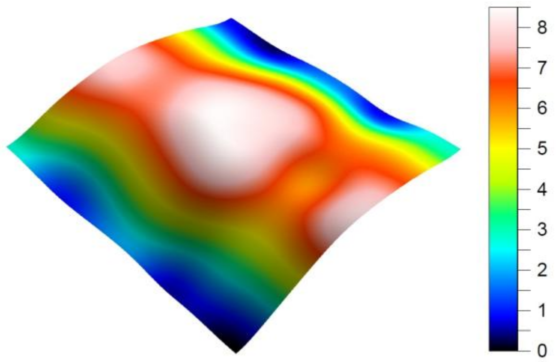

Figure 9 3D image of the waviness of the surface

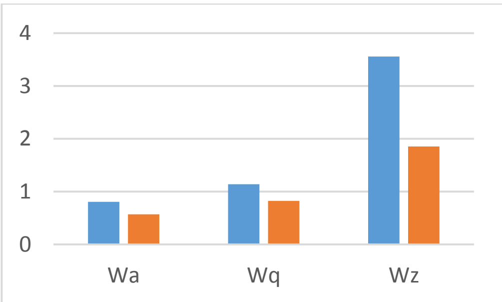

Figure 10 The chart shows the relationship between waviness parameter and their value. The blue color represents the values measured perpendicularly to the longer edge of the sheet, and color orange represents measurements parallel to the longer edge.

3. Conclusions

Thin-walled sheets are fractions of a millimeter thick. In processes of galvanizing with different layers of metals, immersion coating (lacquers, plastics, enamels etc.) sheets are bilaterally coated because of technological reasons. (securing only one side is costly).

If the area of application requires removing the coating from one side, it is done so in a separate technological process where sandblasting is most commonly used.

The results of the experiment indicated that the process of sandblasting brings in stretching tension in the outer layer of treated surface. In effect Thin-walled sheets which are fastened along only one edge evenly bend the central axis of the sheet. It was also indicated that maximal arrow of the bend which is the effect of sandblasting removal of zinc coating from steel sheet (S235) become visible under such treatment parameters: 5 bars, 15 centimeters, and incline angle of 45^{O}. A similar value of arrow of the bending was obtained for: 5 bars, 20 centimeters and angle of 30^{O}. Such values can be a result of the cutting properties of the abrasive in such pressure and cutting geometry of the abrasive.

At the same time, the results indicated that the increase of pressure in the same values of the other parameters increases the roughness of the surface. It is quite certain that the abrasive alongside with the increase of pressure increases the value of kinetic energy.

Thin-walled metal sheets treated with sand blasting require fastening along two edges. It is caused by the tension induced by the abrasive hitting the treated surface. Spherical glass abrasive in not applicable for second technological process due to the fact that during blasting the abrasive crumbles and has different cutting properties as its graininess declines after each blasting.

Abrasive in the form glass spheres does not produce dust in the process.

The results of the experiment allow choosing properly technical parameters in order to obtain minimal and maximal roughness of the surface which is required in for particular treated object.

Due to different initial parameters and different distribution of tension, the results of the experiment do not find application in spatial objects.

References

1. J. Kaczmarek, J. Sikora, Cz. Czyżewicz: *Obróbka strumieniowo-ścierna,* Wydawnictwo Naukowo-Techniczne, Warszawa, 1963.
2. Prof. inż. S. Szulc, dr inż. A. Stefko: *Obróbka powierzchni części maszyn* Wydawnictwo Naukowo-Techniczne, Warszawa, 1976.
3. S. Adamczak: *Pomiary geometryczne powierzchni,* Wydawnictwo Naukowo-Techniczne, Warszawa, 2008.
4. B. Nowicki: *Struktura geometryczna. Chropowatość i falistość powierzchni,* Wydawnictwo Naukowo-Techniczne, Warszawa, 1991.
5. Niżankowski Cz., Cebulski D.: Efektywność usuwania powłok z różnego gatunku klejów przemysłowych wysokoenergetyczną strugą suchego lodu, Mechanik, 2016, nr 8-9.