

Mechanical Pretreatment of Surface of Aluminum Alloy D16-T by Shot Peening

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Abstract: The paper describes the influence of shot-peening onto aluminium alloy D16-T surface. There are estimates focusing into microgeometry of the shot peened surfaces, their roughness and a size of selected shot peened material - the corund. Based on the results of measurements, the evaluation was oriented on the curve of roughness, functionality of the surface roughness R_a and the necessary quantity of shot peening material q_{nR} of estimated material depending on the grain size d_z .

Keywords: shot peening, functional surface, surface roughness

1 Introduction

Surface strengthening by shot peening can make use shot peening to increase resistance to fatigue stress of engineering components. Some alloys (on the basis of magnesium) are inclining to fatigue cracks. Defects like grains and systemless structures begin and accelerate this cracks – tension focusing.

By high frequentional cyclical density, for smallest numbers of cycles to crash locations of cracks start appearing on the surface [1, 2]. For higher numbers of cycles to crash are locations of cracks begin to appear in the thermal area of the experimental sample [3]. After thermal treatment of some alloys the obtained structure, the compound of which is balanced polyedric grains with concrete phases. It involves mechanical properties growth and resistance to fatigue as well [4].

In present time there is enough developed imagination of deposition process of thermal spraying coatings on the surfaces of steel engineering accessories.

Lifetime of coatings depend on the ideal adhesion of functional coatings [5, 6, 7]. Adhesion is conditioned by ideal pretreatment of the functional surface. Shot peening is one of the most frequently used technologies of mechanical pretreatment of surface under thermal spraying coatings. The surface is cleaned by shot peening. It is created applicable microgeometry of the surface, too. It is known that the activation energy of surface made from deformation of surfaces layers during shot peening is definitely influencing on the coating adhesion [8]. This energy value reduces exponentially as a result of background influence. Therefore coating is to be deposited between 1-3 hours. Adhesion of coating to basic material can be evaluated by mechanism of adhesion. Mechanical adhesion of coating in surface relief of sample takes 50-80%. The Van der Waals forces make about 5% and power of chemical compounds make up 15-45%. In comparison with surface pretreatment by cauterization, shot peening is more convenient than cauterization. The technology of surface shot peening can be used for surface strengthening and producing good roughness of surface. The experiment was focused on the research of the microgeometry of surface, character of surface, influence of concrete parameter for making good, strong coating and the substance.

To use of thermal spraying technologies are actual for aviation components renovation, made from light alloys on the base Al, Mg, Ti. Experiment research the influence of sorts and dimensions shot peening material grain and shot peening parameters on the necessary quality of surface under thermal spraying coatings.

2 Experiment Methodology

Experimental research was headed to analyse shot peened coating microgeometry and the influence of technological parameters on the required quality of surface.

2.1 Evaluation of Shot Peened Coatings Microgeometry

Shot peening is a specific form of coatings pretreatment of components. Character of shot peened surface is typical for this technology. In the shot peening process the component surface is hacked. Roughness is evaluated by a touch-profiler. These appliances have bigger scale of measured parameters of surface roughness, for example $R_a=30\ \mu\text{m}$. Middle arithmetic aberrance R_a was selected for surface evaluation. For measuring values and for making profigrams of shot peened surfaces, profiler HOMMEL Tester T3 was used.

To obtain relevant results the next conditions have been used [7, 8]:

- length of measured distance $L = 6,3$ mm,
- terminal undulation (cut-off) $l = 1,25$ mm
- number of measurements $n = 10$.

Poligrams were taken out following next conditions:

- length of measured distance $L = 6,3$ mm,
- terminal undulation pinch $l = \infty$.

Medium arithmetic value as a statistic value has been calculated from measuring values of roughness. Each surface was evaluated by two profilegrams.

2.2 Experimental Samples Preparation

Dural samples D16-T (STN EN 42 49 11) were used in the experiment. Sample dimensions were chosen in such way to eliminate unwanted influence of shot peening device in process of shot peening (e.g heterogeneous consistency of the grain touches in the entire field of shot peening beam). Samples dimensions enabled as to realize adhesion test after thermal spraying coatings on surfaces of shot peened samples. Samples were made by turning into the form of a roll with diameter of 30 mm (Fig. 1). The functional surface of the samples before shot peening had the roughness of $R_a = 0,6$ μm .



Figure 1

Sample of the D16-T aluminium alloy after shot peening

2.3 The Material Used for Shot Peening

There are not uniform selected criteria for shot peening material by now. Selection of the shot peening material was based on the basic material properties.

For surfaces' shot peening process a corund granular was used (STN EN 22 40 12). This material is produced in all granularities and the shot peening material is a polydisperse. To explain the influence of the grain size into the surface roughness was the shot peening material selected by wire screen with a specific grain diameter. The chosen grain diameter was according to STN 15 3105.

2.4 Shot Peening Process

For shot peening of the evaluated sample surfaces a laboratory equipment [5] was used. The influence of the sort of the shot peening material was tested during the experiment at the following speeds: $v_1=78,1 \text{ ms}^{-1}$, $v_2=95,5 \text{ ms}^{-1}$ a $v_3=112,4 \text{ ms}^{-1}$. Grain angle incidence of shot peening material on sample surface was $\alpha=75^\circ$. The sample distance to the shot peening wheel was $L=200 \text{ mm}$. By Matling and Steffens, one cannot prevent hobbing of the shot peening material onto the shot peened surface. It can make galvanic cells [9]. Impresses (by hobbing) can be made by harder shot peening materials, too. Therefore for shot peening of the D16-T material corund was used with a minimum grain speed of $v_1=78,1 \text{ ms}^{-1}$. Next, corund of medium grain diameters: 0,36; 0,56; 0,71; 0,9; 1,12 mm were used.

3 Methodics of Determining the Hacking Curve of the Shot Peened Surface

The experiment was aimed to determination of the necessary quantity q_{HR} of abrasive material, which is needed to completely cover the shot peened surface. Initiate account was determined from character hackingcurves, with completing by visual scan by Meopta stereomicroscope with zoom 100x. The Hacking curve technique specifies the functional dependancy of the shot peened surface roughness onto the quantity of the abrasive material, which shapes the measured surface (Fig. 2). Area from first to second part is important for the determination of covering surface shot peening grade by Hackingcurves (Fig. 2) [6].

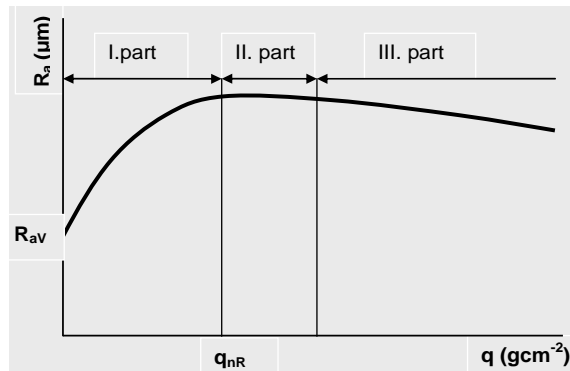


Figure 2
The hacking curve

3.1 D16-T Material Hacking Curves Determination

Samples from the D16-T material were shot peened gradually by amount of 1000 g, with covering grade $q=0,5 \text{ gcm}^{-2}$, number of amount 10. Next samples were shot peened by two amounts of 1000 g, fraction diameter $d_z=0,36; 0,56; 0,71; 0,9$ and $1,12 \text{ mm}$. After each shot peening the roughness R_a was measured. Each of R_a is the arithmetic average of 10 measured accounts. After each shot peening the surface was evaluated by means of optical microscope. After each shot peening another material was selected. The number of amounts in the experiment was selected so that the hacking curve could capture the first and second part, and partially the third one (Fig. 2). Hacking curves are in Fig. 3.

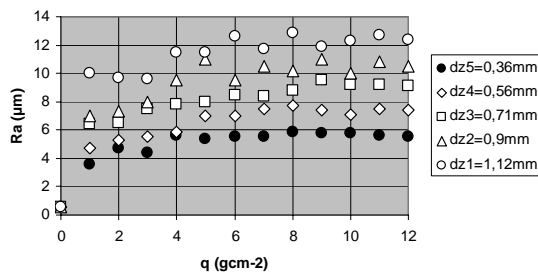


Figure 3
D16-T hacking curves with corundum fractions of diameters d_z

3.2 Necessary Quantity of an Abrasive Material Determination

To cover of shot peened surface with touches by shot peening, it is necessary to know the microgeometry of the shot peened surface. The grade of covering of this surface is to be $n=1$. Now, the necessary quantity of abrasive material for surface covering is on the hackingkurve q_{nR} . It is expected that the linear and planar covering grade is 1 (Fig. 2).

The dependency of determining the necessary quantity of the abrasive material in terms of the grain dimension can be solved from the hackingkurves (Fig. 3). The necessary quantity of abrasive material q_{nR} for dimension of the grain tested d_z was determined (Fig. 4). This way is valid for the shot peening applied.

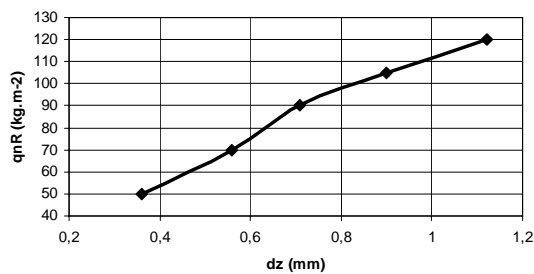


Figure 4

The correlation of necessary quantity of shot peening material q_{nR} on grain diameter d_z

3.3 Grain Diameter Influence of the Shot Peened Material on the Roughness R_a

The roughness value R_a of shot peened surface was dedicated as an arithmetic average from 10 measurements. Finished values for concrete grain diameters of shot peening material by speed $v_1=78,1 \text{ ms}^{-1}$ are in diagram (Fig. 3). There are necessary quantities involved of shot peening material q_{nR} , too. From function dependency it follows that as the grain diameter grows than the roughness value of shot peened material growth too. It is related directly with the touch size after the grains of the shot peening material falls on the surface.

4 Experimental Results Discussion

In the shot peening process were hacked samples surfaces gradually. So one can state that roughness change is different in measured values (Fig. 4). That were given material properties of the evaluated samples. The values R_a , q_{nR} , and d_z are in Table 1.

Table 1
 d_z , R_a and q_{nR} values of the material D16-T

d_z [mm]	0,36	0,56	0,71	0,9	1,12
R_a [μm]	5,8	7,5	9,25	10,8	12,5
q_{nR} [kgm^{-2}]	50	70	90	105	120

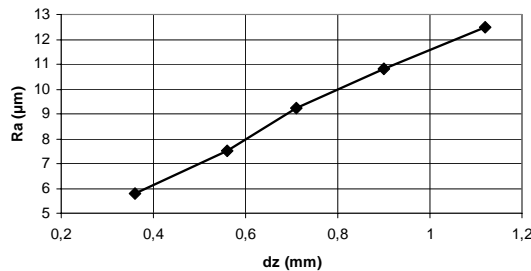


Figure 5

The correlation of surface roughness R_a of D16-T material on grain diameter d_z .

Conclusions

Upon analyses, study and realized experiments, can be said:

- the measured accounts were the basis for drawing the hacking curves – the change depends on the roughness R_a on the quantity of the shot peening material q_{nR} , which fall on the measured surface,
- the change in the roughness of the shot peened surface is influenced by the size of the grain of the shot peening material, as the size of diameter grows so does the roughness of the shot peened surface,
- necessary quantity of shot peening material q_{nR} for full covering of shot peened surface can be determined by the hacking curves,
- necessary quantity of shot peening material q_{nR} (corund) influences: shot peening parameters, especially the grain diameter,
- for the shot peened material D16-T a corund is the most suitable substance. By it can be achieved the cleanness of the shot peened surface and less necessary quantity of abrasive material q_{nR} with high accounts of roughness.

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References

- [1] Piľa J., Sloboda A., Sloboda A.: Some Opportunities of Diagnostic Parameters Utilization in the Aircraft Proactive Maintenance Management. In: DIS 2004 : Teória a aplikácia metód technickej diagnostiky: 7. ročník medzinárodnej vedeckej konferencie, Košice, October 13-14, 2004. Košice: Dom techniky ZSVTS, 2004, pp. 76-82, ISBN 80-232-0237-5
- [2] Neštrák D., Piľa J.: Helicopter Aerodynamics, Structures and Systems (in Slovak): Textbook: Akademické nakladateľství CERM, 2006, p. 454, ISBN 80-7204-484-2
- [3] Kuffová, M., Bella, V., Wolny, S.: Fatigue Resistance of Mg–Alloy AZ 63HP under High-Frequency Cyclic Loading. In *Mechanika Kwartalnik Akademii Górniczo-Hutniczej imienia Stanisława Staśika w Krakowie*, 23, 3, 2004, Poland
- [4] Kuffová, M.: Microstructure of Magnesium Alloys after Heat Treatment. In *proc. "Opatřebení, spolehlivost, diagnostika 2006"*, Brno, p. 139, ISBN 80-7231, Czech Republic
- [5] Mrva P., Kaliský S.: Mathematical Model Evaluation of the Shot Peening Technological Process of Ti Alloys onto Adhesion of Plasma Sprayed Coatings with Thermal Insulating Properties (in Slovak), Corrosion and Corrosion Protection of Materials (in Slovak), 4th International Conference, Trenčín, April 12-13, 2000, pp. 124-128
- [6] Kniewald D., Pivoda P.: Mechanical Pretreatment of the Surface of Parabolic Springs under Protective Al and Zn Thermal Sprayed Coatings (in Slovak), In: *Zborník vedeckých prác VŠT v Košiciach*, 1978, pp. 309-318, Slovak Republic
- [7] Mrva.: Research of the Influence of the Surface Pretreatment of Titanium Alloys (in Czech), Research report VU 070 Brno, 1986, Czech Republic
- [8] Kniewald D., Šefara M.: Vorbehandlung der Metalloberfläche durch Strahlen als Vorbereitung für Schutzüberzüge aus Pulverkunststoffen, *Zborník vedeckých prác VŠT v Košiciach*, 1980, pp. 263-274, Slovak Republic
- [9] Sedláček V.: *Metall Surfaces and Coatings* (in Czech), ČVUT Praha 1992, ISBN 1335-2393