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

Daniel Kottfer[1], Peter Mrva[2]

[1]Department of Technologies and Materials
Faculty of Mechanical Engineering
Technical University of Košice
Mäsiarska 74, 040 01 Košice, Slovakia, e-mail: daniel.kottfer@tuke.sk

[2]Department of Aviation Engineering
Faculty of Aeronautics
Technical University of Košice
Rampova 7, 041 21 Košice, Slovakia, e-mail: peter.mrva@tuke.sk

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 frequential 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 Walls 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 parametres 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-profimeter. These appliances have bigger scale of measured parameters of surface roughness, for example R_a=30 μm. Middle arithmetic aberrance R_a was selected for surface evaluation. For measuring values and for making profigrams of shot peened surfaces, profimeter 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=∞.

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 gain 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 ms^{-1}, v_2=95,5 ms^{-1} a v_3=112,4 ms^{-1}. Grain angle incidence of shot peening material on sample surface was α=75°. The sample distance to the shot peening wheel was L=200 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 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_{nR} of abrasive material, which is needed to completely cover the shot peened surface. Initiate accound was determinated 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].
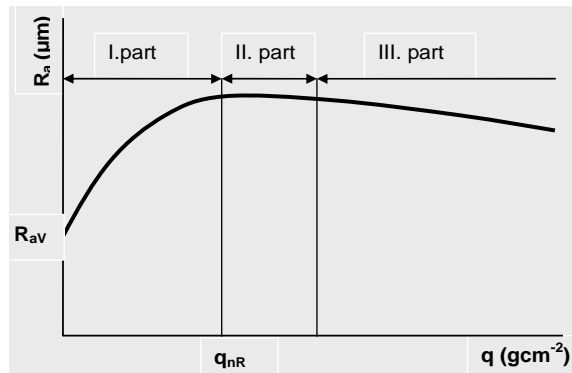
Figure 2
The hacking curve

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 $q=0,5$ 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 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.
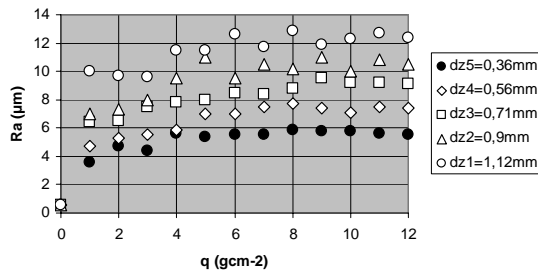

Figure 3
D16-T hacking curves with corundum fractions of diameters d_z

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.
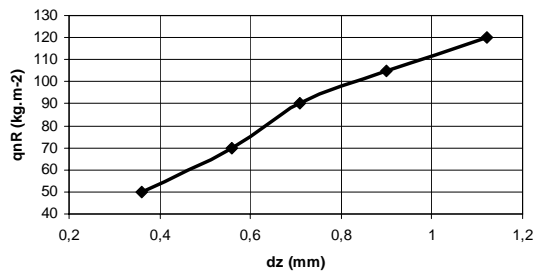

Figure 4

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 Ra

The roughness value R_a of shot peened surface was dedicated as an arithmetic avarage from 10 measurements. Finished values for concrete grain diameters of shot peening material by speed v_1=78,1 ms^{-1} are in diagram (Fig. 3). There are necessary quantities involved of shot peening material q_{nR}, too. From function dependancy 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 Discusion

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

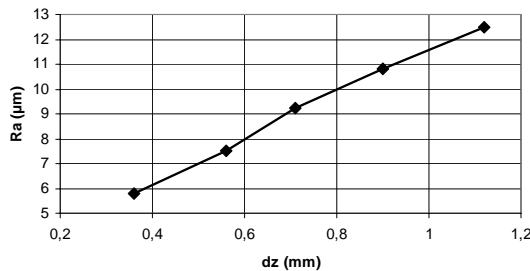| d_z [mm]	0,36	0,56	0,71	0,9	1,12
R_a [μm]	5,8	7,5	9,25	10,8	12,5
q_{nR} [kgm^{-2}]	50	70	90	105	120

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 peenned 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.

Acknowledgement

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