THE EFFECTS OF CUTTING METHODS OF SURFACE ROUGHNESS OF ALUMINUM POROUS MATERIAL PRODUCED VIA VACUUM METHOD

3 authors:

Abdurrahman Karabulut
Afyon Kocatepe University
36 PUBLICATIONS **145** CITATIONS

Lutfiye Dahil
Istanbul Aydin University
19 PUBLICATIONS **33** CITATIONS

M. Serhat Baspinar
Afyon Kocatepe University
32 PUBLICATIONS **366** CITATIONS

INTERNATIONAL JOURNAL OF ELECTRONICS; MECHANICAL and MECHATRONICS ENGINEERING Vol.3 Num 4 pp.(645-652)

THE EFFECTS OF CUTTING METHODS OF SURFACE ROUGHNESS OF ALUMINUM POROUS MATERIAL PRODUCED VIA VACUUM METHOD

Lütfiye DAHIL[1] M. Serhat BAŞPINAR[2] Abdurrahman KARABULUT[3]

[1]Istanbul Aydın University, Department of Machinery and Metal Technology, Turkey
[2]Afyon Kocatepe University, Metallurgy Education, Turkey
[3]Afyon Kocatepe University, Mechanical Engineering, Turkey

lutfiyedahil@aydin.edu.tr sbaspinar@aku.edu.tr kbulut@aku.edu.tr

Abstract*: In this study, the surface roughness values of 3 aluminum porous materials, which were produced via vacuum method and have different porous structures, depending on the implemented cutting method after processing them were assessed comparatively. 3 different cutting methods have been implemented on each of samples, as Water Jet, Wire Erosion, and Band Saw. Setting the speed to 20 m/min, the methods were compared under same conditions. The smoothness measurement has been executed by taking the mean of 3 measurements in parallel with surface and 3 measurements in vertical to surface. By comparing the obtained results, it has been determined that the most advantageous method is the Wire Erosion method.*

Key words: *Aluminum porous material, Pore, Cutting method, Surface roughness.*

Introduction

The open-pored aluminum materials are subjected to cutting process in order to give desired shape and dimensions. Depending on implemented cutting method and pore density of the material, there may be significant differences among the cutting surfaces.

In a study, the open-pored aluminum material has been subjected to 4 different cutting methods (circular saw, band saw, wire saw, and electro-erosion) in order to determine the toleration to thermal contact. The effects were investigated, significantly different contact surface regions emerged between upper and lower layers, and significant plastic erosions occurred in columns near the cutting surfaces. First 2 methods led to significant regional pressures, but these pressures weren't observed in other methods. The highest thermal-resistance was observed in sample obtained via circular saw. The band saw declined the cutting resistance by 25%, electro-erosion led to decrease by 36%, and the wire saw decreased the contact resistance by 64% [1]. A study has been carried out on synchronous optimization of dimensional accuracy and surface smoothness of wire EDM cut of K460 steel. While the peak current has affected only the surface thickness, it has been observed that double peak current and convergence distance have had significant effects on samples [2]. In another kinematic simulation study, 3 different abrasive particles (sapphire, cut cone, and cone) have been used in erosion in order to determine surface smoothness by presenting the single-point diamond coating method where there are flexible cutting and sensitive fragile components. In that study, the implementation of flexible cutting and sensitive fragile components on coating model production under erosion and coating conditions has led only to similar flexible coating regardless of pseudo-abrasive particle shape [3]. The numeric and experimental analyses of surface smoothness created by shot peening have been performed. The roughness parameters obtained via numeric simulation were same with roughness values measured in shot-peened steel types. The roughness increases with increasing impact diameter and/or impact speed; from the aspect of Ra, during the process duration, it increases with increasing covering even if it depends on reaching a certain level. The changes occurring due to increases in covers allow the effects changing the topography of the surface to enlarge, and first 2 dependencies are explained with large dimensions of pores. Various roughness parameters including Ra, Rc and Rz show different development tendencies during the process [4]. Non-Gaussian roughness surfaces were created by LDW. 2 tracking paths and 3 manufacturing structure were designed, and selected to be the most ideal. The results have shown that the vertically segmented process brings better accuracy values in roughness samples than horizontally segmented process. The Platform Roughness structures have decreased the edge roughness in production and type enlargements in SPM measurement. Large statistical parameters have been designed, and compared between produced surfaces. Then it has been demonstrated via LDW that non-Gaussian surface production is appropriate [5]. A study has been carried out on decreasing the surface smoothness by using spray-coated hydrogen silsecusion reflow. This decrease of surface roughness has been measured via 2 different methods as atomic force microscopy (AFM) and vertical scanning estimation (VSC), and a perfect harmony between the optic profilometry results has been [6]. The effects of surface roughness on oxidation in air and steam at certain temperatures have been investigated. While the effects of surface roughness were less significant for longer oxidation periods, the initial weight increase and oxidation rates are more obvious. So, in initial phases of oxidation, the high Zirkoloy-4 surface smoothness allows high oxidation [7]. A study has been carried out on analytical and experimental determination of “Ra” surface roughness during the turning operation. An analytical balance has been provided in order to calculate the Ra theoretical arithmetic average value. The deviation between the estimated and obtained surface roughness values during processing operations has been investigated. The effect of minimum chip thickness on the surface has been discussed considering the events about the pseudo-flow side of processed material [8]. A study has been carried out on measuring the surface roughness by using wiper inserts in turning the AISI 1045 carbon steel. The surface roughness has been demonstrated by using parameters at various widths (Ra, RzD, R3z, Rq, Rt, Ra/Rq, Rq/Rt, Ra/Rt). With wiper inserts and high rates of feed, it is possible to obtain surfaces processed with Ra <0.8 μm. as a result, in mechanic sensitivity topic, it is possible to obtain surface quality without cylindrical drilling operation [9]. In this study, the use of vibration signals in determining the surface roughness during turning the Ti–6Al–4V compound has been investigated. Since it can be directly implemented on computer-based production environment, the artificial neural network model has been developed. The validity of this model in accurate determination of surface roughness has been demonstrated (max. error rate 7.45%) [10]. In another study, the effects of evaporative pattern casting (EPC) on surface roughness of Al–7% compound castings have been investigated. The extendable polystyrene (EPC) template has not been mounted, it has been sunk into the sand, and replaced with molten metal. It is an important feature of EPC process. This study has investigated the effects of the parameters such as vacuum level, casting temperature, number of grainfiness, vibration amplitude, and vibration duration on surface roughness of AL-7% compound castings. The analysis of the results indicates that the surface roughness increases with increase in vacuum level and casting temperature. On the other hand, it has been observed that there is an inverse relationship with the number of grainfiness, vibration amplitude, and vibration duration [11]. Sodick has investigated the effects of C 000, C 500, and C 800 cutting parameters on surface smoothness of the material and microstructure in A320D-EX21 type Wire Erosion bench in AISI 4340 steel. At the end of the study, it has been observed that the surface smoothness, hardness, and the thickness of surface layer affected by temperature have changed depending on cutting conditions [12]. Depending on the parameters of dielectric liquid circulation pressure, pulse duration, voltage, and wire feed rate, the surface roughness and microstructure change of aluminum compound has been investigated in wire erosion method. As a result, the surface characteristics of the samples vary depending on process parameters, and it is required to select parameters in accordance with properties expected from the material [13].

The effects of cutting parameters of AISI52100 steel in finish turning on cutting force and surface roughness have been investigated, and the estimations from developed models have been compared with measured force and surface roughness values. In order to test the reliability of the data, the ANOVA analysis was utilized. The appropriate range of process parameter values was recommended for effective operation of energy [14].

Materials and Method

Preparation of Aluminum Foam Material

Through vacuum method, the aluminum-based, open-pored foam metal material has been obtained via NaCl (sodium chloride) salts used as gap-filler material. As soluble-type gap-filler material, the table salt stone NaCl was utilized. After breaking and sifting the rock salts used in producing foam material, they have been passed through 2-4mm, 4-4.75mm, and 4.75-6.3mm sieves. The salts obtained as a result of this process have been divided into 3 particle-size groups, and different series have been produced. The sifted salts have been kept in drying oven at approximately 100 °C for 30 minutes for removing the moisture. 185gr of the aluminum bullion and aluminum-silicon bullion materials and 190gr of salts have been put into melting pot. The liquid aluminum has been leaked into the particles of NaCl salts placed in the mold through the vacuum method. In order to produce Al- or Al-12Si-based aluminum foams, the mold has been placed into its place on mold table within the vacuum system of NaCl salts, and NaCl salts were poured into it. By operating the vacuum system, the pressure value of -0.8 bar has been obtained. Right after that, the liquid aluminum melted in oven has been poured onto the NaCl salts in mold, and then the vacuum valve has been opened. Hence, the liquid aluminum could penetrate into NaCl salts, and low-density aluminum foam has been obtained. In order for samples to dissolve and to create a gap, they were subjected to dissolution process. For this reason, the dissolution process has been implemented to samples at 100 °C for approximately 60 minutes. The samples were placed into a setting where the temperature was 1000C, and in which they were hanging in a beaker containing 800 ml of water. After the dissolution process, the foam samples have been kept in an oven at 100°C for 2 hours. The order of aluminum foam materials produced for using in experiment is seen in Figure 1, from more porous to less porous structure.

Figure 1: Aluminum foam materials used in experiment

Measuring the Surface Roughness

Aluminum foam materials having 3 different pore structures and produced via vacuum method have been cut by water jet, wire erosion, and band saw bench at 20 mm/min.

a) Cutting with water jet b) Cutting with wire erosion c) Cutting with band saw

Figure 2: Cutting the material through various cutting methods

fixed rate of feed. In Figure 2, the materials being cut at benches are presented.

9 pieces of materials having 3 different pore structures and cut at the benches have been put into Surftest-SV 2100 roughness measurement device, and the roughness measurements have been executed 3 times at parallel and vertical angles. Taking the mean values of these measurement results, the obtained values have been compared. In Table 1, the mean values of surface roughness values of cut materials are presented.

Conclusions

By measuring the surface roughness values of materials, which have been produced via vacuum method and have 3 different pore structures, emerged as a result of being cut at bench by water jet, wire erosion, and band saw, the most ideal cutting method has been determined. Arithmetical average of the roughness measurements performed in parallel and vertical to cutting edge of the material have been taken, and these values have been compared. In cutting via water jet, since the cavernous structure of the

		Water jet			Wire erosion			Band saw		
		Very porous	Medium porous	Slightly porous	Very porous	Medium porous	Slightly porous	Very porous	Medium porous	Slightly porous
Measurement in parallel to cutting surface	R_a	3.885	3.107	2.490	3.146	2.665	3.198	1.018	2.490	3.584
	R_z	20.10	14.90	13.57	13.70	13.30	15.90	6.51	11.55	16.13
	R	29.90	22.10	22.83	19.46	16.56	23.13	9.84	15.00	22.03
	R	11.50	11.48	10.90	12.10	-	9.51	2.94	8.53	10.70
Measurement vertical to cutting surface	R_a	3.357	5.055	3.788	3.908	3.607	3.443	3.298	1.709	1.298
	R_z	17.10	25.33	18.10	17.33	16.86	15.63	15.53	8.02	6.86
	R	24.36	33.03	28.46	25.60	21.56	22.06	20.10	12.32	11.17
	R	9.34	6.86	13.75	-	9.53	14.00	10.80	4.31	3.86

material leads to diversion in water jet beam, the highest roughness values have been observed in this method. In order for a vacuumed foam material to be used as a product, a second processing is required. Despite its advantage of possibility of various geometrical shapes, it has been determined that the water jet method is costly and disadvantageous method in processing the foam material. Despite of its advantage of operational diversity, the current transmission problems have been experienced in wire erosion method due to the cavernous structure within the foam material. Due to this problem, both of the operation duration and cost have increased besides the high surface roughness. It has been determined that the surface roughness values of the samples cut in band saw bench were the lowest values. When the values obtained have been assessed, it has been concluded that the lowest surface roughness values at 20 mm/min. rate of feed in 3 different pore structures has been achieved via band saw bench. Due to both of its operation duration and inessentiality of multiple operations on processed materials, it has been decided that the most efficient method of processing the foam materials is the band saw bench method.

Ra- Mean surface roughness (arithmetic mean roughness. It doesn't give precision results.

Rz- Mean roughness height (Maximum roughness depth.. the highest and 5 tips are measured.

Rmax- Maximum roughness height (measurement of the distance between highest peak and deepest hole.

References

Akhiani H, Szpunar J.A. (2013). Effect of surface roughness on the texture and oxidation behavior of Zircaloy-4 cladding tube. Applied Surface Science DOI: http://dx.doi.org/doi:10.1016/j.apsusc.2013.08.137

Bagherifard S, Ghelichi R, Guagliano M. (2012). Numerical and experimental analysis of surface roughness generated by shot peening. Applied Surface Science. 258. (6831-6840).

Cech J, Pranov H, Kofod G, Matschuk M, Murthy S, Taboryski R. (2013). Surface roughness reduction using spray-coated hydrogen silsesquioxane reflow. Applied Surface Science. 280. (424-430).

De Jaeger P, T'Joen C, Huisseune H, Ameel B, De Schampheleire S, De Paepe M. (2012). Assessing the influence of four cutting methods on the thermal contact resistance of open-cell aluminum foam. International Journal of Heat and Mass Transfer.55. (6142-6151).

Esteves Correia A, Paulo Davim J. (2011). Surface roughness measurement in turning carbon steel AISI 1045 using wiper inserts. Measurement. 44.(1000-1005).

Gaurav B, Choudhury S.K. (2012). Effect of cutting parameters on cutting force and surface roughness during finish hard turning AISI52100 grade steel. Procedia CIRP. 1. (651-656).

Hascalık A,Caydas U, (2003). Microstructure and the effect of cutting parameters on surface roughness in machining and wire erosion Research in Eastern Anatolia Region. 3.

Hascalık A,Caydas U. (2004). Wire erosion method of the effect of the surface structure of aluminum alloy processing parameters. Journal of Polytechnic.1.

Kanlayasiri K, Jattakul P. (2013). Simultaneous optimization of dimensional accuracy and surface roughness for finishing cut of wire-EDMed K460 tool steel. Precision Engineering. 37. (556-561).

Kumar S, Kumar P, Shan H.S. (2007). Effect of evaporative pattern casting process parameters on the surface roughness of Al–7% Si alloy castings. Journal of Materials Processing Technology. 182.(615–623)

Liua Y, Warkentin A, Bauer R, Gong Y. (2013). Investigation of different grain shapes and dressing to predict surface roughness in grinding using kinematic simulations. Precision Engineering. 37. (758-764).

Luoa T, Liua X, Chena Y, Huanga W. (2013). Zhe LiubDesign and laser fabrication of controllable non-Gaussian roughness surfaces at microscale. Applied Surface Science. 276. (95- 100).

Upadhyay V, Jain P.K, Mehta N.K. (2013). In-process prediction of surface roughness in turning of Ti–6Al–4V alloy using cutting parameters and vibration signals.Measurement. 46. (154-160).

Stahla J.E, Schultheiss F, Hägglund S. (2011).Analytical and Experimental Determination of the Ra Surface Roughness during Turning. Procedia Engineering. 19. (349-356).

THE EFFECTS OF CUTTING METHODS OF SURFACE ROUGHNESS OF ALUMINUM POROUS MATERIAL PRODUCED VIA VACUUM METHOD

Lütfiye DAHİL M. Serhat BAŞPINAR Abdurrahman KARABULUT