Examining the Effects of Advanced Cutting Methods on Surface Porosity of Aluminum Foam Material

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Abstract—**In this study, the aluminum foam material having two different pore structures was obtained. These materials were cut using advanced cutting methods (waterjet and wire erosion). And then, the porosity levels of the cut surfaces were examined depending on the cutting method applied. In order to ensure the equal measurement, the rate of feed was set to 40m/min. The porosity measurements were repeated for 6 times in parallel and vertical to cutting surface, and the mean value of those measurements was calculated. There were also problems with the two cutting methods. Both methods require additional processing. In terms of continuity of the cutting process, water jet is more advantageous. Water jetting in high and medium pore specimens yielded better results in places parallel to the cutting surface. It was the result of water jetting better at places that are perpendicular to the cutting surface.**

Key words: **Aluminumfoammaterial, Advanced cuttingtechniques, Pore, Surfaceroughness.**

I. INTRODUCTİON

The porous aluminum material is treated with cutting methods in order to obtain the desired shape. The differences occur on the cutting surface depending on the cutting method being applied and the pore intensity on surface. A number of studies were carried on decreasing the surface porosity. For this purpose, the measurements were performed using Atomic Force Microscope (AFM) and Vertical Scanning Estimation (VSE), and perfect conformity was determined between the optical profilometry results [1].

Numerical and experimental analyses of the surface porosity created by steel ball scraping were performed. The porosity parameters obtained via numerical simulation were found to be same with the porosity values found on steels scraped with steel ball [2].Vibration signals were used in determining the surface porosity during turning procedure. An artificial neural network that can be used in computer-controlled production was developed. The accuracy of this model in determining the surface porosity was approved [3].Wiper inserts were used in turning the AISI 1045 carbon steel, and it was aimed to measure the surface porosity. The surface porosity was presented using parameters having different widths. In mechanical precision, it is possible to obtain surface quality without cylindrical cutting procedure [4].Ra carried out a study on analytically and experimentally determining the surface porosity during turning process. Ra offered an analytical balance for calculating the theoretical arithmetical mean value. The deviations between the expected and obtained porosity values were examined [5].The effects of surface porosity on the oxidation on air and vapor at certain temperature levels were studied. The effect of surface porosity was found to be less significant for longer oxidation durations [6].The effects of AISI52100 steel's cutting parameters during finishing turning on the cutting force and surface porosity were examined. Appropriate range of procedure parameters were recommended for efficient use of the energy [7].

Using AISI 4340 steel, the effects of cutting parameters in wire erosion lathe on the surface porosity and micro structure were examined. It was determined that, depending on the cutting conditions, the surface porosity and hardness and the thickness of surface affected from heat were seen to change [8].In another study, the changes in surface porosity and microstructure based on the parameters were studied in wire erosion method. It was determined that surface properties of the samples changed depending on the procedure parameters [9].In a study, the open-pored aluminum material was cut using circular saw, band saw, wire saw, and electro-erosion methods. First two methods caused regional pressures, while no pressure was observed in other methods. The highest level of thermal contact endurance was determined in the sample cut using circular saw [10].

In this study, the aluminum foam material having two different pore structures was obtained. These materials were cut using advanced cutting methods (waterjet and wire erosion). And then, the porosity levels of the cut surfaces were examined depending on the cutting method applied.

II. MATERİALSANDMETHODS

Aluminum-based open-pored foam material was obtained using vacuum casting method and NaCl (sodium chloride) salts. The rock salts, which were used in obtaining the foam material, were crumbled and then sieved to sizes of 2-4mm, 4-4.75mm, and 4.75-6.3mm. The sieved salts were kept in drying oven at 100˚C for 30 minutes in order to remove the moisture. 185g of ingot aluminum and aluminum-silicon alloy and 190g of salts were mixed in melting pot. In order to allow the easy passage of liquid aluminum through the NaCl salts,

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the metal container and mold were also heated in the oven together with the rock salts. The liquid aluminum was leaked through the NaCl salts (sodium chloride) grains placed into the mold by employing the vacuum method. In order to obtain Al- or Al-12Si-based aluminum foams, the NaCl salts were placed into the mold platform in the vacuum system.

The vacuum system was run and it reached at the pressure level of -0.8bar. And then, the liquid aluminum, which was melted in the oven, was immediately poured on the NaCl salts placed on the mold, and then the vacuum valve was opened. Thus, the liquid aluminum was allowed to pass through the NaCl salts, and the low-density aluminum foam was obtained.

The samples were treated with decomposition process at 100˚C for 60 minutes in order to ensure the gap between salt grains. Following the decomposition process, the aluminum foam samples were kept in oven at 100˚C for 2 hours for drying. The aluminum foam materials prepared for using in experiments are presented in Figure 1.



Fig 1. Aluminum foam materials used in experiment

The aluminum foam materials having 3 different pore structures, which were obtained via vacuum casting method, were cut via waterjet and wire erosion methods at constant feeding rate of 40m/min. In Figure 2-3, the cutting process of materials is presented.



Fig 2. Cuttingwithwater jet

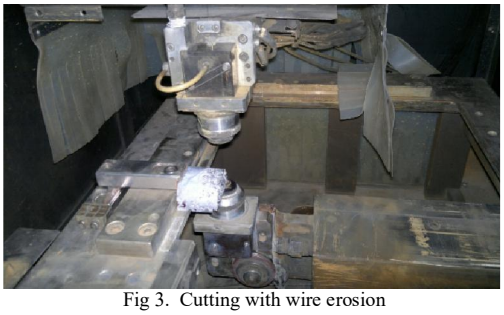


Fig 3. Cutting with wire erosion

The porosity measurements of six materials having three different pore structures, which were cut on the bench, were performed using Surfest-SV 2100 porosity measurement device. The measurements were repeated for 3 times at two different angles (parallel and vertical to the surface). And then the average of these measurements was calculated and the average values were compared.

InTable 1, themeanvalues of surfaceroughnessvalues of cutmaterialsarepresented.

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.

Table I: The mean values of surface roughness values of cut materials are presented

Measuredsurface	Cutting method	Water jet			Wireerosion		
	Roughnessvalues	*Veryporous*	*Mediumporous*	*Slightlyporous*	*Veryporous*	*Mediumporous*	*Slightlyporous*
Measurement in paralleltocuttingsurface	R_a	3.79	3.89	2.61	3.03	2.91	3.36
	R_z	18.9	19.1	14.2	13.1	12.8	16.7
	R_{max}	31.9	25.8	18.1	20.2	21.0	22.2
	R_k	11.1	15.0	-	-	-	9.91
Measurement verticaltocuttingsurface	R_a	2.89	4.92	2.12	4.71	4.43	3.61
	R_z	15.9	25.1	10.9	21.7	18.1	16.0
	R_{max}	22.9	30.8	26.7	35.7	21.3	25.1
	R_k	7.96	6.91	5.41	-	-	13.8
Measurement in paralleltocuttingsurface	R_a	4.49	2.48	1.85	2.58	2.51	2.81
	R_z	20.8	12.1	7.90	11.3	15.3	15.2
	R_{max}	31.2	18.2	26.0	12.8	11.9	19.3
	R_k	12.7	-	-	-	-	7.77
Measurement verticaltocuttingsurface	R_a	3.48	5.51	3.91	3.18	2.93	3.81
	R_z	16.7	25.8	17.2	14.2	16.1	17.2
	R_{max}	28.1	34.3	24.1	19.2	22.0	23.1
	R_k	9.02	-	15.3	-	8.10	-
Measurement in paralleltocuttingsurface	R_a	3.28	2.88	3.22	3.92	2.73	3.41
	R_z	18.9	12.6	18.2	15.8	12.1	15.8
	R_{max}	27.1	23.2	25.3	26.1	16.9	28.2
	R_k	-	8.31	11.1	12.3	-	11.2
Measurement verticaltocuttingsurface	R_a	3.72	4.67	5.23	3.95	3.58	3.07
	R_z	17.1	24.8	25.8	15.8	17.0	13.6
	R_{max}	22.8	34.0	35.8	22.1	22.2	18.8
	R_k	11.2	-	13.3	-	11.2	-

As seen in Table 1, the values obtained with respect to the cutting surface vary. In the measurements parallel to thecutting surface, the values obtained by water jet cutting are larger.

Figures 4 and 5 show graphs of the average values of surface roughness measurements on the cutting surfaces.

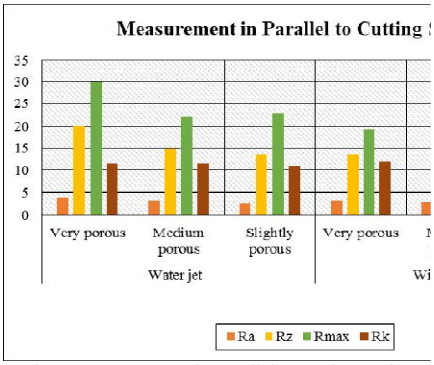


Fig 4. Measurement in parallel to cutting surface arithmeticaverages

As can be seen in Figure 4, the difference between the two cutting methods appears to be greater as the porous density increases on this cutting surface.

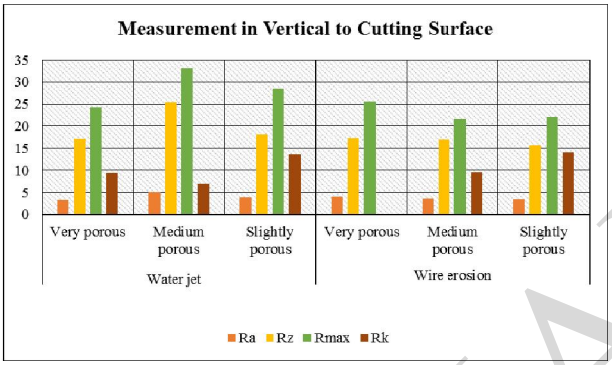


Fig 5. Measurement in vertical to cutting surface arithmeticaverages

As can be seen in Figure 5, it is seen that the values in the water jet cutting method are higher in me diumand slightly poroussamples on this cutting surface.

III. CONCLUSION

By measuring the surface roughness values of materials 3 different pore structures emerged as a result of being cut at bench by water jet and wire erosion 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 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. Therefore, there were problems in the cutting process in both methods. Both methods require additional processing. In terms of continuity of the cutting process, water jet is more advantageous. Water jetting in high and medium pore specimens yielded better results in places parallel to the cutting surface. It was the result of water jetting better at places that are perpendicular to the cutting surface.

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