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An Optimization of AWJM Process by Using Single Objective Function

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A B S T R A C T

It is challenging to process metal matrix composites using conventional machining techniques. Modern technologies like abrasive water jet machining allow almost any technical material to be machined. A particularly effective machining technique that solves problems with cutting temperature and tool wear is abrasive water jet machining. This experiment examines a specific study on hybrid metal matrix composites made with AA7075, reinforced in aluminum alloy with 5% B4C, 3% fly ash, and 1% magnesium, and processed using abrasive water jets created with garnet 80 mesh size.. The average roughness has a significant impact on the speed at which water jets traverse. The combination of water jet traversal speed and standoff distance is observed to have a greater influence on water pressure among interaction effects. The analysis conducted in this paper would aid in the careful selection of process parameters for constructing statistical models for estimating the depth of jet penetration feasible with AWJs caused by the change of different factors.

Keywords: Abrasive Water jet Cutting, Abrasives, Metal Matrix Composites, Sand Casting

1. Introduction

By impacting hard and brittle materials with abrasive slurry particles, abrasive water jet machining (AWJM) is a mechanical material removal technique that creates holes and cavities in materials. The metallurgical and physical qualities of the work piece remain unchanged due to the non-thermal, non-chemical, and non-electrical nature of the operation.

1.1 Applications

Due to the uniqueness of abrasive water jet cutting, there are many applications where it is more useful and economical than standard machining processes. In this section, some of the major applications and uses of abrasive water jet cutting are given.

Abrasive water jet machining is used mostly to cut stronger materials such as steel, and even some tool steels can be cut. Though the applications are somewhat limited listed below are some of the applications.

2. Composite

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their constituents (physical property of steel are similar to those of pure iron) . Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc These days, composite materials are more in demand because of their many qualities, which include low density, excellent wear resistance, high tensile strength, and smooth surface finish. As a solid waste byproduct from ceramic plants, titanium dioxide is one of the least priced and low density reinforcing materials that is readily available in large numbers. We'll also take the Hardness strength into account. An experimental setup with all required inputs has been prepared in order to accomplish the aforementioned. In this work, a composite is created by mixing magnesium, fly ash, and boron carbide into aluminum alloy in different mass ratios. The composite needs to be created using the crucible casting method, and its mechanical properties need to be examined.

2.1 Aluminum-7075

2.2 Al 7075 has a smooth surface, is highly resistant to corrosion, is easy to weld, and is anodize. Usually found in T6 temper, it is formable in T4 condition as well.

2.2 Boron Carbide

2.4 Al 7075 has a smooth surface, is highly resistant to corrosion, is easy to weld, and is anodize. Usually found in T6 temper, it is formable in T4 condition as well.

2.5 Flyash

One of the byproducts of burning that consists of the small particles that ascend with the flue gases is fly ash, sometimes referred to as flue-ash. Bottom ash is the name given to ash that doesn't rise. Fly ash is typically used to describe the ash left over after burning coal in an industrial setting Before the flue gases from coal-fired power plants reach the chimneys, fly ash is typically collected by electrostatic precipitators or other particle filtration devices. When combined with bottom ash that is extracted from the furnace's bottom, this mixture is referred to as coal ash.

Mixing Ratio of Composite

Al7075 + B_4C-5%+FA-3%+Mg-1%

Mixing Ratio- Total Al 7075-1263 gram

RATIO	AL 7075 grams	B_4C gm	FLY ASH gm	Mg 1%
1	1263	63	38	12

3. WJM Process Parameter And Their Level

Process parameters and their levels

LEVELS		PROCESS PARAMETERS		
		LEVEL-1	LEVEL-2	LEVEL-3
1	WATER PRESSURE (Mpa)	100	150	200
2	CUTTING SPEED-mm/min	200	300	400
3	STAND OFF DISTANCE-mm	4	6	8

4. An Orthogonal Array L_9 Formation (Interaction)

An orthogonal array L_9 formation (interaction) of AJM.

No	(A)WATER PR (MPa)	(B) TRAVERSE SPEED (mm/min)	SOD mm
1	100	200	4
2	100	300	6
3	100	400	8
4	150	200	6
5	150	300	8
6	150	400	4
7	200	200	8
8	200	300	4
9	200	400	6

4.1 Experimental Input and Output Values

Experimental data and output response analysis

IP/OP	WP	TS	SOD	RA	CL	RE	CY
1	100	200	4	2.189	1.0525	0.1293	0.2797
2	100	300	6	2.128	1.2818	0.0340	0.1696
3	100	400	8	3.220	1.3079	0.0082	0.2141
4	150	200	6	2.890	1.0855	0.0419	0.1446
5	150	300	8	2.562	1.3205	0.0206	0.1672
6	150	400	4	2.128	1.2838	0.0573	0.2316
7	200	200	8	2.112	1.4930	0.0271	0.2768
8	200	300	4	2.922	1.3357	0.0215	0.1839
9	200	400	6	3.281	1.2715	0.0111	0.0757

5. RA For Each Level Of The Process Parameter

Response Table for Signal to Noise RA-Smaller is better

LEVEL	WP	TS	SOD
1	-7.840	-7.506	-7.559
2	-7.983	-8.015	-8.699
3	-8.709	-9.012	-8.274
DELTA	0.869	1.507	1.140
RANK	3	1	2

Analysis of Variance for RA

SOURCE	DF	SEQ SS	ADJ MS	F	P	% OF CONTRIBUTION
WP	2	0.1275	0.06374	0.11	0.904	7
TS	2	0.3644	0.18219	0.30	0.768	19
SOD	2	0.1907	0.09537	0.16	0.864	10
ERROR	2	1.2073	0.60366			64
TOTAL	8	1.8899				100

6. Diameter Error (Analysis Of Result)

Response Table for Signal to Noise Circle-Smaller is better

LEVEL	WP	TS	SOD
1	-1.644	-1.546	-1.710
2	-1.766	-2.362	-1.652
3	-2.694	-2.196	-2.742
DELTA	1.050	0.816	1.091
RANK	2	3	1

Analysis of Variance for Circle

SOURCE	DF	SEQ SS	ADJ MS	F	P	% OF CONTRIBUTION
WP	2	0.04227	0.021137	1.32	0.430	30
TS	2	0.01708	0.008542	0.54	0.651	12
SOD	2	0.04844	0.024220	1.52	0.397	35
ERROR	2	0.03191	0.015956			23
TOTAL	8	0.13971				100

7. Roundness Error (Analysis Of Result)

Response Table for Signal to Noise Roundness-Smaller is better

LEVEL	WP	TS	SOD
1	29.62	25.55	25.32
2	28.71	32.15	32.01
3	34.60	35.22	35.60
DELTA	5.89	9.66	10.28
RANK	3	2	1

Analysis of Variance for Roundness

SOURCE	DF	SEQ SS	ADJ MS	F	P	% OF CONTRIBUTION
WP	2	0.002087	0.001044	1.57	0.390	19
TS	2	0.003305	0.001652	2.48	0.287	30
SOD	2	0.004311	0.002155	3.23	0.236	39
ERROR	2	0.001333	0.000667			12
TOTAL	8	0.011036				100

8. Cylindricity Error (Analysis Of Result)

Response Table for Signal to Noise Cylindricity -Smaller is better

LEVEL	WP	TS	SOD
1	13.29	13.01	12.83
2	15.01	15.22	18.21
3	16.09	16.17	13.36
DELTA	2.81	3.16	5.38
RANK	3	2	1

Analysis of Variance for Cylindricity

SOURCE	DF	SEQ SS	ADJ MS	F	P	% OF CONTRIBUTION
WP	2	0.003398	0.001699	0.71	0.584	10
TS	2	0.007204	0.003602	1.51	0.398	21
SOD	2	0.018502	0.009251	3.88	0.205	55

ERROR	2	0.004765	0.002382			14
TOTAL	8	0.033868				100

9. Result & Conclusion

The results of this investigation unequivocally show that the sand casting technology is appropriate for producing larger-sized components. The impact of waterjet pressure and traverse speed on the jet penetration depths is greater than that of the abrasive flow rate. In particular, the average roughness has a significant impact on the waterjet traversal speed. The combination of waterjet traverses speed and stand distance is observed to have a greater impact on water pressure among interaction effects. The analysis conducted in this paper would aid in the careful selection of process parameters for constructing statistical models for estimating the depth of jet penetration feasible with AWJs caused by the change of different factors. Hence, the result of the experiment were summarized and concluded as follows:

9.1 Optimal Control Factor

1. Surface roughness- A_3 (WP -200 Mpa) B_1 (TS -200 mm/min) C_2 (SOD 6 mm)
2. Circular Error- A_2 (WP -150 Mpa) B_3 (TS -400 mm/min) C_1 (SOD 4 mm)
3. Roundness Error- A_3 (WP -200 Mpa) B_2 (TS -300 mm/min) C_1 (SOD 4 mm)
4. Cylindercity Error- A_3 (WP -200 Mpa) B_2 (TS -300 mm/min) C_1 (SOD 4 mm)

9.2 Percentage Contribution of Process Parameter

1. Surface roughness – Traverse Speed 19%
2. Circular Error – Water Pressure 30%
3. Roundness error – SOD 39%
4. Cylindercity Error - SOD 55%

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