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Study of Magnetic Abrasive Finishing of Aluminium Pipes using Nanoparticles

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ABSTRACT: Surface texture is roughness. Variations in a surface's normal vector from its ideal shape are measured. If the differences are large, the surface is rough; otherwise, it's smooth. Roughness is a high-frequency, short-wavelength surface measurement. Roughness defines how an object interacts with its environment. In tribology, rough surfaces wear faster and have higher friction coefficients. Roughness is a key indicator of a mechanical component's performance since surface irregularities can induce fractures or corrosion. Roughness encourages adherence. Cross-scale characteristics like surface fractality enable more accurate predictions of surface mechanical interactions like contact stiffness and static friction.

I. INTRODUCTION

Surface finish affects most engineering applications' wear and friction. Various surface finish techniques and processes have been implemented to improve the finish of engineering components, but each has advantages and downsides. MAF's hybrid method is gaining prominence among surface finishing processes [1].

Many researchers have considered spindle speed, type of abrasives, electromagnet workpiece gap, percentage weight of abrasive, magnetic flux density, etc. to optimise for desired responses, but the impact of abrasive particle size (in nano scale) on surface finish and material removal rate has not been explored. This study compares micro and nano-sized Iron Oxide ($Fe3O4$) abrasives under an external magnetic field [2, 3, 4].

Comparing surface roughness profile cutting with micro and nano abrasives enables the MAF process to be a more exact and consistent nano finishing approach. Experiments have also confirmed the results [5, 6].

Full factorial experimental design was used to examine the influence of processing duration, magnetic workpiece gap, and abrasive particle size on surface quality and material removal rate. Current, abrasive type, magnetic flux density, voltage, and spindle rpm remained unchanged [7, 8].

Relevance: The study showed a low-cost approach for magnetically assisted surface finishing of aluminum alloy (Al 6063) pipes for automotive and marine applications. Industries Surface roughness tester measures internal surface finish.

Various researchers around the globe has worked on surface roughness. Few of the most relevant document that has been taken in to consideration for the present work are; [9] created an internal magnetic abrasive finishing technology for nonferromagnetic difficult shaped tubes with straight and curved segments. This article describes finishing theory and equipment that allows a finishing unit to move using a robot. Due to changes in geometry, the tests show how straight and curved pieces are finished. The finishing trials show that a single processing iteration can produce almost uniform interior tubes and the possibility of flexible internal finishing in an automated system. [10] found that as technology progresses, modern enterprises need tungsten, titanium alloys, ceramics, and composites. These materials are preferred in modern industries due to their great hardness, wear resistance, toughness, and strength. These demanding materials are hard to process. Traditional finishing methods including grinding, lapping, honing, and polishing are ineffective. Less productive approaches include abrasive flow machining, magnetic field assisted finishing, and chemo-mechanical finishing. The current study blends chemical oxidation with magnetic field-assisted abrasion for faster processing (magnetic abrasive finishing). To establish the procedure, the impacts of abrasive %, oxidising agent concentration, magnet rotational speed, and working gap were recorded on tungsten work pieces. Tests were planned using Taguchi L9 array. Analyzing variance was used to identify the influence of process factors on process response. SEM micrographs of the finished workpiece's surface morphology were taken. [11] found that finishing the needle's interior and exterior concurrently should save time. This research clarifies the magnetic field and magnetic particle dispersion needed to achieve simultaneous surface finishing of 18 gauge 316 stainless steel needles. Inner and exterior needle surfaces can be polished to 0.01 m Sa in 5 minutes. Kang et al. created a multiple pole-tip approach using a partly heat-treated magnetic tool in magnetic abrasive finishing, enhancing finishing efficiency. New high-speed machinery will cut processing time. This paper addresses the design of high-speed multiple pole-tip finishing equipment capable of spinning the spindle up to 30000 min-1. It discusses the impact of tube rotational speed on abrasive motion during finishing tests. Clarified are the high-speed machine's finishing mechanisms. [12] describe the magnetic-abrasive finishing approach and a few finishing features (magnetic-abrasives). Magnetic field strength introduces magnetic-abrasive pressure, and its measured value reaches conventional lapping pressure. Experiment outcomes are analysed. In a short time, a cylindrical workpiece can be machined smoothly from 1.5 mRmax to submicron. In practise, magnetic-abrasive finishing will be used. [13] found that mechanical producers want to create a smooth, low-roughness surface efficiently. Traditional finishing procedures lack surface quality and machining efficiency. Hybrid machining technology can fix the problem. EMAF combines electrochemical machining (ECM) and magnetic abrasive finishing (MAF). A novel tool that can adapt to two dissimilar processes has been designed, and a comparison experiment has been undertaken to evaluate the EMAF method. EMAF improves surface quality and material removal over normal MAF. ECM must collaborate with MAF throughout operation and remain in passivation. With the appropriate parameters, EMAF can reduce Al 6061's surface roughness to 0.2 m from 1.3 m in minutes. [14] studied how magnetic-abrasive finishing could improve geometrically complex products. The effect of magnetic-abrasive finishing on the surface quality of geometrically difficult objects is highlighted, as is the experimental inquiry that led to a mathematical relation. In the range of magnetic-abrasive finishing components under study, product edge radius changes within the range of = 26.64 m, roughness changes within the range of Ra = 0.09.0.061 m, and micro-hardness changes within the range of Hv = 766.1505 kgf/mm2.

II. OBJECTIVES

Following are the main objectives of the research work:

A. To compare the efficacy of nano and micro sized abrasive particles on surfaceroughness of Al pipes.
B. To study the effect of working gap, abrasive particle size, and processing timeon the surface roughness and material removal rate.
C. To select the optimum parameters for minimum surface roughness and materialremoval rate.

III. DESIGN OF EXPERIMENTS

Markets sold aluminium and abrasive. Redesigned aluminium was cut with a power hacksaw. Weighing abrasives samples prepared samples. The lathe was then set up and coupled with a control panel. The aluminium rod piece was put in the lathe's three-jaw chuck and tail stock and adjusted between the magnetic poles, as illustrated in Figure 1. Then, control panel current was set to design. Simultaneously, the Magnetized workpiece produces a flexible magnetic brush. The machine was switched on at 420 rpm while a timer recorded the time of operation on a piece.

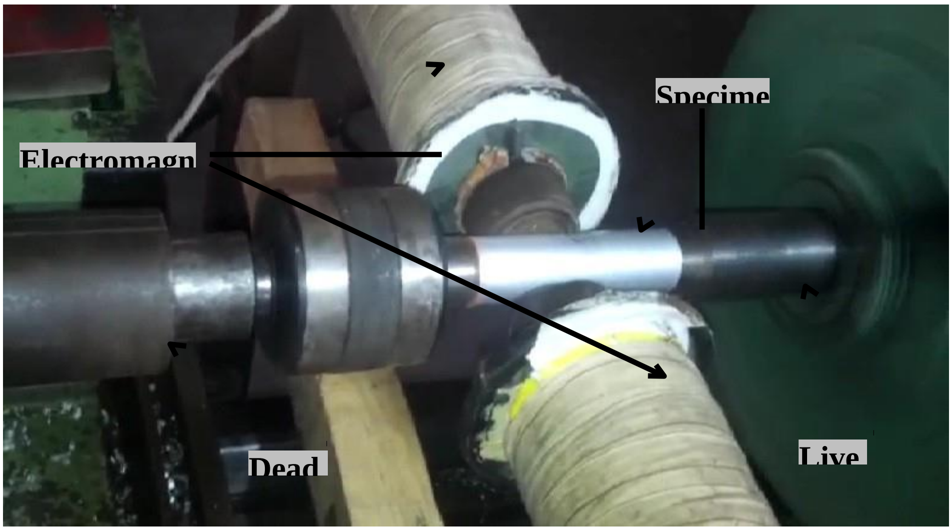

Figure 1 Pictorial view of Set up during experimentation

After the time period, the lathe machine and control panel were switched off, and the work piece was removed from the chuck. Surface roughness observations were collected with a Mitutoyo Surftest SJ 210 roughness tester. Table 1 shows the input parameters for 18 trials. So, aluminium pipe parts were tested.

Table 1 Experimentation values of Ra and MRR

Abrasive Particle Size	Order No.	Processing Time (min)	Working Gap (mm)	Ra before finishing (µm)	Ra after finishing (µm)	%ΔRa	Weight before finishing (g)	Weight after finishing (g)	MRR (g/min)
Micro (400 µm)	1.	3	2	0.185	0.138	25.40	22.04	21.96	0.0267
	2.	6	2	0.181	0.132	27.07	22.04	21.88	0.0267
	3.	9	2	0.184	0.149	19.02	22.04	21.80	0.0267
	4.	3	3	0.187	0.147	21.30	22.04	21.98	0.0200
	5.	6	3	0.176	0.133	24.43	22.04	21.92	0.0200
	6.	9	3		0.154	17.65	22.04	21.86	0.0200
	7.	3	4	0.190	0.165	13.15	22.04	21.99	0.0167
	8.	6	4	0.178	0.148	16.85	22.04	21.94	0.0167
	9.	9	4	0.175	0.149	14.86	22.04	21.89	0.0167
Nano (40nm)	10.	3	2	0.138	0.111	19.60	21.96	21.93	0.0100
	11.	6	2	0.132	0.118	10.60	21.88	21.82	0.0100
	12.	9	2	0.149	0.138	7.40	21.80	21.71	0.0100
	13.	3	3	0.147	0.108	26.50	21.98	21.96	0.0067
	14.	6	3	0.133	0.126	5.30	21.92	21.90	0.0067
	15.	9	3	0.154	0.130	15.60	21.86	21.83	0.0067
	16.	3	4	0.165	0.129	21.80	21.99	21.98	0.0033
	17.	6	4	0.148	0.136	8.10	21.94	21.92	0.0033
	18.	9	4	0.149	0.139	6.70	21.89	21.86	0.0033

IV. INPUT DESIGN

The input type design is defacto the link between the respective information kind system and the respective user. It herein comprises of the developing the specification and those of modus operandi basically for the data in preparation and those chosen steps which are being necessary to put in transaction of the respective data into a usable type form basically for processing and can be defacto achieved basically by examining the considered computer primarily to read the respective data from the written or the printed type document which it can occur by having those of people premeditating or keying the respective data directly into the corresponding system. The whole of the design of the respective input herein focuses on restraining the required amount of input which is essential, administering of those of errors, prohibiting in delay and also preventing those of extra kind steps and keeping the whole of the process very in- complex. The respective input is defacto designed in such a manner that it defacto provides or go forth with the securityand making to ease the utilisation by retaining the privacy. Input type design which is premeditated the following types can be known herein with reading.

V. RESULTS AND DISCUSSION

A. EFFECT OF PARAMETERS ON SURFACE FINISH

Pipe surface polish controls friction. Surface coatings affect fluid flow in both directions. Working gap, abrasive particle size, and processing time affected surface quality, and percent Ra (improvement in finish) was computed:

Table 2: %ΔRa at different parameters

Abrasive Particle	Sample No.	Machining Time	Working Gap	Ra before finishing	Ra after finishing	%ΔRa
Size				(µm)	(µm)	%ΔRa
Micro (400 µm)	1	3	2	0.185	0.138	25.4
	2	6	2	0.181	0.132	27.07
	3	9	2	0.184	0.149	19.02
	4	3	3	0.187	0.147	21.3
	5	6	3	0.176	0.133	24.43
	6	9	3	0.187	0.154	17.65
	7	3	4	0.19	0.165	13.15
	8	6	4	0.178	0.148	16.85
	9	9	4	0.175	0.149	14.86
Nano (40nm)	10	3	2	0.138	0.111	19.6
	11	6	2	0.132	0.118	10.6
	12	9	2	0.149	0.138	7.4
	13	3	3	0.147	0.108	26.5
	14	6	3	0.133	0.126	5.3
	15	9	3	0.154	0.13	15.6
	16	3	4	0.165	0.129	21.8
	17	6	4	0.148	0.136	8.1
	18	9	4	0.149	0.139	6.7

B. EFFECT OF PARAMETERS ON MATERIAL REMOVAL RATE (MRR)

Table 3 shows how working gap, abrasive particle size, and processing time affect Material Removal Rate (g/min):

Table 3 MRR at different parameters

Abrasive Particle Size	Sample No.	Machining Time	Working Gap	Weight before finishing	Weight after finishing	MRR (g/min)
Micro (400 µm)	1	3	2	22.04	21.96	0.0267
	2	6	2	22.04	21.88	0.0267
	3	9	2	22.04	21.8	0.0267
	4	3	3	22.04	21.98	0.02
	5	6	3	22.04	21.92	0.02
	6	9	3	22.04	21.86	0.02
	7	3	4	22.04	21.99	0.0167
	8	6	4	22.04	21.94	0.0167
	9	9	4	22.04	21.89	0.0167
Nano (40nm)	10	3	2	21.96	21.93	0.01
	11	6	2	21.88	21.82	0.01
	12	9	2	21.8	21.71	0.01
	13	3	3	21.98	21.96	0.0067
	14	6	3	21.92	21.9	0.0067
	15	9	3	21.86	21.83	0.0067
	16	3	4	21.99	21.98	0.0033
	17	6	4	21.94	21.92	0.0033
	18	9	4	21.89	21.86	0.0033

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VI. CONCLUSION

Working gap, abrasive particle size, and processing time affect Al 60 pipe. The research finds:

A. Working gap, abrasive particle size, and machining time affect surface finish (percent Ra) and MRR the most.
B. As the work gap is the most optimum parameter on surface finish and MRR, increasing it reduces the percentage improvement of surface finish with Micro abrasives, whereas with Nano abrasives it initially grows and then declines. Micro and Nano MRR decrease with increasing working gap.
C. Particle size affects surface finish and MRR.
D. Increasing processing time with Micro and Nano abrasives boosts surface polish initially, then drops, but MRR hardly changes.
E. Surface roughness was 0.187 m before micro-finishing and 0.108 m after nano-finishing. Total surface finish improvement (% Ra) is 42.25 percent.

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