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EFFECT OF ABRASIVE (FE_3O_4) PARTICLE SIZE ON THE SURFACE ROUGHNESS OF ALUMINIUM (A6063) PIPE USING MAGNETIC ASSISTED FINISHING

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Abstract: The present study investigated the influence of magnetic field on the surface finish of Al 6063 pipe. The various analytical parameters such as work gap, processing time and abrasive particle size were varied in a selected range and their effect was realized in terms of material removal rate (MRR) and percentage change in surface finish. The remaining process parameters were kept constant throughout the experimentation. The work gap was the most influential parameter on surface finish and MRR. The increase of work gap decreases the percentage of surface finish with the use of micro abrasives but in the case of Nano abrasives, the percentage improvement of surface finish first increases and then starts decreases. Moreover, surface finish and MRR both were affected with the change of abrasive particle size. Further, the surface finish increases initially by increasing processing time for both Micro and Nano abrasives and then starts decreases whereas MRR almost remains unaffected with processing time.

Keywords: magnetic abrasive finishing process, material removal rate, grinding process, surface finish.

1. INTRODUCTION

The surface finish has a vital influence on the surface properties such as wear and friction on most of the engineering applications [1] [2] [3]. Although various types of surface finish techniques and processes have been adopted to improve the surface finish of the engineering components but each one has its own advantages and disadvantages [2] [4]. Among various surface finishing techniques, magnetic abrasive finishing (MAF) gains popularity day by day, due to the adoption of hybrid approach [1] [3] [5].

The literature reveals that the various analytical parameters (such as spindle speed, type of abrasives, electromagnet work piece gap, percentage weight of abrasive, magnetic flux density etc.) have been considered by many researchers to optimize for desired responses but the impact of abrasive particle size (in nano scale) on surface finish and material removal rate is yet to be explored. The present work has been focused on the comparative study of surface finishing with micro and nano sized mixture of iron and iron Oxide (Fe3O4) abrasives under the influence of external magnetic field.

The surface roughness profile cutting with micro and nano sized abrasives has been compared so as to enable the MAF process as more precise and consistent finishing technique. The full factorial experimental design has been considered to study the influence of analytical parameters such as processing time, electromagnet work piece gap and abrasive particle size and their interactions on surface finish and material removal rate. The remaining parameters such as current, type of abrasive, magnetic flux density, voltage and spindle rpm remained constant throughout the experimentation.

2. EXPERIMENTATION

2.1. Work Piece Material and Abrasive Materials

The material of work piece was taken as Al 6063 and there were two types of abrasive materials

(Iron and Iron Oxide (Fe3O4)) are used throughout the experimentation. As Iron Oxide is a paramagnetic material so Iron Oxide could not be used alone for material removal in magnetic abrasive finishing process. Iron powder was mixed with iron Oxide in the ratio 3:1. Iron powder act as a bonding agent. The average particle size of nano abrasives was 30-50 nm whereas for micro abrasives it was 350-450µm.

2.2. MAF Process Parameters

The variable input parameters are shown in Table 1 below:

Table 1
Variable Input Parameters

S. No.	*Input Parameters(Variable)*	*Range*
1	Working Gap	2mm, 3mm, 4mm
2	Abrasive Particle Size	400 µm, 40 nm
3	Processing Time	3 min, 6 min, 9 min

2.3. Response Characteristics

The effect of selected process parameters on the surface finish and material removal rate (MRR) of magnetic abrasive finishing was studied. The surface roughness was measured at 6 different places of Aluminium pipe work piece with the digital "Surftest SJ 210" roughness tester having least count of 0.001 µm. Surface roughness (Ra) average values was calculated from mean of 6 values and percentage improvement in roughness was estimated as:

$$\%\Delta Ra = \frac{(\text{Initial roughness} - \text{Final roughness})}{\text{Initial roughness}} \times 100$$

The material removal rate (MRR) in g/min was calculated by measuring the weight of the work piece before and after machining and the processing time is recorded. MRR was estimated as:

$$MRR = \frac{(\text{Initial weight} - \text{Final weight})}{\text{Processing time(min)}}$$

3. RESULTS AND DISCUSSIONS

3.1. Effect of working gap on surface finish with Micro abrasives

As shown in Fig. 1, the larger value of %ΔRa exists for the 2mm working gap. With the increase in working, percentage improvement of surface finish decreases. Givi et al. [2] also reported similar results that with an increase in working gap, the ΔRa reduces.

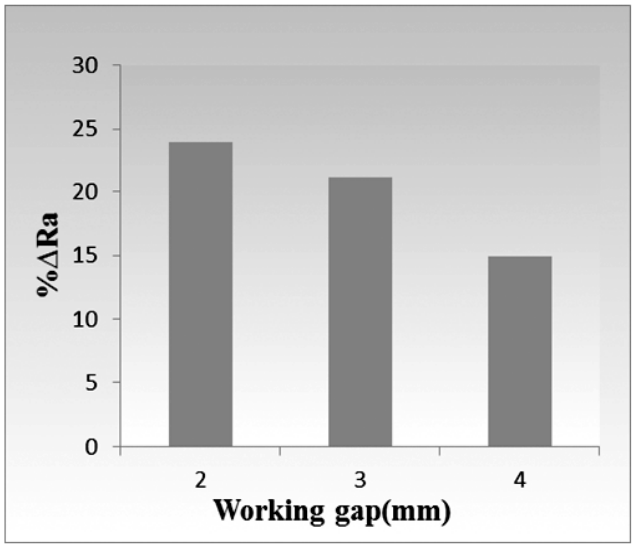

Figure 1: Effect of working gap on surface finish with Micro abrasives

3.2. Effect of working gap on surface finish with Nano abrasives

The maximum value of %ΔRa exists at 3mm working gap (Fig. 2). As the working gap increases percentage improvement of surface finish increases and then becomes maximum at 3mm gap and decreases further as the magnetic abrasive brush becomes weak and applies lesser effect on the work piece.

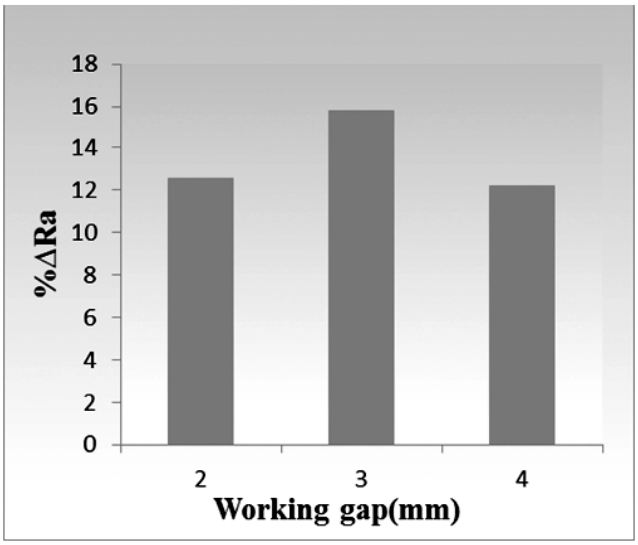

Figure 2: Effect of working gap on surface finish with Nano abrasives

3.3. Effect of processing time on surface finish with Micro abrasives

The Fig. 3 illustrated the percentage improvement in surface finish with micro sized abrasives and found to be maximum when processing time is 6 minutes. It is concluded that surface finish gets improved when processing time increases but up to certain limit and after that it starts decreasing because abrasive powder becomes less effective after a certain interval of time.

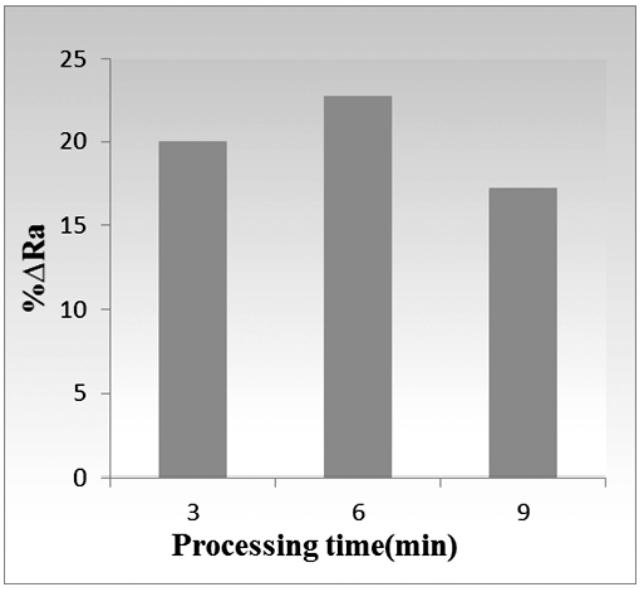

Figure 3: Effect of processing time on surface finish with Micro abrasives

3.4. Effect of processing time on surface finish with Nano abrasives

The Fig. 4 showed that percentage improvement in surface finish is optimum when processing time is 3 minutes. Surface finish decreases with increase in processing time up to 6 min and then slightly increased further as nano abrasives due to their smaller size creates more smoothening action after a certain interval of time.

3.5. Effect of working gap on Material Removal Rate (MRR) with Micro Abrasives

The Fig. 5 showed that on increasing the working gap, the material removal rate decreased. As the working gap increases the magnetic force gets reduced due to which material removal rate gets decreased. At low value of working gap, magnetic abrasive brush is stronger and can take deeper

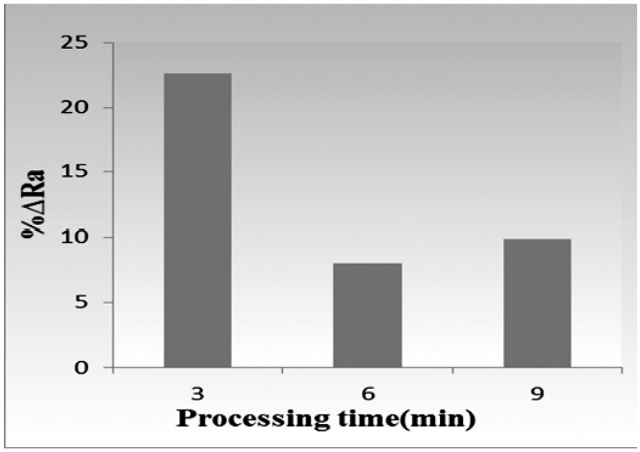

Figure 4: Effect of processing time on surface finish with Nano abrasives

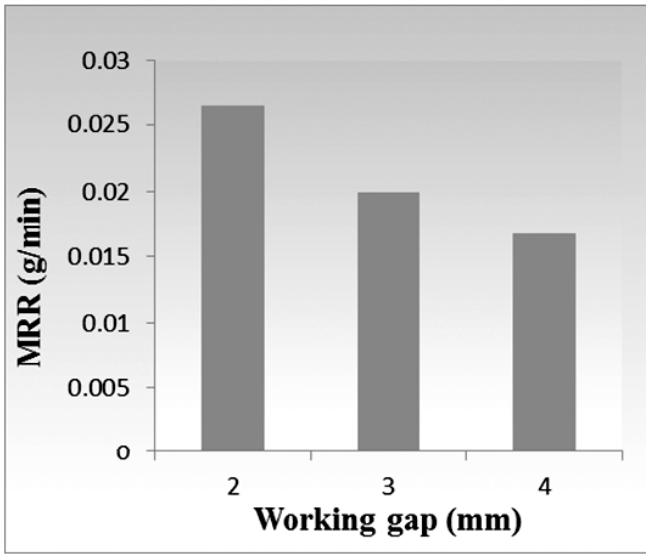

Figure 5: Effect of working gap on MRR with Micro abrasives

cuts to remove more amount of material from the work piece [4].

3.6. Effect of processing time on Material Removal Rate (MRR) with Micro Abrasives

From Fig. 6, it is clear that the processing time do not affect the material removal rate (MRR). MRR remains same for different processing time. Increasing the time has positive effects on surface finish less or no improvement by further increasing machining time [5] [6]. The Fig. 7 showed that on increasing the working gap, the material removal rate gets decreased. As the working gap increases, the magnetic force gets

reduced due to which material removal rate gets decreased.

3.7. Effect of processing time on Material Removal Rate (MRR) with Nano Abrasives

From the Fig. 8, it is clear that the processing time do not affect the material removal rate (MRR). MRR remains same for different processing time.

4. CONCLUSIONS

The analytical parameters such as working gap, abrasive particle size and processing time have significant effect on aluminum Al 6063 pipe. The research work concludes the following results:

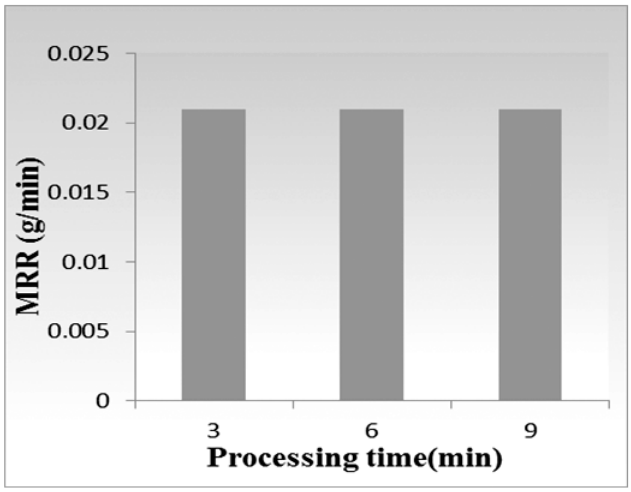

Figure 6: Effect of working gap on Material Removal Rate (MRR) with Nano Abrasives

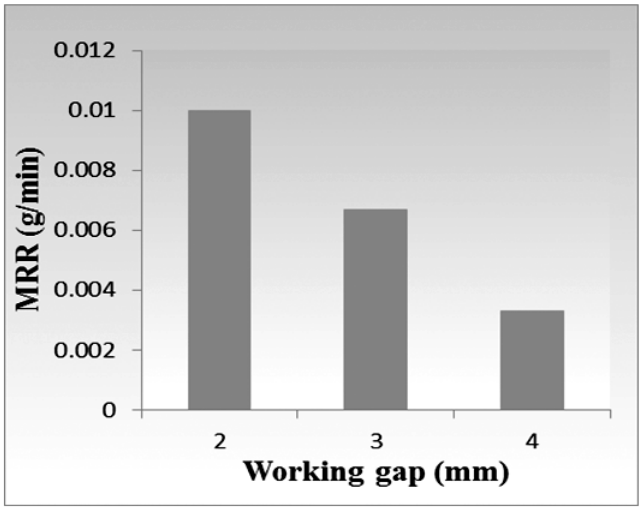

Figure 7: Effect of working gap on MRR with Nano abrasives

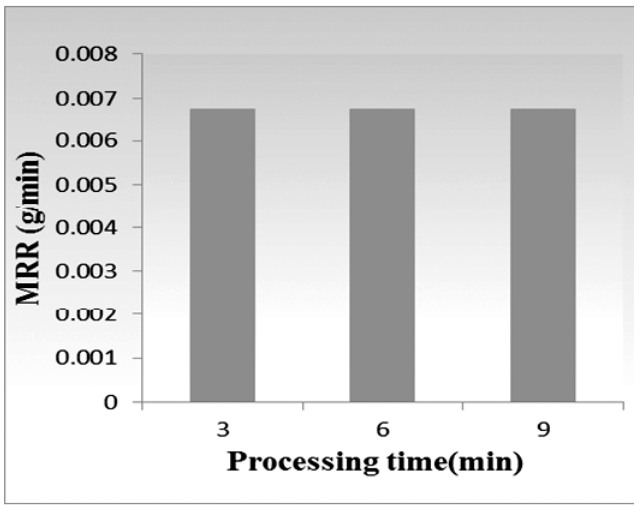

Figure 8: Effect of processing time on MRR with Nano abrasives

i. The most significant parameter for percentage improvement in surface finish (%ΔRa) and MRR is working gap followed by abrasive particle size and machining time.

ii. As the work gap is the most significant parameter on surface finish and MRR, with the increase in its value, the percentage improvement of surface finish decreases when Micro abrasives are used whereas in the case of Nano abrasives, the percentage improvement of surface finish first increases and then starts decreases. In addition to above, the MRR decreases with Micro as well as Nano abrasives with the increase in working gap.

iii. The surface finish increases initially by increasing processing time with both Micro and Nano abrasives and then starts decreases whereas MRR almost remains unaffected with processing time.

iv. Initial surface roughness was 0.187 µM which is reduced to 0.147 µm after micro finishing and further reduced to 0.108 µm after nano finishing. Therefore total percentage improvement in surface finish (%ΔRA) is found to be 42.25%.

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