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**Original Research Article**

# Effect of various input process parameters on surface finishing and material removal rate in electrolyte magnetic abrasive finishing

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**ABSTRACT**
As per the demand of the industries for the machining of the materials with accuracy, there are so many options available in the market; hybrid machining is one of the method which is frequently used for the machining of the industrial component with accuracy. The Electrolytic Magnetic Abrasive Process is generally used as hybrid process in industries in which magnetic abrasive machining is combined with the electrolytic machining to get the better results compared with the individual one. Electrolytic magnetic abrasive finishing (EMAF) also saves the time and the hard materials are easily machined with this process. The machining parameters are having the major impact on the output results in any machining process. We can see the significant effect of the each parameter on output results by varying it and the range can be selected after preliminary experimentation in which there is major improvement seen on the results parameters. The objective of this study is to investigate the work done carried out by the different researched on the effects of the several input factors such as rotational speed of the work piece, machining time, concentration of the electrolytic liquid, electrolytic liquid flow rate, etc. on the output parameters of improvement in surface roughness and the removal rate of the work piece (MRR) in EMAF process. The review of the study revealed that the rotational speed of the work materials and the electrolytic currents are the most significant parameters contributing in higher machining efficiency.

## 1. Introduction

Hybrid manufacturing technology may produce goods more effectively and productively than traditional methods, due to this reason it has attracted a lot of attention from both industry and academics [1]. The majority of these technologies can be used to create optical, mechanical, and electronic components with surface roughness that is within the nanoscale range and form accuracy that is either micrometer or sub-micrometer with very few surface flaws [2]. Another significant class of HMPs are assisted-type HMPs, which use outside aid to get over the drawbacks of the primary material removal procedure and enable more productive and efficient machining [3].

We can enhance process capabilities in terms of surface roughness, material removal rate, tool life, and geometric precision by using hybrid micro-machining techniques [4]. According to Aspinwall et al. [5], the combination of machining operations can be thought of as either an assisted machining approach, in which two or more processes are used simultaneously, or as a hybrid machining method, in which two or more machining processes are applied independently on a single machine.

## 2. Process principle

The positive and negative poles of the DC power supply are linked to the workpiece and the electrode, respectively. The workpiece is placed inside the magnetic poles as shown in the figure 1 make up the compound processing instrument. The workpiece and the electrode surface are filled with electrolyte during the EMAF processes which comes from the holes from the electrode.

Because the workpiece is rotate in between electrode and the magnetic poles, the electrolytic reactions and the MAF processing act on the workpiece surface simultaneously. Surface protrusions are effectively removed by the electrolysis processes, and the workpiece's surface is further refined by the MAF process. Because the electrolytic processes in the EMAF process are so effective and unaffected by the material's hardness, it has a better processing efficiency than the conventional MAF process. The passive layer created on the surface by electrolytic reactions is also removed using the MAF procedure that is a part of the EMAF process. The great precision of the MAF process and the high efficiency of the electrolytic reaction are both preserved in the features of the EMAF process [9].

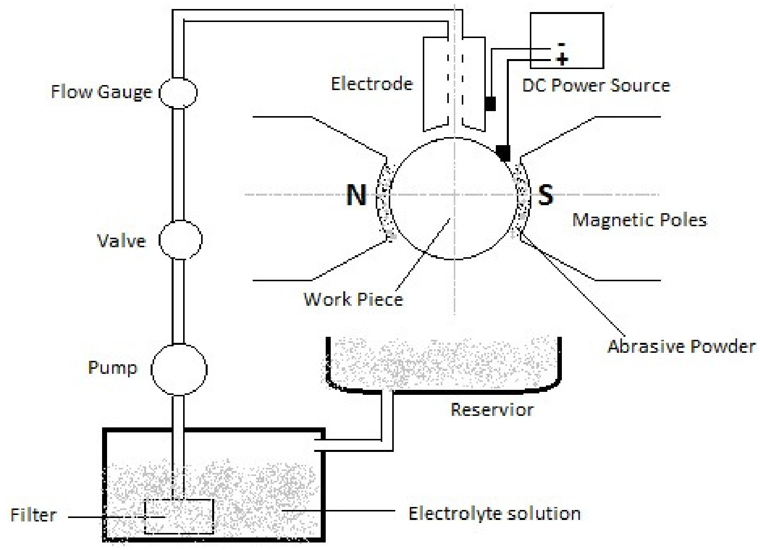


**Figure 1:** Schematic diagrame of EMAF

## 3. Analysis of process parameters

### 3.1 Influence of work piece speed

Judal and Yadava [6] took experimentation and find the effect on surface roughness and MR data at various workpiece rotational speeds by keeping magnetic flux and electrolytic current constant at 0.47 T and 2 A respectively. It is evident that more MR and a quicker initial decrease in surface roughness are correlated with increased rotating speed. This is due to the fact that at faster rotational speeds, the abrasives cover a greater total distance during abrasion in a given amount of machining time, removing more material and shortening peaks. Abrasion-assisted dissolution is also favoured by a shorter time gap between the creation of a passive film and its removal (frequency of depassivation) at a greater speed [7]. Khattri et al. [10] concluded in his study with increase in rotational speed surface roughness and MRR rise, leading to improved surface finishing. Additionally, rotational speed gives the abrasive greater energy to enter the workpiece, improving Ra and MRR. However, as rotational speed increases, surface roughness decreases. An increase in rotational speed is matched by an increase in centrifugal force. With increasing force, the MAP mixes are cast out of the machining zone, resulting in a decrease in magnetic flux density there and a reduction in the amount of MAP accessible for shearing with the workpiece's surface. Thus, Ra decreases as the electromagnet's spinning speed increases. Singh et al. [11] also concluded that with increases in rotational speed $\Delta R_a$ increases and the experimental results are shown in Figure 2.

Judal and Yadava [12] Ra value falls and MR increases linearly as workpiece speed increases. This is because, in a given machining period, abrasives must travel a greater total distance to scratch the workpiece surface due to an increase in rotating speed. Yan et al. [13] demonstrates that a faster initial improvement in surface roughness and greater material removal associated with a higher rate of workpiece revolution. The work surface improves rapidly from 0.187 to 0.03 µm Ra in 2 min at 800 rpm–8 Hz; however, after that, the surface roughness gradually decreases as it gets closer to saturation. After five minutes, it can finally be enhanced to 0.02 µm Ra. Nevertheless, under 500 rpm–5 Hz circumstances, the surface roughness can improve to 0.017 µm Ra after 5 minutes, albeit improving more slowly at first. On the other hand, the improvement is limited to 0.03 µm Ra under 200 rpm–2 Hz circumstances because to the reduced rate of rotation, which results in less material being removed.

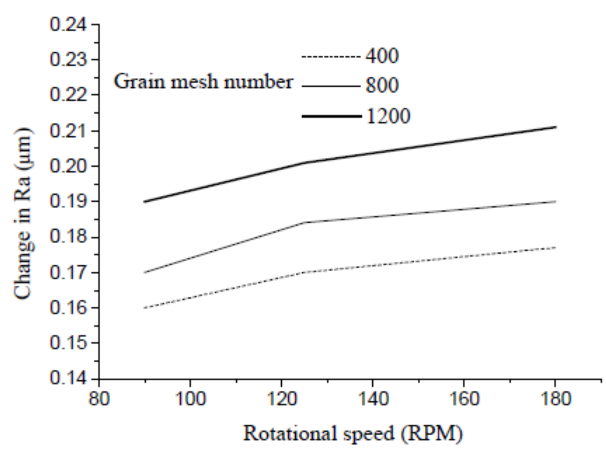


**Figure 2:** Effect of rotational speed on $\Delta R_a$

### 3.2 Influence of workpiecegap

Yan et al. [13] described that compared to the 5 mm gap, the 3 mm electrode gap has a superior surface roughness and has removed more material. Because of the lower electric field intensity; the angle of approach of the ions toward the anode surface for the 5 mm electrode gap is greater than that of the 3 mm electrode gap. This lessens the possibility of an electrolytic reaction between the electrolytic ions and the anode surface, resulting in a poorer electrolytic effect. As a result, the results of surface roughness and material removal are slightly worse than those obtained with the 3 mm electrode gap. Khattri et al. [10] reveals that Ra and MRR increases as a result of the working zone percentage declining. However, as the working zone increases, the surface finish decreases because there is less magnetic field generated, which makes ferromagnetic particles less magnetized and produces less pressure force at the workpiece boundary in FMAB because the abrasive particle size doesn't have an exact indentation with a large working zone. Ra and MRR therefore decline.

### *3.3 Influence of magnetic flux*

Judal and Yadava [6] concluded that when electrolytic current and workpiece rotational speed were maintained at 1 A and 420 RPM, respectively. A greater magnetic flux density results in increased magnetic resonance and decreased final surface roughness. This is because additional flux causes abrasives beneath steel grit to experience more machining pressure, which will abrade more material [8]. Surface roughness decreases as a result of material being removed mostly from the surface's peaks. A research of electrochemical magnetic abrasive machining process shows that increased magnetic flux density again causes abrasive grains to penetrate the workpiece surface to a large depth, increasing the amount of fresh metal surface (active area) exposed to electrochemical reaction. The abrasion-passivation synergism is enhanced by the bigger active area, which raises the MR even further. A higher flux density at a given electrolytic current improves surface polish quickly in the beginning, which boosts process efficiency. Judal and Yadava [12] has been noted that when the electromagnet's current increases, MR also increases. This is due to the fact that as excitation current increases, so does magnetic flux density, providing more machining pressure and deeper penetration of abrasives into the workpiece surface. More material is removed simultaneously by the relative motion of the workpiece surface with abrasives caused by rotation. Additionally, it is noted that material is removed at a greater rotational speed (710 RPM) than at a lower speed (420 RPM), and that the difference in MR rises as the electromagnet's current increases. This is due to the fact that passive layer creation and removal occur more frequently at greater rotating speeds. Once more, abrasive penetration depth increases with higher current to electromagnet, increasing the active wear track area. Khattri et al. [10] concluded that with increase in magnetic flux density results in improvements in the workpiece's Ra and MRR. Ra and MRR rise as a result of the increase in magnetic flux density, which also raises the tangential finishing force—a critical cutting force needed to smooth the surface by eliminating materials like microchips. The qualities of the materials used in the operational workpiece should determine the use of magnetic flux density and other factors.

### *3.4 Influence of electrolytic current*

Judal and Yadava [6] observed that when the magnetic flux density and rotational speed of the workpiece were maintained at 0.29 T and 710 RPM, respectively, higher electrolytic current has been shown to produce significantly greater MR and reduced final roughness. This results from increased material passivation at high electrolytic current, especially from the peaks or hills of the surface imperfections. Abrasive action readily removes the passive coating that forms at peaks, exposing new metal there for repassivation. Therefore, a smoother surface is the result of higher electrolytic current. Judal and Yadava [12] has been noted that when electrolytic current rises, MR rises and Ra falls. This is because a larger dissolution of workpiece material and the creation of a thick passive coating on surfaces damaged by magnetic abrasion are linked to increased electrolytic current. The abrasive action of the flexible brush further removes the passive layer that has formed, enhancing the synergy between abrasion and passivation. Once more, the peaks of the surface imperfections will have a higher chance of passive film creation and its removal than the valleys. Yan et al. [13] concluded that surface roughness improves quickly when the electrolytic current is increased, increasing finishing efficiency. In addition higher electrolytic current can disturb the magnetic field lines and can affect the machining efficiency so as a result, there is less utilization of high electrolytic current.

## 4. Discussion

For all kinds of engineering materials, EMAF is one of the best non-traditional machining processes for surface finishing; it can be used to achieve high precision and efficiency in surface finishing. Surface finish and MRR are examples of output parameters where a large contribution from input parameters is not necessarily essential. In comparison to other parameters, certain of them are important.

## 5. Conclusions

This paper theoretically analyzes the effects of different processing parameters on MRR and Ra in EMAF process, including work piece rotational speed, working gap, magnetic flux density and electrolytic current. The following conclusions from the current work are drawn in light of the discussion above:

1. The increase in workpiece speed can increase the surface finishing and MRR initially with great results but after that the improving is linearly.
2. The gap between the workpiece and electrode is very important, higher the gap results lesser electrolytic reaction which results lower machining efficiency. On the other hand higher gap between the workpiece and magnetic poles results lower the intensity of the magnetic field results in decrease in MRR and surface finishing.
3. With increase in magnetic flux machining efficiency increases because of the more pressure applied by the magnetic abrasive powder on the workpiece. The magnetic flux can be increased by increasing the current to electromagnet.
4. Higher electrolytic current cannot fast the electrolytic reaction and can create the passive layer on the workpiece fast which can be removed bythe abrasion action of the abrasive powder results in higher machining efficiency.

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