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Abrasive Flow Finishing: A State of Art

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ABSTRACT

Today not only the demand of functional quality of product has raised but also the demand of its aesthetic value has also increased. There is more emphasised on the surface finish and appearance of the product which is reflected by its surfaces rather than its functional value, which has shifted the point of view of the researchers from the machining to surface finish improving. With the development of modern non-conventional energy resources where there is no need for the physical contact between the tool and the work piece, The Abrasive flow Finishing has emerged as an golden tool to obtained the requisite finishing up to the micro level. This paper highlights the abrasive flow finishing process and accounts some work on the same.

Keywords: *Abrasive Flow Finishing; Machining; Non Conventional Energy Resources.*

1.0 Introduction

MAF which is abbreviated as magnetic abrasive finishing is not an old process which has showed its emergence from 1940 has emerged as an essential weapons to achieve the effective requisite surface finish in the field of machining. Many researchers have showed interest in this field and has contributed in the field of its development. Kuppusamy [1] in his experimental verification of magnetic field effect on electrolytic grinding found that Material removal rate proportionally increases with increase in Magnetic field, similarly Faraday’s efficiency proportionally increases or decreases with increase or decrease in Magnetic field strength. He observed that there exists an inverse relationship between the magnetic field and the Surface energy.

T. Shinmura et al.[2] in their experimental study observed that the magnetic forces are proportional to the Volume of the magnetic abrasive, however, the magnitude of the finishing pressure does not depend upon the abrasive particle size. It had also been observed that the surface finish depends upon the abrasive particle size, finer particle gives lesser penetration and hence the surface finish is better on the other hand material removal is proportional to the size of the abrasives. Magnetic abrasive prepared by coating the diamond particle over the Cast iron particle had been used for finishing Si3N4 bars. The best surface finish obtained is of the order 0.04 µm. The bigger magnetic abrasive would remove higher stock removal with lesser surface finish. Jeong – Du Kim et al. [3] performed the simulation for the Magnetic abrasive finishing process and found that the Magnetic flux density significantly depends upon the air gap between the work piece and the magnet and does not depend on the Cross section area of the air gap.

Material removal does not bear a proportional relation to the machining time though increases with the time. Machining Pressure increases slowly with the increase in magnetic flux density at initial stage and then increases very rapidly. Jeong – Du Kim et.[4] al have conducted an experiment known as Magneto Electrolytic abrasive polishing using permanent magnet with a capacity of 0.06T, Which creates a Viscoelastic sheet produces finishing pressure. Neither the roughness nor rate of roughness decrease depend on the working speed. For getting proper surface finish, Magnetic pressure during the initial stages must be higher than the magnetic pressure during the finishing stages. Ming Jiang et al. [5] had performed Magnetic float polishing technique for Ceramic balls (Si3N4) and found the optimum process parameters for Arithmetic (Ra) value and Peak value (Rt). In their optimization they found that for getting the optimum values of Ra & Rt Polishing force is the most significant parameter. For Ra the second most significant parameter was Polishing speed and third most significant parameter was Abrasive concentration, whereas for Rt, the second most significant was abrasive concentration and third most significant parameter was Polishing speed. The best possible value obtained for Ra Was 20 nm and Rt was 200 nm .Jeong –Du Kim et al. [6] proposed a new type of surface finishing method by using a

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Newly woven abrasive pad, which can be used for the finishing process of difficult to cut materials. The surface of both very hard and very soft material can't be finished easily and the method proposed will address the problem of machining these type of materials. Finishing takes place as a combined effort of Magnetic pressure, electrolytic reaction and abrasive finishing.

V K Jain et al. [7] in their experimental study on the effect of working gap and rotational speed of the work piece on material removal and surface finish and found that the higher rotational speed gives higher metal removal. As the working gap increases the flux density decreases so the material removal decreases. It has also been observed that increase in working gap initially increases surface finish rate and reaches an optimum value then starts decreasing this is due to the fact that larger the gap, more fresh abrasive particles enter as continuous supply of the abrasives and CIP take place.

Geeng-Wei Chang et al. [8] has performed external surface finishing of a cylindrical surface using un bonded SiC abrasives of two different sizes, mixed separately with steel grit with a maximum hardness of HV940 and iron grit with a maximum hardness of HV125 along with the SAE30, which gives bonding of Sic and steel or iron grit. For a finishing time of 30 minutes performed for a mixture of Iron grit 180 μm and SiC 1.2 μm surface roughness reduced from Ra0.25 μm to Ra 0.13 μm. On the other hand, when the steel is used as grit with 180 μm and SiC 1.2 μm a surface finish of Ra 0.06 μm is obtained in 5 minutes. Medium comprising Steel grit size 180 μm and SiC 5.5 μm has given the highest metal removal and a saturated value of Ra 0.09 μm is obtained.

Highest abrasion pressure is obtained while using Steel grit with SiC 5.5 μm, which gives higher material removal, but deep scratches are also observed. Higher abrasion pressure will not permit the rotation of the Ferrous particles freely, which hampers the finishing process. T. Mori et al.[9] have discussed the micro-mechanism involved in Magnetic abrasive finishing.

They proposed that the Net energy in finishing of the nonmagnetic SU304 is the algebraic sum of Magnetisation energy, repulsive energy and Tension energy and found that the stable brush for finishing by the magnetic abrasive finishing is formed when the net energy is minimum. Normal force and tangential force are the two forces involved in finishing operation. Both the tangential and Normal forces increase with the increase in Weight fraction of the abrasives, also found that the magnetic flux density at the centre of the magnet is the highest and reduces as measured away from the centre of the magnet.

Biing-Hwa Yan et al. [10] proposed a hybrid type of magnetic abrasive finishing of the external cylindrical surface using an electrolyte comprising of 20% of NaNO3 by volume and having PH value of 9. The electrolyte reacts with the surface of the work piece and subsequently generates a passive layer, which in turn reduces the hardness of the surface. The Magnetic abrasive finishing operation hence forth carried on the surface will remove the passive layer along with the material of the work piece. In their experiment they observed that the thickness of the passive layer in presence of the magnetic field is higher than that of the thickness under no magnetic field condition. Thickness near the peaks is greater than that of valleys. SIC and WA are two abrasives used for finishing operation and it has been observed that the metal removal by SiC is higher than that of WA, however due to softening of the surface due to the formation of passive layer, scratches have been observed while using SiC. For a given finishing time the material removal is proportional to the rotational speed of the work piece. However appreciable percentage improvement in surface finish is not observed even though rotational is increased.

2.0 Working Principle of MAF

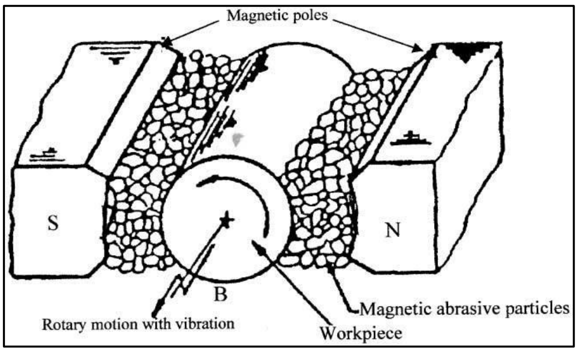
In MAF process, granular magnetic abrasive composed of ferromagnetic material (as Iron particles) and abrasive grains such as Aluminum Oxide (Al2O3), Boron Carbide (B4C), diamond powder etc. are used as cutting tools and the necessary finishing pressure is applied by electro-magnetically generated field. The magnetic particles are joined to each other magnetically between magnetic poles S and N along the lines of magnetic forces forming flexible magnetic abrasive brushes (FMAB) . . Iron particles are attracted towards each other along the magnetic lines of force due to dipole interactions and form a flexible magnetic abrasive brush. The FMAB has multiple, random cutting edges and it behaves like a multi point cutting tool. When a cylindrical workpiece with rotary, vibratory, and axial movement is inserted in such a magnetic field, surface and edge finishing is performed by the magnetic abrasive brush. The finishing efficiency and quality are greatly influenced by the rigidity of the magnetic abrasive brush. If the workpiece is of non-magnetic material, the lines of magnetic field go around it. (i.e. through the magnetic abrasives), and if it is of magnetic material then they pass through the workpiece. Magnitude of magnetic force prevailing between the two poles is also affected by the material, shape, and size of the work piece, and shape and size of the magnetic poles.

The important parameters that contribute for the final finishing of the work piece include mesh size of the Magnetic particles and the abrasive particles, Concentrations, working gap, Work piece shape and the material hardness, no of strokes of operation, magnetic field strength The quality of finishing depends upon the relative diameters of the Magnetic particles and the abrasives. It has been observed that when the diameter ratio is around 4, the best possible surface finish is obtained, keeping other parameters constant.

Apart from internal and external finishing the circular shapes, Magnetic abrasive finishing process is also used for finishing the flat surfaces. During finishing of the plane surfaces a circular rotating magnetic pole is used and the magnetic abrasive mixture passes through the bottom end of the rotating magnetic pole . Here, the magnetic material like Carbonyl Iron particles reorient themselves and form a chain like structure and hence protrudes the abrasive particles to the surface which will perform the finishing/polishing operation of the work piece in contact. Both magnetic and non magnetic workpiece material, from soft to very hard materials like ceramics could be done. Finishing, cleaning, deburring and burnishing of metallic parts, as well as other advanced engineering material parts and to correct geometric errors. The magnetic flux density B, controlled by the input current on the magnet, the air gaps between magnetic poles and workpiece, cutting speed, grain size of magnetic and abrasive particles, processing time and the existence or not of mechanical vibrations.

Figure 1 shows the schematic diagram of the Abrasive flow finishing where the workpiece is given the rotary motion with the vibrations and the abrasive are kept in compact form between the magnets and the workpiece. In the variant form a rotating tool is often used and as stated earlier there is formation of magnetic brush which carry out machining.

Fig 1: Schematic Diagram of Magnetic Abrasive Finishing [7].



3.0 Conclusions

Following conclusion can be drawn from the review.

1. Abrasive flow finishing is an effective finishing process
2. Micro level finishing can be achieved
3. Effective for finishing the magnetic and non magnetic material also.
4. No special setup is required.
5. Variant of MAF is possible.

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