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A Study of Various Techniques of Preparing Magnetic Abrasives

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Abstracts

With the development in the industries like Aeronautics, Optical Electronics, Medical instruments and Nuclear Reactors the need of part surface finish and geometric precision has increased drastically. The Magnetically Assisted Abrasive Finishing (MAAF) processes are emerging as one of the most suitable techniques for obtaining quality finish in which deep cutting marks left by conventional finishing processes like Grinding, Honing, Lapping etc have been removed and replaced by a new surface texture. In MAAF processes, Ferromagnetic particles are mixed with fine abrasive particles like Al2O3, SIC, CBN and Diamond to form magnetic abrasive particles. Sometimes, simply mixed loose ferromagnetic and abrasive particles are also used in certain applications. The major barrier on the road of commercial adoption of this technology is the non availability of magnetic abrasives. The objective of the present study is to review the various existing techniques of preparing magnetic abrasives particles and to suggest some alternate methods for producing magnetic abrasives.

Keywords: MAAF, FMAB, Surface finish.

Introduction

Polishing of surfaces like Liquid piping systems, Vacuum tubes, Sanitary tubes, High purity gas tubes and Pharmaceutical industries demands high cost and controlled atmosphere. These are not easy to be polished by conventional finishing techniques such as grinding, because of their shapes and the conventional finishing processes apply uncontrolled high pressure on the workpiece which may cause micro cracks. Magnetically assisted abrasive finishing is one of the methods which uses a controlled magnetic force to finish surfaces. Magnetically assisted Abrasive Finishing has been able to give good surface and edge finishing by help of Flexible Magnetic Abrasive Brush (FMAB) formed in the magnetic field. Under the action of magnetic field the magnetic abrasives gets compressed against the surface to be finished and When rotary motion is given to the workpiece the abrasives wear out the workpiece material in the form of very small chips.

Working principle of MAAF

Figure 1 shows the magnetic abrasive process for internal finishing. The magnetic abrasive particles which are formed by mixing ferromagnetic particles with abrasive particles are introduced into the hollow cylindrical workpiece.

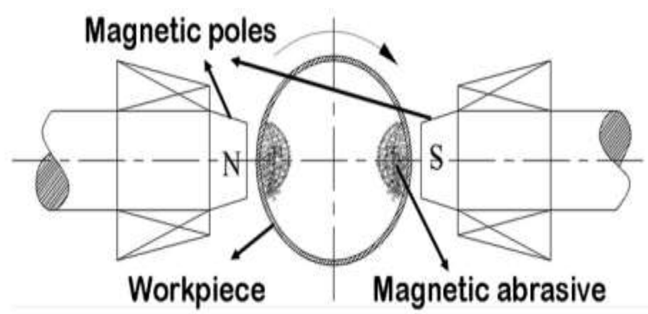

Fig: 1. Schematic view of the internal magnetically assisted abrasive finishing principle [15]

When current is passed through the coils of electromagnet, the poles of DC electromagnet generate the magnetic field, Due to which the abrasive particles join each other along the lines of magnetic force due to dipole–dipole interaction and form a Flexible Magnetic Abrasive Brush (FMAB). Under the influence of magnetic field FMAB pushes against the work piece surface and develops finishing pressure. This finishing pressure gives micro indentations in the work piece surface and the abrasives acts as cutting tool. In order to have good surface finish results, a small quantity of material is removed by producing a relative motion between the workpiece and abrasive particles.

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Techniques of preparing magnetic abrasives

Previous literature reveals the use of magnetic abrasives for part surface finish. The different techniques for preparing magnetic abrasives are:

Sintered magnetic abrasives

It is a method of making solid objects from powder with the help of heat and pressure. The powder materials are heated in a sintering furnace below its melting point until its particles adhere to each other. It is commonly used for manufacturing ceramic objects.
Lin et. al (2007) developed magnetic abrasives by mixing iron powder (60 wt%) and aluminium oxide (40 wt%) and compressing the mixture into the cylindrical shapes. These compacts were sintered into a vacuum sintering furnace. After the sintering process, the cylinders were crushed to produce magnetic abrasives.

Plasma based magnetic abrasives

In this method the material in the form of powder or wire is introduced into the plasma jet passing through a plasma torch. In the jet, the material gets melted and starts flowing towards a substrate. When the molten droplets contact the substrate they get flatten and speedily solidify into a deposit that remains adhered to the target material.
Anzai et. Al. (1989) investigated the NbC-Fe magnetic abrasive grains, produced by plasma powder melting method. NbC particles were dispersed uniformly in the iron matrix.

Mechanical alloyed magnetic abrasives

It is a two stage process, firstly the alloy materials are combined in a ball mill and converted into a fine powder. Then, a Hot isostatic pressing (HIP) process is applied simultaneously to compress and sinter the powder.
Hakaru et. al. (1996) produced Si-M alloy powder by mechanical alloying process. Crystalline powder of Si-M in different composition ratio varying from 1:2 to 2:1 were mechanically alloyed in ball mill.

Loosely bonded magnetic abrasives

In this technique magnetic abrasives are prepared by simply mixing ferromagnetic particles and abrasive particles without adding any bonding material. It is believed that ferromagnetic particles sandwich abrasive particles. Under the action of magnetic field, the mixture of iron and abrasive particles causes abrasion action on the workpiece surface.
Jain et. al (2001) utilizes loosely bonded magnetic abrasives i.e mixture of iron particles, Al_2O_3 particles and lubricant for the external finishing of stainless steel cylindrical rods.

Adhesive based magnetic abrsives

In this method the ferromagnetic and abrasive components are mixed with an adhesive material. The quantity of adhesive in mixture of abrasive and ferromagnetic components was decided in `such a way that the adhesive completely wets the mixture and at the same time the mixture should not act like a fluid.
Feygin et. Al. (1998) developed magnetic abrasives by mixing iron powder, aluminium oxide and an industrial crazy glue.

Conclusion

Some existing methods (simply mixed/ adhesive bonded) of preparing magnetic abrasives do not provide a good performance. There is a need to explore new methods of producing magnetic abrasives.
Previously published literature indicates the application of microwave technology in the sintering of alloys in powder metallurgy processes and in heat treating of various alloys, metals and non metals. It is reported that microwave sintering technology possesses excellent capabilities in producing parts within very short time and at very low energy consumption.
Microwave sintering process can be used for producing magnetic abrasives and the magnetic abrasives produced by this process may show better performance in terms of surface finish and material removal rate.

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