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Investigation of Magnetic Abrasive Finishing Process Using Abrasives Obtained by Different Techniques

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Abstract - The most suitable processes for producing quality finish on non-metallic and metallic surfaces are the Magnetic Abrasive Finishing (MAF) processes. The developed magnetic field between the electromagnetic poles and magnetic abrasives generate and control the cutting forces in these processes. Although MAF processes shows remarkable results still there were many constraints towards the adaptation of this technology due to less- availability of magnetic abrasives. Also the existing magnetic abrasives were very costly as the manufacturing techniques that were used for preparing these abrasives were time consuming and complicated. The present study aims to develop and explore the use of alternative magnetic abrasives. In the present work, ferromagnetic powder, abrasive powder and a special type of adhesive were mixed to prepare the magnetic abrasives. For comparing the performance of developed magnetic abrasives, three more types were prepared by using sintering, simple mixing and mechanical alloying. Brass pipes were used as work pieces. The performance was experimentally measured and compared between various magnetic abrasives. Best performed magnetic abrasives were produced by mechanical alloying. Sintered magnetic abrasives also performed well but simple mixing technique did not show better results.

Keywords: ***super finishing, magnetic abrasive polishing, surface roughness, material removal rate.***

I. INTRODUCTION

With the development of modern manufacturing trends various industrial applications require very high surface finish ranging from nanometers or even above. Presently, it has been found that very fine surface roughness is required in the manufacturing of semiconductors, atomic energy parts, medical instruments and aerospace applications. Due to the shapes of vacuum tubes, wave-guides and sanitary tubes it is difficult to polish them by conventional finishing methods like lapping.

1.1 Working Principle

The Figure 1.1 depicts the internal polishing process for magnetic abrasive. The principle of magnetic abrasive machining utilizes the machining force generated by the magnetic field strength as well as the gradient of the magnetic field.

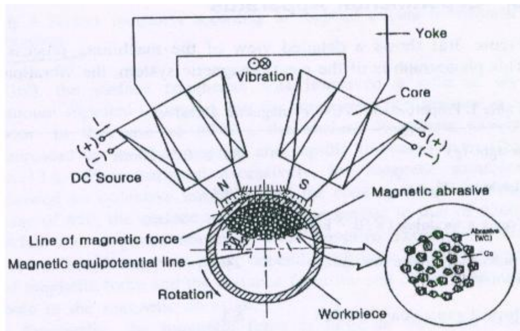

Fig. 1.1 Schematic view of the internal polishing system using magnetic abrasive machining

1.2 General Introduction About techniques

Sintering: A technique in which powder is used for making objects, by heating the material below its melting point in a sintering furnace (solid state sintering) until its particles adhere to each other. Traditionally ceramic objects are manufactured by sintering using it as powder metallurgy.

Adhesive bonding: For providing a strong bond between magnetic and abrasive component a special type of adhesive was selected. In the mixture of abrasive and ferro-magnetic components the amount of adhesive was decided in such a way that the mixture gets completely wet with the adhesive and at the same time the mixture should not behave like a fluid.

Simple Mixed Magnetic Abrasives: In this technique magnetic abrasive was prepared without adding any bonding material in the mixture of Iron powder and SiC powder. It is believed that under the influence of magnetic field the iron particles sandwich SiC particles causing abrasion action on the work piece surface.

Mechanical alloying: the solid state powder processing technique which consists of fracturing, repeated cold welding of powder particles in a ball mill is called mechanical alloying. The process includes the mixing of powders and then the mixture is loaded into the mill along with steel balls. After milling the mix for particular time, it is then consolidated into a bulk shape, then the desired microstructure is obtained through heat treatment.

II. LITERATURE REVIEW

The literature, which was reviewed for this project selection, was based upon different aspects of abrasive mixtures that were prepared by various techniques. The non magnetic abrasives were required to be attached these with any ferro-magnetic material, so that the combination of ferro-magnetic material and abrasives can be attracted by magnetic field. Various researchers have prepared different mixing techniques for this purpose for testing surface finish, finishing time, wear of abrasives mixture.

[1] Carried out experiments upon MAF having a slotted magnetic pole. This study deals with the effect on the forces and surface quality of a slot made in the electromagnet during MAF.

[2] Prepared abrasives of diamond and non diamond carbon poly-crystalline composites by conventional sintering of diamond particles at a temperature above 1440 K and pressure below which the diamond was stable or meta stable with respect to its conversion to graphite.

[3] For finishing of silicon wafer, glass and copper has used magnetic field. In this study the researcher prepared magnetic fluid, which had the ability to move under magnetic field.

[4] Has performed abrasive machining of parts in magnetic field with ferromagnetic abrasive powders by developing a rotor type machine.

[5] Has compared the performance and characteristics of magnetic abrasives prepared by a newly developed technique (Mechanical alloying) and a common technique (Sintering). Experiments were conducted to examine the effect of mesh size of magnetic abrasives and machining time on the performance, when MAF is done on Stainless Steel 304 with sintered magnetic (SM) abrasives and mechanically alloyed magnetic (MAM).

[6] Has performed their study on Electrolytic magnetic abrasive finishing (EMAF). EMAF is a compound finishing process which involves the traditional magnetic abrasive finishing (MAF) and an electrolytic process.

III. Problem Formulation

Earlier research on Magnetic Abrasive Machining was carried out only to utilize this machining process in different operations. Only different types of material work-parts are processed upon this machine by various research personnel and organizations. But the cost can also be reduced by maximizing the production rate and by making the best quality product in shortest time. This can also be achieved by making an optimum abrasive grain-work-part combination, in which the processing time will be less and the quality of the processed component is the best. Therefore, the present study aims to develop a suitable combination of abrasives and work-part materials by taking different material abrasive particles to optimize the whole process.

IV. Objectives of study

1. To find the suitable combination of work piece – abrasive that is prepared by various techniques of the Magnetic Abrasive Machine in which the process parameters will be fixed so that to find the optimum machining conditions at which there will be maximum material removal rate and maximum surface finish.

2. To study the surface finish obtained through the optimum combination of work part and abrasive grains and to compare them under different conditions (dry & wet)

V. EXPERIMENTATION

Table 5.1 Composition of Magnetic Abrasive used for Adhesive Bonding (Sample 100 gm each) (Adhesive taken- 30 ml each)

Sample Number	Percentage of ferromagnetic component (By weight)	Percentage of abrasive component (By weight)
1.	90	10
2.	85	15
3.	80	20
4.	70	30
5.	60	40

Table 5.2. Sintering Conditions (Time taken – 1 Hour) (Temperature maintained – 1250 ºC)

Sample Number	Percentage of ferromagnetic component (By weight)	Percentage of abrasive component (By weight)
1.	90	10
2.	85	15
3.	80	20
4.	70	30
5.	60	40

Table 5.3: Composition for Mechanical Alloying

Sample Number	Percentage of ferromagnetic component (By weight)	Percentage of abrasive component (By weight)	Quantity of steel ball
1.	90	10	1 kg
2.	85	15	1 kg
3.	80	20	1 kg
4	70	30	1 kg
5	60	40	1 kg

VI. RESULTS AND DISCUSSION

Table. 6.1. Simple Mixed Abrasive

S. No.	Initial surface finish in µm	Final surface finish in µm (Dry condition	%age improvement (Dry condition)	Final surface finish in µm (wet condition)	%age improvement(Wet condition)
1.	4.05	3.70	8.64	3.53	12.83
2.	4.08	3.68	9.80	3.49	14.46
3.	4.10	3.50	14.63	3.44	16.09
4.	4.11	3.46	15.81	3.40	17.27
5.	4.19	3.66	12.64	3.58	14.55

Table. 6.2. Adhesive Bonded Abrasives

S. No.	Initial surface finish in µm	Final surface finish in µm (Dry condition)	%age improvement (Dry)	Final surface finish in µm (wet condition)	%age improvement (Wet condition)
1.	4.16	3.63	12.74	3.01	27.64
2.	4.12	3.15	23.54	2.72	33.98
3.	4.13	2.99	27.60	2.53	38.74
4.	4.08	2.70	33.82	2.34	42.64
5.	4.05	2.82	30.33	2.43	40.06

Table. 6.3 Sintered Abrasives

S. No.	Initial surface finish in µm	Final surface finish in µm (Dry condition)	%age improvement (Dry)	Final surface finish in µm (wet condition)	%age improvement (Wet condition)
1	4.19	2.85	31.98	2.66	36.50
2	4.21	3.03	28.02	2.82	33.01
3	4.23	2.68	36.58	2.43	42.53
4	4.20	2.57	38.88	2.12	49.52
5	4.22	2.63	37.67	2.18	48.34

Table. 6.4. Mechanical Alloyed Abrasives

S. No.	Initial surface finish in µm	Final surface finish in µm (Dry condition)	%age improvement (Dry)	Final surface finish in µm (wet condition)	%age improvement (Wet condition)
1	4.19	3.15	24.82	2.60	37.94
2	4.21	2.87	31.82	2.45	41.80
3	4.23	2.50	40.89	1.91	54.84
4	4.20	2.40	42.85	1.81	56.90
5	4.22	2.62	37.91	2.16	48.81

6.1. PERCENTAGE IMPROVEMENT IN SURFACE FINISH

In the following points the effect of three input parameters (Proportion of Ferromagnetic / Abrasive Powder, Application Condition, Type of Magnetic Abrasive) on percentage improvement in surface finish (ΔRa) has been discussed:

- The main significant factor is the type of magnetic abrasive. On comparing magnetic abrasives prepared by Adhesive bonding, sintering,simple mixing and mechanical alloying of iron powder and abrasive powder, discernible improvement in surface roughness of workpiece was found under all other similar conditions.

- The percentage improvement in surface roughness in case of simply mixed magnetic abrasives and Silicon Carbide was not very good. For Adhesive bonded iron-SiC, the percentage improvement was up to the mark. But for sintered iron-SiC, this value was good & was maximum for mechanical alloying .

- The pattern of variation of percentage improvement in surface roughness remains same for the four type of iron-SiC i.e. simple mixed, glued, sintered and mechanical alloying.

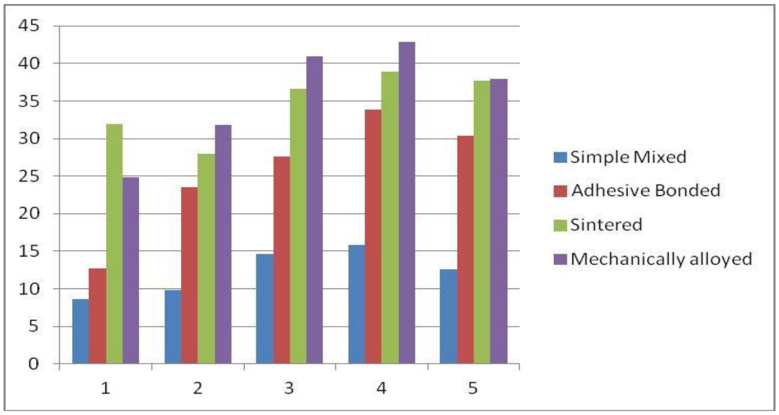

Figure 6.1.Percentage improvement in surface Finish for all the four techniques under dry condition

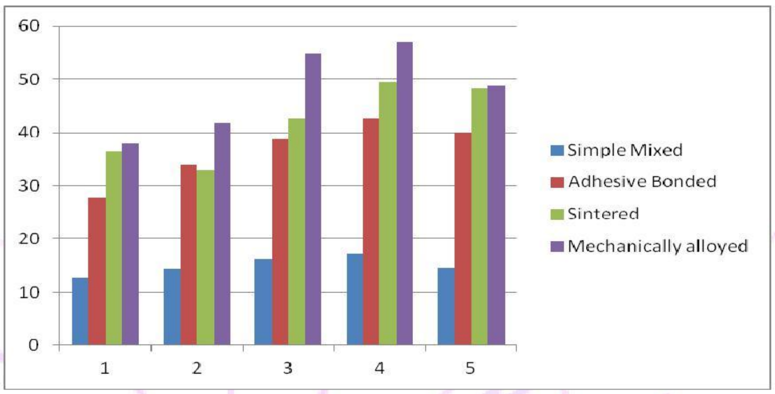

Figure 6.2.Percentage improvement in surface finish for all the four techniques under wet Condition

VII. CONCLUSIONS

1. The magnetic abrasives developed by mechanical alloying were able to machine brass surface with reasonable percentage improvement in surface roughness of the work piece (Approximately 57%).

2. Type of magnetic abrasive is a conclusive factor. The magnetic abrasives prepared by Adhesive bonding, sintering, simple mixing & mechanical alloying of iron powder and abrasive powder, on comparing showed discernible improvement in surface roughness of workpiece under all other similar conditions.

3. The maximum percentage improvement in surface roughness for simply mixed magnetic abrasives and Silicon Carbide was approximately 18%. For Adhesive bonded iron-SiC, this value was up to 42 %, for sintered iron-SiC it was 49% and in case of mechanical alloying it was 57%.

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