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Design and Performance of Magnetic Abrasive Finishing Set Up for Finishing of Extended Surfaces

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Abstract **-Some of the materials used in modern industries and industrial applications are difficult to finish with high accuracy and minimal surface defects using conventional machining and polishing techniques. Use of traditional machining techniques for finishing of these materials may lead to various defects like micro cracks, errors in work piece geometry and work piece surface distortions. Due to the these limitations of the traditional machining processes, there was need of new family of machining and finishing methods known as non-traditional or modern machining methods has been developed. Among the various non-traditional processes, magnetic abrasive finishing is one. This process is used to machine and finish material surfaces that are otherwise very difficult to finish. The aim of this research article, To design and develop a Magnetic abrasive finishing set up for finishing of extended plane surfaces and to finish thin sheets (3-5mm), as finishing of thin sheets is difficult by conventional method like grinding due to high temperature generated by large grinding forces.**

Keywords: **Magnetic Abrasive Finishing, Non-Conventional machining Process, Percentage Improvement In Surface Finish.**

I.INTRODUCTION

Some of the materials used in modern industries and industrial applications are difficult to finish with high accuracy and minimal surface defects using conventional machining and polishing techniques. Use of traditional machining techniques for finishing of these materials may lead to various defects like micro cracks, errors in work piece geometry and work piece surface distortions. Due to the these limitations of the traditional machining processes, there was need of new family of machining and finishing methods known as non-traditional or modern machining methods has been developed.

In MAF, to form the magnetic abrasive brush, magnetic strength and magnetic abrasives are the primary requirements. These can be classified into two groups depending on the method of application of abrasive grains on the work piece. The first one is known as bonded abrasive process and the other one is known as loose abrasive process. In case of bonded abrasive processes, the geometry of the finished work piece depends on shape of abrasive tool formed by clasping together the abrasive grains within a matrix. Grinding wheel is a classic example where the particles are bonded together. When the rotating grinding wheel is forced into the part then its shape is shifted on to the work piece. Generally bonded process includes: Diamond wire cutting, Honing, Abrasive belt machining, Grinding, Buffing etc. The abrasive grains are not connected to each other in loose abrasive processes. They may be used without lubricant in the form of dry powder, or with lubricant in the form of abrasive slurry. In this process the independently moving grains are forced into the work piece with the help of some other object like polishing cloth. Processes employing loose abrasives include: Polishing, Lapping, Abrasive Flow Machining (AFM), Water-jet cutting, Magnetic Abrasive Machining etc. Electromagnets or permanent magnets serve the purpose of providing required magnetic field strength. Different materials like Niobidium, rare earth and alnico may be used to make permanent magnets as per the required strength of magnetic field. Electromagnet is made by winding a wire around a core of soft iron. Number of turns, current intensity and wire diameter decide the magnetic field intensity. In the present setup square shaped permanent magnets of niobidium are used. This process is used to machine and finish material surfaces that are otherwise very difficult to finish. Literature survey, industrial use and various experimental results rank MAF above traditional finishing methods owing to its ability to produce better surface finish efficiently. Shinmura et al. [3] performed out experiments on plane work pieces using the MAF process. They lead to the conclusion that with increase in finishing time up to a particular limit, the surface roughness value decreases. Beyond that limit no further improvement in surface roughness value took place. They also concluded that stock removal and surface roughness improvement can be remarkably improved by adding fluid to unbounded MAPs. Kremen [2] performed out experiments cylindrical parts of ceramic material and silicon wafers using magnetic abrasives of different mesh number to study their effect on removal rate of material and roughness of surface.. In all processes of abrasives, the use of larger grain size leads to high metal removal & increased roughness and vice-versa. But in MAF process, when the author studied the effect of diamond grain size of powder, roughness & metal removal on ceramic tube & silicon wafers, their result show variation of grain size has no effect on surface finish obtained in both cases. But material removal rate increase with increase in mesh number of the diamond abrasives with mixture of iron powder. Singh et al. [6] analysed the performance of flexible magnetic brush and identified four parameters which magnetic field intensity (by varying current to the electromagnet), space between the work piece and poles of magnets, abrasive grain size and number of cycles. They conducted a number of experiments and used RSM and ANOVA and lead to the conclusion that magnetic flux density which depends upon the current to the electromagnet and machining gap is the main parameter followed by mesh number and number of cycles. To understand the material removal mechanism of MAF process, they used AFM and scanning electron microscope. Literature survey reveals that MAF has been used on localised areas and the capability of MAF for finishing of extended areas on rods, plates and pipes has not been much explored. The present work has been undertaken to design & develop a Magnetic abrasive finishing set up for finishing of extended plane surfaces and to finish thin sheets (3-5mm), as finishing of thin sheets is difficult by conventional method like grinding due to high temperature generated by large grinding forces.

II.PRINCIPLE OF MAF

Figure 1 shows finishing of plane work pieces by magnetic abrasive finishing process using a rotating magnetic pole system and linear feed motion of the worktable. Required machining force against the work piece upper surface is generated with the help of magnetic field that brings together the abrasive grains place on the work piece surface in the area to be finished. In the process, the magnetic field attracts the magnetic abrasives placed on the surface of work piece and forces them against the work piece surface. These particles gets collected to form a flexible brush of magnetic abrasive particles which acts against the work piece due to the forces of attraction between the flexible brush and magnets. Indentations are formed on the work piece surface due to the finishing pressure. The centrifugal force and reciprocating force acting on the abrasive particles in FMAB play a major role for cutting the work piece surface and formation of microchips. During the finishing operation the magnetic poles are rotated and linear feed motion is given to the work piece. The MAP grains should be strongly bound by the magnetic force otherwise they may scatter or fly away from the cutting zone due to centrifugal forces acting on them. In this process, two magnets are placed below the work piece..

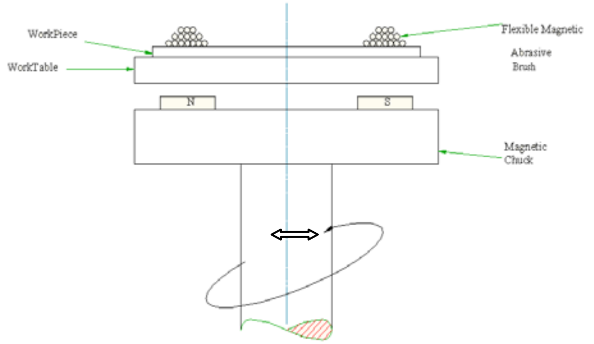

Fig.1 Magnetic Abrasive Finishing Process

The two poles of magnets designated as N & S were mounted on chuck which is placed below the work table on which plane work piece is clamped. The centrifugal force and reciprocating force acting on the abrasive particles in flexible magnetic abrasive brush play a major role for cutting the work piece surface and formation of microchips. These controllable forces removes the particles from the surface and helps to attain a mirror like finish on the surface.

III.EXPERIMENTAL SET UP

The experimental setup for plane surfaces finishing using MAF process consists of 2 permanent magnets mounted on aluminium disk which act as a carrier and insulator to separate them. This disk is placed below acrylic working table. Magnets are rotated by a D.C. motor. Fig. 2 shows the front view & Fig. 3 shows top view of the setup. The feed is given to work table by another D.C. motor. Work piece is placed over the working table and abrasives are placed upon the work piece. The speed of the magnets & feed of worktable is varied by changing the speed of D.C. motor.

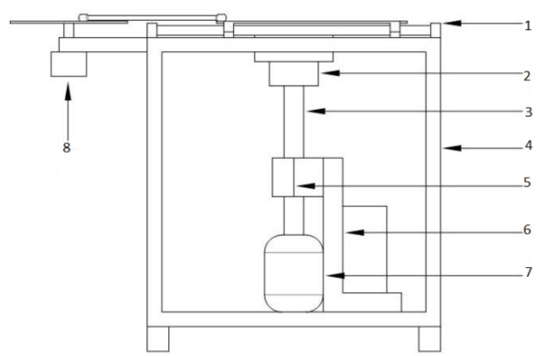

Fig.2 Front view of plane finishing set up
1.Rod Clamp, 2. Aluminium Chuck, 3. Shaft, 4. Frame, 5. Bearing Block, 6. L-Plate, 7. D.C Motor for rotary motion, 8. D.C Motor for reciprocating motion 9. D.C Motor for reciprocating motion, 10. Connecting Rod, 11. Work Table 12. Rods

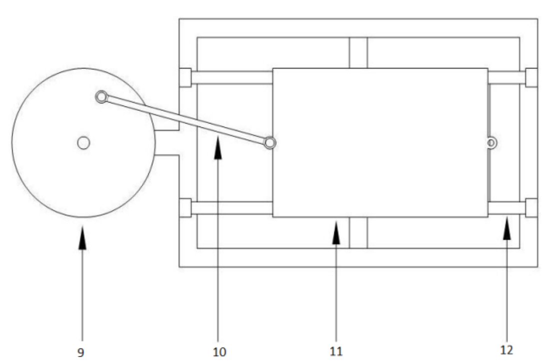

Fig. 3 Top view of plane finishing set up

IV.EXPERIMENTAL CONDITIONS

In this work, the abrasives are formed by mixing Diamond powder (abrasive) (mesh size-250) 15 % by volume in Iron powder (mesh size-300) 85%. The mixture is then compressed into cylindrical mode by using die and sintered in a specially designed furnace an 1100˚C in the presence of H_2 gas. The sintered compacts were crushed mechanically by using Mortar and Pestle. Then the powdered abrasives were separated by sieves to get different abrasive size by using sieve set. Mesh size 140 of abrasives were used in this study. 316 L Steel thin sheets 3-5 mm were used for this work as work pieces. Variables of three levels for experimentation such as rotational speed (100,150 & 200 rpm), feed (30,35 & 40 mm/sec), machining time (30,60 & 90 minutes) and constant parameters are: magnetic flux density (6000 Gauss), percentage of iron in magnetic abrasives, size of magnetic abrasive particles, quantity of lubricant was 1ml for 5 gm wt. of MAPs and 316L stainless steel work piece were considered. Mitutoyo (SJ-410) surface roughness tester having a least count of 0.001μm (cut off length = 0.8 mm) was used to study the effect of abrasive behaviour on work piece and to view the uniformity in surface roughness.

TABLE 1 EXPERIMENTAL CONDITIONS

Work piece Material	:	316 L Stainless Steel
Magnetic Flux Density	:	6000 Gauss
Lubricant	:	Light Oil (5% of quantity of abrasives)
Work piece & Pole gap	:	1 mm

V.SURFACE TESTER RESULTS

The result of the surface produced after the magnetic abrasive finishing is shown in figure 4. This profile indicates that the peaks and valleys are reduced to greater extent leading to higher surface finish.

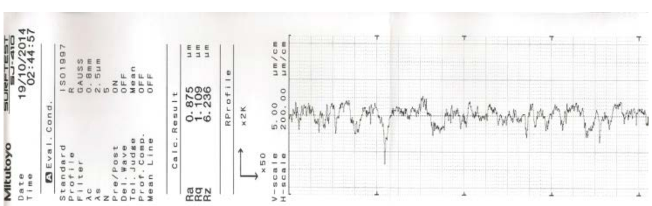

Fig. 4 Surface report after MAF

VI. UNIFORMITY IN SURFACE ROUGHNESS

In order to check the uniformity of the roughness of the surface of specimen finished with magnetic abrasive finishing operation, the value of surface roughness was checked at different points of the specimen having maximum PISF as shown in figure 5. It was observed that the variation in roughness value of surface in the finished area lie between 0.324 to 0.403 μm Ra.

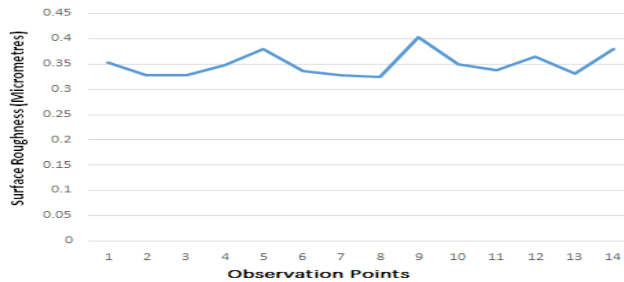

Fig. 5 Uniformity in surface roughness

VII.CONCLUSIONS

After carrying out the finishing on non-magnetic steel (316L Stainless steel) sheets with MAF process by using diamond based sintered abrasive, it is found that rotational speed, feed of work piece and machining time are the significant parameters that affect the percentage improvement in the surface finish. Initially, the work pieces were finished by using conventional machining with the help of special purpose machine that uses emery paper fixed on grinding wheel to finish the work piece.

The surface roughness readings were taken with the help of Mitutoyo (SJ-410) roughness tester. The surface roughness of the conventionally finished work pieces were found to lie within the range of 0.50μm to 0.90μm Ra. Same work pieces were mounted on Magnetic Abrasive Finishing machine for surface finishing by non conventional methods. As compared to the surface finish obtained by using conventional surface grinding, the work piece surface finish was improved 45% by using Magnetic Abrasive Finishing.

The summary of results obtained from this research is as detailed below:

(1) New designed set up was successfully used to cover extended areas of thin sheets with magnetic abrasive finishing (MAF).
(2) The surface finish of 316 L steel plate improved by 45% by Magnetic Abrasive Finishing.

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