To Study the Effect of Various Parameters on Magnetic Abrasive Finishing

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Abstract
Magnetic Abrasive Finishing (MAF) process is one in which material is removed in such a way that surface finishing and deburring are performed simultaneously with the applied magnetic field in the finishing zone. In this research paper, a SS 305, SS 316 and brass cylindrical work piece was finished using a magnetic abrasive finishing process at different speed, magnetic flux density, hardness and work piece gap and corresponding to these parameter improvement in surface finish is investigated. The aim of this paper is to study maximum efficiency in terms of material removal rate. Magnetic abrasive finishing as an efficient tool for internal finishing of bent tubes. In this research a cylindrical work pieces was finish using a magnetic abrasive finishing process on a apparatus developed for carrying out testing work. The process principle and the finishing characteristics of magnetic abrasive finishing of cylindrical pipes using sintered magnetic abrasives are described in this research work. The sintered magnetic abrasive is a mixture of Al2O3 abrasive and ferromagnetic particles. The Al2O3 based sintered magnetic abrasives have been developed in sintering machine.

The process parameters were the gap between work piece and magnet, rotational speed of work piece, magnetic flux density, hardness and the work piece gap. The improvement of surface roughness was achieved because the vibrational motion effectively removes unevenness in rotational direction and direction orthogonal to it.

Keywords
Magnetic Abrasive Finishing; Sintering; Surface Roughness, Roundness, Percentage Improvement in Surface Finish

I. Introduction
High technology industries require ultraclean smooth finished surfaces for their critical applications. Liquid piping systems, vacuum tubes, sanitary tubes, high purity gas tubes and Pharmaceutical industries require smooth finished inner pipe surface to prevent the Contamination of gas and liquid. But polishing of such surfaces involves high cost and Controlled atmosphere during polishing. To meet the requirements of the industry new Methods are being developed continuously. Magnetic abrasive finishing is one of such Method which uses a controlled magnetic force to finish surfaces. In magnetic abrasive Finishing, a cutting tool that consists of iron particles and abrasives is flexible in nature. To minimize the surface damage, gentle/ flexible finishing conditions are required, namely, a low level of controlled force. Magnetic field assisted manufacturing processes are becoming effective in finishing, cleaning, deburring and burnishing of metal and advanced engineering material parts. Magnetic Abrasive Finishing (MAF) is one of the non conventional machining processes which came to the surface in 1938 in a patent by Harry P. Coats. The countries which are involved in the study and development of this process are USA, CIS, France, England, Bulgaria, Japan and Germany. In modern time, fine surface finish applications. A relatively new finishing advanced machining process in which cutting force is primarily controlled by the magnetic field. A magnetic abrasive finishing process is the one in which material is removed in such a way that surface finishing and deburring are performed simultaneously with the applied magnetic field in the finishing zone and it can achieve highly finished surfaces that conventional techniques MAF is a fine finishing technique which can be employed to produce optical, mechanical, and electronic components with micrometer or sub micro meter form accuracy and surface roughness within nanometer range with hardly any surface defects. Finishing of bearings, precision automotive components, shafts, and artificial hip joints made of oxide ceramic and cobalt alloy are some of the products for which this process can be applied. A magnetic abrasive finishing process is a non traditional process that employs magnetic field action and mixed magnetic abrasives (2-5).

II. Principles of Internal Finishing
Figure 1 shows a schematic of internal magnetic abrasive finishing process using a stationary pole system. Magnetic abrasives introduced into the pipe are conglomerated at the finishing zone by a magnetic field, generating the finishing force against the inner surface of the tube. In the process, magnetic abrasive particles introduced into the work piece are attracted by the magnetic field and bear on the inner surface of the work piece. These particles join each other along the lines of magnetic force due to dipole–dipole interaction and form a Flexible Magnetic Abrasive Brush (FMAB) which pushes against the work piece surface and develops finishing pressure. This finishing pressure originates micro indentations in the work piece surface. The tangential force developed by FMAB is the major cutting force responsible for micro chipping. Abrasives generally rely upon a difference in hardness between the abrasive and the material being worked upon, the abrasive being the harder of the two substances. In MAF operation, work piece is kept between the two magnets. The magnetic poles N & S were placed face to face with their axes crossing at right angle with a brass pipein the configuration as shown in figure 1. The Magnetic field extends in the inner region of the pipe without regard to presence and absence of the pipe to the machined and actuates magnetic force to magnetic abrasive particles packed inside pipe. Abrasive particles can be used as unbounded, loosely bonded or bonded. Bonded magnetic abrasive particles are prepared by sintering of ferromagnetic powder (iron) and abrasive powder (Al2O3) at a very high pressure and Manufacturing process employed determines surface finish level. Some processes are inherently capable of producing better surfaces than others. The processes recognized for good surface finish are honing, lapping, polishing and surface finishing. Tolerance and range of surface roughness produced by different processes are given below.

Table 1: Tolerance and Range of Surface Roughness by Various Process

<table>
<thead>
<tr>
<th>Process</th>
<th>Tolerance (mm)</th>
<th>Roughness (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grinding</td>
<td>±0.008</td>
<td>5 to 75</td>
</tr>
<tr>
<td>Lapping</td>
<td>±0.005</td>
<td>2 to 15</td>
</tr>
<tr>
<td>Honing</td>
<td>±0.005</td>
<td>4 to 30</td>
</tr>
<tr>
<td>Super finishing</td>
<td>±0.003</td>
<td>1 to 10</td>
</tr>
</tbody>
</table>
III. Experimental Setup

A schematic of experimental set up is shown in fig. 1 and 2, which embodies the principles of internal finishing described in the previous section. The experimental setup has major components like electromagnet (10 k Gauss), control unit, d.c. motor, variable D.C. supply.

The main elements of MAF equipment include the electromagnet (10 k Gauss), variable D.C. supply and abrasive powder (Sintered AI2O3 + Fe). The cylindrical work piece i.e. SS305, SS316 and brass pipe, was held in the chuck attached to D.C. motor and abrasives were packed in the pipe and over the and on one end cap is provided with the help of dead centre to kept the abrasive inside of pipe. Magnetic field was applied to the abrasives by electro magnet. Magnetic field strength is varied for experimentation with the help of variable D.C. supply. Electromagnet plays and important role in present experimentation. The space between work piece and electromagnet is kept constant. The magnetic field strength depends upon weight percentage of the magnetic particles, present in the magnetic abrasive powder. Both the working gap and size of the work piece are taken into consideration, while designing. The objective of the design is to give rotational motion to the cylindrical work piece. The work piece is rotated at 80, 95 and 170 rpm. ADC motor is chosen for providing rotational motion to the work piece. A schematic view of the setup is shown in the figure. Magnetic abrasive particles through magnetic pressure finish the work piece. AI2O3 based sintered magnetic abrasives are used as magnetic abrasives.

IV. Experimental Conditions

In this work AI2O3 based sintered magnetic abrasives were used for internal finishing of cylindrical SS305, SS316 and brass pipes. The Alumina (AI2O3) based sintered magnetic abrasives were prepared by blending of AI2O3 (10%) of 300 mesh size (74 µm) and iron powders (90%) of 300 mesh size (51.4µm)), compacting them by a Universal Testing Machine (UTM), sintering the mixture in a sintering set up at 1100°C in H2 gas environment, crushing the compacts into small particles and then sieving to different ranges of sizes. The obtained sizes are 120µm, 200µm, 300µm, 420 µm. The experimental conditions are shown in table no.2 Cylindrical Brass, SS305 and SS316 pipes (Ø18 x60mm) were used for the experiments as work pieces. In this work, experimental variables such as magnetic flux density, revolution, gap between work piece and pole and work piece hardness were considered. The finishing characteristics of magnetic abrasives were analyzed by measuring the surface roughness, which was measured at four points before and after finishing using a Mitutoyo surface roughness tester (SJ-210P) having a least count of 0.001 µm (cut off length = 0.8 mm) and averaged.

<table>
<thead>
<tr>
<th>Abrasive grain size</th>
<th>120,150 and 220 grits (106, 75 and 53 µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic pole</td>
<td>SS 400:Material</td>
</tr>
<tr>
<td>Work piece</td>
<td>SS 304,SS316 and Brass tubes</td>
</tr>
<tr>
<td>Revolution</td>
<td>80, 95 and 170 rpm</td>
</tr>
<tr>
<td>Magnetic abrasives</td>
<td>Aluminium oxide AI2O3, Ferrite particles 30g</td>
</tr>
<tr>
<td>Magnetic flux density</td>
<td>3000, 4000 and 5000 gauss</td>
</tr>
<tr>
<td>Gap between work piece and pole</td>
<td>2, 3 and 4 mm</td>
</tr>
<tr>
<td>Work piece hardness</td>
<td>45, 50 and 55 RC</td>
</tr>
<tr>
<td>Machining duration</td>
<td>60, 90, 120 min</td>
</tr>
</tbody>
</table>

V. Results and Discussions

To establish the feasibility of usage of MAM, the experiments were conducted by selecting the process parameters based on the findings of trial runs and some of the parameters influence is discussed below. Influence of work piece circumferential speed on surface finish Fig. 3 shows the effect of work piece circumferential speed on surface finish. In this study, the rotational speeds of 80, 95 and 170 rpm and the duration of machining of 60 minutes were experimented. It can be seen that the improvement in surface finish is more with higher rotational speed. The improvement in surface finish can be due to more abrasives that come in contact with the work piece during high speed.
A. Influence of Magnetic Flux Density (MFD)

On surface finish fig. 4, illustrates the effect of magnetic flux density on surface finish. The flux density used in the experiments was 0.3, 0.4 and 0.5 tesla (T) and the machining duration was 60 minutes. From the results, it can be noticed that the increase in flux density reduced the improvement in surface finish this could be due to the abrasives with high magnetic field density, the movement of the abrasives is also redirected in the machining zone.

B. Influence of Work Piece Hardness on Surface Finish

Fig. 6 illustrates the effect of work piece hardness after a machining duration of 60 minutes. Turned work pieces hardened to 45, 50 and 55 RC and ground to 0.2 to 0.6 μm Ra are considered for this study. Large improvement in the finish is noticed on work piece with a hardness of 55 RC with Al2O3 and ferrite abrasives. A number of trials were conducted with various types of machined surfaces such as turned, ground specimen to ascertain the feasibility of this system for polishing the work surface.

VI. Conclusion

The conclusions of this research work are as follows:
1. This research work showed the feasibility of using Al2O3 based sintered magnetic abrasive particles for the internal finishing of cylindrical brass, SS305 and SS316 pipes and gained an understanding of the mechanism involved.
2. The process of Magnetic Abrasive Machining (MAM) for polishing of cylindrical work piece was developed using available abrasives. A machining setup was developed using a apparatus. The lathe was modified to accommodate a heavy-duty electromagnet on the carriage in place of tool post and a work piece holding mandrel was supported between the chuck and the tailstock. The experimentation with these process parameters reduced the surface roughness value on a cylindrical component from an initial Ra value of 0.257μm to 0.075μm Ra over a machining duration of 3 minutes with Aluminium Oxide, 220 grit semi magnetic abrasives. These studies also indicated the need to consider the work piece initial roughness, apart from its hardness for achieving an improved finish on the work surface. From these studies it was clear that work piece having initial roughness around 0.4μm Ra is found to give a significant improvement in surface finish with semi magnetic abrasive machining.

3. Study shows that on various parameters improvement in surface finish is maximum in case of brass as compared to other materials.

V. Acknowledgement
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VI. Future Scope
In addition to the present work further work can be done in following directions:
1. The effect of then surface roughness, roundness, micro-diameter change, and removed weight can be investigated and analyzed.
2. Study can be conducted further for finding out the optimum range of various parameters to find maximum improvement in surface finish.

References