An Approach to Magnetic Abrasive Finishing Process

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Abstract— Magnetic abrasive finishing (MAF) process is an advance machining process that produces high quality surface by removing material from the work piece surfaces. The magnetic abrasive finishing process have been classified according to finishing profile of surface i.e. cylindrical surface finishing, inner surface finishing and plane surface finishing. This paper summarized better understanding about the experimental work that had been performed on process and response parameters. The surface roughness and material removal highly depend on machining gap and magnetic flux density.

Keywords: Magnetic Abrasive Finishing (MAF), Flexible Magnetic Abrasive Brushes (FMAB)

I. INTRODUCTION

The magnetic field assisted grinding process is based on the electromagnetic behavior of magnetic abrasive grains in a magnetic field. In the magnetic abrasive polishing (MAF) process, magnetic forces play a dominant role in forming flexible magnetic abrasive brushes (FMAB) and generating abrasive pressure. Investigations into finishing processes using magnetic fields are being conducted not only in R&D laboratories, but also at the industrial level. The force is evenly distributed over the work surface and is easy to control. So they do minimal damage to it. This process can achieve surface roughness in the nanometer range. The surface finish, accuracy, and surface integrity of parts produced by conventional machining (i.e., the tool is harder than the work piece) consist of the machine tool, cutting tool, work piece, cutting conditions, and cutting fluid. Depends on the machine tool system being used. In traditional superfinishing processes, the tool is mechanically pressed against the surface of the work piece, resulting in surface defects such as micro cracks, shape and dimensional errors, and warpage. There is also a strong interaction between machines, tools and work pieces, making it difficult to achieve the required tolerances and surface finishes. with the advent of advanced materials such as ceramics and glasses, few cutting tool materials with geometrically defined edges (including polycrystalline diamond and cubic boron nitride) can effectively remove material. Ceramics and glasses are inherently brittle, and failure of parts made from these materials is caused by cracks and other defects formed during machining. In order to minimize the damage caused by processing, it is necessary to process under mild conditions. Therefore, Magnetic Abrasive Finishing (MAF) was used as an alternative superfinishing process to finish surfaces efficiently and accurately. MAF applies a magnetic force to the abrasive grains to remove material, making the cutting process virtually labor intensive. This minimizes damage to the machined surface. MAF has proven to be a versatile process for finishing internal, external, flat and complex shaped surfaces

II. PROBLEM FORMULATION

The current scenario demands extreme surface finish in the wide range of mechanical use. The need for extreme precision in production was sensed by manufacturers general to advance interchangeability of elements, correct control of product quality and more protracted wear/fatigue life. Presently, it is necessary that the parts used in production semiconductors, atomic energy parts, healing tools and aerospace parts, have a very accurate surface roughness. Amongst them, vacuum tubes, wave guides and sanitary tubes are troublesome to polish by conventional finishing patterns just for lapping, because of their shapes Traditional fine finishing movements in the way that grinding, overlapping, or sharpening engage a strict tool that matters the workpiece to solid rational stresses that may cause microcracks happening in lessen strength and reliability of the machined part. A proportionate new fine finishing procedure, magnetic abrasive finishing (MAF) is an progressive finishing process in which the cutting force is generally conditional the magnetic field of currents. It minimizes the possibility of microcracks superficial of the workpiece, specifically in hard fragile material, on account of controlled reduced forces pursuing abrasive particles. This process is proficient to produce surface roughness of nanometer range on flat surfaces in addition to internal and external tubular surfaces. This order can not only machine ferromagnetic materials such as steel but can also tool non ferromagnetic materials such as aluminium, stainless steel and brass. It can also be cast-off for internal finishing of non-rotatable workpieces to a degree elbows and bent tubes. The MAF process offers many advantages, to a degree self-honing, self-changeability, controllability, and the perfecting tools demand.

Most of the experiments have been performed on finishing of iron or brass tubes utilizing magnetic field of produced by electromagnets. Very little work has been done on ceramic pipes utilizing sintered abrasives. So commercially accessible Ceramic pipes have been selected as whole piece to study the effect of magnetic abrasive machining with ferromagnetic TiC sintered abrasives. The present research work has happened tried accompanying the following goals:

1) To prepare sintered abrasive using Titanium Carbide (TiC) as abrasive.
2) To review the effect of input process parameters (Magnetic flux density, rotational speed of the workpiece, machining time and weight of the abrasives) on the performance characteristic like Percentage improvement in surface finish (PISF)
3) To study the efficiency of sintered Titanium Carbide (TiC) magnetic abrasives.

4) To expand practical connection between the process input parameters and output characteristics utilizing regression model.

III. Experimental Setup

For present work development of sintered magnetic abrasives are important .Also, experiments have been designed and performed using statistical technique

IV. Techniques of Preparing Magnetic Abrasives

Most of the existing research on MAF shed light on the development of the process and the improvement of its function and application. Various techniques used in the manufacture of magnetic abrasives are:

- Sintering
- Adhesive based
- Plasma based (powder melting/ plasma spraying)
- Mixing (loose bonding/unbonding) etc.

V. Machining Principle

When magnetic poles N and S are placed opposite each other with their axes perpendicular to each other in a non-ferromagnetic tube. Magnetic field extends in the inner region of the tubing without regard to presence and absence of the tubing to the machined and actuates magnetic force to magnetic abrasive particles packed inside pipe which leads to the formation of Flexible Magnetic Abrasive Brush. The magnetic force on the abrasive grains provides the necessary machining force. This force causes pipe wear from abrasive particles.

VI. Control of the Abrasion

In MAF, the main factors which control abrasion are:-

A. *Magnetic Field Density:*

The friction of the tube surface was greatly affected by the magnetic flux density, ie. the strength of the magnetic field. At low magnetic flux density, the abrasive pressure created by the magnetic abrasive particles was less than required for machining, sometimes the abrasives were dragged along with the pipe. Certain values of magnetic flux density gave the best results. At high magnetic flux density, the friction pressure is so high that less surface finish results

B. *Rotational Speed of Work Piece:*

The rotational speed of the workpiece also affects the surface finish. At very slow and very high speeds, there was very little improvement in surface finish. At particularly high speeds, it was impossible to improve the surface roughness, because the magnetic abrasive particles are dragged along with the tube. It took more time slowly. At reasonable speed, the results were good. So, in this study, the workpiece speed range was taken as 400 rpm to 1200 rpm.

C. *Amount (Quantity) of the Magnetic Abrasives:*

The amount of abrasives affects the surface finish. Very low and high amounts result in poorer surface finish compared to moderate amounts of abrasives .This happens due to mixing of particles. Thus, in the present experiment, the amount or weight of abrasives was taken from 5 grams to 25 grams

D. *Grit Size of the Magnetic Abrasives:*

Bigger particles lead to high machining but do not improve the surface finish to a desired level. Very small particles also lead to machining but not considerable improved finish. Better results were obtained at an average value of the grit size of the magnetic abrasives and hence the grit size was set to 180µm.

E. *Machining Time:*

We tested different samples of PISF at different time intervals PISF has been observed to improve continuously up to 60 minutes, and then worsen. Therefore, the processing time was set to 60 minutes

F. *Response Variable for Experimentation*

The response variables selected for the current experiment are: Surface Finish Improvement Factor (PISF). The ratio of surface roughness reduction to initial roughness is considered one of the response variables during this experiment. This is called the surface finish improvement factor and is given by

PISF (%) = (Initial Surface Roughness - Final Surface Roughness) *100/Initial Surface Roughness

VII. Procedure

A. *Preparation of Work Piece Samples*

A ceramic tube having an outer diameter of 40 mm and a thickness of 5 mm was cut into 30 samples each of length 4 inches long samples cut with a grinder using a silicon carbide cutting wheel. All samples have nearly the same surface finish. Four marks were made at equal intervals on the circumference with a knife. Each sample was labeled with the sample number and covered with cello tape to retain identification. Using a Mitutoyo surface roughness meter (SJ-410) having standard (ISO1997), the surface roughness of each sample was measured at four points and the average value was calculated. Body weight of the samples was also recorded before the start of the experiment

B. *Preparation of Sintered Magnetic Abrasives*

Due to facility availability, sintered Titanium Carbide magnetic abrasives are prepared for experiments in this study. The following process was used to manufacture the sintered magnetic abrasives.

1) Mixing of powders
2) Preparation of green compacts
3) Sintering under controlled atmosphere
4) Crushing of Compacts
5) Sieving of crushed powder

- Mixing of Powder: The magnetic abrasives must be able to be magnetized (Fe) and have the ability of finishing (Ceramic). So Iron powder (mesh number-300) and natural titanium carbide powder (mesh number-250) were mixed mechanically by different weight percentages.
- Preparation of Compacts: The mixture is then compressed into a cylindrical mode by using a and by applying a pressure of 2.5 ton/cm2 of load using hydraulic press.The dimensions of the compacts are 20mm diameter and 26mm length approximately

- Sintering of Compacts: Sintering is the process by which metal powder compacts (or loose metal powders) are transformed into coherent solids at temperatures below their melting point. During sintering, the powder particles are bonded together by diffusion and other atomic transport mechanisms, and the resulting somewhat porous body acquires a certain mechanical strength. After the preparation of compacts they were sintered in a specially designed furnace to a temperature of 1100˚C in H2 gas atmosphere and kept at selected temperature for 2 hrs. During Sintering the titanium carbide particles get cohered with the iron particles and are difficult to separate. The sintering temperature was selected on the basis of preliminary experiments. Crushing sintered compacts and sieving of crushed compacts: The sintered compacts were crushed mechanically into desired size. Then the powdered abrasives were separated by sieves to get different abrasive size by using sieve set. The different abrasives used in this study are of 450, 250, 180, 100, 60 mesh size.

After mounting the work piece on the set up, power supply was switched on. The magnetic abrasives were put in the work piece and magnetic field was set according to the desired value by measuring the current. The motor to rotate the work piece was started and rotational speed in rpm was set with the help of a tachometer and varying the voltage input. The time was noted at the start of the motor. On completion of the set time for the experimentation the whole system was stopped, power supply was switched off and work piece was taken. The abrasives were removed and it was cleaned with the help of acetone. The surface roughness was again measured at four points and its mean was calculated. The work piece was weighed again. The same procedure was repeated for all the samples and readings were taken and recorded.

An experiment is a test or series of tests in which the input variables of a process or system are deliberately altered to allow observation and identification of the reasons for observable changes in the output response. Experimental design methods are widely applied in many fields. Design of Experiments is a very important tool for improving the performance of manufacturing processes in the engineering world. It is also widely applied in the development of new processes. Early application of Design of Experiments in process development can result in higher process yields, lower variability, tighter adherence to nominal or target requirements, shorter development times, and lower overall costs increase. Experimental design methods also play an important role in the engineering of new product development and improvement of existing products.

Applications of experimental design in engineering design include:

1) Evaluation and comparison of base design configurations
2) Evaluation of alternative materials
3) Choose the design parameters so that the product performs well under various field conditions, i.e. it is robust.
4) Determining key product design parameters that affect product performance.

VIII. CONCLUSIONS:

The following are the conclusions from this study, "Experimental Study on Finishing Ceramic Tubes by Magnetic Abrasive Machining Using Sintered Magnetic Abrasives".

1) Current, machining time, quantity of abrasives and rotational speed of work piece are affecting the metal removal and %age surface finish improvement.
2) The process yields best result of PISF =86.95% at rotational speed= 600rpm, current= 4.5 amp, machining time =55 min and 15 gm weight of the abrasives.
3) The surface finish (Ra) of the workpiece can be finished to about 0.95 µm.

IX. SCOPE FOR FUTURE WORK

Further efforts in research on MAF may be directed in the following direction:

1) Constant dc power supply may be replaced by pulsed dc supply.
2) The experimentation can be carried out by switching the direction of rotation with time.
3) The process may also be carried out on different rotational speeds and at different intervals of time
4) The process may also be carried out on various intricate shapes.
5) The process may be carried out for different grit sizes of abrasives like diamond, boron carbide, aluminium oxide etc.
6) The process may be carried out with different grit sizes of Titanium Carbide and Iron in the preparation of magnetic powder. Loose or adhesive bonded abrasives may also be used for comparison.

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