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Magnetic Abrasive Finishing Process (MAF) :A Review

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ABSTRACT

Magnetic Abrasive Finishing (MAF) is an advanced surface finishing process that utilizes a magnetic field to hold the work piece and abrasive particles to achieve desired surface finish. This study presents experimental investigations on the MAF process to analyze its effectiveness in achieving the desired surface finish on various materials. The effects of process parameters such as magnetic field strength, abrasive size, and flow rate of the abrasive slurry were studied, and the results were analyzed using statistical tools. The experimental results showed that the MAF process is capable of producing high-quality surface finishes on various materials, including ferrous and non-ferrous metals, ceramics, and composites. The process parameters significantly affect the surface finish, and optimum conditions were identified to achieve the desired finish. The study also highlighted the advantages of MAF over other surface finishing processes, such as its ability to achieve high- quality finishes on complex geometries and the absence of heat generation and tool wear. The findings of this study can provide valuable insights into the optimization of the MAF process for industrial applications.

Keyword: - *MAF, Magnetic field, Abrasive particles*

1. INTRODUCTION

Magnetic Abrasive Finishing (MAF) is a non-conventional finishing process that is gaining significant attention in the manufacturing industry. It is a surface finishing process that uses magnetic force to hold the workpiece and abrasive particles together to achieve the desired surface finish. The process involves the use of a magnetic field to hold abrasive particles in a slurry against the workpiece surface to remove the material and achieve the desired surface finish.

MAF process was first introduced in the 1950s by General Electric for finishing turbine blades. Since then, this process has been widely studied and developed for various applications. The process has several advantages over conventional finishing processes such as grinding, polishing, and lapping. It is capable of producing high-quality surface finishes on complex geometries, and it eliminates the risk of tool wear and heat generation.

The MAF process is a combination of mechanical, chemical, and magnetic forces that work together to achieve the desired surface finish. The process is used to improve the surface quality of various materials, including ferrous and non-ferrous metals, ceramics, and composites. The process can be used for finishing surfaces of different shapes, sizes, and complexities.

The working principle of the MAF process is based on the magnetic attraction between the workpiece and the abrasive particles in the slurry. The process involves the use of a magnetic field to hold abrasive particles in a slurry against the workpiece surface to remove material and achieve the desired surface finish. The magnetic field is created by a permanent magnet or an electromagnet placed below the workpiece. The workpiece is then immersed inthe abrasive slurry, and the magnetic field holds the abrasive particles in place.

The MAF process can be carried out using various parameters such as magnetic field strength, abrasive size, slurry flow rate, and processing time. The magnetic field strength determines the holding force between the workpiece and the abrasive particles. The abrasive size determines the surface finish achieved, with smaller abrasive particles producing finer surface finishes. The slurry flow rate determines the amount of abrasive particles that come in contact with the workpiece surface. The processing time determines the total time required to achieve the desired surface finish..

The MAF process has several applications in the manufacturing industry, including the finishing of turbine blades, gears, dies, molds, and biomedical implants. The process has been extensively studied and developed for various applications. The process has also been used for the finishing of non-metallic materials such as ceramics and composites.

2. MAGNETIC ABRASIVE FINISHING

"Magnetic Abrasive Finishing: A Review" by M. Anil Kumar and K. Ramesh. In this review, the authors provide an overview of the MAF process and its various applications. The article discusses the advantages and limitations of the MAF process and provides a summary of the recent advancements in the field. The article also highlights the research gaps and future directions for the development of the MAF process.

"A review of magnetic abrasive finishing" by R. Kou and X. J. Zhang. This article provides a comprehensive review of the MAF process, including its principles, materials, process parameters, and applications. The article discusses the advantages and disadvantages of the process and provides an overview of the recent research in the field. The article also highlights the challenges and future directions for the development of the MAF process.

"Advances in magnetic abrasive finishing: a review" by S. K. Pal and B. Bhattacharyya. In this review, the authors provide an overview of the recent advancements in the MAF process. The article discusses the improvements in the process parameters and materials used in the MAF process. The article also highlights the applications of the MAF process in the aerospace, automotive, and biomedical industries.

"Effect of process parameters on magnetic abrasive finishing: a review" by R. P. Jaiswal and M. K. Pradhan. This article focuses on the effect of process parameters on the MAF process. The article discusses the influence of magnetic field strength, abrasive size, slurry flow rate, and processing time on the surface finish achieved. The article also provides an overview of the recent studies on the optimization of the MAF process parameters.

"Magnetic abrasive finishing of non-magnetic materials: a review" by S. S. Joshi and N. D. Dhangar. This review focuses on the application of the MAF process for the finishing of non-magnetic materials such as ceramics and composites. The article discusses the challenges and opportunities for the use of the MAF process in the finishing of non-magnetic materials. The article also provides an overview of the recent advancements in the MAF process for the finishing of non-magnetic materials.

2.1 Experimental setup

A schematic view of the setup is shown in Figure 1. Due care was taken while installing the work-piece in holding device so as to provide smooth rotation and proper alignment during rotation. The holding device attached to motor was used to hold the work-piece.

Magnets were screwed on the frame to vary the working gap. While designing, both the working gap and size of the work-piece were taken into consideration. DC motor was used to give rotational motion to the cylindrical work- piece. MAPs through magnetic pressure were used to finish the work-piece. Abrasive particles (diamond) and magnetic particles (iron) were loosely bonded together by lubricating oil (or conglomerate).

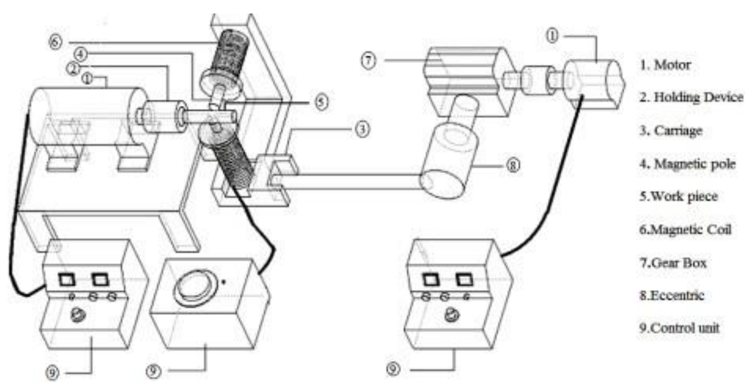

Figure: Magnetic Abrasive Finishing Process

2.2 Process parameters

The Magnetic Abrasive Finishing (MAF) process involves several process parameters that can be adjusted to achieve desired surface finish and dimensional accuracy. The following are some of the process parameters in the MAF process:

Magnetic field strength: The magnetic field strength is a critical parameter in the MAF process, as it determines the attraction force between the magnetic abrasive particles and the workpiece surface. Higher magnetic field strength can increase the removal rate, but excessive magnetic field strength may lead to excessive wear of the abrasive particles.

Abrasive particle size: The size of the abrasive particles used in the MAF process can significantly affect the surface finish and material removal rate. Larger particles are more effective in removing material, but they may produce deeper scratches on the workpiece surface, resulting in a rougher finish.

Slurry flow rate: The slurry flow rate affects the distribution of abrasive particles on the workpiece surface, which can impact the material removal rate and surface finish. Higher slurry flow rates can increase the removal rate, but excessive slurry flow rates may cause erosion and uneven material removal.

Processing time: The processing time is the duration for which the workpiece is subjected to the magnetic field and abrasive particles. Longer processing times may result in higher removal rates but may also lead to excessive surfacedamage and a rougher finish.

Workpiece material: The material of the workpiece is a critical parameter that can affect the magnetic field strength and the abrasive particle properties, such as shape, size, and hardness. The magnetic properties of the workpiece also determine the effectiveness of the MAF process, as the process relies on the attraction between the magnetic abrasive particles and the workpiece surface.

2.3 Problem formulation:

Following are the problems in the MAF Process which are being observed through the literature review.

a. Providing engineering engineers with alternative strategies for addressing unique manufacturing problems.
b. Cost-effective operations by technological advancements in the current finishing method.
c. Process management that is consistent, as well as computational modeling to propose a process mechanism.
d. The MAF process has a long processing time, which can be reduced using the established method. It extracts a comparable amount of content in a shorter amount of time.

2.4 Research Objectives:

From the above-mentioned research gaps, the present investigation aims to develop a new MAF Setup with the following objectives-

a. Development of a new magnetic abrasive for the MAF process and investigation of process behaviour.
b. To study the effect of various process parameters (i.e., Voltage (DC), Voltage (PC), Magnetic abrasive size, Magnetic abrasive quantity, Machining gap, Rotational speed, finishing time, type of abrasive etc.) of MAF on the response such as material removal and surface roughness of different workpiece material.
c. multi-response optimization of MAF.
d. Modelling of developed MAF process.

2.5 Research Methodology:

To achieve the required MAF processing and develop its reputation, the following research methodology was used.

a. Choosing MAF parameters, main process parameters, and quality attributes.
b. Creating the MAF process and putting in place the required facilities, equipment, and resources.
c. Use Design of Experiments principles such as Taguchi orthogonal array to plan and perform the experiments.
d. To use a multi-response optimization strategy to find a balance between the chosen quality characteristics and thereby find the best solutions.
e. Verifying the findings using experimental observations and evidence from the literature.

3. CONCLUSIONS

In conclusion, the Magnetic Abrasive Finishing (MAF) process is a versatile, non-conventional finishing process that has gained significant attention in recent years due to its advantages such as improved surface finish, reduced surface roughness, and improved dimensional accuracy. The MAF process has been applied successfully to a wide range of materials, including ferromagnetic and non-ferromagnetic materials, and has been used in various industriessuch as aerospace, automotive, and biomedical industries.

The MAF process offers several advantages over other finishing processes, including flexibility in achieving desired surface finish, improved material removal rate, and cost-effectiveness. The process can be easily controlled by adjusting process parameters such as magnetic field strength, abrasive particle size, slurry flow rate, andprocessing time, which makes it highly customizable and adaptable to specific applications.

Despite its numerous advantages, the MAF process also has some limitations and challenges, including the difficulty in achieving high removal rates and the need for specialized equipment. Further research is required to optimize the process parameters, enhance the efficiency of the process, and expand the application range of the MAF process.

In summary, the MAF process is a promising finishing process that has shown significant potential in improving surface finish and dimensional accuracy. With further development and optimization, the MAF process could become a highly competitive and preferred finishing process in various industries.

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