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EXPERIMENAL PROCESS TOWARDS IMPROVING THE PARAMETERS THAT AFFECTS PERFORMANCE OF ABRASIVE FLOW MACHINING

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ABSTRACT

Under the mechanical processes advanced manufacturing process, the abrasive flow machining is one of the advanced manufacturing processes. In this paper, the work is emphasis on various process parameters that are Material Removal Rate, Machining Time, and Abrasive Mesh size that affects the performance of AFM. Let us see the material removal mechanisms in abrasive flow machining process and hybridization of abrasive flow machining process. Abrasive flow machining also known as abrasive flow de-burring or extrude honing, is an interior surface finishing process characterized by flowing an abrasive-laden fluid through a work piece. This fluid is typically very viscous, having the consistency of putty, or dough. In this paper, the main purpose of the process is to investigate the experimental process towards improving the efficiency the surface finishing of die steel with the use of abrasive flow machining. Grinding medium is pressed along the contours at a defined pressure and temperature. Depending on the respective machining task, different specifications of media are used. The surface finishing is better with use of abrasive flow machining process as compared to other flow machining processes.

***Keywords:* Abrasive flow machining; Material removal rate; Surface roughness.**

1. INTRODUCTION

Abrasive flow machining (AFM), also known an extrude honing, is an industrial process used in metal working. Abrasive flow machining (AFM), also known as abrasive flow deburring or extrude honing, is an interior surface finishing process characterized by flowing an abrasive-laden fluid through a work piece. This fluid is typically very viscous, having the consistency of putty, or dough. AFM smoothes and finishes rough surfaces, and are specifically used to remove burrs, polish surfaces, form radii, and even remove material. The nature of AFM makes it ideal for interior surfaces, slots, holes, cavities, and other areas that may be difficult to reach with other polishing or grinding processes.

Abrasive flow machining was first patented by the Extrude Hone Corporation in 1970.This process is used to finish the interior surfaces of cast metals and produce controlled radii in the finished product. The process of abrasive flow machining produces a smooth, polished finish using a pressurized media. The medium used in abrasive flow machining is made from a specialized polymer. Abrasives are added to the polymer, giving it the ability to smooth and polish metal while retaining its liquid properties. The liquid properties of the polymer allow it to flow around and through the metal object, conforming to the size and shape of the passages and the details of the cast metal. Abrasive flow machining equipment is made in single and dual flow systems. In a single flow system, the abrasive media is forced through the project at an entry point and then exits on the other side, leaving a polished interior to mark its passage. For more aggressive polishing, the dual flow abrasive flow machining system might be employed. In dual flow system, the abrasive media flow is controlled by two hydraulic cylinders. These cylinders alternate motions push and pull the media through the project. This delivers a smoother, highly polished end result in much less time than a single-flow system. The process of abrasive flow machining is used in the finishing of parts that require smooth interior finishes and controlled radii. Examples of these parts include automotive engine blocks and other precision finished parts. This process is also used in the metal fabrication and casting industry to deburr the dies and remove recast layers from molds used during production.

2. LITERATURE REVIEW

The review of literature reveals that experimental studies about the effects of various process parameters on material removal and surface roughness have been done by many researchers [1]. Williams and Rajurkar [2] used a stochastic modeling and analysis technique called data dependent system (DDS) to study the surfaces generated by AFM. Rhoades [3–5] studied the basic principle of AFM and reported that the depth of cut primarily depends upon abrasive grain size, relative hardness and sharpness and extrusion-pressure. The literature review projects the major research analysis like as the abrasive loading increases, the improvement in surface roughness increases.

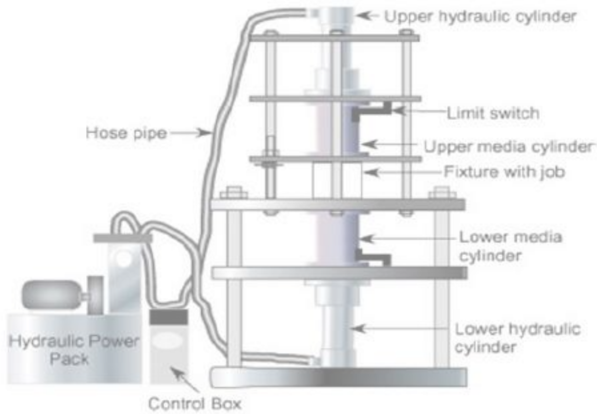
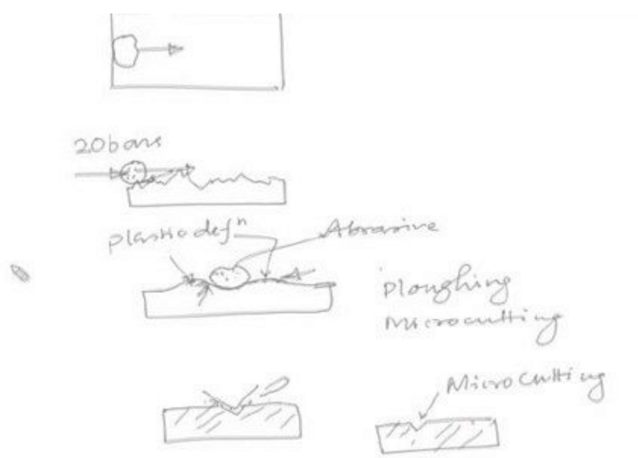


Fig.1. Schematic diagram of abrasive flow finishing set-up

3. MECHANISM OF MATERIAL REMOVAL IN (AFM)

Initially, the material is ploughed by the fine abrasives

Let us start with mechanism of material removal in abrasive flow machining. In this process generally there are two different modes of material removal are prevalent. These two are ploughing and then abrasion. The material is initially ploughed by fine abrasives which come in contact with the work material as they rub over the metal surface with high pressure. The material flow occurs in the direction of motion of abrasive particles as well as in lateral direction. The further flow of abrasive particles causes continued work hardening which results in embattlement and fragmentation of the lips into micro chips. This can be also seen in this way.



If this is the work piece in which one abrasive particle say this is the abrasive particle which is flowing through this surface and the surface contains some asperities like this then this abrasive particles as we have seen in the last session also, will either remove this peaks on its way while pushed in the form of media under some pressure something like 20 bars or so. So, here in this case this cutting is taking place and it is in the form of micro groups on the work, work piece surface. If this is the work piece then this will be the result of micro cutting. This will be in the dimension of few micro meters or the fraction of micro meters and repeated cutting off in this fashion of the work surface causes smoothening of the surface.

4. CLASSIFICATION OF AFM MACHINE

AFM machines are classified into two categories: one is one way AFM, & second is two ways AFM. A brief discussion of the same is given below.

5. ABRASIVE FLOW MACHINING (AFM) PRINCIPLE

In the AFM process, a semi-solid media is used which comprises of a carrier in the form of a polymer base containing abrasive powders in a desired proportion, which is extruded under the given pressure across the surface, which is to be machined. The media acts as a Flexible tool whenever it is subjected to some restrictions due to the uneven surface. The special deformable ability of media is responsible for its movement through any shape of the passage. Generally, a fixture is required to offer restriction or to direct and focus the media to desired locations in the work piece.

6. ONE WAY AFM PROCESS

The schematic diagram (fig.2) is a one way AFM process, which was designed and fabricated by Saad saeed siddiqui [7]. One way AFM process apparatus is provided with a hydraulically actuated reciprocating piston and an extrusion medium chamber adapted to receive and extrude medium unidirectional across the internal surfaces of a work piece having internal passages formed therein. Fixture directs the flow of the medium from the extrusion medium chamber into the internal passages of the work piece while a medium collector collects the medium as it extrudes out from the internal passages. The hydraulically actuated piston intermittently withdraws from its extruding position to open the extrusion medium chamber access port to collect the medium in the extrusion medium chamber. When the extrusion medium chamber is charged with the working medium, the operation is resumed.

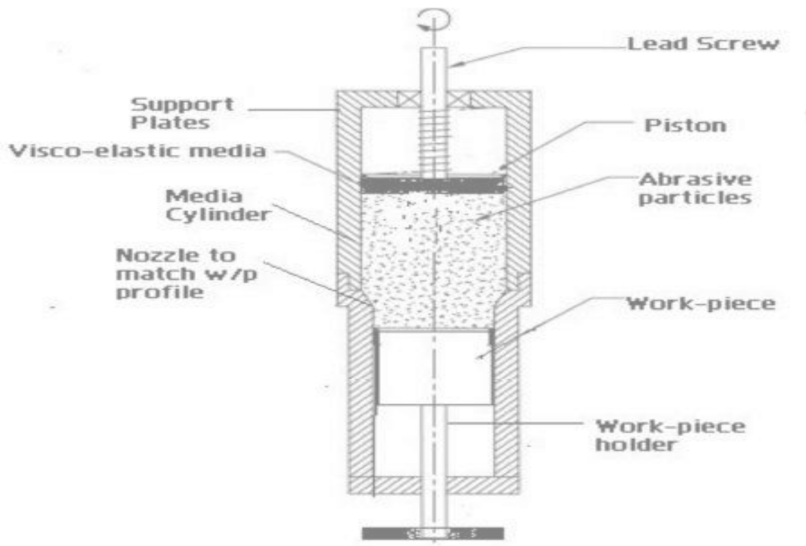


Fig:-2 One way AFM process

7. TWO-WAY AFM PROCESS

Two-way machine has two hydraulic cylinders and two medium cylinders. The medium is extruded, hydraulically or mechanically, from the filled chamber to the empty chamber via the restricted passageway through or past the work piece surface to be abraded. Typically, the medium is extruded back and forth between the chambers for the desired fixed number of cycles. Counter bores, recessed areas and even blind cavities can be finished by using restrictors or mandrels to direct the medium flow along the surfaces to be finished. The schematic diagram of two-way AFM process is shown in the figure (3)

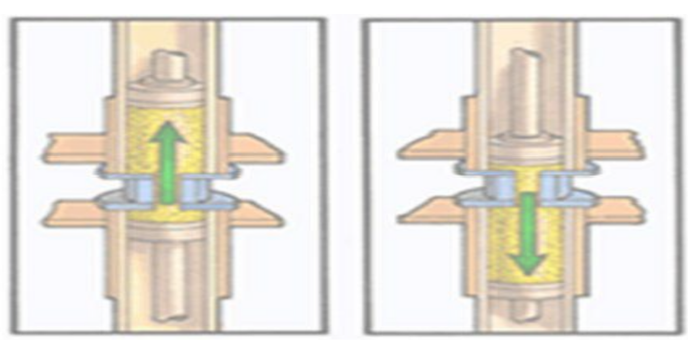


Fig: -3 Two-way AFM process

8. EQUIPMENT

An abrasive flow machine normally includes two medium chambers equipped with hydraulic rams, a fixture for holding the work piece, and a clamping system that holds all the components tightly together. Most machines allow for the loading of different types of abrasive medium, and include the capacity to adjust the pressure used in extruding the medium through the work piece. They may be manually operated, or automated using CNC For machines designed to accommodate high production volumes, accessories such as part-cleaning stations, unloading and reloading stations, and media reefed devices, and media heat exchangers may be included.

9. PROCESS

In abrasive flow machining, the abrasive fluid flows through the work piece, effectively performing erosion. Abrasive particles in the fluid contact raised features on the surface of the work piece and remove them. The fluid is forced through the work piece by a hydraulic ram, where it acts as a flexible file, or slug, molding itself precisely to the shape of the work piece. The highest amount of material removal occurs in areas where the flow of the fluid is restricted; according to Bernoulli's Principle, the flow speed and pressure of the fluid increase in these areas, facilitating a higher material removal rate. The pressure exerted by the fluid on all contacting surfaces also results in a very uniform finish.

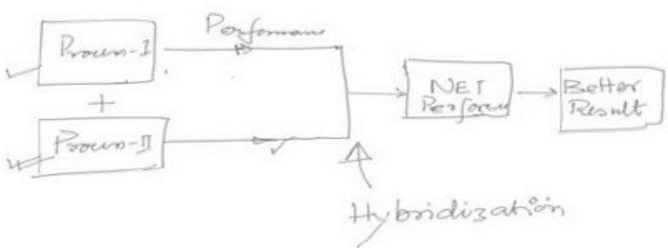
AFM may be performed once, as a one-way flow process, or repeatedly as a two-way flow process. In the two-way flow process, a reservoir of medium exists at either end of the work piece, and the medium flows back and forth through the work piece from reservoir to reservoir.

10. EXPERIMENTAL SET UP AND PROCEDURE

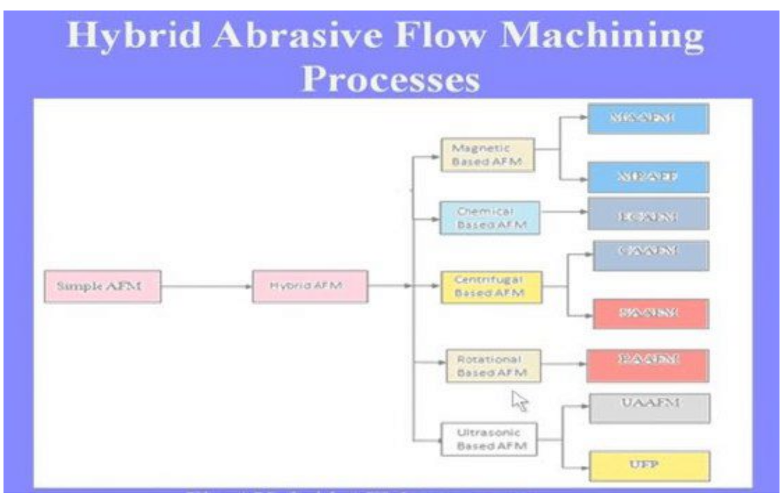
An experimental set-up is designed and fabricated, as shown in figure 1 it consists of two cylinders containing the medium along with oval flanges. The flanges facilitate clamping of the fixture that contains the work piece and index the set-up through 180° when required. Two eye bolts also support this purpose. The setup is integrated to a hydraulic press. The flow rate and pressure acting on piston of the press is made adjustable. The flow rate of the medium can be varied by changing the speed of the press drive whereas the pressure acting on the medium is controlled by an auxiliary hydraulic cylinder, which provides additional resistance to the medium flowing through the work piece. The resistance provided by this cylinder is adjustable and can be set to any desired value with the help of a modular relief valve. The piston of the hydraulic press imparts pressure to the medium according to the passage size and resistance provided by opening of the valve. As the pressure provided by the piston of the press exceeds the resistance offered by the valve, the medium starts flowing at constant pressure through the passage in the work piece.

11. HYBRIDIZATION

In general hybridization is a combination of two or more processes in order to achieve better performance in terms of enhanced productivity, enhanced product quality and reduced cost.



If there is a process 1, process 1 and it has got some performance. This performance is along with its the process an inherent limitations, then if we add one more process in this say process 2 which is being added to this and then what we can have is the combined effect of these two and we can get the net performance of both the processes and this gives naturally a better result.



12. HYBRID AFM PROCESS.

However, we should be very, very careful while choosing this process 1 and process 2 because simply adding two processes will not give rise to the net performance enhancement of this process. We have to be very careful about how these, the limitations of process 1 or either process 2 can be nullified by each other and as a result we can get better performance in the end. So, this causes, this calls for the term hybridization which nowadays is very popular among the machining process, different machining processes. This is not only true with abrasive flow machining processes, but also with other advanced manufacturing processes, this hybridization is nowadays very popular.

Now, let us see how this hybridization in abrasive flow machining can improve the performance of this process. As we have discussed in the last session itself abrasive flow machining is basically a low MRR process, low material removal process. Therefore, hybridization in abrasive flow machining is directed to improving the efficiency of the process in terms of higher MRR and to obtain better surface quality.

13. RESULTS AND CONCLUSIONS

From the above mentioned process and literature review, we come to the conclusion that Abrasive Flow Machining is an unconventional machining process by which we can machine the inner surfaces of even those geometries like square shaped or rectangular etc. where traditional machining is not possible. It has far accuracy and precision as compared to the traditional machining methods. It can simultaneously deburr, radius and polish critical surfaces of precision equipment. One recent application which has gained significant attention is the improvement of air flow and fluid flow characteristics for injector nozzles and cast automotive engine parts such as cylinder heads, intake manifolds and exhausts manifolds. But at the high percentage (above 78%) of abrasive loading, the flow becomes difficult as well as carrier acts as inefficient binder for abrasives. Similarly as hardness of work piece increases, the number of cycles to achieve better Surface roughness also increases. FAX increases linearly with passage length and applied piston pressure. The change in surface roughness, ΔRa increases with the increase in length of the work-piece and decreases with the increase in cross section of the work-piece. Fig.4 and 5 shows the surfaces of the work piece having single vent for media outflow have higher material removal and more improvement in surface roughness and the performance measures decrease with increase in the number of vents for media outflow.

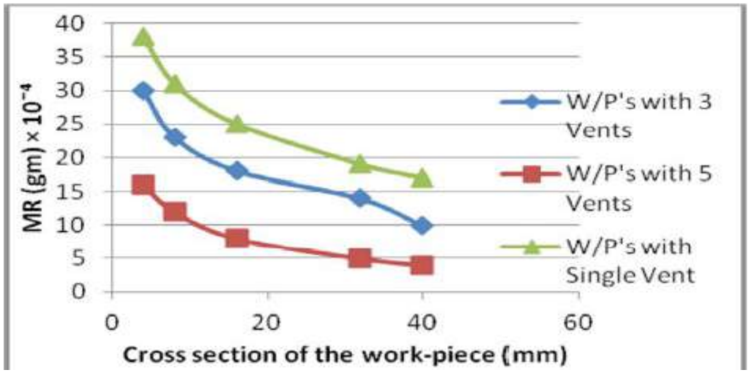


Fig.4. Effect of different vent considerations in work-pieces of varying cross sections on MR. [7]

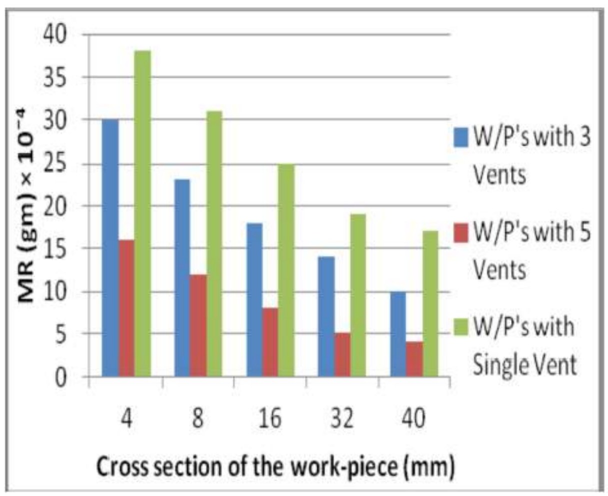


Fig.5. MR in micromachining work-pieces of varying cross sections having different vent Considerations.

14. AFM APPLICATIONS

The process was initially developed for effective de-burring of hydraulic control blocks. Later on, the field of applications got rapidly diversified into defense, medical and manufacturing units. The inaccessible areas in components that are very difficult to finish with traditional methods, can be easily finish machined by AFM process with up to 90 % improvement in it with respect to the original accuracy. The typical applications of AFM are in improving airfoil surfaces of compressor and turbine components, edge finishing of holes and attachment features, improvement in fatigue strength of blades, disks, hubs and shafts with uniform polishing on its edges.

The adjustment of air flow resistance in blades, vanes, combustion liners, nozzles and diffusers, finishing of fuel spray nozzles, fuel control bodies, bears components, reworking the components to remove coke and carbon deposits and to improve its surface integrity.

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