Modeling and Fabrication of Abrasive Flow Machining

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Abstract: Abrasive Flow Machining (AFM) was developed in 1960s as a method to deburr, polish, and radius difficult to reach surfaces like intricate geometries and edges by flowing an abrasive laden visco-elastic polymer over them. Based on the application, three different types of machines have been reported i.e., one way AFM, two ways AFM and orbital AFM. Because of simplicity in analyzing the physics, analysis of AFM process always refers to two ways AFM. Abrasion occurs wherever the medium passes through the highly restrictive passage. The key components of AFM process are the machine, tooling and abrasive medium. Process input parameters such as extrusion pressure, number of cycles, grit composition and type; tooling and fixture designs have impact on AFM output responses. AFM is capable to produce surface finish (Ra) as well as 0.05 mm, debur holes as small as 0.2 mm and radius edges from0.025 mm to 1.5mm. AFM has wide range of applications in industries such as aerospace, medical, electronics, automotive, precision dies and moulds as a part of their manufacturing activities. To overcome some of the draw backs such as low finishing rate and inability to correct the form geometry, researchers have proposed various versions of AFM machines abbreviated as M-AFM, DBGAFF, CFAAFM, spiral polishing and R-AFF. It is more time consuming to finish only one component at a time, hence to improve productivity the mass production in abrasive flow machining is the best way.

***IndexTerms* - Hydrulic Cylinder, Fixture, Limit Switch, Hose pipe**

I. Introduction

Conventional process such as honing, lapping, boring, and grinding and other process have been used for finishing. But their use is limited to the geometry of the work-piece and up to a certain value. But Abrasive flow machining (AFM) is mostly used in finishing of complex in accessible geometry and critical components. It removes very small quantity of material by flowing a semi-solid abrasive media inside the surface to be machined. AFM setup consist of two vertically opposite cylinders with the help of media was extruded back & forth through the passage formed by the work-piece and tooling. The abrasive media was made up of polymer, gel and abrasive grains. Different types of abrasive grains were used like silicon carbide, aluminum oxide, boron carbide and diamond etc. This abrasive media consist of large number of random cutting edge with indefinite orientation & geometry for effective material removal. The extremely thin chip produced during operation produce better surface finish.

To counter the problems such as high direct labor cost and to produce finished precision parts with specific features for finishing inaccessible areas, abrasive finishing techniques are developed. Abrasive finishing process is carried with large number of cutting edges which have indefinite orientation and geometry. Abrasive fine process are commonly employed due to their capacity of finishing various geometries of form (i.e. Flat, round etc.) with desired dimensional accuracies and surface finish
However, the proposed area-efficient carry select adder retains partial parallel computation architecture as the conventional carry select adder to excess-1 code converters (BEC) to improve the speed of addition. This logic can be implemented with any type of adder to further improve the speed. Using Binary to Excess-1 Converter (BEC) instead of RCA in the regular CSLA we can achieve lower area and power consumption. The main advantage of this BEC logic comes from the lesser number of logic gates than the Full Adder (FA) structure. the basic idea of the proposed work is by using n-bit binary to excess-1 code converters (BEC) to improve the speed of addition. This logic can be implemented with any type of adder to further improve the speed. Using Binary to Excess-1 Converter (BEC) instead of RCA in the regular CSLA we can achieve lower area and power consumption. The main advantage of this BEC logic comes from the lesser number of logic gates than the Full Adder (FA) structure.

II. Liteature Survey

Abrasive flow machining (AFM) was developed by Extrude Hone Corporation, USA in 1960. There are three types of AFM machines that have been reported in the literature: one way AFM, two way AFM and orbital AFM Commonly used AFM is Two-way AFM in which two vertically opposed cylinders extrude medium back and forth through passages formed by the polymer abrasive medium which is used in this process, possesses easy flow ability, better self deformability and fine abrading capability.

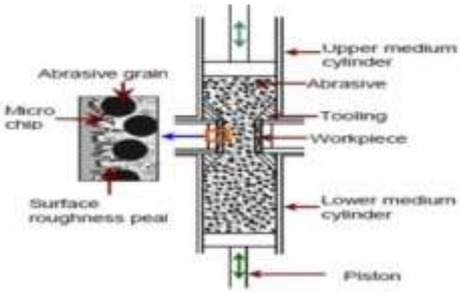

Fig.1: Abrasive Flow Machining

The polymer abrasive medium which is used in this process possesses easy flow ability, better self deformability and fine abrading capability. Layer thickness of the material removed is of the order of about 1 to 10 µm. Best surface finish that has been achieved is 50 nm and tolerances are +/- 0.5 µm. In this process tooling plays very important role in finishing of material, however hardly any literature is available on this of the process. In AFM, Deburring, radiusing and polishing are performed simultaneously in a single operation in various areas including normally inaccessible areas. It can produce true round radii even on complex edges.

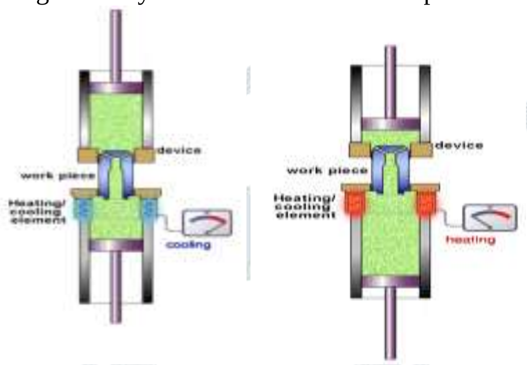

Fig. 2: Deburring and Surface Finishing

AFM reduces surface roughness by 75 to 90 percent on cast and machined surfaces. It can process dozens of holes or multiple passage parts simultaneously with uniform results. Also air cooling holes on a turbine disk and hundreds of holes in a combustion liner can be deburred and radiused in a single operation. AFM maintains flexibility and jobs which require hours of highly skilled hand polishing can be processed in a few minutes; AFM produces uniform, repeatable and predictable results on an impressive range of finishing operations. Important feature which differentiates AFM from other finishing processes is that it is possible to control and select the intensity and location of abrasion through fixture design, medium selection and process parameters. It has applications in many areas such an aerospace, dies and moulds, and automotive industries.

III. CLASSIFICATION OF AFM

There are three types of abrasive flow machining:-
(i) One Way Abrasive Flow Machining
(ii) One Way Abrasive Flow Machining
(iii) Orbital Abrasive Flow Machining

(i) One Way Abrasive Flow Machining

One way AFM was first developed by Rhoades LJ, Kohut TA, Nokovich NP in 29 November 1994 is assembled with a hydraulically actuated reciprocating piston and an abrasive medium chamber adapted to receive and extrude medium in one direction through the internal surfaces of a work piece having internal passages, as shown in Figure. Fixture directs the flow of the medium from the abrasive 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.

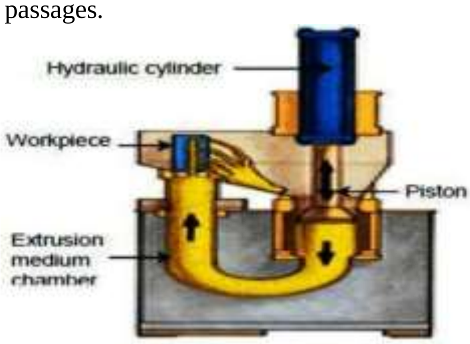

Fig 3: One way AFM

(ii) Two Way Abrasive Flow Machining

Two-way AFM is made of two hydraulic cylinders and two abrasive medium cylinders. The medium is pressurized, hydraulically or mechanically from the filled abrasive media chamber to the empty chamber via the small passageway through or past the work piece surface to be machined. The medium is extruded back and forth through the chambers for the desired number of cycles. Counter bores and even blind cavities can be finished by using restrictors to assist the abrasive medium flow along the surfaces to be finished. The diagram of two-way AFM process is shown in the figure.

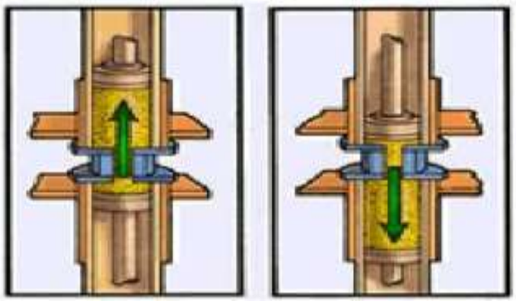

Fig. 4: Two-way AFM

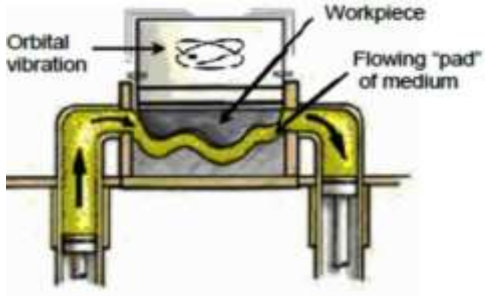

Fig. 5: Orbital AFM

(iii) Orbital Abrasive Flow Machining

In orbital AFM, the work piece is oscillated in two or three dimensions in between a slow flowing ‘pad’ of elastic/plastic AFM medium. In Orbital AFM, surface polishing and edge finishing are achieved by rapid and low-amplitude oscillations of the work piece relative to a elastic plastic abrasive polishing tool. The tool is a pad or layer of abrasive-laden elastic plastic medium higher in viscosity and more in elastic. Figure shows orbital AFM process.

IV. WORKING PRINCIPLE

In abrasive Flow Machining process, polymer based on visco-elastic material matrix is mixed with abrasive particle and additives which called as the medium, which is extruded back and forth in two vertically opposed cylinder .While extruded through the passage formed by the work piece and tooling, this medium tries to finish the work piece surface selectively. Tooling plays the important role in this process. So tooling or fixture design should be done carefully

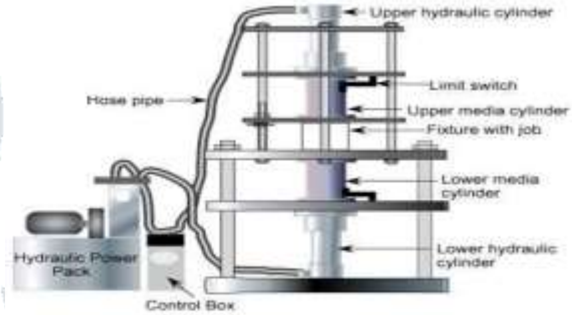

Fig. 6: Basic Principle of AFM

Because of the flow through the restricted passage of work piece region, the polymer chain holds the abrasive particle flexibly and moves them around in the direction of extrusion pressure. Hence the medium acts as a multi-point cutting tool and starts abrading the work piece surface. Extrusion pressure, Number of cycle, work-piece initial surface roughness and medium viscosity are the significant variable parameter having an impact on final surface roughness. The viscoelastic medium moves along the direction of applied pressure with axial velocity and axial force when sufficient extrusion pressure is applied. On the application of extrusion pressure due to elastic component of medium, it exerts radial force which is responsible for penetration of the abrasive on the work-piece. Axial force is responsible for removal of material in the form of micro-chips by shearing the indented abrasive particle in the axial direction. This method is applicable for different types of abrasive finishing process.

V. MODELING

Fig.7: Single and double Fixture Modeling in AutoCAD Software

Fig. 8: Piston and connecting rod

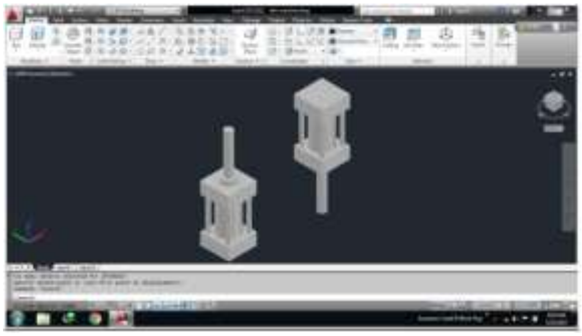

Fig. 9: Hydrulic Cylinder

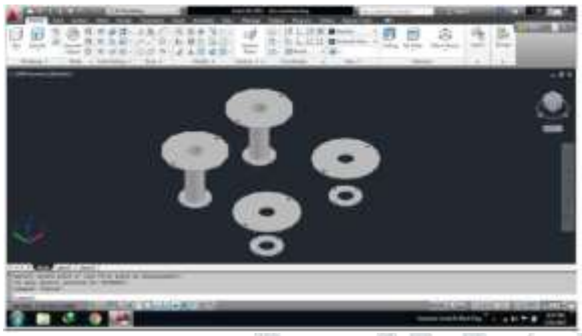

Fig. 10: Hydrulic Cylinder

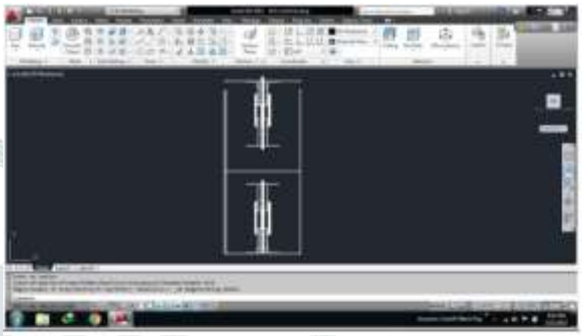

Fig. 11: 2D Front View Assembly Drawing

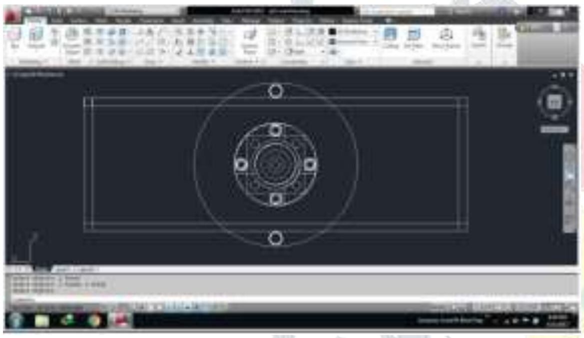

Fig. 12: 2D Top View Assembly Drawing

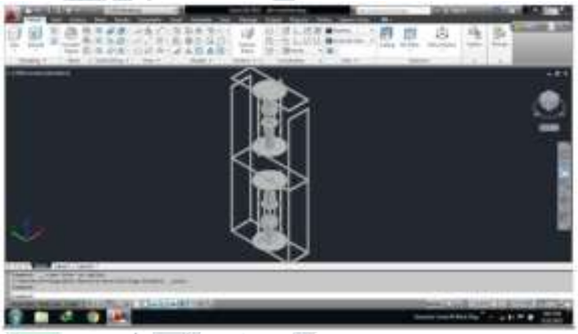

Fig. 13: 3D Final Assembly Drawing

VI. WORKING PRINCIPLE

6.1 Frame: Dimension of frame

Length: 460 mm
Height: 990 mm
Width: 150 mm

6.2 Dimension of Power Pack

Length: 510 mm
Height: 420 mm
Width: 305 mm

6.3 Hydrulic Piston Cylinders

Diameter: 50 mm
Height: 130 mm
Pressure: 145 PS

Fig. 14: Hydrulic power system

Fig. 15: Cylinder

It is one of the main components of AFM. It works by the use of hydraulic power. Piston & Cylinder are made up from the aluminum and bright material respectively.

6.4 Media Cylinder

Outer diameter: 60 mm
Inner diameter: 50 mm
Height: 165 mm

The abrasive media is carried by Media cylinder, which is made from the Stainless Steel and the piston moving in it is made from the Aluminum.

6.5 Piston

Fig.16: Piston

6.6 Fixtures

Fig.17: Single and Double Fixture

Fig.18: Flange

6.7 Flange Plate

Different types of flange faces are used as the contact surfaces to seat the sealing gasket material. There are various types of flange facings, including the raised face, the large male and female facing which have identical dimensions to provide a relatively large contact area.

6.8 Pressure Gauge

Many techniques have been developed for the measurement of pressure and vacuum. Instruments used to measure and display pressure in an integral unit are called pressure gauge or vacuum gauges. A manometer is a good example as it uses a column of liquid to both measure and indicate pressure.

Fig. 19: Pressure Gauge

6.9 Stud and Bolts

Fig. 20: Stud and Bolt

6.10 Silicon Dioxide

Silicon dioxide also known as silica is a chemical compound that is an oxide of silicon with the chemical formula SiO_2. It has been known since ancient times. Silica is most commonly found in nature as quartz, as well as in various living organisms.

Silica is one of the most complex and most abundant families of materials, existing both as several minerals and being produce synthetically.

Fig. 21: Silicon Dioxide material

6.11 Aluminum Dioxide

Aluminum Oxide is a chemical compound of aluminum and oxygen with the chemical formula Al_2O_3. It is the most commonly occurring of several aluminum oxides, and specifically identified as aluminum oxide. It is commonly called alumina, and may also be called aloxide, aloxite and alundum depending on particular application.

Fig. 22: Aluminum Dioxide material

6.12 Different Abrasive media

Fig. 23: Abrasive Material

6.13 Final Experimental Set-up AFM

Fig. 24: Experimental Setup of AFM

VII. BILL OF MATERIAL

Table 1 Abrasive flow machining cost

Sr. No	Item	Qty	Unit Price	Total Price
1	Frame	1	1200	1200
2	Hydrulic cylinder	2	1600	32000
3	Medium cylinder	2	800	1600
4	Flange	4	400	1600
5	Fixture	2	800	1600
6	Pump	1	3000	3000
7	Electric motors	1	1500	1500
8	Flow control valves	1	700	700
9	Delivery valve	1	400	400
10	Pressure gauge	1	500	500
11	Delivery tube	4	600	2400
12	3’8 Stud	5	200	1000
13	Motor Pulley	1	300	300
14	Pump Pulley	1	600	600
15	V-Belt	1	350	350
16	Oil	2-Litre	700	140
Total				**21350/-**

IV. CONCLUSION

For improved surface integrity, smoothness and performance, non-stop progresses are taking place for altering the existing AFM process technology and AFM machine structure. To overcome some of the draw backs such as low finishing rate and incapability to correct the form geometry, investigators have proposed various types of AFM machines abbreviated as Orbital AFM, MRAFM, UAAFM, AFM, R-AFM, Spiral polishing etc. There is a big need of a process which improves the surface finish externally as well as internally simultaneously. Abrasive flow machining is a potential candidate for this direction

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