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Design and Fabrication of advanced Abrasive flow machine for superfinishing machine members

Rahul G. Karmankar, Ranjit Kumar Nandeti, Vidya Y Kondru

Mechanical Engineering department
Usharama college of Engineering and Technology-[Autonomous]-Vijayawada-AP-521109-India

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ABSTRACT: - In a modern high-precision manufacturing environment, there is a general thrust towards complex shape with higher geometrical and dimensional accuracy, higher surface integegrity at low cost. The severe service requirements of product also lead to utilization of materials

This scenario chased by manufacturing industries through existing available process as well as by continuous developing an existing or new process. New process is generally known as 'Advanced manufacturing Process'. Product performance and its life cycle dominating by many factors and surface finish is one of them. Surface finish. Presently there are many advanced processes are being in use for this purpose and one of them is abrasive flow machining process. Even though it is found in mid of 1960 it is playing important role and continuous efforts are made to exploit it for new challenging manufacturing process. Basically, it was developed by deburring purpose but later use for surface finishing process. In this process material is removed by extrusion action of viscoelastic media. The main ingredients of media are viscoelastic carriers, abrasive, oil and some additives. The performance of AFM is generally governed by properties and percentage of ingredients of media as well as operating parameters. Design of the various parts of AFM machine also plays a major role for the operating performance of AFM system.

AFM system is contribution of Machine, Tooling and Media.So design of various parts with dimension as per requirements of raw materials are more effective like other parameters also. Main components of AFM machine are piston assembly, media cylinder, plates, Rods, Fixtures; power pack etc should have to design as per the requirements of finishing process and finishing parts. This paper work show only the basic machine as per design of work piece not like as versatile machine. Generally, machine are classified as one direction abrasive flow finishing process, two direction abrasive flow finishing process and orbital abrasive flow finishing process. This design parameters are used for two-way abrasive flow finishing process.

Key words- AFM machine, Tooling, Fixtures, Media cylinder

INTRODUCTION-

This paper shows the details guideline for fabrication and working of advanced Abrasive Finishing Processes, where in you will see the advance versions and you will do the finishing of a complex surfaces as well as the simple surfaces also, So, what is the need of advanced finishing processes? So, conventional finishing processes such as grinding, honing, super finishing, lapping, these are all you have seen and we move on to the advanced machining processes were the MRR or the material removal is the primary criteria. Now, we move on to the advanced finishing processes where our primary criteria is to finish to the nano level of simple to complex geometries. Advanced finishing is needful to reduce friction, to improve fatigue life, to reduce generation of crack formation, to reduce corrosion effects. AFM produce predictable, repeatable and consistent result. Up to 90% of time can be saved by using AFF as compared to hand finishing operations. Using this AFM system, it is possible to get surface finish Ra up to 50 nm and deburr holes as small as 0.2 mm radius and edge from1.5 mm to 0.0255 mm. It is easy to integrate AFF in any automatic manufacturing environment and also by understanding and controlling the process parameters AFM can be applied to an impressive range of finishing. It helps for producing compressive residual stress and can be finish very complex machine parts. One of the important terms is it give super surface finish at lower cost than others conventional machine.

Typical application

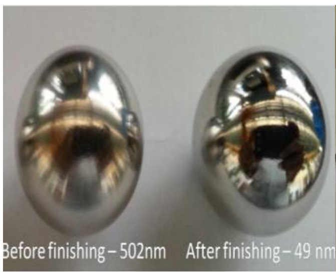

Figure –Impeller

Centre tube **Welded bend pipe**

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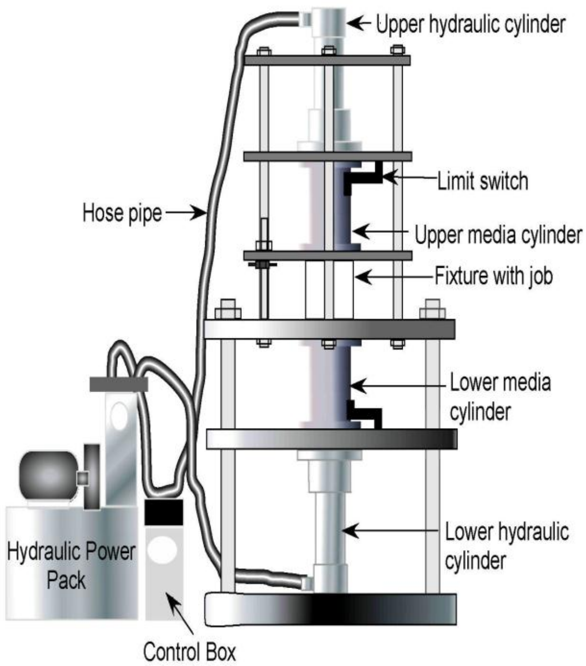
SEQUENCE OF OPERATION

1. Media has been filled in lower media cylinder.

   By keeping the position of the piston in the top and upper media cylinder piston has been kept in bottom position.

2. After filling the sufficient amount of the media, the fixture has been set. With dummy work piece and run at require pressure with few numbers of cycle so that there is form filling of media occur.
3. Next fixture has been taken out and again some amount of media has been filled if require.
4. Fix the work piece along with the cleaning of surface with acetone and initial measuring of roughness value in fixture and check the set up.
5. Set the require pressure
6. Run the set up for particular number of cycles.
7. After competition of cycles take out the sample and cleaned it with acetone and measure its roughness value.
8. Repeat the cycle
9. Check for another abrasive also

CONFIGURATION OF AFM SYSTEM: -



MAIN COMPONENTS OF AFM SYSTEM ARE

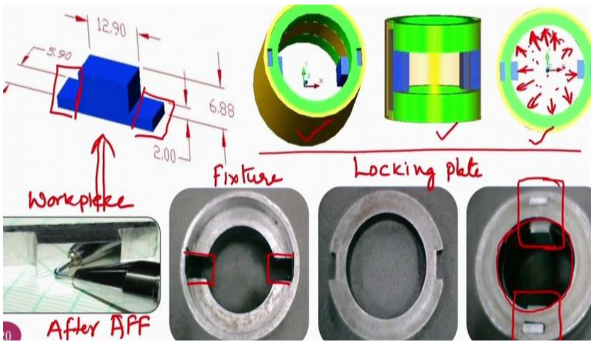
1. Upper hydraulic cylinder
2. Lower hydraulic cylinder
3. Upper media cylinder
4. Lower media cylinder
5. Fixtures
6. Hydraulic power pack
7. Hose pipe
8. Control Box
9. Limit switch

AFM SYSTEM'S MAIN ELEMENTS: -There are three main elements for AFM system 1. Machine 2. Media 3. Tooling

MACHINE-AFM machine are available in a various size and configuration depends on the require capacity and workpiece configuration. It consists of frame structure, hydraulic cylinders, hydraulic power pack and control system. General working pressure range is in between 7 to 220 bars and flow rate exceeding 380 liters per minute volume of flow depends on the displacement of each media cylinder stroke and total number of cycles used to complete the workpiece. The control and monitoring system can also be added to make the result more efficient and reliable

MEDIA: -It is a mixture of polymer and abrasives. Most frequently used polymer for the purpose is polyborosiloxane and many others grade of polymers are also used depending on the configuration of workpiece. Generally, use abrasive s are alumina, silicon carbide, boron carbide or diamond. The function of polymer used in media are to act as a binder and to transfer the extrusion force where as the function of abrasive is to abrade the material when media is passing through restricted area. The rheological properties (viscosity) govern the performance of the media. Higher viscosity is suitable for large passage (the length is smaller than two times the passage width) and lower viscosity is suitable for radiusing and small passage. The life of media is depended on many factors like initial batch quantity, abrasive ratio of mixtures

TOOLING: -The function of tooling is to locate and hold the workpiece in position and direct the flow of media. The tooling is designed in a such way that it should restrict the flow at domain material removal is desired. The complexity of tooling depends on the complexity of workpiece, number of workpieces to be machined etc. The modern high level production tooling are also designed for automatic loading and unloading.



Tooling -Jig and Fixtures

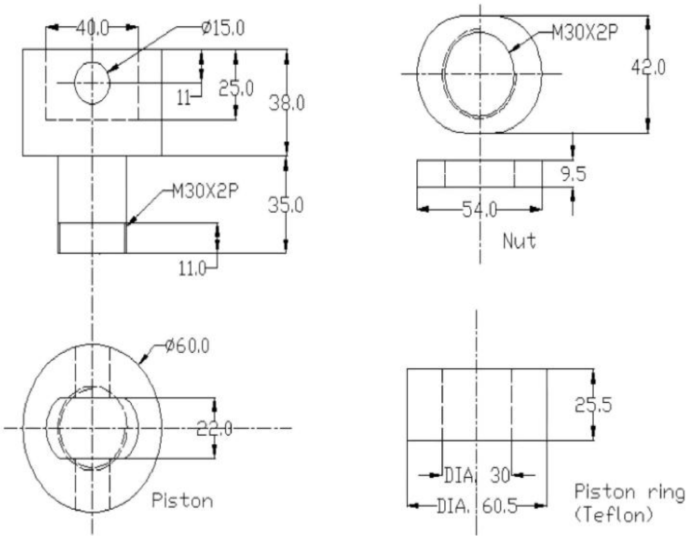
DESIGN CONSIDERATION-

1. Set-up design by taking 10 MPa as maximum working pressure
2. Strength is important for set-up, so set up is designed with strength criteria.
3. Dynamic situation is not taken into account
4. Self-weight of part is neglected
5. Selected fasteners and spacer pipes are fit for use.

DESIGN CALCULATION: -

1.PISTON ASSEMBLY: -

The main function of piston is to transmit the media from one media cylinder to other media cylinder via restricted passage by compressive force which is exerted by the hydraulic cylinder on piston. The common materials used for piston are cast iron, cast aluminums, forged aluminum, cast steel and forged steel. The forged aluminum has been chosen for piston because of its light weight and good strength characteristic reduce friction between inner surface of cylinder and piston the "Teflon ring" is used and this has a very low wear, friction and good temperature resistance. It is assumed that no much temperature is rise



1.Piston thickness =13 mm

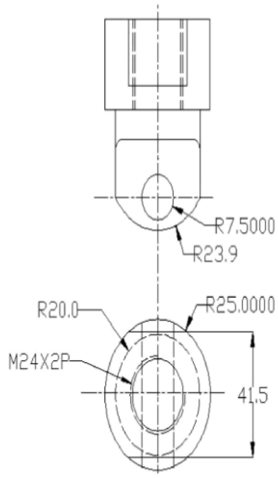
2.Teflon piston ring =Radial thickness= 15 mm

Axial thickness= 25 mm

3.Gudgeon Pin= Out dia.=15 mm, Inner dia.=10mm

Length=45 mm

CONNECTING ROD: -



MEDIA CYLINDER: -

The main function of media cylinder is to contain the media as well as to guide the piston under maximum working pressure. To satisfying these requirements inside the piston, liners are inserted and during calculations it is treated as open ended pressure vessel

Assumption

1.Stress induced in the wall is uniform throughout thickness

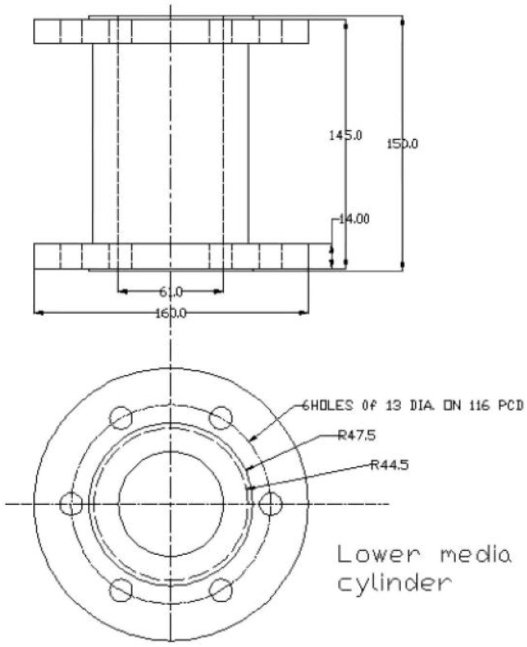
2.Effect of curvature of wall is neglected.

Length of the cylinder

Length of cylinder=Piston length +stroke length + Allowance=73+75+2=150 mm

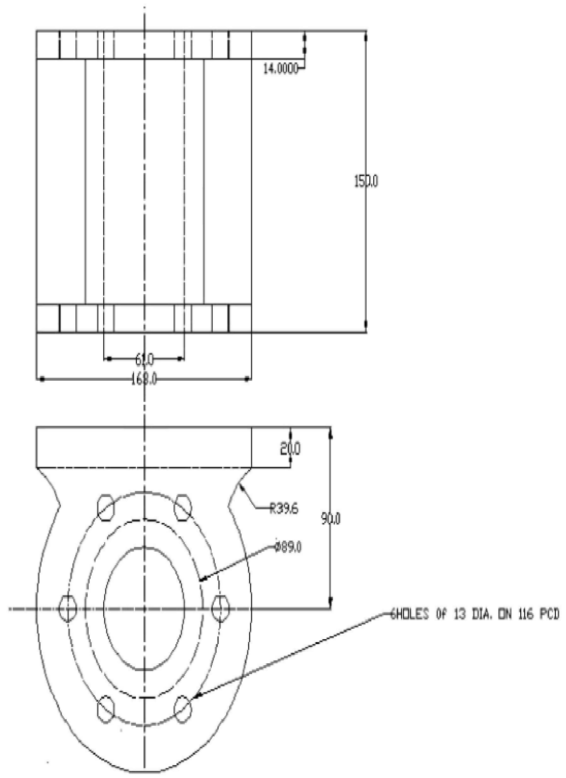
Diameter and wall thickness of cylinder

The cast iron material (Brittle) used so design criteria is maximum normal stress theory of failure. The following wall thickness equation is applicable (both open and closed ended cylinders)



Lower media cylinder

Design is safe as all limits of stress are low.



Upper media cylinder

HYDRAULIC POWER PACK: -

1. Make-Static hydraulic Pvt.Ltd
2. Maximum pressure=100 Bar
3. Oil tank capacity=50 Liters
4. Maximum pump flow=2.5 LPM

FIXTURES: -

The fixture has been made from En8 material. The main function of fixture is to locate and hold the workpiece as well as enough strength against acting force during actual working. The dimension of fixture is fixed with respect to requirements and designing point of view. It is checked under compression with consideration as hollow short cylinder and both ends fixed.

Outer diameter Do= 38.8 mm

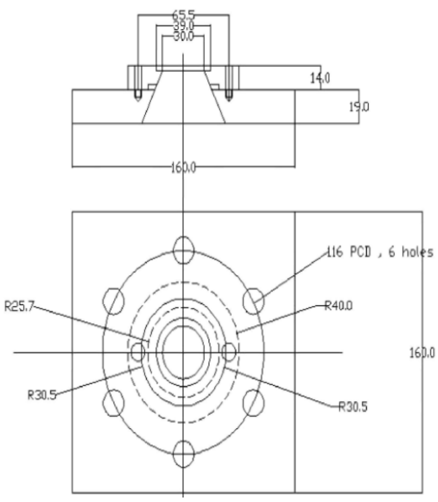
Inner diameter Di= 26.8 mm

MI= $\pi/4$ [$Do^4 - Di^4$]

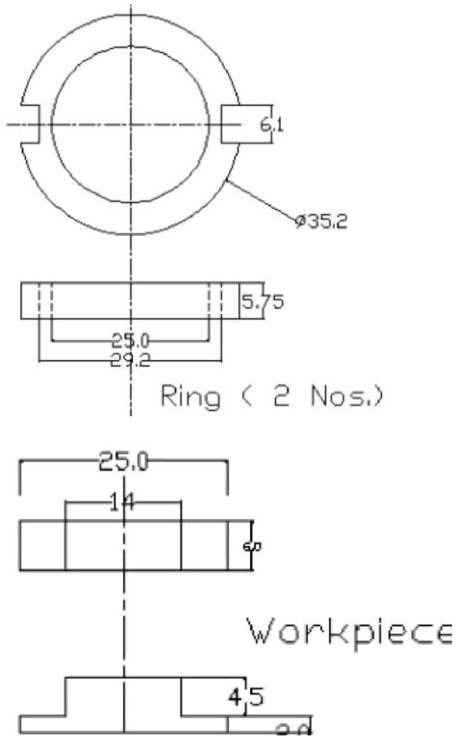
109405.06 mm^4 and E= 2 x 10^5 N/mm^2

Compression strength = 390 MPa

Crippling load = 4 [π^2 E I / L^2] which can give safe value can be calculated using Euler's formula.

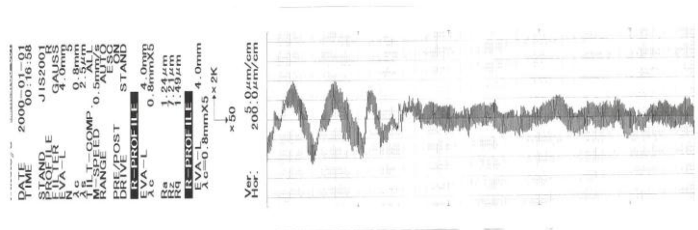


Fixture Plate

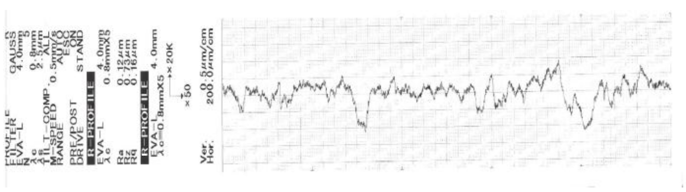


Fixture barrel with workpiece.

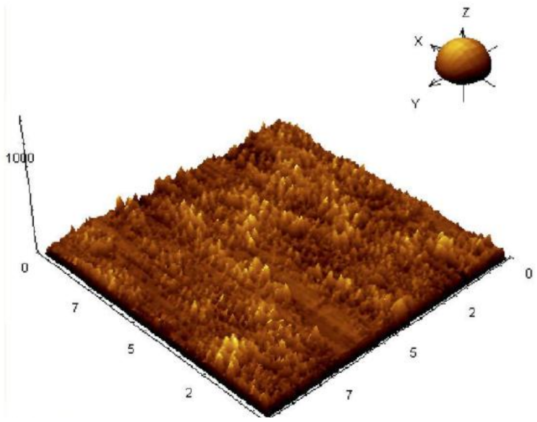
OBTAINED RESULT USING AFM SYSTEM



1. Initial Ra=1.24 micron on En8 for continuous finishing using 220,400,800and 1000 mesh size for 450 cycles with 5 MPa pressure.



1. Final Ra=0.120-micron micron on En8 for continuous finishing using 220,400,800and 1000 mesh size for 450 cycles with 5 MPa pressure.



Actual Surface topography by AFM for Al material using atomic force microscope system

CONCLUSION-

After having made the study on configuration of AFM system along with specifications and parameters it is infer that this system can be utilize for deburring, finishing and superfinishing operation by controlling and monitoring the actual performance of the system. Design parameters, configuration can be modified as per the requirements of the workpiece and specification of machine to achieve superfinishing up to nano-level.

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BIOGROPHY

Rahul G. Karmankar
Asst.Professor
Usharama College of Engineering and Technology-Vijayawada
State-A.P.- 521109I-NDIA-
mech.rahul@usharama.in