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A Study of Abrasive Flow Machining by Modeling with ANSYS

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Abstract:
Abrasive flow machining (AFM) is gaining wide spread application finishing process on difficult to reach surfaces in aviation, automobiles, and tooling industry. A multiple regression model is proposed by using SPSS to simulate and predict the surface roughness, and material removal for different machining conditions in (AFM) on aluminum alloys. Based upon the experimental data of the effects of AFM process parameters, e.g., length of stroke, extrusion pressure, number of cycles, percentage of abrasive concentration, and abrasive grain size. This report deals in an innovative modelling of abrasive flow machining process and simulation of the problem is done with CFD. High surface Finishing is achieved through Abrasive flow machining (AFM) process. In my project, a 2 D ANSYS assisted design is made to verify the axial and radial stress during the machining process. An already derived formulation for metal removal has been modified as per given conditions and assumptions to derive a new formula for the same. A new theoretical approach has been proposed in the current work with limitations of its own. Finally the model has been analyzed in ANSYS to compare with a previously done work, and the results verified that the current work is going in right direction. The MRR and surface removal were calculated for Titanium work piece with an industrial grade abrasive media with aluminum oxide as abrasive.

Keywords: Modeling, CFD, abrasive machining process, ANSYS, Surface roughness, Abrasive flow machining

I. INTRODUCTION

Exactness and Ultra finishing system identifies with a segregating and luxurious time of the general creation process. Gathering of precision parts embodies a period of last finishing operation. It is for the most part wild, work heightened and as regularly as could be expected under the circumstances incorporates a sensible bit of the total amassing cost. The valuable properties, for instance, wear resistance and power incident on account of crushing are affected by surface resistance of the facilitating parts [3]. Abrasive finishing methods are created to mitigate problems like work cost, in accessibility to obtain high surface finish. Abrasive finishing method is passed on with broad number of bleeding edges which have dubious presentation and geometry. Abrasive fine process are regularly used due to their capacity of finishing distinctive geometries of structure (i.e. Level, round et cetera.) with desired dimensional correctness and surface finishing [1,6]. Before talking about cutting edge finishing methodology, it is advantageous to comprehend the MRR that we get normally during other machining and finishing. Grinding, sharpening, micro honing are the samples of conventional abrasive finishing methodology. Multi point cutting tools as abrasive cutting particles are utilized as a part of these Method.
In all these finishing process the molecule work piece collaboration includes one or a greater amount of the essential MRR that is cutting, ploughing, grinding. Fundamentally cutting is a slicing procedure, ploughing means to dig a little and making a furrow and grinding turning into dust. The force of material distortion and change in surface harshness relies on the sufficiency of strengths and the quantity of dynamic abrasive cutting edges in abrasive finishing methodology [3]. In the process of grinding a large wheel is made up of abrasives. Grinding is more powerful in removing material than finishing surfaces because of irregular conveyance of abrasive particles. Finishing of complex parts is troublesome and obliges lavish formed granulating wheel. In lapping process the surfaces are smoothly created and more precise than delivered in the pounding procedure. Free abrasive slurry is utilized between the work piece and the crevice. Lapping is utilized at low scraping weight and a moderate development of lap builds the surface completion and the dimensional exactness is achieved. The states of the surfaces by and large worked in lapping are constrained to rudimentary structures, for example, round and hollow and plane. Honing is a smoothening process than removal of material process. This process works generally on low pressure, low cutting velocity, and large contact area. An abrasive made solid tool is utilized in this process. The tool rotates inside the work piece with very low reciprocating motion. Thus scratch is produced in this process [5]. Super-finishing process has a low velocity method of abrasion. The stick used in the process is made up of very fine abrasives. It is held by a holder mounted with a spring to give light pressure which is applied on work piece. Feed is given to the work piece and reciprocating motion is given to the tool [6].

II. LITERATURE REVIEW

Rhodes [11-14] discovered quoted that viscosity of medium has a main part in finishing. The pattern of flow affecting the finish characteristics depends mainly on medium formulation, settings of machine and configuration of tool. In the restricted passage, there is increase in viscosity of medium temporarily which gives nearly pure extrusion of the medium. High viscosity medium was recommended for abrading walls of greater cross section and for radiusing edges, low viscosity medium. Experimental investigation by Przyklenk [15] suggests that, the MRR capacity of a medium with more viscosity is 300 times more than a lower one. The important factors that affect mrr and velocity of medium- abrasive loading, their size and medium viscosity. Rajurker and Williams [16-21] performed additional experiments to know the effect of viscosity of medium and pressure of extrusion on MRR and surface finish. Loveless et.al [20] reached a conclusion through their experiments that surface finish improvements are also influenced by initial surface roughness and viscosity. Rhodes [11-14] studied the fundamental guidelines of this process and clearly noted down the variables that control the process. He proposed that upon forcing of the medium into restricted area viscosity of the medium increases. The efficiency of abrasion while AFM depends on tooling and fixtures. Increase in volume of medium results in more interaction between the abrasives and the work piece; hence more abrasion per cycle takes place. Slow medium flow rates are preferred for uniform finishing and small radius of edges, while high flow rate results in large radii. Low viscosity medium is to be used to get better results rather than high viscosity medium. Medium flow rate depends on size and number of passage to be processed. Perry [35] got principle and industrial usages of the AFM, i.e. precision deburring, edge contouring, surface finish and removal of layers. William and Rajurker [17-19] used a factorial approach for research to calculate the effect of medium pressure and viscosity and MRR and surface finish. Metal removal plots show that the viscosity effect was profound while the pressure effect is not so much. Jainet.al. [3-4] showed that the material removal during the AFM process is affected by the surface roughness during the start of process and hardness of the work piece. In case of softer metal, change in roughness and Material removal were found to be more as compared to harder metal. With Increase in abrasive loading MRR rate increases. It was determined out of all the parameters, the leading parameter is abrasive concentration and then abrasive size and next number of cycles that affect the most. Fletcher and Davis [22] showed the dependency between number of cycles, pressure drop, temperature, and the abrasive concentration used. Lowering of value of viscosity and increase in medium flow rate is observed by an increase in temperature results.

III .CFD MODELLING OF AFM

To find outputs in the above mentioned AFM process we need to conduct experiments. But this is time taking and too expensive as we have to run multiple tests on multiple samples to get many results, so it is difficult to get the optimum input parameter for better result. So the simulation of AFM is done numerically by using the software CFD (FLUENT) of ANSYS15. Then we get the desired outputs out of the simulation. CFD, generally abbreviated as CFD. It is the augmentation of mechanics of fluid that utilizes different numerical methods and large amount of iterative calculations to handle and examine issues that involve flow of fluid. Processors are used to do the tallies essential to reproduce the interaction between liquids and gasses when they are given a set of conditions. Fast main frame computers produce results faster. Here a tapered pipe is taken for the simulation. It is used to join pipes or tube sections on same axis and provide in line conical transition

Some applications of the pipes are:

- Help in transporting slurries or abrasive liquids
- Useful in services where cavitation is present.
- Used in discharge of pump.
- Used in chemical industries, in thermal equipment's, mining processes.

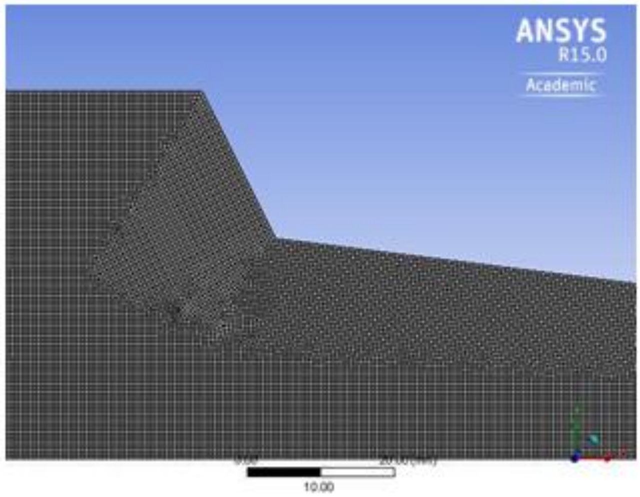

Figure.1. Mesh Report and diagram of work piece with fixture by ANSYS

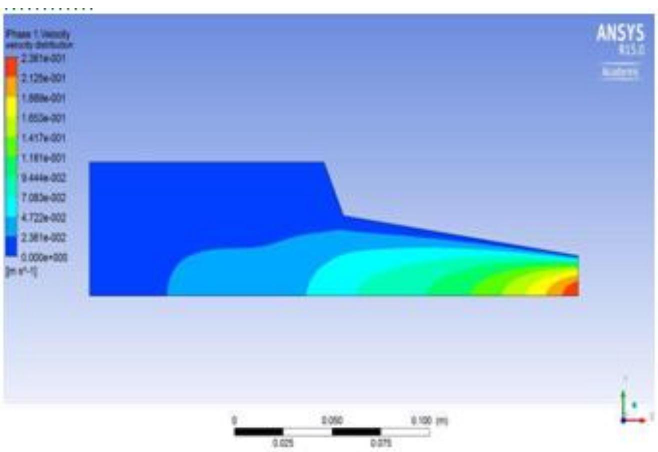

Figure.2. velocity distribution

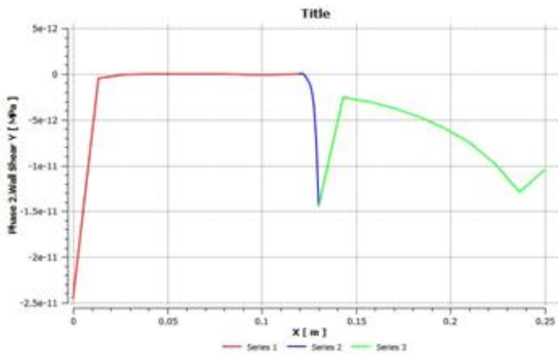

Chart 1.phase velocity vs position

IV. RESULTS

The CFD model that had been applied to the present case was tested and the results were verified with a previously done work on a cylindrical work piece. The crucial factor of the problem was the calculation of proper indentation force, or radial stress (from CFD analysis). The CFD analysis gave a value of 0.15 Pa for Radial stress. Whereas the theoretical normal force gave a result of 0.26 Pa. This fluctuation might be due to the fact that a no. of assumptions were taken while its calculation. However the errors were within the tolerance limits.

Limitations of the proposed model

The medium is assumed to be perfectly homogenous. The calculation of no of active particles involved assuming a unit thickness of media on the inner wall which is not always feasible. The particle is assumed to be abrading the whole length of the work piece. It is also not very helpful as this model suggests that the abrasives which are not in contact with the work piece never come in contact.. The axial and radial stresses at the work piece were found through CFD analysis of the tapered pipe.

V. CONCLUSIONS

 Material removal rate was formulated and also calculated from this simulation.

 an existing model of material removal was selected and modified according to suitable assumptions.

 The results came with a little error due to the assumptions taken during their calculations.

 However the errors were within the limitations of experimental procedure.

 Future study into the model and modifications can be done to the current model.

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