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Study of Hybrid Abrasive Flow Machining Process alongwith other non traditional machining processes: A Review

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Abstract:
The paper describes the basic principle of abrasive flow machining (AFM) process, its advantages, limitations and applications. Further, the different types of AFM process and the elements of the machine setup are explained in detail. The elements include machine setup, fixture, polymer media used, etc. The process parameters used by different researchers and the work done in the field of polymer media and magnetorheological fluids are discussed. In addition, the process hybrid forms are categorised and given a brief introduction. The literature work done by various scientists and researchers in the field of non- conventional machining processes and abrasive flow machining (AFM) process and its hybrid form has been explained. The different process parameters used, work output and input techniques used by researchers are tabulated and explained in detail. The electrolytic, magnetic and centrifugal force assisted AFM processes literature in addition to different polymer media used is analysed.

Keywords: *hybrid AFM, polymer media, material removal*

1 INTRODUCTION

1.1 Non Conventional Manufacturing Processes

There are two types of manufacturing processes i.e. conventional and non-conventional processes. In case of conventional process, there is job and tool contact and the tool must be harder than workpiece in order to achieve cutting. There is no direct tool and workpiece contact in unconventional machining processes and various types of energy is used to remove unwanted material and find uses in many of the industries, hard and brittle materials. The life of the tool is reduced and residual stresses are induced in the workpiece due to large cutting forces requirement and production of large amount of heat in the form of cutting chips off the workpiece.

1.2 Abrasive Flow Machining (AFM)

It is a process of polishing internal surfaces and producing controlled radii by the action of pressurised abrasive laden media against the workpiece surafce. The advantages of this process include more tolerance in terms of surface finish, finishing of more difficult to reach areas and faster finishing rates as compared to manual methods. Abrasive flow machine was first introduced in American based extrudes hone company in 1960s which is used for complex internal inaccessible cavity and shapes. AFM is a unique process developed for fine finishing,

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polishing by flowing an abrasive laden media. The hard and tough materials are machined because of the flexibility and mouldable properties of the media and it acts as deformable grinding media which is subjected to restricted flow passages.

The AFM process is mainly divided into three parts, i.e.

(a) Machine
(b) Tooling
(c) Process input parameters of AFM

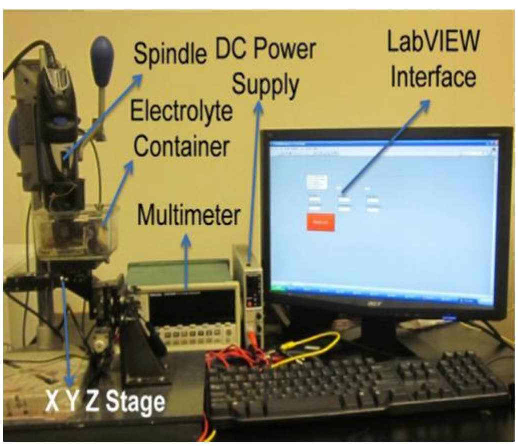
Its applications can be diversified into pharmaceutical, chemical, production, automobile and aeronautics industry, etc.

2. LITERATURE SURVEY OF NON TRADITIONAL AND ABRASIVE FLOW MACHINING PROCESS VARIANTS

2.1 Non-Conventional Manufacturing Processes

In non conventional machining processes, the material removal of workpiece takes place without the necessary condition of tool being harder than workpiece. It can be of various kinds like electric discharge, electrochemical, ultrasonic, etc depending on the type of energy source. The various types of unconventional processes and their combination variant processes are explained.

(a)



(b)

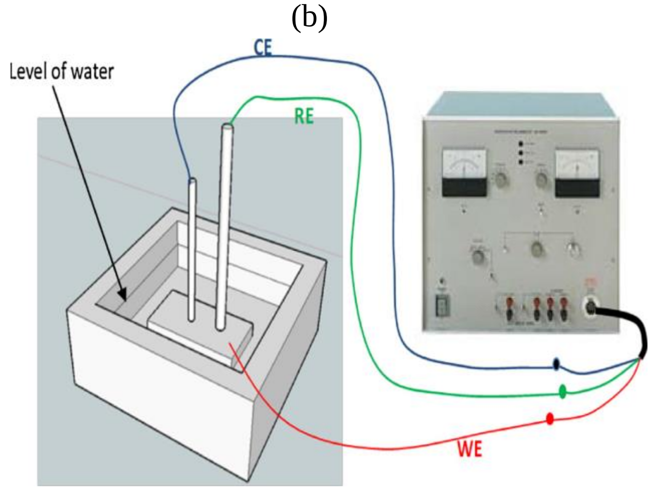


Figure.4 (a) ECDM apparatus setup (Jui et al. 2013) [4], (b) Electrochemical cell and polarization system (Yang et al. 2011) [5].

The various EDM process variants and the parameters, tool used in the particular process is given in table 1 and electrolytic process variants are explained in table 2.

Table 1 Electrical Discharge Machining and its variants

Author, year, area of research/process	Workpiece	Tool	Electrolyte/media/particles	Parameters
Zhang et al, 2009, EDM [6]	$Cu-ZrB_2$ shell electrodes	brass	Al_2O_3/6061 Al composites (toughness 29 MPa, yield strength 0.3 MPa, hardness 27-87 HRB, thermal conductivity 0.168-0.122)	Pulse off time 450 ms
Yan et al, 2000, Rotary EDM [7]	Steel		Al_2O_3 vol. Fraction 0-20%, dielectric used was kerosene	current 1-15 A, pulse off time 1-650 ms, pressure 0-3 kg/cm^2
Lin and Lee, 2009, Magnetic-EDM [8]	SKD 61			frequency 100 Hz

Table 2. Electrochemical force assisted AFM process and its variants

Author, year, area of research/process	Workpiece	Tool used	Electrolyte/media/ particles	Parameters
Jui et al, 2013, ECDM [4]	Glass of thickness 200 µm	Electrode: Anode: Steel of thickness 8 mm, cathode: WC rod of diameter 100-300 µm	NaOH of 0.1-7.5 M	Rotation speed:0-2500 RPM, feed with step size 0.1 µm, multimeter of resolution 0.01 mA
Yang et al, 2011, Eco-friendly ECM [5]	working electrode (WE) was workpiece i.e. SUS304	counter electrode (CE) is tool i.e. WC rod of diameter 0.3mm.		
Kurita and	EDM	machine tool size 557		Power supply

Hattori, 2006, EDM and ECM/ECM lapping [9]	processed workpiece	x 604 x 655 mm, weight 80 kg		0.75kVA, travel range 200 x 110 x 110 mm, feed rate 600 mm/s, resolution 0.1 fEm
Ghoshal and Bhattacharya, 2015, ECMM [10]		Micro tools 110 µm straight, conical 10.5º taper, reverse taper 2º	Sludge H_2SO_4 electrolyte of molarity 0.05-0.3 M	pulse frequency 5 MHz, duty ratio 35%.
Paul, 2013, RSM-ECDM [11]	Graphite plate 50 mm x 30 mm x 5 mm	WC wire of 300 µm	30 wt.% electrolyte,	MRR was found to be increased at high concentration and equal to 0.96 mg/hr at 25 wt% concentration and 60% duty cycle, whereas tool wear rate was minimum at high concentration i.e. 0.62 mg/hr.
Liu et al, 2015, ECM [12]	TiAl intermetallic	electrode feed 2 mm/min	electrolytic pressure 0.8 MPa	35 V

The magnetic field assisted AFM process and its variants as well as magnetorheological finishing processes are explained in table 3 with details of tool, workpiece and dielectric media used.

2.3. Effect of different factors on AFM process:

The vibration causes more number of abrasive particles to contact with the work surface and increases the surface finish. Many authors have been successful in improving the surface quality of workpiece in AFM process. However the reshuffling or intermixing process depends on the polymer media self-deformability properties. It resulted in proper hitting of abrasive particles to the work surface A lot of researchers have incorporated rotation effect in AFM process in the form of centrifugal force of rod or helical effect of drill bit, etc. The electromagnet showed 200 V at 250 mA and 260 V at 500 mA, copper wire resistivity taken as equal to 1.7

micro-ohm cm and the step-down transformer 12012 was used, denoting 12 V, 5408- 4 diodes used to build bridge rectifier, having filter capacitor (2200 µF, 50 V). The conventional fused abrasive particles are Al_2O_3, SiC, ZrO_2 based and super abrasives like CBN, diamond, etc. In order to hold or support the abrasives, a polymer or resin based bond should be prepared.

For modeling the process in such a way that it perform like human being, we have to apply neural network method. It has three features, i.e. topology, functionality and learning. A set up was fabricated in which the input current to the solenoids was changed and accordingly the magnetic pressure was controlled. It was also concluded that the magnetic pressure between the poles attained maximum value at 1.2 Tesla flux density. The experimental and simulation results matched exactly at lower values of flux density. The genetic algorithm (GA) approach used for process optimization started with formulation of constrained optimization problem. Initialization of GA parameters, i.e. population size, string length, crossover, mutation probability and maximum number of genes is done. Put generation number = 0. Now, initial feasible random population is obtained. If the generation number > maximum number of genes, then the program is terminated, else again we have to evaluate fitness of each individual and the program is run in the similar manner.

3. CONCLUSIONS

a) The electrolytic process is explained alongwith electrolyte used and Lorentz force study.
b) The electric discharge process including micro EDM, wire EDM and magnetic EDM processes are studied in detail.
c) Various hybrid conventional and non conventional processes included electrical grinding, centrifugal EDM, electrochemical turning processes, etc.
d) Further the variants of AFM process included the use of vibrational force, magnetic force and magnetorheological AFM processes are studied.

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