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Micro-pocket formation on DELRIN by optimizing the parameters of Abrasive Jet Machining (AJM)

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Abstract

Abrasive Jet Machining (AJM) is a unique process operates on compressed air alongwith SiC as a abrasive material. The machine works with the help of mach3 mill software as a controller. The machine operates under high 'air pressure'. The process uses a narrow bore nozzle ranging from 0.5mm to 1.5mm depending upon the type of work to form a coherent, high velocity air jet, which has a pressure up to 100 PSI. Compared with other machining process, AJM is advantageous in various manners such as no thermal distortion(NTD), high flexibility ,high accuracy with great precision , high machining versatility and small machining force. The effects of processing parameters on machined surfaces which are analyzed and summarized in our study and basically we are focusing on nozzle stand-off distance(NSD). In this article our other target is to reduce the environmental effect i.e. reduction of polluting particles from abrasives. This study also intended to highlight and categorize the machining performance of the materials on machining with AJM.

Keywords: AJM; Mach3 mill; NTD; Nozzle Standoff Distance(NSD); Polluting particles.

1. Introduction

Abrasive Jet Machining (AJM) is a NON conventional machining process gained its importance in the last few decades The advancements in this technology have attracted various manufacturing sectors AJM makes use of the principles of abrasive jet machining. The process is most suitable for machining wide range of materials especially brittle materials like glass, ceramics, stone, composite materials, ferrous and non-ferrous alloys.

The machined surface characteristics produced by AJM process depend on many factors like jet pressure, standoff distance, abrasive flow rate, traverse speed, properties of work materials, etc. The basic phenomenon of material removal in AJM is erosion caused due to the impact of abrasive particles. In this case, parameters such as jet traverse speed, jet pressure, stand-off distance and abrasive flow rate were investigated to study their effect on the milling process. AJM is one of the most suitable processes for machining or cutting high performance materials. In this work, we are focusing on nozzle stand-off distance (NSD) [3] and to reduce the environmental effect i.e. reduction of polluting particles from abrasives.

This work examines the AJM milling behavior of DERLIN in terms of the surface properties of the milled component, like roughness, waviness and there plastic behaviour and behaviour which fills the gap between plastic and metal. Cutting at higher pressure is more efficient than at low pressure for the same power consumption. The increased pressure also reduces the cost due to reduction in abrasives usage and increased cutting speed. The study shows that the depth of cut increases with increase in jet pressure. The present study is carried to characterize machined pockets and optimizing the input parameters in AJM for pocket dimensions, cutting depth and surface roughness

1.1. Experimental Setup

All the experiments are carried on abrasive jet machine at Inderprastha Engineering College having a maximum pressure of 150-170 PSI. The work piece is 10 mm thick which gives the fixed parameters maintained during experimentation and selected factors.

- **Air Compressor/Gas propulsion system**
  The main purpose of air compressor is to supply clean and dry, high speed air or gas for machining. Mostly air, carbon dioxide, nitrogen etc. are used as gas in gas propulsion system. This system consists compressor, air filter and drier.
- **Abrasive Feeder**
  Abrasive feeder is employed to produce abrasive particles in mixture chamber. It is fed through a sieve that vibrates at 50-60 cps (character per second) and mixture magnitude relation is management by the vibration of the sieve and its amplitude.
- **Nozzle**
  A nozzle is a device designed to control the direction or characterstics of fluid flow (especially to increase the velocity) as it exits or enters an enclosed chamber or pipe. A nozzle is often a pipe or tube of varying cross sectional area and it can be used to direct or modify the flow of a fluid (liquid or gas). These are usually made of tungsten carbide. They are obtainable in each circular and square cross section. Its life is approximately 12-300hrs.
- **Filter**
  It filters the gas before coming into the mechanical device and combining chamber.
- **Hopper**
  Hopper is employed for feeding the abrasive powder.
- **Pressure gauges and flow regulators**
  These are used for the management of pressure and regulate the rate of abrasive jet.
- **Vibrator**
  A vibrator is used to control the feed of the abrasive powder. The abrasive powder and the compressed air are thoroughly mixed in the chamber. The pressure of this mixture is regulated and sent to nozzle.

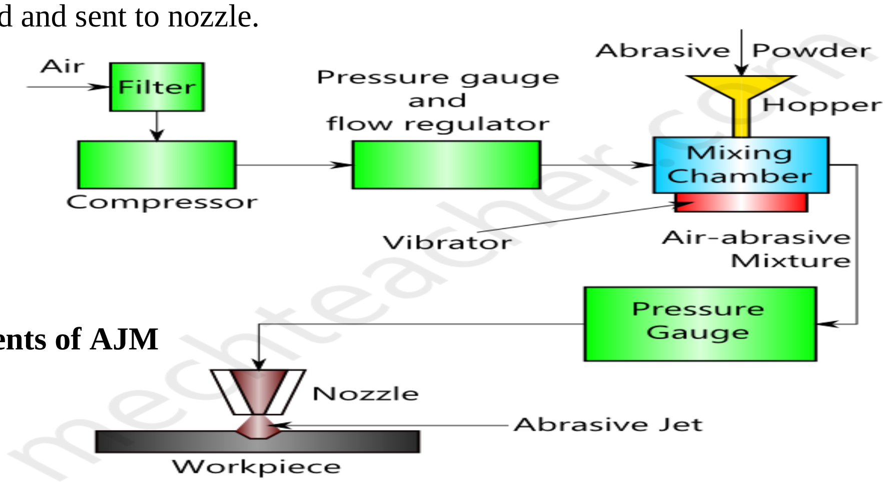

Fig.1 Components of AJM

1.2. Tables

Table 1: Various parameters for AJM.

Particulars	**Values**
Medium	Air, CO_2, N_2
Abrasive	Silica sand, SiC, Al_2O_3 (of size 90-150 microns)
Flow rate of Abrasive	3 to 20 gram/min
Velocity	150-300 m/min
Pressure	150-170 psi
Nozzle size	2-5 mm
Material of Nozzle	Mild steel
Nozzle life	12-300 hrs
Standoff Distance	0.25-15 mm (8 mm generally)
Work material	Derlin
Part application	Drilling, cutting, deburring, etching, Cleaning

1.3 Result and discussion

a) For higher precision work higher pressure and lower stand off distance are adopted to attain a higher accuracy and penetration rate for AJM.In our case pressure is between 150-170PSI and stand off distance is 0.25-15mm.

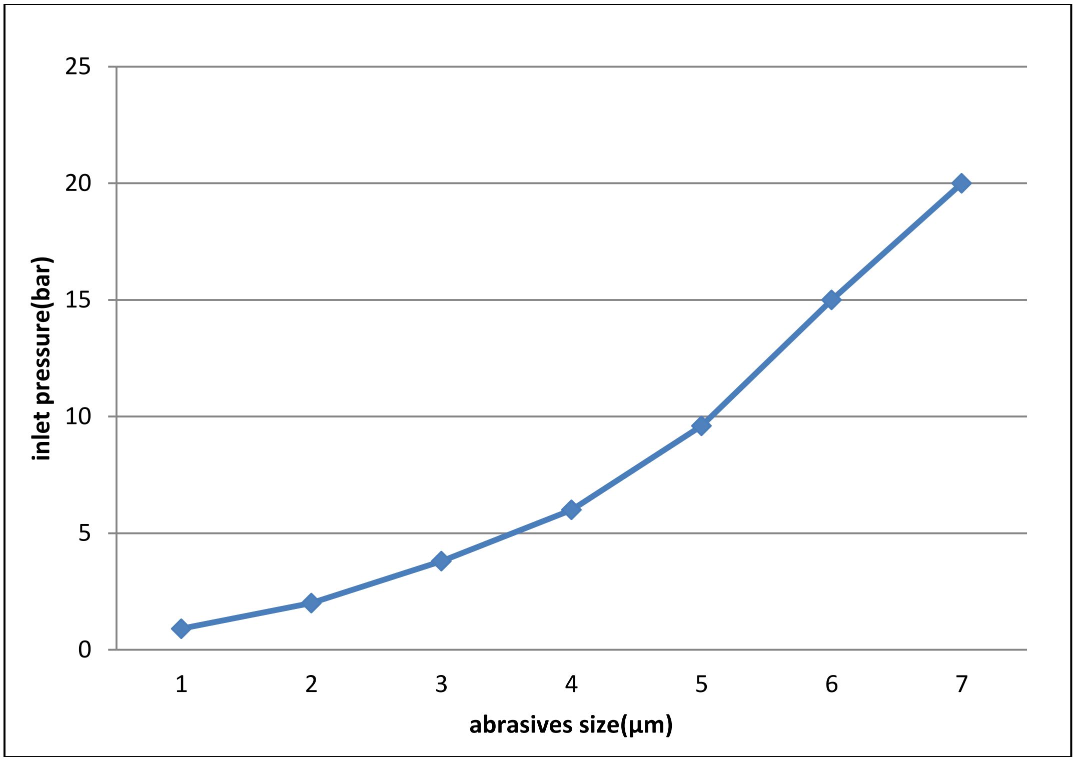

Fig.2 variation between inlet pressure and abrasive size

b) By using aluminium oxide abrasive particles getting better surface finishing compared with silicon carbide abrasive particles. The various results plotted in fig. 2.

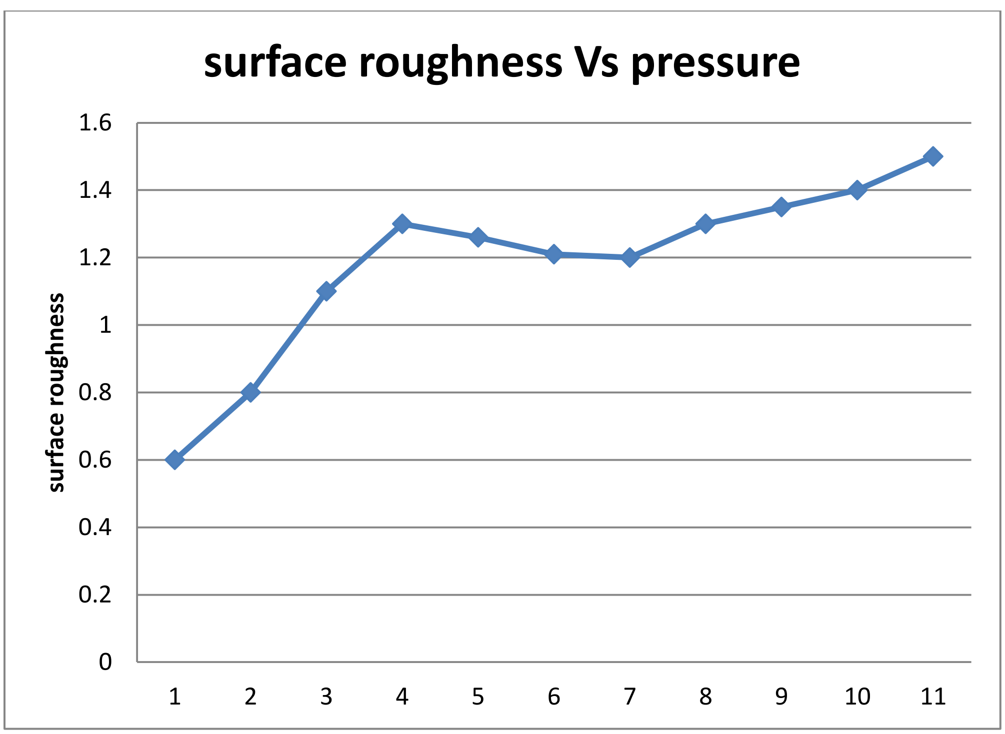

Fig.3 The impact of pressure variation on surface roughness.

c) The higher standoff distance is preferable where material removal is prime importance.
d) MRR increase with an increase in abrasive jet flow rate, mixing ratio, internal pressure, standoff distance under certain condition.

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