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Development of Laval Nozzle for Micro Abrasive Jet Machining [MAJM] Processes

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Abstract

The modern manufacturing era demanding miniaturization of devices with micro features in fields of electronics, optics, medicine, biotechnology, communications, and avionics. A large number of investigations carried out in micro abrasive jet machining on glass with conventional nozzle but very little study is carried on metals. To do machining on metal higher velocity of abrasive particle is required so attempt is made to develop Laval type of nozzle for difficult to machine materials such as stainless steel ANSI 316 plate. A nozzle is conceived to assure specific characteristics of the mixture (compressed air and abrasive particle) owing through it. During this flow, the force of abrasive particle is converted to kinetic energy, so the velocity of the mixture is increased. The flow characteristics and machining performance of Laval nozzle are examined precisely by experimentally also investigate that the Laval nozzle reduce dimensional variation of machined hole and increase concentration of flow with guiding pressure.

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Keywords: Laval Nozzle, Micro-abrasive, Micro Abrasive Jet Machining

1. Introduction

Recent study says it is difficult to do the micromachining of materials like ceramics and glasses as these materials are extremely hard, brittle & corrosion resistant. For machining of these materials, chemical and thermal machining methods (such as laser and electron beam machining, chemical etching, electrolytic machining and EDM) are less

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recommended because of excessive heat affected zone. Also mechanical machining methods (such as grinding, ultrasonic machining and polishing) are less popular because of less accuracy & productivity. Recent development of micro Abrasive jet machining (MAJM) become an attractive and promising technology for processing hard and brittle materials such as ceramics and semiconductors. This technology posses distinct advantages like less damage during micro machining & negligible heat affected zone. Because of these reasons it finds its application in fabricating electronic devices and micro-fluidic channels.

Recent studies on MAJM have focused on the following topics: technological trend and application with case studies [1–5]. characteristics of machining MAJM [6–9], Identification of abrasive jet machining mechanism [10,11], Numerous empirical studies on particle velocity arrived later on investigating the influence of nozzle length [12], particle loading ratio and roughness [13], radial position of the particles and distance from the nozzle exit [14,15]. The fluid flow conditions in the micro abrasive jet machining nozzle have been recognized early as one of the most indispensable components to control erosion [16]. The micro abrasive jet machining process has been analytically demonstrated regarding disintegration and miniaturized scale stream machining profile [17, 18]. Generally in micro abrasive jet machining nozzles are used with cylindrical cross section and the flow of jet is converging. It also achieves speed of sound, because of the presence of particle velocity, boundary layer and the pressure of particle at centre line of the nozzle is higher. As an outcome, the machining result is hard to control for greater cylindrical cross sectional nozzle. The efficiency is decreases with the flux effect [19]. The flexible magnetic abrasive jet machining is novel hybrid method for researching the machining attributes of the self-made magnetic abrasive in abrasive jet machining [20]. Using the Bernoulli's equation of compressible of flow jet air velocity of abrasive Particles in an abrasive air jet machining was calculated with considering nozzle length, air density, particle mean diameter and air flow velocity at exit of nozzle. It is determined theoretically and mathematically [21]. The main objective of this study is to develop Laval nozzle for MAJM to machine difficult to machine materials such as stainless steel ANSI 316 plate for improve machining productivity of micromachining. Study of micro drilling efficiency measured with the function of Laval nozzle using of mesh sizes 50 μm silicon carbide (SiC) particles. Also study of flow characteristics of jet examined precisely by experimentally.

2. Development of Laval Nozzle

Need of high velocity nozzle in micro abrasive jet machining is essential for difficult to machine materials. So

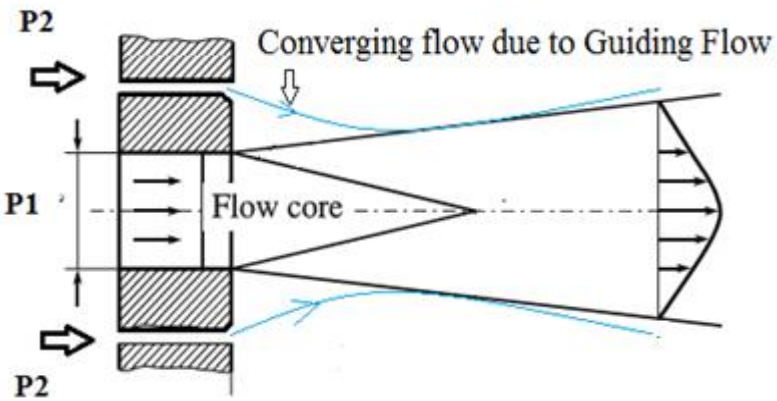

Fig.1. Distribution of flow over the jet

attempt is made to developed Laval type nozzle based on principle of The Coanda effect as say that tendency of a liquid stream to stay attached to a curved portion for concentricity of fluid jet with high velocity.