International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Optimization of Abrasive Waterjet Machining Process Parameters Using Taguchi & Anova on Aluminium Al-6061: A Review

Madhu Keshav Sharma[1], Himanshu Chaudhary[2], Ashwani kumar[3]

[1]Master student of Mechanical Engineering Department, S.S.C.E.T, Badhani,Pathankot, Punjab

[2]Assistant Professor, Mechanical Engineering Department, S.S.C.E.T, Badhani, Pathankot, Punjab

[3]Assistant Professor, Mechanical Engineering Department, S.S.C.E.T, Badhani, Pathankot, Punjab

Abstract: ***Abrasive Waterjet Machining (AGWM) is an emerging machining technology alternative for hard material parts, which are extremely difficult-to-machine by conventional machining processes. A narrow stream of high velocity water mixed with friction particles provides a relatively inexpensive and environmentally friendly production with a very high content removal rate. Because of that abrasive waterjet machining, has become one of the leading manufacturing technologies in a relatively short time. This letter reviews the research work from the beginning to the development of AWJM in the beginning of the last decade. It reports related to AWJM processes to optimize process variables, improve performance measures, monitoring and control of the process. A wide range of AZJM industrial applications for various class items are reported with variations.***

Keywords: Abrasive jet, process parameter, optimization, Taguchi, ANOVA

1. Introduction

However development of newer methods has always been the endeavour of engineering personnel and scientists. The main ideas behind such endeavours have generally been the economic considerations, replacements of existing manufacturing methods by more efficient and quicker ones, achievement of higher accuracies and quality of surface finish, adaptability of cheaper materials in place of costlier ones and developing methods of machining such materials which cannot be easily machined through the conventional methods etc. Of all this reasons, the last one has contributed considerably to the post-war developments in machining methods, particularly because of the use of a large number of 'hard to machine' materials in the modern industry. A few of such materials are tungsten, hardened and stainless steel, inconel, uranium, beryllium and some high strength steel alloys. The increasing utility of such materials in the modern industry has forced research engineers to develop newer machining methods, so as to have full advantage of these costly materials.

Abrasive jet machining (AJM) process is one of the non-traditional machining processes that have been used extensively in various industry related applications. The basic principles of abrasive water jet machining (AJM) were reviewed in details by Momber and Kovacevic 1998[1]. This technology is less sensitive to material properties as it does not cause chatter, has no thermal effects, impose minimal stresses on the workpiece, and has high machining versatility and high flexibility. But it has some drawbacks; especially it may generate loud noise and a messy working environment (Wang and Wong 1999) [2]

The use of composite materials becomes prominent in today's modern technological applications. These materials have better mechanical properties such as low densities, high strength, stiffness and abrasion, impact and corrosion resistances. The creation of aramid fibers called Kevlar has lead to the big breakthrough in the development of modern ballistic armour due to its unique properties of special application in armour which give ballistic protection (Komanduri et al. 1991). It has unique characteristics such as high strength to weight ratio, high chemical resistance, high cut resistance, flame resistance and good corrosive resistance (Komanduri et al. 1991).

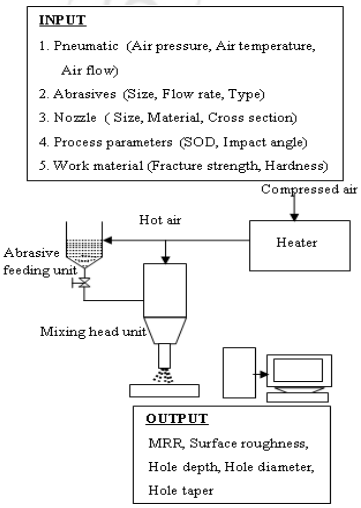

Figure 1.1: Schematic of Abrasive hot air jet process

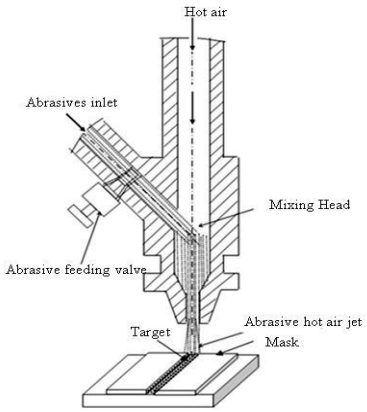

Figure 1.2: Abrasive hot air jet striking on surface of glass plate

2. Literature Review

Ramprasad, Gaurav Upadhyay, Kamal Hassan (2015) [3] accepted effective technology for cutting various material as of its advantages over other non-conventional techniques such as No heat is generated in the cutting process, high machining versatility, minimum stresses on the work piece. Abrasive water jet machine is an industrial machine in which we can cutting of the any types of materials i.e. softer materials and harden materials. In the abrasive water jet machine, the water is supplied at a very high pressure from 20,000-60,000psi and provides the good cutting and surface finishing. In the abrasive water jet machine there is a orifice in which a nozzle fixed and through the nozzle water exit in the cutting stream formation, this nozzle is move in the x-y axis as like in CNC machine.

K. S. Jai Aultrin, M Dev Anand (2015) [4] realised a rapid growth in cutting of hard metals and alloys using unconventional machining process. AWJM is recently developed unconventional machining processes in cutting different kinds of hard materials these days. The principle in which this process works is based on the principle water jet mixed with abrasives resulting in very high velocity that when it impacts on the work piece removes the surface of the work piece. Machine economics and quality of machining are determined by the machining parameters. In

M.Sreenivasa Rao, S.Ravinder and A. Seshu Kumar (2014) [7] investigated to study the effect of parameters, viz water pressure, Traverse speed, and Standoff distance, of Abrasive Waterjet Machine (AWJM) for mild steel (MS) on surface roughness (SR).Further Taguchi's method, analysis of variance and signal to noise ratio (SN Ratio) are used to optimize the considered parameters of abrasive Water Jet Machining. In Taghuchi's design of experimentation, L9 orthogonal array is formulated and it can be concluded that water pressure and transverse speed are the most significant parameters and standoff distance is sub significant parameter.

3. Conclusion

From the literature view it has been observed that lot of work is reported on Water Jet machining of different metals using different parameters but, very little work has been this study the effect of five process parameters on MRR and SR for the American element named Lead Tin alloy which is cut by abrasive waterjet cutting machine was experimentally done and analyzed. Based on the Response Surface Methodology, different sets of experiments were conducted on this element by varying the water pressure, abrasive flow rate, orifice diameter, focusing nozzle diameter and standoff distance. In this paper a predictive model for MRR and SR is developed for this Lead Tin alloy using regression analysis and the effects of process parameters on MRR and SR has been studied in abrasive waterjet cutting of Lead Tin alloy and found that all parameters and along with their interactions have significant effect on the MRR and SR.

Partek and Vijay Kumar [5] studied that the abrasive jet machining (AJM) is a non-conventional machining process in which an abrasive particles are made to impinge on the work material at a high velocity. This project deals with the fabrication of the Abrasive Jet Machine and machining on tempered glass, calculating the material removal varying various performance parameters like pressure, angle & abrasive grit size so on. Before performing the experiment fabrication done on AJM which are also discussed.. The different problem faced while machining on tempered glass are also discussed. Taguchi method and ANOVA is used for analysis of metal removal rate.

P. P. Badgujar, M. G. Rathi (2014) [6] optimize the input parameters of AWJM, such as pressure within pumping system, abrasive material grain size, stand-off distance, nozzle speed and abrasive mass flow rate for machining SS304. The Taguchi design of experiment, the signal-to-noise ratio, and analysis of variance are employed to analyze the effect of the input parameters by adopting L27 Taguchi orthogonal array (OA). In order to achieve the minimum surface roughness (SR), five controllable factors, i.e. the parameters of each at three levels are applied for determining the optimal combination of factors and levels. The results reveal that the SR is greatly influence by the abrasive material grain size. Experimental results affirm the effectiveness of the solving the stated problem within minimum number of experiments as compared to that of full factorial design.

reported on Aluminum 6 Series (Al 6061) using these input parameters i.e. Pressure, Standoff Distance, Transverse Rate with sand as abrasive material. In this research work, attempt has been made to study the effect of parameters on the machining characteristics of Aluminum 6 series using Taguchi method and ANNOVA to analyze the Material Removal Rate (MRR) and Surface Roughness.

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Author Profile

Keshav, M.tech (Mechanical Engineering) student of Sri Sai College of Engineering and Bio-Technology, Badhani, Pathankot He did is B.tech7 from Sri Sai College of Engineering and Bio-Technology, Badhani, Pathankot. His areas of interest are Advance Manufacturing Techniques, Benchmarking.

Er. Himanshu Choudhary is presently associated with Sri Sai College of Engineering and Bio-Technology, Badhani, Pathankot as Assistant Professor. His area of interest are Advance Machining Processes and Operations Management.

Er. Ashwani kumar is presentaly associated with Sri Sai College of Engineering and Bio-Technology, Badhani, Pathankot as Assistant Professor. His area of interest is Taguchi, ANOVA, and Optimization