EXPERIMENTAL INVESTIGATION AND OPTIMISATION OF PROCESS PARAMETERS IN ABRASIVE WATER JET MACHINE

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ABSTRACT

In the present work, we are accommodating a non-conventional machining process in which mechanical energy of water along with abrasives is used for removing material. This process is observed in Abrasive Water Jet Machining. For this, Design of Experiments are selected and optimized by adopting Taguchi technique. Taguchi method is a statistical method developed by Taguchi and Konishi. Initially it was developed for improving the quality of goods manufactured (manufacturing process development), later its application was expanded to many other fields in Engineering, such as Biotechnology etc. Professional statisticians have acknowledged Taguchi’s efforts especially in the development of designs for studying variation. Success in achieving the desired results involves a careful selection of process parameters and bifurcating them into control and noise factors. Selection of control factors must be made such that it nullifies the effect of noise factors. Taguchi Method involves identification of proper control factors to obtain the optimum results of the process. Orthogonal Arrays (OA) are used to conduct a set of experiments. Results of these experiments are used to analyse the data and predict the quality of components produced. The AWJM process parameters selected are Abrasive Flow Rate, thickness of the material, Pressure, Nozzle Diameter, Stand of Distance, Time & Kerf Factors. This process will become a greater advantage in machining industry.

Keywords: Abrasive water jet, Taguchi, Orthogonal array.

INTRODUCTION

ABRASIVE WATER JET MACHINING (AWJM): Abrasive water jet cutting is an extended version of water jet cutting; in which the water jet contains abrasive particles such as silicon carbide or aluminum oxide in order to increase the material removal rate above that of water jet machining. Almost many type of material ranging from hard brittle materials such as ceramics, metals and glass to extremely soft materials such as foam and rubbers can be cut by abrasive water jet cutting. The narrow cutting stream and computer controlled movement enables this process to produce parts accurately and efficiently. This machining process is especially ideal for cutting materials that cannot be cut by laser or thermal cut. Metallic, non-metallic and advanced composite materials of various thicknesses can be cut by this process. This process is particularly suitable for heat sensitive materials that cannot be machined by processes that produce heat while machining.

The schematic of abrasive water jet cutting is shown in Figure. Which is similar to water jet cutting apart from some more features underneath the jewel; namely abrasive, guard and mixing tube. In this process, high velocity water exiting the jewel creates a vacuum which sucks abrasive from the abrasive line, which mixes with the water in the mixing tube to form a high velocity beam of abrasives.

EQUIPMENT

EXPERIMENTAL INVESTIGATION

Step 1: Glass specimen of 10mm thickness is used. Abrasive type is used is Sic (silicon carbide intensifier pumping system has operating pressure of up to 380 MPa.) The motion of the nozzle is controlled by a computer. The principle AWJM is, abrasives like aluminium oxide, are fed into the nozzle via an abrasive inlet the high pressure. Water jet metal cutting machine yields vary little heat and therefore there is no heat affected zone (HAZ).Water jet machining is also considered as “cold cut” process and therefore is safe for cutting flammable materials such as plastic and polymers.

Step 2: The machine is equipped with a gravity feed type of abrasive hopper, anabrasive feeder system, a pneumatically controlled valve and a work piecetable. A sapphire or if ice was used to transform the high-pressure water into a Collimated jet, with a tungsten carbide nozzle of 2mm diameter to form an abrasive water jet. The abrasives used were 60 mesh garnet particles. The abrasives were delivered using compressed air from a hopper to the mixing chamber and were regulated. The abrasive water jet pressure is manually controlled using the pressure gauge. The standoff distance 1.5,2.5 and 3.5. The traverse speed was controlled automatically by the abrasive waterjet system programmed by NC code.

Step 3: To achieve a thorough cut it was required that the combination of the process variables give the jet enough energy to penetrate through the specimens. The variables in AWJM was varied and readings were taken with combination of process parameters together the required data. Three different readings were taken at each sample and the average readings were calculated.

PARAMETERS CONSIDERED:

- PRESSURE
- METAL REMOVAL RATE (MRR)
- STAND OF DISTANCE (SOD)

MACHINING OPERATION:

FINAL WORK PIECE:

OPTIMISATION USING TAGUCHI & ANOVA

Taguchi Design

Taguchi Analysis: MRR versus PRESSURE, AFR, SOD
Response Table for Signal to Noise Ratios
Larger is better

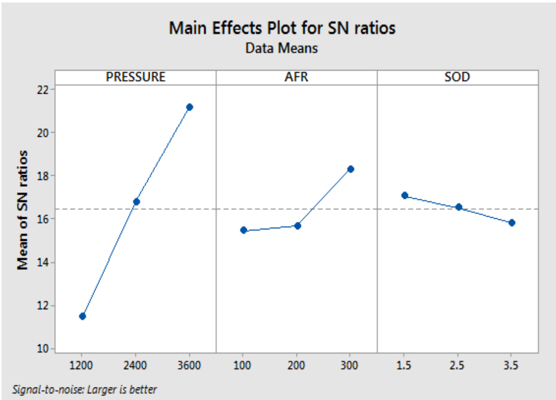
Level	PRESSURE	AFR	SOD
1	11.44	15.44	17.05
2	16.80	15.66	16.52
3	21.15	18.29	15.82
Delta	9.71	2.85	1.23
Rank	1	2	3

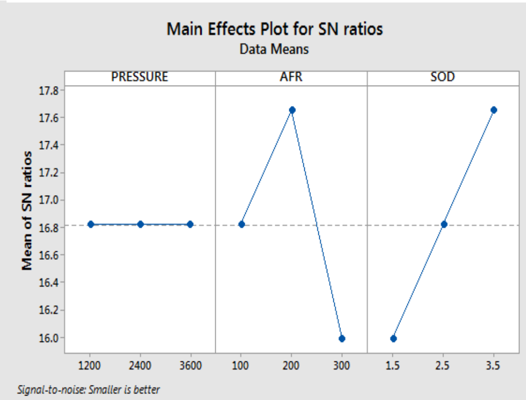
Taguchi Analysis: KERF versus PRESSURE, AFR, SOD

Response Table for Signal to Noise Ratios

Smaller is better

Level	PRESSURE	AFR	SOD
1	16.82	16.82	15.99
2	16.82	17.65	16.82
3	16.82	15.99	17.65
Delta	0.00	1.67	1.67
Rank	3	1	2





CONCLUSION: The present study is limited to specific materials of certain thickness, whose hardness is well known. The optimization techniques are also for those particular combinations. It is considered worthwhile exercise to arrive at generalized parameters for a particular group of materials, which can be classified using the Brinells /Rockwell hardness values or such common parameters. For arriving of such a generalized equation more experiments need to be performed for different varieties of material. Abrasive materials are used as a tool in these cases are also a much needed subject of study. As advances in materials technology is progressing fast we may have to substitute the present abrasive particles which have less erosion rate in nozzles, but high machining rate at the work piece. The use of nano materials may be an answer to this improvement in this technology. Researches towards specific industrial application may result in better usage of the AWJM process for commercial exploitation.

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