# Minimization of surface roughness in abrasive waterjet cutting of aluminium alloy 7075-T6.

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*Abstract*— **Abrasive Waterjet (AWJ) cutting is an emerging technology for material processing with the distinct advantages of no thermal distortion, high machining versatility, high flexibility and small cutting forces. In this paper, an experimental investigation of the machinability and surface roughness of Aluminium alloy 7075 T6 under abrasive waterjets is presented. It shows that this unique 'cold' cutting technology is a viable and effective alternative for polymer matrix composite processing, with good productivity and kerf quality. Plausible trends of surface roughness with respect to the input parameters are discussed, from which recommendations are made for process control and optimization.**

**Keywords— Cutting parameters, waterjet cutting, Taguchi.**

## I. INTRODUCTION

Abrasive Water Jet Machining (AWJM) is the non-traditional material removal process. It is an effective machining process for processing a variety of Hard and Brittle Material. And has various unique advantages over the other non-traditional cutting process like high machining versatility, minimum stresses on the work piece, high flexibility no thermal distortion, and small cutting forces.. In this project we are going to predict the surface roughness on Aluminium alloy while working under water jet machine using Artificial Intelligence and its hybrid techniques. 7075 aluminium alloy is an aluminium alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability.. The T6 temper is usually achieved by homogenizing the cast 7075 at 450°C for several hours, quenching, and then aging at 120°C for 24 hours. This yields the peak strength of the 7075 alloy. These processes involve large number of respective process variables (also called as process parameters) and selection of exact parameters setting is very crucial for these highly advanced machining processes which may affect the performance of any process considerably. These processes work on a particular principle by making use of certain properties of materials which makes them most suitable for some applications and at the same time put some limitations on their use.

Fig 1. Waterjet machine

Ramesh Babu et al [1] had worked on AWJM considering the variation in orifice and focusing nozzle diameter in cutting 6063 T6 Al alloy. They have assessed performance in terms of different parameters such as depth of cut, MRR. Oktem et al [2] they implemented an integrant approach of design of experiments GA and neural network to find minimum Ra value. They applied taguchi method to investigate impact of various machining parameter on Ra.Aizuddin et al [3] used RSM technique to optimize the value of surface roughness of Al alloy. Harish[4] concluded that during AWJM the MPP and its mechanism depends on type of abrasive and on a range of process parameter. Vandavilli et al [5] carried out various experiments and investigated that traverse speed has great effect on surface roughness at the bottom of the cut. Begic et al [6] concluded that at constant or same traverse speed these variation of surface roughness remains smaller at lower abrasive mass flow rate. Chithirai [7] studied influence of parameter of Ra in AWJ of cast iron and result obtained is that after pressure is the main cause for surface roughness they also observed that as pressure increases surface Ra decrease. Surface Ra decreases with increasing abrasive flow rate and increase with traverse speed and SOD. Prajapati et al [8] studied that for soft material surfaces Ra depend upon abrasive flow rate. J. Wang et al [9] explained that AWJ is used in industry for material processing with many advantages such as , no thermal distortion . High machining versatility , High flexibility , quick machining and small cutting forces. Pal et al [10] investigated that the intensity and the efficiency of machining process depend on several AWJ process variable which may be classified as Hydraulic, abrasive , work material and cutting variable. Durmus [11] conducted the experimentation to investigate the multivariable effect on Ra for Al6013 aluminium .it is used for optimization of process using spcific material the presented work deal with optimization of surface roughness used for manufacturing of parts in aerospace industry. Process parameters affecting surface roughness are shown in figure 2.

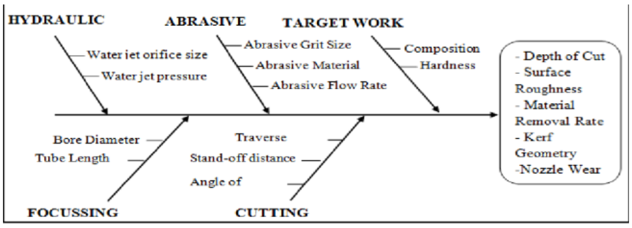


Fig 2. Parameters affecting surface roughness

.Chithirai et al [12] performed experiment to conduct varying water pressure, nozzle traverse speed , abrasive mass flow rate and stand off distance for cutting granite tiles using abrasive water jet cutting process. Metinkon et al [13] explained surface roughness which is used to determine and to evaluate the quality of a product is one-off the major quality parameter of plain water jet milling 17 product where arithmetic mean of surface roughness , maximum roughness of profile height and mean spacing of profile irregularty are dependent output variable. Asif iqbal [14] investigates the effect of AWJ input parameter on response parameter in cutting of ductile material of AWJ input parameter like jet pressure abrasive mixing rate cutting feed and plate thickness and response parameter like surfaces finish of cutting wear zone , percentage proportion of striation free area and maximum width of cut ,AISI 4340 and Al 2219 used as a material striation free area depend on pressure feed rate and sheet thickness surfaces roughness in cutting wear zone can be reduced by increasing abrasive mixing rate and reducing cutting feed. Wang Jun [15] presented study of machinibility of polymer matrix composite using AWJ it is noted that topology of AWJ cut surfaces may be divided into microscopic component and macroscopic component. The overall methodology is shown in figure 3.

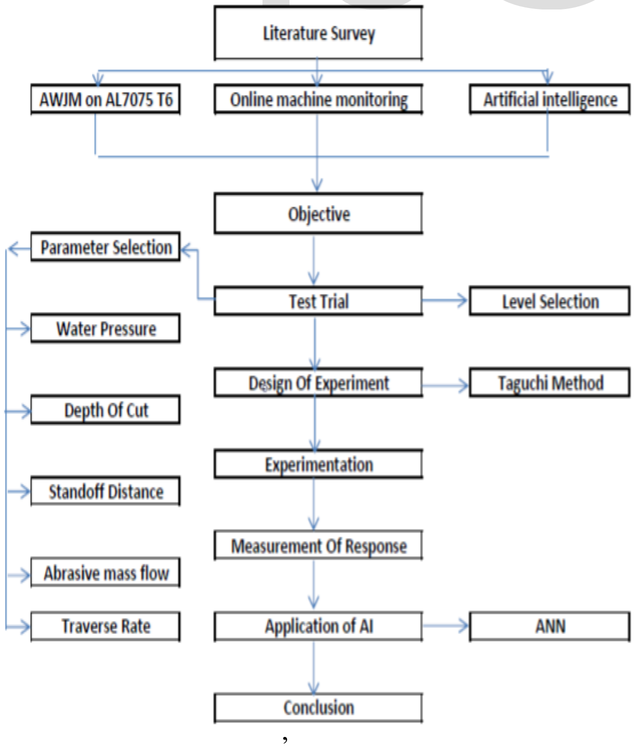


Fig.3.Overall Methodology of Taguchi.

## II. EXPERIMENTAL DETAILS AND MEASUREMENT

Roughness can be measured by manual comparison against a "surface roughness comparator" (a sample of known surface roughness), but more generally a surface profile measurement is made with a profilometer. These can be of the contact variety (typically a diamond stylus) or optical (e.g.: a white light interferometer or laser scanning confocal microscope).

However, controlled roughness can often be desirable. For example, a gloss surface can be too shiny to the eye and too slippery to the finger (a touchpad is a good example) so a controlled roughness is required

The profile roughness parameters are included in BS EN ISO 4287:2000 British standard, identical with the ISO 4287:1997 standard. The standard is based on the ″M″ (mean line) system.

There are many different roughness parameters in use, but is by far the most common, though this is often for historical reasons and not for particular merit, as the early roughness meters could only measure . Other common parameters include , , and . Some parameters are used only in certain industries or within certain countries. For example, the family of parameters is used mainly for cylinder bore linings, and the *Motif parameters* are used primarily in the French automotive industry. The MOTIF method provides a graphical evaluation of a surface profile without filtering waviness from roughness. A *motif* consists of the portion of a profile between two peaks and the final combinations of these motifs eliminate ″insignificant″ peaks and retains ″significant″ ones. Please note that is a dimensional unit that can be micrometer or microinch. Material composition is as follows:

TABLE 1. COMPOSITION OF ALUMINIUM ALLOY 7075 T6.

| Component | Al | Cr | Cu | Fe | Mg |
|---|---|---|---|---|---|
| Wt. % | 87.1-91.4 | 0.18-0.28 | 1.2-2 | Max 0.5 | 2.1-2.9 |

| Component | Mn | Si | Ti | Zn | Other |
|---|---|---|---|---|---|
| Wt. % | max 0.3 | Max 0.4 | Max0.2 | 5.1-6.1 | Max 0.05 |

## III. TAGUCHI METHOD

The Taguchi method mostly focuses on reducing the variation in products or processes. In Taguchi method works in three steps namely tolerance, parameter and system design. In system design, process sequence, production equipment and parameter values are fixed. Then, the parameter design decides the best setting of the process variable values for improving the performance characteristics. Lastly, tolerance design is analysis the tolerance at the best setting recommended by parameter design. Hence, parameter design is most important step for enhancing the quality without increasing the cost as the factors affecting the quality characteristics are determined in this stage. The steps in this method are selection of orthogonal array, running the experiment, analyzing the data, identifying the best setting and conducting the confirmation test. The selection of an OA is based on overall degree of freedom. For example, a three level process parameter can be compared with two other levels, hence degree of freedom is two. There are four process parameters considered for end milling operation and each parameter is of three levels, hence overall degree of freedom is 8. The selected OA should have degree of freedom greater than or equal to those of control variables. Therefore, in this study L18 orthogonal array is used. The levels of factor and final experimentation are illustrated in TABLE II and TABLE III.

## IV. Results and Conclusions

This work dealt with the optimal selection of cutting parameters to minimize surface roughness and maximize productivity. The experimental results illustrated that there was significant improvement in surface roughness (61%), material removal (37%) and MRPI (38%) compared to initial machining setting as illustrated in TABLE VI. The plot of MRPI versus factors obtained by Taguchi method showed influence of control factor towards the variations in MRPI. It was found that traverse speed and abrasive flow rate contributed more towards variation as compared to the type of tool and depth of cut.

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