IJEAST

INTERNATIONAL JOURNAL OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

VOLUME : 4 ISSUE : 01 Print / Issue Publication Date: 27-Jun-2019

ISSN : 2455-2143

DOI : 10.33564/IJEAST.2019.v04i01.021

Indexed In

Google Scholar · Open Access · doi · Crossref

WWW.IJEAST.COM

editor@ijeast.com

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 1, ISSN No. 2455-2143, Pages 126-131
Published Online May 2019 in IJEAST (http://www.ijeast.com)

APPLICATION OF GENETIC ALGORITHM IN OPTIMIZING THE WATER JET MACHINING PARAMETERS TO IMPROVE THE QUALITY OF THE SURFACE FINISH

S.SaravanaKumar,Assistant professor,
Department of Mechanical Engineering,
Rathinam Technical Campus, Coimbatore
Tamilnadu, India.

K.Mujiburrahman, Assistant professor,
Department of Automobile Engineering,
Hindustan Institute of Technology, Coimbatore
Tamilnadu, India.

A.Logesh Arunkumar,
Senior Engineer,
Coimbatore.
Tamilnadu, India.

D.Praveenkumar, Assistant professor,
Department of Mechanical Engineering,
Rathinam Technical Campus, Coimbatore.
Tamilnadu, India.

***Abstract*—This work is carried out to examine the effects of three different controllable parameters like speed (S), pressure (P) and feed rate (F) cutting conditions which influencing the surface roughness value. From the previous studies, the application of GA optimization technique is not yet considered by researchers to find the optimum parameter for improving the quality of the surface finish in water jet machining. Therefore this work attempt to find the optimum solution for water jet machining parameters by using GA. The regression model is developed by conducting experiments for 27 samples as per Design of Experiment. With the help of JMP software full factorial design is selected for this experiment. The surface roughness value (R_a) is measured by using surftronic measuring instruments for the 27 samples and noted. With the application of GA and regression model, the optimum parameters for minimizing surface roughness value is done and compared with the experimental result.**

Keywords— **Water Jet Machining, Process parameter optimization, Genetic Algorithm**

I. INTRODUCTION

Mostafa et al., (2017) stated in their works as Nickel-iron based super alloys are widely used in applications that require considerably high strength and high corrosion resistance at elevated temperatures such as jet engine components, aerospace parts, and fossil fuels and nuclear power plant components.

Components made of Inconel 718 alloys have generally complex geometry and complicated parts particularly considering components used in aircraft engine such as spool, shaft, turbine disc etc. Yusuf kaynak et al.,(2018) presented in their work as, all these components have been manufactured using conventional manufacturing methods, considerable difficulties during fabricating processes of this alloy due to its thermal and mechanical properties are faced with.

Abrasive Water Jet Machining (AWJM) technology is one of the fastest growing non-traditional machining processes. It can machine almost all engineering materials, irrespective of material properties. Ultrasonic Machining (USM), Water Jet Machining (WJM) and Abrasive-Water Jet Machining (AWJM) are generally used for material removal process particularly suitable for hard and brittle materials such as ceramic, Inconel718 etc., The continuous jet is the most common type of working water jet which is used in most industrial and commercial cleaning and cutting applications. These jets are used over an extremely wide range of system pressure and rates of water flow through the nozzles. In water jet cutting of coal, high-pressure water is focused through a nozzle to create a high-velocity water stream. So in order to understand the mechanisms of water jet cutting system and to develop a high productivity system, it is first necessary to analyze the cutting mechanism of the water jet and then obtain an optimum combination of the effective process parameters. With reference to the published literature, it is clear that, current usage of the GA technique, which is labeled as a soft computing approach for the machining cutting process which is given less consideration by researchers. It was found that usage of the GA technique for R_a in optimization of cutting conditions in the WJM process was very limited. In general, optimization is the process of estimating the potential minimum value of machining performance at the optimal point of process parameters. Some established soft computing techniques applied by previous works to suggest the process parameters in machining problem such as GA, SA, Tabu Search (TS), Ant Colony Optimization (ACO), and Particle Swarm Optimization (PSO). Some of the advantages in soft computing technique such as GA in optimizing process parameters may include.

II. METHODOLOGY

The steps for the proposed integration system are given as follows:
Experiments were conducted for 27 samples as per DOE to examine the cutting conditions used (cutting speed, Pressure and feed rate) that affect the quality of surface finish values.

Develop the machining model to describe the relationship between independent machining variables (cutting conditions) and dependent machining variables by using the regression technique. By the t-test, the best regression model is determined as the choice for the fitness function in the GA optimization module.

Find the optimal set value of independent variables to present the minimum objective function by using the GA technique. The objective function or fitness function of GA leads to the minimum (lower) value of surface roughness. MATLAB Software is used to write the GA code to find the optimal solutions that lead to the minimum value of surface roughness.

Evaluate the GA optimization solution. The optimal cutting condition gives the minimum surface roughness values which is generated from GA and compared to the experiment sample data and the regression model.

.

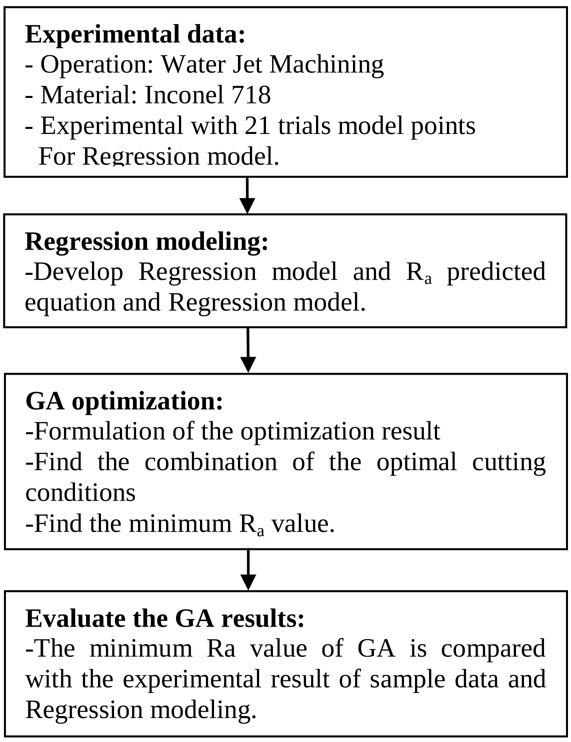

Fig.1 Flow of searching for optimization of WJM parameters

III. CASE STUDY – EXPERIMENTAL DATA

The Water Jet Machining experiment is done for the 21 samples as per DOE. The material used for the Water Jet Machining is Inconel 718 and the chemical composition of the Inconel 718 material is shown in the table -1.

Table -1 Chemical Composition of Inconel 718

Element	Content in %
Cobalt (Co)	1.00
Chromium (Cr)	17 up to 21
Molybdenum (Mo)	2.8 up to 3.30
Iron (Fe)	17.0
Silicon (Si)	0.35
Manganese (Mn)	0.35
Carbon (C)	0.08
Aluminium (Al)	0.60
Titanium (Ti)	0.90
Copper (Cu)	0.30
Phosphorous (P)	0.015
Boron (B)	0.006
Sulphur (S)	0.015
Niobium + Tantalum	4.75 to 5.5
Nickel (Ni)	50 to 55

A. EXPERIMENTAL DESIGN FOR SURFACE ROUGHNESS MEASUREMENTS

The experimental designs of three process parameters are given in Table 2. The measurements were taken at distance of 5 mm from the top of the cutting surface. A surftronic portable surface roughness measurement device was used in order to measure the average (R_a) value in micron.

Symbol	Cutting parameters	Level 1	Level 2	Level 3
X	Speed	20	40	60
Y	Pressure	30000	40000	50000
Z	Feed rate	50	100	125

Table - 2 Setting of Cutting Parameters for Water Jet Machining.

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 1, ISSN No. 2455-2143, Pages 126-131
Published Online May 2019 in IJEAST (http://www.ijeast.com)

B. EXPERIMENTAL DESIGN

Three independent variables for machining Inconel 718 material is selected by Design of Experiment has shown in table 3. From this table, the coded variables used in the 27 factorial design are only for levels -1, 0 and +1. For this experiment, Water Jet Machining machine is used which is shown in fig.2. The surface roughness value of the machined work piece was measured by using the Taylor Hobson Surftronic +3 which is shown in fig.3. Before conducting the measurement, the instrument is well calibrated using standard specimen.

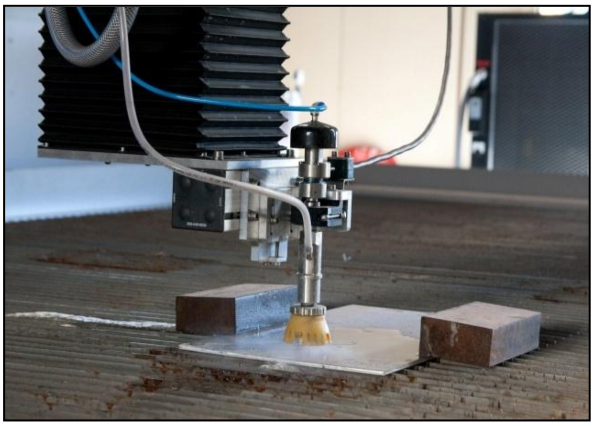

Fig.2 Water Jet Machining Machine

C. EXPERIMENTAL RESULTS

Experimental trials were conducted based on full factorial design totally 21 number of experiments are done shown in fig.5.DOE is done by using MINITAB software. All the data were tested in real machining for three different cutting conditions.

The R_a values of each experimental trial are observed for the selected cutting conditions of the experiment are given in Table-3.The machined samples are shown in fig.4.

Fig.3 Taylor Hobson Surftronic +3

Table-3 DOE and Experimental Results

S. No	X - Speed (%)	Y- pressure (PSI)	Z- feed rate (mm/min)	R_a
1	20	30000	50	80
2	20	30000	100	95
3	20	30000	125	110
4	20	40000	50	90
5	20	40000	100	100
6	20	40000	125	110
7	20	50000	50	100
8	20	50000	100	110
9	20	50000	125	120
10	40	30000	50	90
11	40	30000	100	100
12	40	30000	125	110
13	40	40000	50	90
14	40	40000	100	100
15	40	40000	125	110
16	40	50000	50	100
17	40	50000	100	120
18	40	50000	125	130
19	60	30000	50	100
20	60	30000	100	110
21	60	30000	125	120
22	60	40000	50	110
23	60	40000	100	120
24	60	40000	125	130
25	60	50000	50	110
26	60	50000	100	125
27	60	50000	125	140

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 1, ISSN No. 2455-2143, Pages 126-131
Published Online May 2019 in IJEAST (http://www.ijeast.com)

IV. Regression Modeling

Normally the measurements of surface roughness in Water Jet Machining in relation to the independent variables are commonly investigated mathematically as follows.

$$R_a = c(X)^q(Y)^r Z^s \varepsilon' \quad \ldots\ldots\ldots (1)$$

Where (R_a) is the experimental surface finish value measured in micron,

(X) is the speed in %,
(Y) is the water pressure in PSI
ε' is the experimental error

Using experimental data model parameters such as *c, q, r and s* to be found.

By using logarithmic transformation the above mathematical model in Eq.(1) is liberalized to develop the regression model to predict (R_a).

$$\ln R_a = \ln c + q \ln(S) + r \ln(P) + s \ln(F) + \ln\varepsilon' \quad \ldots\ldots\ldots(2)$$

Eq. (2) can be written as:

$$y = b_0x_0 + b_1x_1 + b_2x_2 + b_3x_3 + \varepsilon \quad \ldots\ldots\ldots (3)$$

The logarithmic value of the experiment (R_a) is y and $x_0 = 1$, imitation variables x_1,x_2 and x_3 are the process parameter values of (S),(P) and (F) respectively, ε its is the logarithmic transformation of experimental error ε' and b_0,b_1,b_2 and b_3 are the model parameters to be estimated using the experimental data.

Eq.(3) can be written as

$$y - \varepsilon = b_0x_0 + b_1x_1 + b_2x_2 + b_3x_3 \quad \ldots\ldots\ldots(4)$$

Where $(y\text{-}\varepsilon)$ is the logarithmic value of predictive (R_a)

The developed mathematical model for the Water Jet Machining of 21 experimental trial data is given below

$$R_a = 33.10 + 0.41(x_1) + 0.000778(x_2) + 0.30(x_3)$$

Where,

x_1 - Speed
x_2 - Pressure
x_3- Feed rate.

The coefficient of determination ($R^2 = 0.91$) shows the variations between the predicted result.

V. GA Optimization

The genetic algorithm is a method for solving both constrained and unconstrained optimization problems and is based on natural selection, which drives the biological evolution. Fig.4 illustrates the flow of how the GA technique operates in order to optimize a problem. The solution of an optimization problem with the GA algorithm begins with a set potential solution that is known as chromosomes.

The entire sets of these chromosomes comprise populations which are randomly selected. The chromosomes evolve during several iterations or generations. New generations known as offspring are generated by utilizing the cross over and mutation techniques. Crossover involves the process of splitting two chromosomes and then combining one-half of each chromosome with the other pair. Mutation involves the process of flipping a chromosome. The genetic algorithm repeatedly modifies a population of individual solutions.

At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population evolves towards an optimal solution as shown in Fig.4 in order to get an optimal solution. The generated population is evaluated by employing a certain fitness criterion. Some conditions for obtaining the best fitness function are:

(1) The algorithm stops when the number of generation searches the value of generations.

(2) The algorithm stops after running for an amount of time in seconds equal to the time limit.

(3) The algorithm stops when the value of the fitness function for the best point in the current population is less than or equal to the fitness limit.

(4) The algorithm stops when the weighted average changes in the fitness function value over stall generations and is less than Function tolerance.

(5) The algorithm stops if there is no improvement in the objective function during an interval of time in seconds equal to stall time limit.

(6) The algorithm runs until the weighted average change in the fitness function value over stall generations and is less than function tolerance.

(7) The nonlinear constraint tolerance is not used as a stopping criterion. It is used to determine the feasibility with respect to nonlinear constraints. The evaluation of the process is repeated until one chromosome with the best fitness criteria is obtained. Then this best fitness is taken as the optimum solution for the problem.

International Journal of Engineering Applied Sciences and Technology, 2019
Vol. 4, Issue 1, ISSN No. 2455-2143, Pages 126-131
Published Online May 2019 in IJEAST (http://www.ijeast.com)

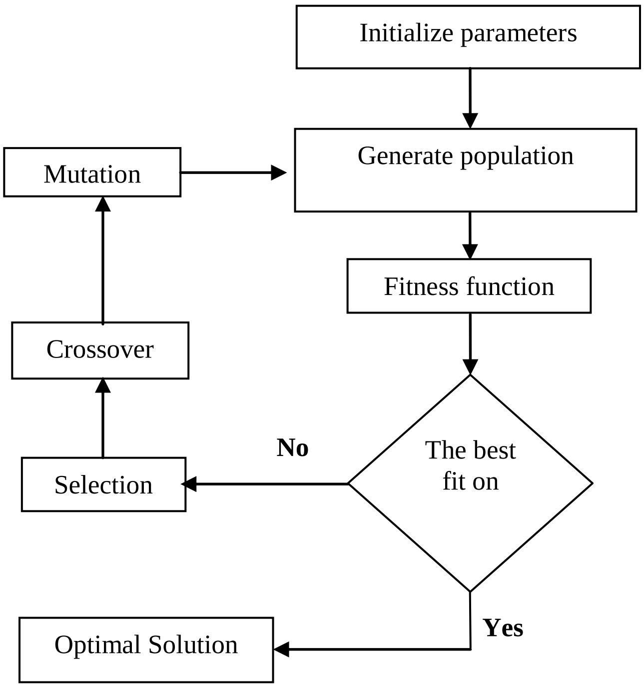

Fig.4 The flow of GA optimization

VI. RESULTS AND DISCUSSIONS

The issues concerned in this study to evaluate the GA results are as follows:

(1) The GA predicted surface roughness value (best fitness function) is expected to be lower than the minimum (smallest) R_a value of the experimental and regression model.

(2) The GA average predicted surface roughness value (the mean fitness) is expected to be lower than the average (mean) surface roughness value of the experimental and regression model.

(3) The optimal cutting conditions that lead to the best fitness function which is obtained at the last iteration of GA and is expected to be in the same range of values as those with the cutting conditions of the experimental.

By referring the table-4,

The predicted minimum surface roughness value is found to be 27.61 microns.

The experiment is carried out to check the predicted result and gives 29.32 microns as shown in fig.6.

It clearly shows that GA technique has given the minimum result of surface roughness value.

Table – 4

Approach	**Issue 1: minimum (R_a)**	**Issue 2: speed, pressure, feed rate**	**Issue 3: no. of iterations**
Experimental [1]	80	(20, 30000, 50)	-
Regression [1]	79.85	(20, 30000, 50)	-
Genetic Algorithm	27.61	(20.39, 30175.9, 124.1)	44
Experimental – Genetic Algorithm	29.32	(20.35, 30150.9, 126)	-

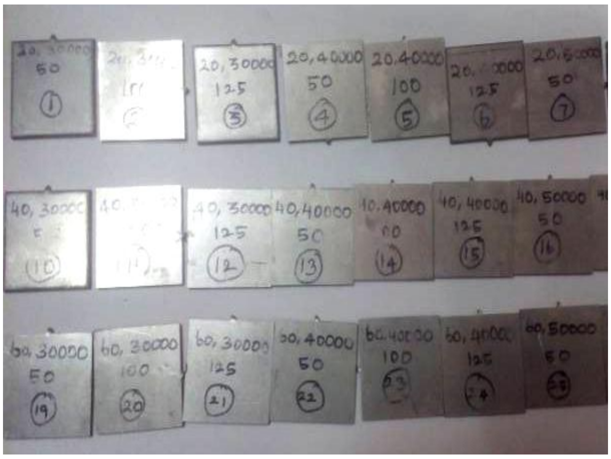

Fig.5 Experiment Samples

Fig.6 Minimum R_a Predicted sample

VII. CONCLUSION

In this experiment, the minimum surface roughness value for the Water Jet machining parameters on Inconel 718 material is predicted by using JMP software.

DOE is done and 21 trial experiments were done and the R_a value is measured and regression model is developed by MINITAB. Using GA technique the predicted minimum R_a value is found and compared with the experimental results.

The result is almost equal to predicted R_a value which clearly shows that GA technique is an effective method to find the optimum solution.

VIII. REFERENCE

[1] Mostafa A, Picazo Rubio I, Brailovski V, Jahazi M, Medraj M. (2017) Structure, texture and phases in 3D printed IN718 alloy subjected to homogenization and HIP treatments. Metals 2017, 7,196.

[2] Yusuf kaynak, Emre Tascioglu (2018). Finish machining-induced surface roughness, micro hardness and XRD analysis of selective laser melted Inconel 718 alloy, 4th CIRP Conference on Surface Integrity (CSI 2018).

[3] Padmakar J. Pawar, Umesh S. Vidhate, Mangesh Y. Khalkar (2017). Improving the quality characteristics of abrasive water jet machining of marble material using multi-objective artificial bee colony algorithm.

[4] Valíček J, Hloch S, Kozak D (2009). Surface geometric parameters proposal for the advanced control of Abrasive Water Jet technology. International Journal of Advanced Manufacturing Technology 41, (323–328).

[5] Yanaida K (1974). Flow characteristics of water jets symposium on jet cutting paper no A2.

[6] Wang J (1999). Abrasive water jet machining of polymer matrix composites- cutting performance, erosive process and predictive models. International Journal of Advanced Manufacturing Technology 15, (757–768).

[7] Hloch.S (2007). Experimental study of surface topography created by abrasive water jet cutting. Strojarstvo 49,(303–309).

[8] Zain A.M, Haron.H, Sharif.S, (2010). Simulated annealing to estimate the optimal cutting conditions for minimizing surface roughness in end milling Ti–6Al–4V, Machining Science and Technology 14 (1) (43–62).

[9] Mukherjee.I, P.K. Ray, (2006). A review of optimization techniques in metal cutting processes, Computer and Industrial Engineering 50, (15–34).

[10] Manolas D.A, Gialamas T.P, Frangopoulos C.A, Tsahalis D.T, (1996). A genetic algorithm for operation optimization of an industrial cogeneration system, Computers and Chemical Engineering 20, (1107–1112).

[11] Cus .F, Balic.J, (2003).Optimization of cutting process by GA approach, Robotic and Computer Integrated Manufacturing 19, (113–121).

IJEAST

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

ABOUT IJEAST

International Journal of Engineering Applied Science and Technology (IJEAST) is a peer-reviewed, open access journal that publishes high-quality research papers in the field of Engineering, Applied Science and Technology.

IJEAST aims to provide a platform for researchers, academicians, and professionals to share their innovative ideas, research findings, and practical experiences with the global scientific community.

FOCUS AREAS

- Engineering
- Applied Science
- Technology
- Innovation & Development
- Interdisciplinary Studies

PEER REVIEWED
All submissions are rigorously peer reviewed to ensure quality.

OPEN ACCESS
Free and unrestricted access to research for all.

GLOBAL REACH
Connecting researchers and professionals worldwide.

TIMELY PUBLICATION
We ensure a swift and efficient publication process.

For more information, visit our website
www.ijeast.com

INTERNATIONAL JOURNAL
OF ENGINEERING APPLIED SCIENCE AND TECHNOLOGY

editor@ijeast.com
www.ijeast.com
India

2455-2143