

Optimization of Process Parameters for Turning Operation on CNC Lathe for Inconel 600 using Genetic Algorithm

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Abstract---The increased use of alloy materials has led to an increase in demand for facilities to machining them. Therefore no of methods are also increase then required optimize the machining parameter for different material. While the process of metal cutting has been well researched over the years, relatively little research has been carried out on the cutting of alloy of INCONEL materials. This report presents brief review of turning process on INCONEL materials and Genetic Algorithm as an optimization technique. This report also presented the mathematical modelling of setup and experimental data of the machining.

I. INTRODUCTION

A. Machining Process

The machining processes are classified in various heads, which are used in produce various design of parts. Slandered and common processes are turning, facing, tapes turning, knurling, parting off, drilling, boring, threading, chamfering, forming etc...

B. Genetic Algorithm

In 1975, Holland developed this idea in his book "Adaptation in natural and artificial systems". Genetic algorithms are based on the principle of genetics and evolution. The genetic algorithm loops over an iteration process to make the population evolve. Each iteration consists of the following steps crossover, mutation, selection, reproduction, evaluation, loop, replacement.

C. INCONEL Material

INCONEL is a group of austenitic nickel-chromium-based Superalloys. Inconel alloys are generally used in high temperature applications. The Inconel alloy family was first developed in the 1940s by research teams at Wiggin Alloys (Hereford, England), which has since been acquired by Special Metal Corporation in support of the development of the Whittle jet engine

II. LITERATURE REVIEW

In past researcher research on turning parametric optimization work but they took various optimization techniques.

A. Turning Operation with Genetic Algorithm

S.V. Bhaskara Reddy ET. al. [1], Nafis Ahmad ET. al. [2], R. Saravanan et. al. [3], R. QuizaSardinas et. al. [4], T. Srikanthet. al. [5], Doriana M. D' Addona, et. al. [6] were worked with genetic algorithm for parameters of turning operation they determine the optimal machining parameters that minimize the surface roughness, production time, production cost without violating any imposed cutting constraints based on Genetic Algorithm approach

B. Turning Operation for Inconel Material

L. Li ET. al. [7], J. P. Costeset. al. [8], D. G. Thakur et. al. [9], Satyanarayana B., et. al. [10], K. Sarvanakumar, et, al, [11] were worked on various grade of INCONEL alloy material with various cutting tool material e.g., Coated and uncoated Ceramic, carbide, titanium with different nomenclature rack angle, nose radius and get optimize value of the objective function.

C. Machining Operation For Inconel 600

Y.S. Sato, et., al., [12], C. D. Shah, et., al., [13], performed with the various machining process e.g., Friction Stir Welding, Wire Cut EDM, hard turning that the optimum parametric combination for the minimum surface value, maximum material removal rate were obtained by using different optimize technique on INCONEL 600.

III. EXPERIMENTAL SETUP AND METHODOLOGY

A. Experimental Setup

In this research work machines and instruments are required for optimization of process parameter for turning process. Which are CNC lathe (DX 200, Jyoti), INCONEL 600 as a workpiece material, Surface Roughness Tester (SJ 210P, Mitutoyo)

B. Selection of Parameters

There are many parameter effects on the desire output function of the turning operation but in that mainly depth of cut, speed or feed there.

C. Mathematical Model

Mathematical model is required for the set of the experiments.

Table 1 Mathematical Model for machining process

Sr. No.	Control Factor	Unit	Level 1	Level 2	Level 3
1	Depth of Cut (d)	mm	0.3	0.5	0.7
2	Speed (v)	rpm	350	600	850
3	Feed (f)	mm/rev	0.04	0.08	0.12

D. Formulation of Objective Function:- The objective of this work is to minimize machining time subjected to the desired surface roughness value and its corresponding equation is given below

$$tm=60l/vf$$

$$SR=\alpha+\beta d+\gamma v+\delta f+\epsilon$$

E. Design of Experiment

Design of Experiments is a series of test in which purposeful changes are made to the input variables of a system or process. In the research work design the sets of experiment by Full Factorial Method.

Table 2 Sequence table for experiments

Exp. No.	Stand. Ord.	Input Parameter		
		Depth of cut (mm)	Speed (RPM)	Feed (mm/rev)
1	1	0.7	350	0.04
2	2	0.7	350	0.08
3	3	0.7	350	0.12
4	4	0.7	600	0.04
5	5	0.7	600	0.08
6	6	0.7	600	0.12
7	7	0.7	850	0.04
8	8	0.7	850	0.08
9	9	0.7	850	0.12
10	10	0.5	350	0.04
11	11	0.5	350	0.08
12	12	0.5	350	0.12
13	13	0.5	600	0.04
14	14	0.5	600	0.08
15	15	0.5	600	0.12
16	16	0.5	850	0.04
17	17	0.5	850	0.08
18	18	0.5	850	0.12
19	19	0.3	350	0.04
20	20	0.3	350	0.08
21	21	0.3	350	0.12
22	22	0.3	600	0.04
23	23	0.3	600	0.08
24	24	0.3	600	0.12
25	25	0.3	850	0.04
26	26	0.3	850	0.08
27	27	0.3	850	0.12

For the experiments we use INCONEL 600 rod with ϕ 20 mm and length of each set 10 mm.

IV. RESULTS AND DISCUSSION

A. Implementation of Objective Technique

The second objective of this work is to find the optimal machining parameters to minimize the machining time for the given surface roughness value by using optimization technique. The result of experiments has revealed that decrease in feed rate improved surface finish but machining time gets increased. Use of higher speed may enhance surface finish but the tool life is lost. So an optimization technique is required to solve this machining problem. The machining parameters are identified and the best combinations of parameters are selected by using optimization technique. Different optimization techniques are used to solve the mathematical models for machining problems.

B. Practical Output Responses

Table 3 Response table from the various experiments

Ex. No.	Stand. Ord.	Input Parameter			Output response	
		DOC (mm)	Speed (RPM)	Feed (mm/rev)	RA (μ m)	t _m (sec)
1	1	0.7	350	0.04	0.685	51
2	2	0.7	350	0.08	1.014	22
3	3	0.7	350	0.12	1.687	14
4	4	0.7	600	0.04	0.79	25
5	5	0.7	600	0.08	0.525	13
6	6	0.7	600	0.12	1.032	8
7	7	0.7	850	0.04	1.428	18
8	8	0.7	850	0.08	2.765	8
9	9	0.7	850	0.12	2.009	6
10	10	0.5	350	0.04	1.838	43
11	11	0.5	350	0.08	4.216	22
12	12	0.5	350	0.12	1.239	14
13	13	0.5	600	0.04	2.51	25
14	14	0.5	600	0.08	3.113	13
15	15	0.5	600	0.12	1.212	8
16	16	0.5	850	0.04	0.771	18
17	17	0.5	850	0.08	1.346	8
18	18	0.5	850	0.12	1.7	6
19	19	0.3	350	0.04	0.816	44
20	20	0.3	350	0.08	1.244	21
21	21	0.3	350	0.12	1.971	14
22	22	0.3	600	0.04	1.42	25
23	23	0.3	600	0.08	1.319	13
24	24	0.3	600	0.12	1.957	8
25	25	0.3	850	0.04	0.537	19
26	26	0.3	850	0.08	0.985	8
27	27	0.3	850	0.12	1.697	7

C. Algorithm

Step 1: create a fitness function of the objective function.

For the fitness function first create equation of the output parameter from the regression analysis. From this analysis create the equations of the surface roughness and machining time. For this, use Minitab 16 and create general regression equations.

$$RA = 1.33479 - 0.00305556 \text{ cut} - 0.000327111 \text{ speed} + 5.15139 \text{ feed}$$

$$T_m = 60 * 1/v * f; \%l=10$$

Step 2: select no of variable

“3” for RA function

“2” for MT function

Step 3: enter bounds of variable

LB	UB	
[0.3 350 0.04]	[0.7 850 0.12]	for RA function
[350 0.04]	[850 0.12]	for TM function

Step 4: select population type & size

Population type: double vector

Population size: 20

Step 5: fitness scaling

“Rank”

Step 6: select selection procedure

“Roulette”

Step 7: select mutation and crossover function

Mutation function: Use constraint dependent default

Crossover function: Heuristic

- Ratio: 1.5
- Step 8: Migration
Use as a default
- Step 9: Algorithm settings
Use as a default
- Step 10: hybrid function
Use as a default
- Step 11: stopping criteria
Generations: 100
Time limit: use as a default
Fitness limit: use as a default
Stall generation: 50
Stall time limit: use as a default
Function Tolerance: use as a default
Nonlinear constraint tolerance: use as a default
- Step 12: plot function
Plot interval: 1
Best fitness
Best individual
Scores
Selection

D. Results Of Fitness Function

Based on the objective function optimal value find from the Genetic Algorithm

By the help of GA find first optimal value of the surface roughness as an output parameter.

From the results Objective functions RA value: 1.2686045785239428 for set of input parameter: [doc speed feed] = [0.6864289285685153 847.5354859388498 0.041377217341700544]

From the results Objective functions MT value: 5.882355502364232 for set of input parameter: [speed feed] = [849.9999952180783 0.11999994842688694]

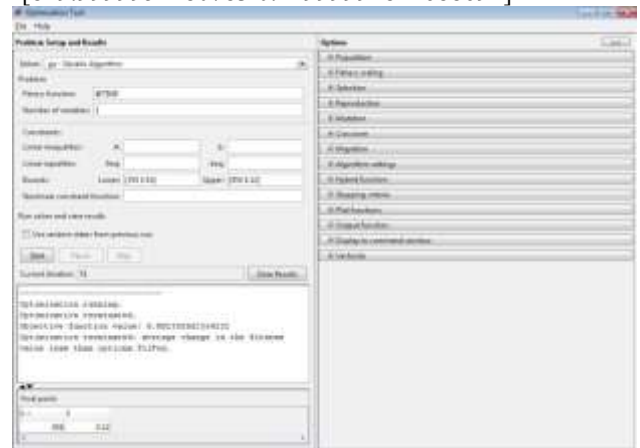


Fig. 2: Result snap from MATLAB for TM

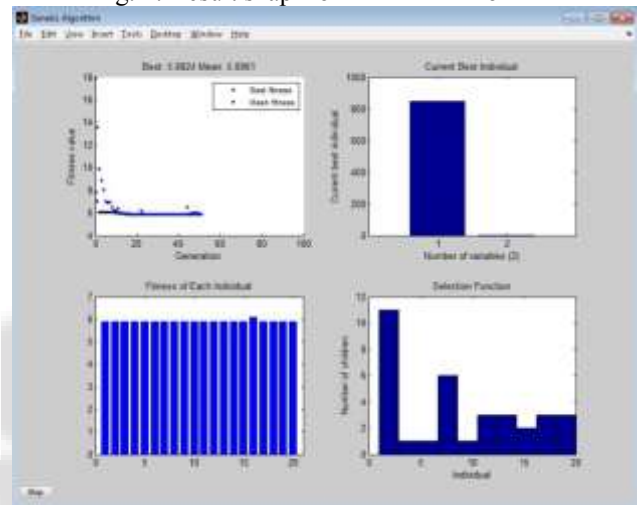


Fig. 3: Graph results for TM

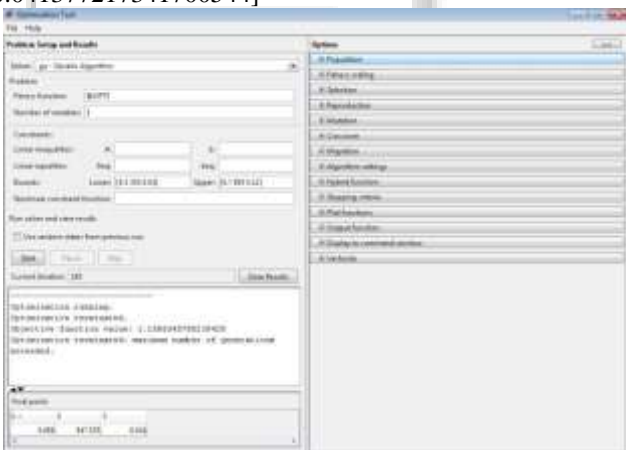


Fig. 1: result snap from MATLAB for RA

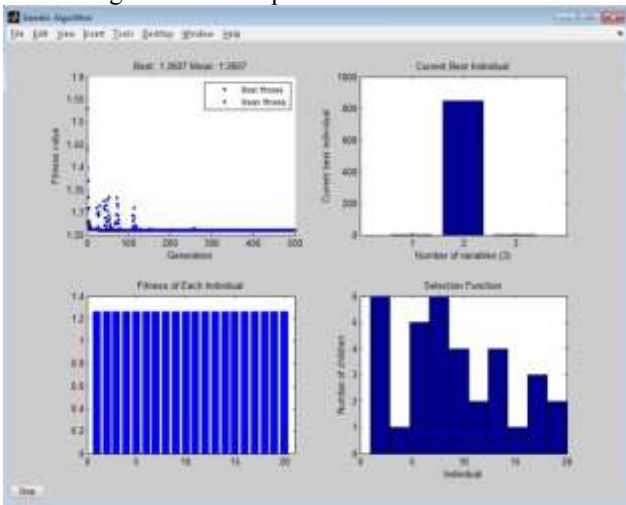


Fig. 1: Graph result for RA

V. SUMMARY OF THE WORK

After completion of the experimental work and analysis of the response conclude that the desired surface roughness achieve by the set of the different experimental value such that optimum value of this experiments, RA = 1.2686045785239428 for set of input parameter: [doc speed feed] = [0.6864289285685153 847.5354859388498 0.041377217341700544]

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