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OPTIMIZATION OF PROCESS PARAMETER IN TITANIUM ALLOY BY USING GENETIC ALGORITHM

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Abstract

Turning is one of the very important machining operations in engineering industries. Optimization of turning processes parameters still remains as one of the most challenging problems because of its high complexity and non-linearity. Hence, there is a need to apply most powerful optimization techniques to get desired accuracy of optimum solution. In this paper, non-conventional optimization techniques, genetic algorithm (GA) results were compared with Taguchi Optimization technique. The process variables considered for optimization are speed, feed, and depth of cut. The objective considered in the present work is surface finish subjected to the constraints.

Keywords: Turning, Optimization, Process parameters, Taguchi Analysis, Genetic algorithm.

1. INTRODUCTION

Process parameters composed of cutting speed, feed and depth of cut (for turning operation), have essential effects on the machining productivity and cost. The selection of cutting parameters has long depended on the skills and experience of machine tool operators or handbooks, and conservative cutting parameters are usually selected. This situation would cause significant productivity loses and lead to a costly machining operation. The determination of optimum cutting parameters is a combinatorial optimization problem and is usually realized by applying optimization algorithms. These algorithms include neural network, geometric programming, simulated annealing, genetic algorithm (GA), particle swarm optimization (PSO) etc. GA was considered as a suitable algorithm for solving any type of machining process optimization problem. In this paper, Process parameters optimization by using GA and Taguchi Method were discussed comprehensively.

2. LITERATURE REVIEW

Tarng. Y.S , S.C. Juang and C.H. Chang [2] proposes the use of grey-based Taguchi methods for the optimization of the Submerged Arc Welding (SAW) process parameters in hard facing with considerations of multiple weld qualities. In this new approach, the grey relational analysis is adopted to solve the SAW process with multiple weld qualities. A grey relational grade obtained from the grey relational analysis is used as the performance characteristic in the Taguchi method.

Vijayan. P and V. P. Arunachalam[3] reported research in their work Taguchi off-line quality control method applied for determines the optimal process parameters which maximize the mechanical properties of squeeze cast LM24 aluminum alloy. For this purpose, concepts like orthogonal array, S/N ratio and ANOVA were employed.

Anshuman Sahu and Rudrajit Tapadar attempts to solve the generalized Assignment problem through genetic algorithm and simulated annealing. The generalized assignment problem is basically the N men N jobs problem where a single job can be assigned to only one person in such a way that the overall cost of assignment is minimized. While solving this problem through genetic algorithm (GA), a unique encoding scheme is used together with Partially Matched Crossover (PMX).

3. EXPERIMENT DETAILS

Work Piece & Cutting Tool:

The work piece used here is Titanium Alloy grade (II) because it’s high strength and low density[1]. We are using carbide cutting tool for machining titanium CNMG PR-3215.

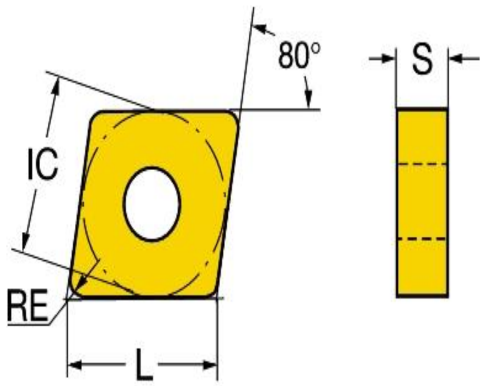

Fig.1: Insert geometry

Fig.2: CNC Machining

Tablel Cutting parameters

Parameter	Level 1	Level 2	Level 3
Cutting	60	70	80

Speed(m/min)			
Feed (mm/rev)	0.05	0.1	0.15
Depth Of Cut (mm)	0.2	0.4	0.6

4. TAGUCHI METHOD

The Taguchi method is a well-known technique that provides a systematic and efficient methodology for process optimization and this is a powerful tool for the design of high quality systems. Taguchi approach to design of experiments (DOE) is easy to adopt and apply for users with limited knowledge of statistics, hence gained wide popularity in the engineering and scientific community. This is an engineering methodology for obtaining product and process condition, which are minimally sensitive to the various causes of variation, and which produce high-quality products with low development and manufacturing costs. Signal to noise ratio and orthogonal array are two major tools used in the design.

The S/N ratio characteristics can be divided into three categories when the characteristic is continuous

a) Nominal is the best

b) Smaller the better

c) Larger is better characteristics.

For the minimum Cutting Force, the solution is "Smaller is better" and S/N ratio is determined according to the Following equation

Table 2. S/N Ratio

Cutting Speed	Depth Of Cut	Feed	Surface Roughness	S/N Ratio
60	0.2	0.05	6.415	-16.1439
60	0.4	0.10	1.804	-5.1247
60	0.6	0.15	4.594	-13.2457
70	0.2	0.10	2.714	-6.7452
70	0.4	0.15	2.946	-9.3847
70	0.6	0.05	2.145	-6.6285
80	0.2	0.15	3.632	-11.2029
80	0.4	0.05	3.084	-9.7823
80	0.6	0.10	2.298	-7.2270

ANOVA Table:

Analysis of variance (ANOVA) was introduced by Sir Ronald Fisher. This analysis was carried out for a level of significance of 5%, i.e., for 95% level of confidence. The purpose of ANOVA is to investigate which turning parameter significantly affects the performance characteristics.

Table 3. ANOVA Table

Source	Df	Ss	Ms	F-Value	P-Value	C(%)
Cutting Speed	2	5.36	2.68	1.93	0.34	30.45
Depth Of Cut	2	3.24	1.71	1.23	0.44	19.60
Feed	2	5.89	2.94	2.12	0.32	33.75
Error	2	2.78	1.39			15.73
Total	8	17.46				

According to the data obtained from the ANOVA table the following were place major and minor contribution on the surface roughness of the work piece. Here cutting speed contribution on surface is 30.40% of the total contribution, depth of cut 19.6% of total contribution and feed plays a most important role on surface roughness in the range of 33.75% of total contribution.

5. GENETIC ALGORITHM

Genetic algorithms are robust and adaptive methods, successfully used for solving optimization problems. They are powerful tools for the optimization of functions that can more easily locate the global optimum.

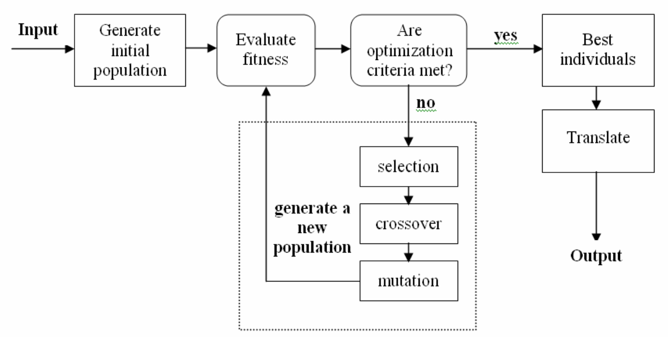

Fig.3: Genetic Algorithm procedure

The reason lies in the fact that GA seeks an optimal solution in the space of solutions, starting from groups of points, rather than a starting point. GA use only the objective function to search optimal solutions [4]. Genetic algorithm is stopped after a certain number of generations or after a certain time interval, after which the quality of the best individuals is tested. If the result is not acceptable, we can start again to search for new (better) solutions [6].

Objective function,

C = 800+8088.64/(x(1)*x(2))+6.332*10^-7*x(1)^4.55*x(2)^.67;

Constraint functions,

$V_c f^{0.3} \leq 146.65$

$V_c f^{0.75} \leq 849.15$

$F^{0.75} \leq 129.45$

$F^{0.75} \leq 55.33$

$V_C \leq 5.278$

$V_C \geq 7.345$

$F_{min} \leq 0.05$

$F_{max} \geq 0.15$

Program 1:

```
function C = turning_cost(x)
C = 800+8088.64/(x(1)*x(2))+6.332*10^-    7*x(1)^4.55*x(2)^.67;
end
```

Program 2:

```
function [c, ceq] = nonlinear_constraints(x)
c = [x(1)*x(2)^0.3-146.46;
x(1)*x(2)^0.75-849.15;
x(2)^0.75-129.63];
ceq = [];
end
```

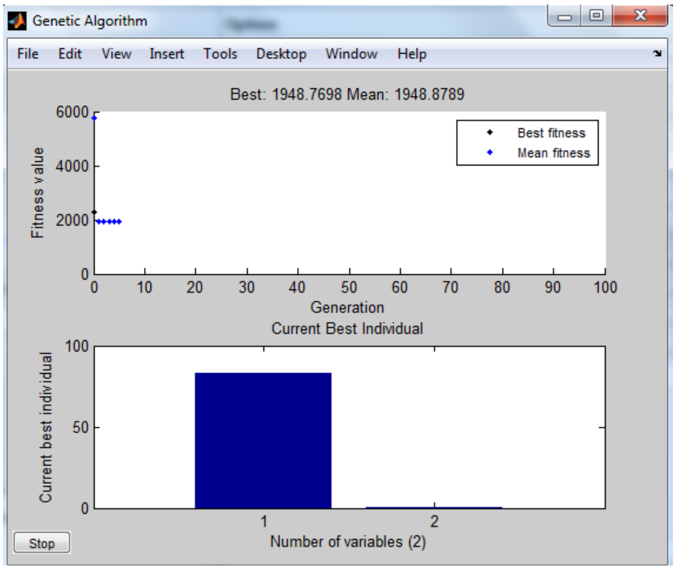

Fig.4: Genetic Algorithm plot

6. CONCLUSION

Modern methods of optimization are powerful and popular tools for solving complex engineering optimization problems. This paper shows the possibilities of using genetic algorithms for solving such problems. Cost of machining in turning process, depending on cutting speed and feed was minimized under some nonlinear constraints. The final result obtained from the GA is

Cutting speed = 83.33 rev/min Feed = 0.09 mm/rev

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