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Application of Artificial Immune Algorithm for Drilling Parameters on Al 6063 NMMC

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***Abstract*— New optimization techniques are evolving every year and one of the technique evolved was artificial immune algorithm, in this paper AI algorithm was used to optimize machine parameters of prepared NMMC. Aluminium Alloy (Al6063) was reinforced with Magnesium Oxide Nanoparticles in the weight % of 0.1%, 0.2%, and 0.3% to prepare NMMC through stir casting method at a temperature of 750 ℃. The product value depends on surface finish (Ra), to have good 'Ra' thrust force and cutting temperature plays vital role. The precise values of thrust force and temperature are obtained using drill tool dynamometer and infrared pyrometer. These values are used to generate a multi response regression equation which has to be optimized. In this paper the application of the Artificial Immune optimization is presented to optimize thrust force and temperature using Matlab. These equations are minimised using immune optimization technique. The results show the optimum machine parameters.**

Keywords*— *Artificial Immune system, Artificial Immune optimization technique, Drilling, NMMC, Optimizing machining parameters

I. INTRODUCTION

The applications of aluminium matrix composite materials are growing continuously in the field of automotive and aerospace because of their superior physical, mechanical and tribological properties as compared to base alloy. Composite materials with metal matrix material e.g. aluminium or magnesium are finding broad level applications in many industries because of their lower density, better wear and corrosion resistance, high strength to weight ratio, good formability, high hardness, high thermal shock resistance, high modulus, high fatigue strength etc. In automotive industry they are being used in various parts such as pistons, cylinders, engine blocks, brakes etc. [1-2]. The machining parameters of machine have a vital role in defining the properties of the job. The value of the material depends upon the Ra [3,4], strength, and durability . To achieve the above properties the job must processes some properties while machining such as machining temperature, force and Ra [5].

To achieve good material properties the machining properties must be optimized. There are many optimization techniques such as genetic algorithm, simulated annealing, and many heuristic models. This paper describes the artificial immune algorithm and how it has been used for optimizing machine parameters. The artificial immune algorithm was developed based on the working of human immune system this system can be modernized and applied for various engineering applications [6,7,8,9]. The proposed algorithm increases the speed of convergence and diversity. Till now the technique was used for transportation, scheduling and flow shop problem and this paper adds some extension [10,11,12]. Matlab is software used to create code for artificial immune algorithm.

II. METHODOLOGY

A. Artificial immune algorithm

Artificial immune algorithm is an algorithm based on immune system of human. The immune system consists of B-cells these are also called as antibodies. The pathogen is called as antigen. The antigens cause deceases, in order to cure these decreases the antibodies are generated. If these antibodies are not capable of curing or killing the present type of pathogen then the antibody of highest capability is cloned for no. of times and then mutated to get a high affinity antibody. The antibodies produced may either high or low affinity and the high affinity antibody is selected to kill antigen.

The above procedure is used in real life engineering problems as an optimization technique same as genetic algorithm. In this algorithm the antibodies are represented in the form of binary codes which is easy for mutation. Inverse mutation is used in this paper.

B. Cloning

The clonal selection principle describes the basic features of an immune response to an antigen stimulus. The main features of the clonal selection theory are

1. The new cells are copies of their parents(clone) subjected to mutation
2. Proliferation and differentiation on contact of mature cells with antigens.

The antibody having higher fitness is selected for clone for minimization and vice-versa

Fitness value=1/affinity value

2.3 Mutation.

It is the formation of new antibodies with different affinity value. In this we use inverse mutation.

E.g. Let x, y be the positions generated randomly
x=1, y=3

Antibody before mutation

0	0	1	1	1

Antibody after mutation

1	0	0	1	1

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The following steps describes the immune algorithm procedure

1. Set population size
2. Find fitness value for antibodies
3. Select *i*th antibody having best fitness
4. Convert the antibody into binary system
5. Clone the *i*th antibody for C no of times
6. Mutate each clone
7. Get the mutated clone with the best fitness(f)
8. If f fitness better than the fitness of initial antibody replace it with latest
9. Repeat step from 2-9 for (I) no of iterations.

III. EXPERIMENTAL PROCEDURE

A. *Materials*

Base material used in the present paper is Al 6063 due to wide and vast applications in various sectors. Elemental composition of alloy is listed below (Table 1).

Table1. Chemical Composition of Al 6063

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.20–0.6	0.35	0.1	0.1	0.45–0.9	0.1	0.10	0.1	Bal

Reinforcement used is MgO nano particles where the average particle size is about 15nm were selected due to its suitable properties related to Al 6063.

B. *Preparation of NMMC*

A stir casting furnace is used for preparation of NMMC samples. It consists of a furnace with top opening, stirrer setup with a motor, a graphite crucible and K-Type thermo couple to measure the temperature. The stirring speed is controlled by variable speed motor which is equipped with frequency controller.

C. *Machining parameters*

For minimizing the experimental cost Taguchi mixed design of experiments OA L18 is used. Various parameters such as NMMC, spindle speeds, feeds, drill tool materials, which influences the temperature, force and surface roughness. Considered parameters and their levels shown in the Table.2.

Table2. Influential Parameters and their levels

S. No	Influential Parameters	LEVEL1	LEVEL2	LEVEL3
1	Tool Material	HSS	TIN COATED HSS	-
2	NMMC	Al6063 +0.1%MgO	Al6063+0.2 %MgO	Al6063+0.3 %MgO
3	Speed (rpm)	220	355	500
4	Feed (mm/rev)	0.15	0.2	0.3

D. *Experimental results*

The experimental results are determined by using technically high instruments and sensors. The Ra, temperature and force are determined by using Talysurf surface roughness tester, Infrared pyrometer and drill tool dynamometer respectively. (Fig 1,2,3)

Fig1. Infrared Pyrometer

Fig2. Drill tool dynamometer

Fig3. Talysurf

Fig4. Drilled Holes

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Table3. Experimental Results

S.No	Temp (°C)	Force (kgf)	Surface Roughness (µm)
1	49.4	20.5	0.88
2	61.8	22.1	0.9
3	64.7	24.2	1.1
4	40.5	21.2	1.15
5	52.3	22.8	1.29
6	63.5	24.6	1.65
7	43.4	20.9	1.33
8	45.4	22.2	1.61
9	49.2	23.6	1.74
10	36.3	16.8	0.67
11	39.9	19.2	0.79
12	44.4	20.5	0.85
13	41.4	15.7	0.97
14	43.6	17.5	1.07
15	45.3	20.2	1.13
16	47.8	21.1	1.23
17	49.2	22.6	1.48
18	51.8	24.1	1.52

As materials cant be optimized through equations, those can be selected by analysis the obtained results from conducted drilling experiments. In this work, Al6063+0.3%MgO and TiN coated HSS are selected as best materials for machining as they got reduced burrs and minimal surface roughness values.

E. Regression equations

A multi response regression equation was generated for each set of experiments. These equations resemble the objective function used in artificial immune optimization. Since to get the better Ra the cutting vibrations, cutting temperature and roughness has to be minimised. Therefore these equations should be minimized to find optimum machine parameters.

The objective functions generated for various responses are

$$F(n) = 0.90076 - 0.001117(n) + 0.000001n^2 \quad (1)$$

Subject to $220 \leq n \leq 500$

$$F(f) = 0.53020 - 0.030260(f) - 1.5f^2 \quad (2)$$

Subject to $0.15 \leq f \leq 0.3$

- n= Speed
- f=Feed

- Results.

The results obtained from through immune algorithm are

- Speed = 450 rpm
- Feed = 0.3 mm/rev

Speed (rpm)	Feed (mm/rev)	Temperature (°C)	Surface roughness (µm)	Force (kgf)
450	0.3	36.8	0.54	15.4

The surface roughness, temperature and force values are good at the optimum parameters.

IV. CONCLUSIONS

a. Al6063 is successfully reinforced with Nano Magnesium Oxide at varying Wt. % via Stir casting technique.
b. The Drilling Responses such as Temperature, Force and surface roughness are evaluated.
c. TiN coated HSS drill tool shows better performance compared to HSS.
d. The immune system is highly distributed, highly adaptive, self organizing in nature, by maintaining a memory of past encounters.
e. The optimum parameters are obtained from the parametric study yield good results in the minimization of responses Temperature, Force and surface roughness.

V. ACKNOWLEDGMENT *(HEADING 5)*

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