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Optimization of process parameters in Abrasive Flow Machinig with Particle Swarm Opimization

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Abstract—Abrasive flow machining (AFM) process is a non-traditional finishing process used for polishing and radius difficult to reach surfaces by the abrading action of the abrasives. The material to be machined is taken in the form of a cylinder. The abrasives are taken in the work piece and rotated at high RPM.AFM can be used to produce high surface finish.Vaious process parameters are abrasive size, Machining time, Hardness of abrasives and speed of abrasives. The experimental results reveals that the efficiency of the process strongly linked to the mechanical properties of the machined material and machining time. This technique offers good surface finish without affecting closesest geometrical tolerances of materials.

Keywords-Abrasive flow machining, Surface finish, Particle swarm optimization; fitness function.

I. Introduction

AFM is widely used as a finishing process to finish complicated shapes and profiles. This technique developed in 1960s.AFM is mainly classified into three types. (1) one way AFM (2 two way AFM (3) Orbital AFM.The polymer abrasive medium which is used in this process, posses easy flow ability, better self deformability and fine abrading capability. The ability of media in AFM process to finish difficult to reach areas, to follow complex contours and to simultaneously work on multiple edges and surfaces, makes it more versatile than other finishing process. A thickness of 1 to 10μm can be removed by this process.AFM reduces surface roughness by 75 to 90 percent on cast and machined surfaces. It can be used to produce uniform, repeatable and predictable results on an impressive range of polishing operations. Important feature which differentiates AFM from other finishing process is that it is possible to control and select the intensity and location of abrasion through fixture design, medium selection and process parameters. Optimization of process parameters in AFM with neural networking has been done by R.K.Jain and V.K.Jain[1] The objective of the present paper is to optimize the process parameters of the process through Particle Swarm Optimization method. –

2. Particle Swarm optimization (pso)

Particle swarm Optimization is a stochastic optimization technique developed by Dr Eberhart and Dr Kennedy, inspired by social behavior of bird flocking or fish schooling.PSO is initialized with a group of random particles (solutions) and then searches for optima by updating generations. In every iteration each particle is updated by following two best values. The first one is the best solution (fitness) it has achieved so far. This value is called pbest. Another best value that is tracked by the particle swarm optimizer is the best value obtained so far by any particle in the population. This value is the global best and called gbest. When a particle takes part of the population as its topological neighbors, the best value is called local best or I best. After finding the two best values, the particle updates its velocity and positions.PSO is easy to implement compared to GA. This method is effectively applied in the areas of function optimization, artificial neural networking and fuzzy system control.

2.1 PSO algorithm

Each particle keeps track of its coordinates in the problem space, which are associated with the best solution (fitness) it has achieved so far. (The fitness value is also stored.) This value is called pbest. Another best value that is tracked by the particle swarm optimizer is the best value, obtained so far by any particle in the neighbors of the particle; the best value is a global best and is called gbest[2,3]. The steps involved in PSO are outlined as follows.

Phase I - Initialization

The particle parameters are randomly generated in solution space. This provides a set of values to begin the iteration.

Phase II – Evaluation

(1) The *fitness* of the particle is evaluated.
(2) In every iteration, each particle is updated by following two "best" values.
(i) Best solution (fitness) it has achieved so far (pbest).
(ii) The best value, obtained so far by any particle in the population (gbest).

(3) After finding the two best values, the particle updates parameters.

Phase III – Stopping Criteria

The iterative procedure is stopped if one of the following criterions is met:
(1). Maximum change in best fitness smaller than specified tolerance.

(2). If maximum number iterations are attained**.**

2.2 Pseudo code for the algorithm

For each particle
{
Initialize particle parameters
}
END
Do
{For each particle
Calculate fitness value (If the fitness value is better than the best fitness value (pBest) in history set current value as the new pBest)
}
END
(Choose the particle with the best fitness value of all the particles as the gBest)
For each particle
{
Update particle parameters
END
(While maximum iterations or minimum error criteria is attained)

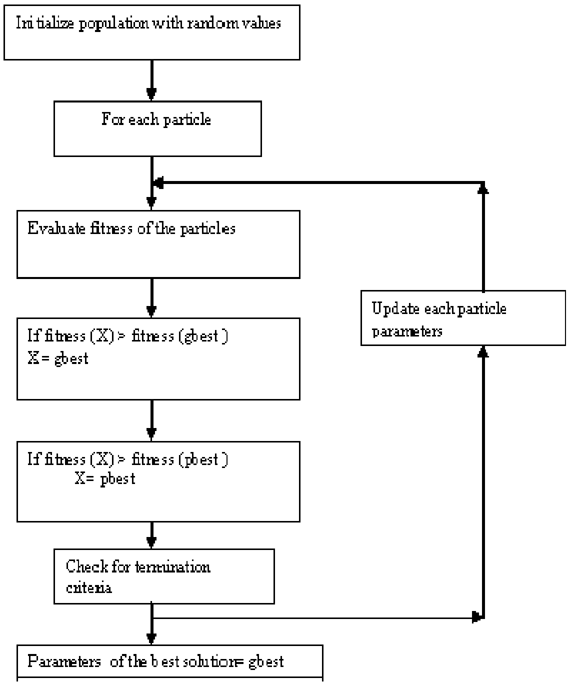

Figure 1. Pso flow chart

3 Experimentation

Machining experiments were carried out with aluminum as the work piece material. The medium was silicon carbide and putty mixture. Experiments were carried out by changing rpm of the work piece. Percentage concentration is defined as the ratio of weight of the abrasives and total weight of the medium multiplied by 100.When the rpm changes the linear velocity of abrasive changes from40 to 90cm/min. The variation of and surface finish with respect to velocity, abrasive size were measured. The data collected from these experiments were used for PSO analysis.

3.1 Experimental details

PROCESS PARAMETERS

Abrasive flow speed (v) cm/min

Vmin <v <vmax

Percentage concentration of abrasives (c)

C min < C < C max

Abrasive mesh size

d min <d <d max

Number of cycles (n)

3.2 Constraint

The constraint evaluated is Surface roughness constraint (Ra).It indicates the quality of machined surface (surf test equipment is used to measure surface roughness).

3.3 Work piece material

The work piece material used in the study was Aluminium. They were in the form of cylindrical tubes of diameter 4cm and length 10cm.

3.4 Abrasive used

Silicon Carbide(SiC)

Table 1. Experimental results

S.I no	Abrasive flow speed (cm/min)	Concentration (c)	Mesh size	n (N0)	Hardness	Roughness Ra (µm)
1	40.60	45.03	100	50	160	1.52
2	51.50	37.0	100	20	160	1.82
3	51.50	45.0	150	50	160	1.40
4	65.20	45.0	100	50	170	0.95
5	81.20	45.0	100	50	170	1.60

3.5 Results obtained

The analysis was made by running PSO program(C language), for 50 iterations. The fitness function is evaluated using following relation

$$\text{Fitness function} = \sum_{i=1}^{n}(Ra(i) - R_r a(i))^2$$

Empirical model for surface roughness

$$R_a = K\, v^x c^y d^z n^p$$

The results obtained are

Value of K=28270

X = - 1.82

Y = - 1.32

Z = - 1.40

P = - 0.23

Empirical model by PSO

$$R_a = 28270\, v^{-1.82} c^{-1.32} d^{-1.140} n^{-0.2258}$$

4 Conclusions

For solving machining opimisation probles,various conventional techiniques has been used so far,but they are robust and have problems when they applied to AFM,Which involves a number of variables and constraints.They are non linear also.To overcome the above problems,partcle swarm opimisation is used in this work.Particle swarm opimisation converges to the global opimal solution faster. *The PSO technique was found to converge to opimum in a faster rate.PSO is a generalised techinique and can be easily modified.The methode requires only primitive mathematical operatives,so it is computationallly inexpensive in terms of memory and requirements and speed.*

Comparison of PSO results with those of neuralnetworking shows that the PSO algoritham is more effective for optimization of machining parameters.The algoritham is simplar in PSO.Number of iterations required to reach opimum value is also less in PSO.

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