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Evaluation of cutting and geometric parameter of single point cutting tool for turning operation

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Abstract—Evaluation of cutting and geometric parameter is one of the most important elements for quality and productivity which play significant role in today's manufacturing market. From customers' viewpoint quality is very important because the extent of quality of the procured item (or product) influences the degree of satisfaction of the consumers during usage of the procured goods. Therefore, every manufacturing or production unit should concern about the quality of the product. Apart from quality, there exists another criterion, called productivity which is directly related to the profit level and also goodwill of the organization. Turning is the first most common method for cutting and especially for the finishing machined parts. In a turning operation, it is important task to select cutting and geometric parameters for achieving high cutting performance. In this paper,particle swarm optimization technique is used efficiently to optimize cuttingand geometric parameter like cutting speed,feed,depth of cut and rake angle due to complexity of cutting and geometric parameter optimization. The overall objective of this study is to predict the tool wear evolution and tool life in orthogonal cutting

Keywords— particle swarm optimization, tool wear, tool life, rake angle, cutting speed

INTRODUCTION:

Turning is the first most common method for cutting and especially for the finishing machined parts. In a turning operation, it is important task to select cutting parameters for achieving high cutting performance. Usually, the desired cutting and geometric parameters are determined based on experience or by use of a handbook. Cutting parameters are reflected on surface roughness, surface texture and dimensional deviations of the product. Surface roughness, which is used to determine and to evaluate the quality of a product, is one of the major quality attributes of a turning product. To select the cutting parameters properly, several mathematical models *[7]* based on statistical regression or neural net-work techniques have been constructed to establish the relationship between the cutting performance and cutting parameters. Then, an objective function with constraints is formulated to solve the optimal cutting and geometric parameters using particle swarm optimization techniques. Therefore, considerable knowledge and experience are required for this approach. In this study, an alternative approach based on the particle swarm optimization technique is used to determine the desired cutting and geometry parameters.

In present project work. flank wear is measured with difference of weight before and after machining of work piece material.It is well known that as the tool life increase, the tool wear reduce. It is observed that tool life is inversely proportional to tool wear. By using mathematical modeling it is also observed that the tool life is increase and tool wear is decrease. There are many significant to be analyzed in order to optimize the cutting and geometric parameter because it will affect the quality and the productivity of that material. Optimization of cutting and geometric parameters is usually a difficult work, where the following aspects are required like knowledge of machining, empirical equations relating the tool life, specification of machine tool capabilities and knowledge of mathematical and numerical optimization techniques also is compulsory. Similarly in this work software are used for analysis i.e. MATLAB (.particle swarm optimization techniques).

2. EXPERIMENTATION

The scope and objectives of the present work have already been mentioned in the forgoing chapter. Accordingly the present study has been done through the following plan of experiment

a) Checking and preparing the CMT-200 CNC Turner ready for performing the machining operation.
b) Cutting MS bars by power saw and performing initial turning operation in CMT-200 CNC to get desired dimension of the work pieces.
c) Performing straight turning operation on specimens in various cutting..Environments involving various combinations of process control parameters like: spindle speed, feed, depth of cut and rake angle.
d) Calculating weight of single point cutting tool by the high precision digital balance meter before machining. Involving various combinations of process control parameters like: spindle speed, feed, depth of cut and rake angle
e) Calculating weight of single point cutting tool by the high precision digital balance meter after machining. Involving various combinations of process control parameters like: spindle speed, feed, depth of cut and rake angle
f) Take nine readings before and after machining of single point cutting tool by the high precision digital balance meter. Involving various combinations of process control parameters like: spindle speed, feed, depth of cut and rake angl
g) Measuring cutting tool flank wear in difference of before and after machining of single point cutting tool.i.e tool life
h) Measuring surface roughness or surface finish of the work piece with the help of dial height gauge

Table No.1 Recommend Value from Data Book

Factor	Level 1	Level 2	Level 3	
Cutting speed(m/min)	30	45	60	A
Feed Rate (mm/rev)	0.2	0.250	0.3	B
Depth of cut (mm)	0.5	1.0	2.0	C
Rake angle(back rate)	07	08	9	D

Equipments for Experiment:

The list of equipments used during experimentation is provided below together with some basic information on their specifications:

CMT-200 CNC Turner Lathe:

It is used for the turning operation. The machine's motor horse power is 8.3 kW and the spindle speed ranges between 100 to 6000 rpm. The machine has a capacity of 8 tool. Figure No. 1 shows the CNC lathe machine.

Figure No. 1: CMT-200 CNC Turner

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3. Experimental Data

Expt. No.	WEIGHT OF TOOL		
	BEFORE EXPT.(gm)	AFTER EXPT. (gm)	DIFFREN-CE (gm)
1	141.354	141.322	0.032
2	141.352	141.3262	0.0258
3	141.355	141.3277	0.0273
4	141.35	141.321	0.029
5	141.351	141.3183	0.0327
6	141.353	141.323	0.03
7	141.352	141.3223	0.0297
8	141.354	141.3298	0.0242
9	141.351	141.3227	0.0283

The following value shows the material loss of single point cutting tool at different cutting parameters. These values are nothing but the tool wear of the cutting tool as it loses its weight during operation.

	A	B	C	D	F
Expt No.	Cutting Speed (m/min)	Feed Rate (mm/Rev)	Depth Of Cut(mm)	Rake Angle (degree)	Difference Weight (gm)
1	30	0.2	0.5	07^0	0.032
2	30	0.250	1.0	08^0	0.0258
3	30	0.3	2.0	09^0	0.0273
4	45	0.2	1.0	09^0	0.029
5	45	0.250	2.0	07^0	0.0327
6	45	0.3	0.5	08^0	0.03
7	60	0.25	2.0	08^0	0.0297
8	60	0.3	0.5	09^0	0.0242
9	60	2.0	1.0	07^0	0.0283

The reading of experiment no.8 shows the lowest value of difference in the weight before operation and after operation. Lowest value shows that there is less amount of material removed from the tool. So we can say that there is less wear occurred. Hence the experiment no.8 shows that the optimum parameter for the tool life for single point cutting tool.

4 ANALYSIS OF SURFACE ROUGHNESS:

After conducting the experiment of the single point cutting tool at different condition the following values are measured on height gauge.

Table No.2 Avg. Value Of Surface Roughness Of The Tool

EXPT.NO	SURFACE ROUGHNESS OF THE TOOL		
	DEFLECTION OF DIAL INDICATOR		
	MAX	MIN	AVERAGE(μ m)
1	1.32	1.48	1.40
2	1.12	0.38	0.75
3	1.45	1.73	1.59
4	0.47	0.33	0.40
5	0.52	1.12	0.82
6	0.43	1.77	1.10
7	0.54	0.32	0.43
8	0.28	0.32	0.30
9	1.36	2.04	1.70

Table No.3 Experimental Data After Turning Operation At Different Cutting And Geometric Parameter

	A	B	C	D	F
Expt. No.	Cutting Speed (m/min)	Feed rate (mm/rev)	Depth of cut(mm)	Rake angle(degree)	Surface Roughness value(μm)
1	30	0.2	0.5	07^0	1.40
2	30	0.250	1.0	08^0	0.75
3	30	0.3	2.0	09^0	1.59
4	45	0.2	1.0	09^0	0.40
5	45	0.250	2.0	07^0	0.82
6	45	0.3	0.5	08^0	1.10
7	60	0.250	2.0	08^0	0.43
8	60	0.3	0.5	09^0	0.30
9	60	2.0	1.0	07^0	1.70

The above reading of experiment no.8 shows that mean surface roughness value of the tool after operation is the lowest value of all the readings. Lowest value shows that there is less amount of material removed from the tool, hence less flank wear occurs and it gives less surface roughness value. Hence experiment no.8 shows the optimum parameter for the tool life.

5 ANALYSIS OF EXPERIMENT SOFTWARE MATLAB7.5.0 (R2007B): PARTICLE SWARM OPTIMIZATION TECHNIQUE INTRODUCTION:

The Particle Swarm Optimization (PSO) is introduced by James Kennedy and Russell Eberhart in 1995. PSO is an evolutionary computation technique like genetic algorithms. Since PSO have many advantages such as comparative simplicity, rapid convergence and little parameters to be adjusted, it has been used in many fields such as mechanical, chemical, civil, aerospace design etc. The particle swarm algorithm is an optimization technique inspired by the metaphor of social interaction observed among insects or animals. The kind of social interaction modelled within a PSO is used to guide a population of individuals (particles) moving toward the most promising area of the search space. In a PSO algorithm, each particle is a candidate solution and each particle "flies" through the search space, depending on two important factors; the best position the current particle have found so far and the global best position identified from the entire population. The rate of position change of particle is given by its velocity. k is the iterations number. Particles velocity and positions are updated according to (2), (3) and (4) equations related to the pbest and gbest values.

Methodology:

PSO is similar to a genetic algorithm (GA) in that the system is initialized with a population of random solutions. It is unlike a GA, however, in that each potential solution is also assigned a randomized velocity, and the potential solutions, called *particles*, are then "flown" through the problem space. 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 *global* version of the particle swarm optimizer is the overall best value, and its location, obtained so far by any particle in the population. This location is called *gbest*. The particle swarm optimization concept consists of, at each time step, changing the velocity (accelerating) each particle toward its *pbest* and *gbest* locations (global version of PSO). Acceleration is weighted by a random term, with separate random numbers being generated for acceleration toward pbest and gbest locations.

1. Initialize a population (array) of particles with random positions and velocities on d dimensions in the problem space.
2. For each particle, evaluate the desired optimization fitness function in d variables.
3. Compare particle's fitness evaluation with particle's pbest. If current value is better than pbest, then set pbest value equal to the current value, and the pbest location equal to the current location in d-dimensional space.
4. Compare fitness evaluation with the population's overall previous best. If current value is better than gbest, then reset gbest to the current particle's array index and value.
5. Change the velocity and position of the particle according to equations

Algorithm

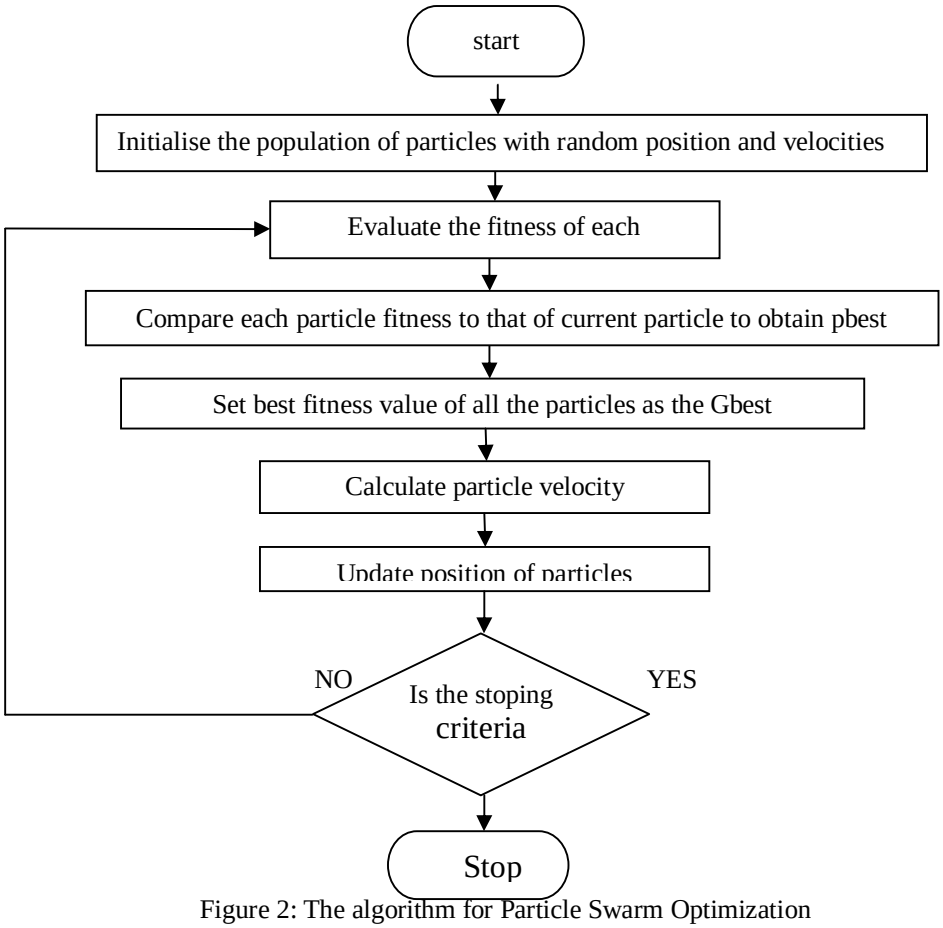

Figure 2: The algorithm for Particle Swarm Optimization

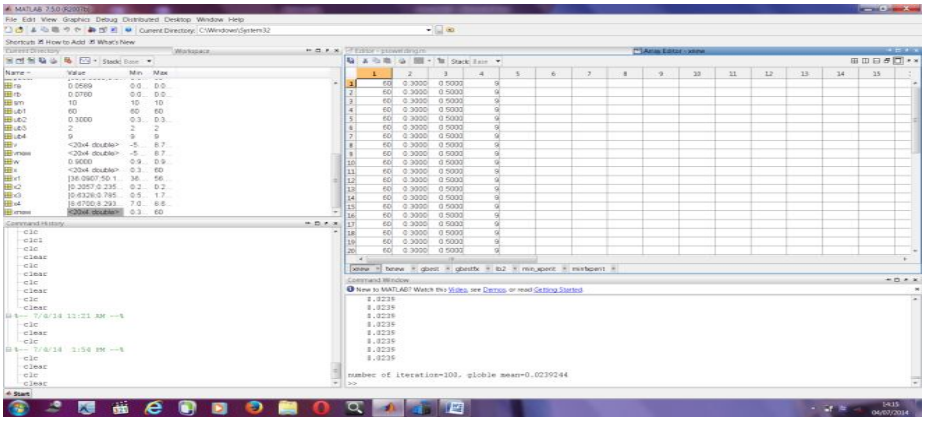

Figure No.3: Screen Print Out Of The Design-Expert Plot Using The MATLAB7.5.0(R2007b**)**

5. CONCLUSION

The metal cutting operation and tool life both are the most complicated phenomena in the manufacturing industry. So optimization of this parameter (cutting and geometric) is the most important aspect for increasing tool life and quality of the production for the manufacturing industry.

This project work proves that the tool life increases by optimizing the parameter, whereas it also increases the quality of production by reducing the surface roughness of the work piece. This works also studied the machining parameter and the geometrical parameter for optimization.

The Particle swarm optimization gives the design for optimizing parameters and it also gives the desired results. The regression technique is used for generation of mathematical model, which helps for better experimental results of the optimum designed tool.

And at the last, the relational model developed by using BUCKINGHAM'S π-theorem helps for further design if the parameter changes.

Thus, a multi-objective optimization problem has been converted into a single objective function optimization problem which can be solved by The Particle swarm optimization

RESULTS		
Sr. No.	Experimental value (gm)	MATLAB Software value (gm)
1	0.0242	0.0239

The following result obtained which gives the optimized value for better tool life.

- Co-relational Model: T.L. = V/dp. ϕ(Fr/V dp, γ)
- Math. Model: T.L =0.0949[V/dp]-0.0137 ×[Fr/Vdp]-0.00527×[γ]-0.592
- Moderated Rake Angle= 9^0
- Moderate Value Of The Depth Of Cut=0.5 mm
- Moderate Value Of Speed= 60m/min.
- Moderate Value Of feed rate= 0.3mm/rev.

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