Cost Minimization of Turning Machining Process with Materials using Abc, Auction, Ant Lion, Elephant, Spiral, Bacterial, Greedy, Lawlers Fireworks and Pattern Search

1T. Jagan, 2S. Elizabeth Amudhini Stephen

1Scholar, Department of Mathematics, Karunya Institute of Technology and Sciences; 1Assistant professor, Department of Mathematics, KG College of Arts and Science, Coimbatore, 2Associate professor, Department of Mathematics, Karunya Institute of Technology and Sciences, elizi.felix@gmail.com

Abstract: The optimization algorithms are used in machining process for improving product quality and minimizing cost and time. The turning machine process is used for cutting speed and feed. This paper describes the optimization of machining process by using the ABC algorithm, Auction, Spiral, Ant lion, Elephant herding, Bacterial colony, Greedy, Lawler's, Fireworks and pattern search for these ten non-traditional methods. In this paper, we have compared the solution to minimize the total cost and time of turning machine process using ten artificial optimization methods. We conclude which method gives a better solution for turning machine process.

Keywords: Turning machine process, Optimization Algorithm, Cost minimization, ABC algorithm, Auction, Ant lion, Elephant herding, Spiral, Bacterial colony, Greedy, Lawler's, Fireworks and Pattern search.

1. Introduction: The machine process involves the different ranging from cutting speed, feed, depth of cut and number of passes to output of production cost, tool life, production time, cutting forces, cutting temperature and power consumption etc. Selecting particular of cutting condition has a significant impact on product quality and machining cost. The parameters are Feed (f), Cutting speed (Vc) and Cutting depth (D).

Optimization machining process condition related to parameter selection problem of multi pass turning (2). The different authors attempted optimization of the same problem using varies methods (3, 4). The hybrid technique based on simulation algorithm and pattern search to minimize the production cost proposed by Chen (5). The optimization based on genetic algorithm approached in optimization technique (6). The pattern search method attract more researcher by solving a complex optimization problem (3). The same model is attempted using hybrid algorithm and genetic algorithm (7).

The above literature review presented, turning machine process is a complex problem to solve various optimization approaches. In this work pattern search is developed to minimize the unit production cost. The proposed optimization method is highlighted by comparing the obtained results with non-traditional optimization methods.

In this next session, we present objective of the problem to minimize subject to various constraints. In same, we proposed an algorithm is studied and results are presented and compared with other non-traditional optimization methods.
2. Process optimization

2.1. Machining Process

Various process in machining, which is a raw material is cut into final desired shape and size.

2.2. Turning

Turning process is machining internal or external cylindrical surfaces, which is the part is rotated as the tool against on machine. It is called LATHE. The lathe is a surface revolution. When the feed rate is increasing then the work piece is rotated. The cutting speed is determines the rpm of the work piece. Generally the process of turning involves rotating a single point cutting tool is moved to axis of rotation. The other process is casting, forging, extrusion or drawing in turning machine process.

2.3. Cutting Tools

The lathe is also known as a single point cutting tool. The cutting edge or point are drill has cutting edges of numerous points of teeth. The lathe is rather than cutting and it only do if there is motion between the tool and work piece. For example, the tool and work is rotating is moved into a path. The amount of movement is too much of instance result in breakage.

2.4. Tool Life

As a general rule the relationship between the tool life and cutting speed is $V T^n = C$

Where; $V =$ cutting speed in m/min; $T =$ tool life in min; $C =$ a constant
2.5. Cutting Speed & Feed

We proceed to the process of relative speed work rotation, metal cutting and feed rates of cutting tool to be cut must. The items to be manufactured cost effective in minimum time, accordance with specification of quality and accuracy if this relationship of paramount importance.

2.5.1. Cutting Speed

The optimum cutting speed with all the materials and its defined speed with a point on the surface. The work process to the cutting edge or point of the tool. Then we calculate the spindle speed.

\[ N = \frac{CS \times 100}{\pi d} \]

Where:

N = Spindle Speed (RPM)
CS = Cutting Speed of Metal (m/min)
d = Diameter of Work piece

2.5.2. Feed

The word feed is used to determine the distance of the tool moves per revolution of the work on the surface. The out of a soft material a feed of up to 0.25mm per revolution used. The materials should be reduced to a maximum of 0.10mm/rev.

3. MATHEMATICAL MODELLING OF MACHINING COST.

Machining optimum provides the nearest optimum solution in actual cutting process. There is two types of optimization. The first part is mathematical formulation and second part is finding global optimum solution.

\[ C = C_c t_c + C_t t_m + \frac{t_m}{T} (Cr \cdot t_d + Ca) \]

Machining time in turning process

\[ t_m = \frac{\pi DL}{1000 \cdot Vc \cdot f} \]
tool life
\[ T = \frac{Cr}{v_c^p \cdot f_q \cdot d_p} \]

Cost of machining
\[ C = C_1 + C_2 \cdot v_c^{-1} \cdot f_0^{-1} + C_3 \cdot v_c^{-1} \cdot f_0^{-1} \]

Where:
\[ C_1 = C_r \cdot t_L \]
\[ C_2 = \frac{\pi \cdot D \cdot L \cdot Cr}{1000} \]
\[ C_3 = \frac{\pi \cdot D \cdot L \cdot r \cdot (Cr \cdot t_d + Ca)}{1000 + Cr} \]

Constraints functions:

a. Constraint on the cutting tool ability: \[ V_c \cdot f_0^l \leq \frac{C_p \cdot K_v}{T \cdot m \cdot a_p} \]

b. Machine tool power force constraints: \[ V_c \cdot f_0^l \leq \frac{6 \cdot 12 \cdot 0.1}{P_m \cdot \eta \cdot C \cdot k \cdot f \cdot a_p} \]

c. Strength tool constraints: \[ f_0^l \leq \frac{R_s d}{C_k \cdot l \cdot C_0 \cdot k \cdot f \cdot a_p} \]

d. Stiffness work piece constraints: \[ f_0^l \leq \frac{\delta \cdot E \cdot I}{0.8 \cdot C \cdot k \cdot f \cdot a_p} \]

e. Constraints on the minimal spindle speed: \[ v_c \geq \frac{\pi \cdot D \cdot n_{min}}{1000} \]

f. Constraints on the maximal spindle speed: \[ v_c \leq \frac{\pi \cdot D \cdot n_{max}}{1000} \]

g. Constraints on the minimal feed: \[ f \geq f_{min} \]

h. Constraints on the maximal feed: \[ f \leq f_{max} \]

The Mathematical model of the objective function is represented as:

Objective function: \[ \text{min } C = 0.30 + \frac{4.60}{v_c \cdot f} + 1.72 \cdot 10^{-1} \cdot v_c^{4.55} \cdot f^{0.67} \]
The above problem is solved using all the ten non-traditional optimization methods. And each method is run for 20 trials and the average values are taken for \( V_c \), \( f \) and the cost.

### 4. PARAMETERS:

The problem is solved using all the ten nontraditional optimization methods and the parameters are tabulated for comparison purpose.

| Trial No. | ABC  | AUCT | ANT  | ELE  | SPIRAL | BACT | GREEDY | LAWLERS | FIRE  | PATT  |
|-----------|------|------|------|------|--------|------|--------|---------|-------|-------|
| Objective | 0.3454 | 0.3455 | 0.33998 | 0.3462 | 0.3461 | 0.3655 | 0.3458 | 0.3553 | 0.3445 | 0.32561 |
| t (Sec)   | 1.6376 | 1.6736 | 1.584 | 1.6613 | 1.6615 | 1.5962 | 1.6541 | 1.6508 | 1.5879 | 1.561 |
| Feed (mm) | 6.1541 | 6.1408 | 6.1354 | 6.3149 | 6.1374 | 6.1474 | 6.1395 | 6.1555 | 6.3619 | 6.1246 |
| \( V_c \) (mins) | 14.8174 | 14.5211 | 14.7 | 14.8915 | 14.8873 | 14.7739 | 15.023 | 15.152 | 14.714 | 13.995 |
5. RESULTS AND DISCUSSION.

The cost minimization of turning machine process problem is solved by ten non-traditional methods in optimization. The ten algorithms are implemented by using MATLAB. The problem is made by 20 trials. From the above graph, we observe that time is minimum in pattern search method (1.561 sec) is followed by Ant lion (1.584sec). The cutting speed Vc is minimum in pattern search method (13.995mins) followed by Auction algorithm (14.5211mins). The Feed also minimum in pattern search method (6.1246 mm) followed by Ant lion algorithm (6.1354 mm). From the above result we conclude that pattern search algorithm have minimum evaluation.

6. CONCLUSION

In this paper ten algorithms are applied to solve engineering process problem. The simulation results are presented in ABC algorithm, Auction, Spiral, Ant lion, Elephant herding, bacterial colony, Greedy, Lawler’s, Fireworks and pattern search for these ten non-traditional methods tested effectively. Then three proposed algorithms are pattern search (1.561sec), ant lion algorithm (1.584sec) and Fireworks algorithm (1.5879sec). In the three methods pattern search method (1.561sec) is minimum. The above all the results shows that pattern search method is better than other methods. Finally we conclude that, the pattern search method have minimum cost and minimum time.
REFERENCE

1. Dr. S. Elizabeth Amudhini, K. Susmitha, A. Joe (2015), Cost Minimization of Turning machining process using cuckoo search, pattern search, Firefly and flower pollination.
2. Y.C Chin and Y.C Joo (1992), Optimization of machining conditions with practical constraints. 2907-2919.
3. N. Yusuf (2012), Techniques in optimization machining parameters. 9909 – 9927.
4. B. Naithani (2012), Mathematical modelling approaches for optimal machining parameters 403-419.
5. M.C Chen (1996), Simulated annealing approach for optimization of multi pass turning operation. 2803 – 2825.
6. G.C Onwubolu (2001), Optimization of turning machine process with genetic algorithm. 3727-3745.
7. M.C Chen (2003), Optimization of turning operations with genetic algorithms. 3385 – 3388.
8. Abdellah El barkany (2017), Multi pass turning operations process optimization using hybrid genetic algorithm.