Simulation of ant colony optimization on hole making performance

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ABSTRACT – Hole making operation one of machining process widely used in industrial industry. One of the main criteria in determining the efficiency of machining performance in hole making operation is shortest machining time. In this paper, simulation approach based on Ant colony optimization (ACO) has been done on hole making operation in order to minimize the machining time. The result based on ACO has been compared with the result obtain based on Genetic Algorithm (GA). Based on the simulation results, the ACO is enhance the performance of hole making process by reducing 13.5% of machining time. The results show that ACO is capable to minimize the machining time of hole making process.

1. INTRODUCTION

Optimization of machining process can lead to significant reduction in machining time which directly improves productivity of manufacturing systems. Solimanpur et al. reported that tool movement and tool switching time take 70% of the total time in a manufacturing process [1]. Therefore, it is important to do characterization on machining time in drilling process to ensure the efficiency and accuracy of machining process. Recently, the non-traditional technique had been accepted as a popular approach in order to solve and optimize the cutting process. Guiotoko and Pezer proposed a genetic algorithm to find the near-optimal safe cutting tool travel path between each drilling hole location [2-3]. The results obtained based on optimization were compared with the results achieved with CAM software. While, Dalavi and Adam use particle swarm optimization (PSO) to minimizing the cost operation which is consist tool travel cost, tool switch cost, and tool machining cost [3-4]. The results obtained using PSO were compared with those obtained using tabu search method. As the results, the result by PSO were slightly better than obtained using tabu search method. Lim used cuckoo search algorithm to determine the optimal machining time in drilling process [5]. Ant colony optimization (ACO) is one of the famous method to optimize the tool path length in hole making operation especially in drilling process. ACO was used to determine the sequence of hole making in drilling to obtain optimal machining time [6 - 8]. There is also research conducted to compare the effectiveness of ACO with GA in minimizing the tool path length such as Abbas [8]. In this paper, a study has been done to assess the performance of ACO algorithm on minimizing the tool path length and machining time in hole making process by considered the effect of number of number of ant.

2. RESEARCH METHODOLOGY

In this paper, a simple rectangular with the holes of the same radius is designed using Solidwork software with dimensions 60x100x10mm as shown in Figure 1. The model consists of 158 holes with the same diameter of each holes, 1.5 mm [8].

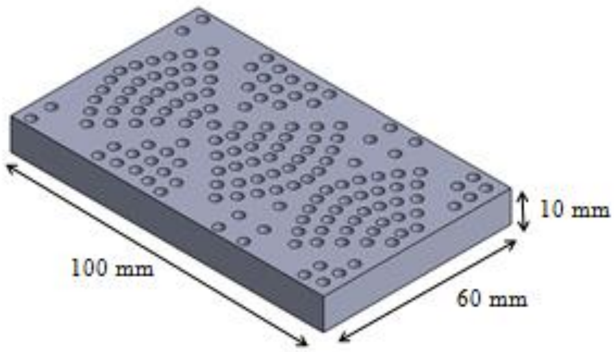

Figure 2.1 Simple rectangular block

In order to reduce the machining time, Ant Colony Optimization (ACO) has been used to minimize the tool path length. Since the tool path length is reducing, it can be decreasing the machining time in drilling process. In the ACO method, ants are placed on n cities, and it moves from city *i* to city *j* using a formula called the rule arbitrary probability as Equation 1:

$$P_{i,j}^{k}(t) = \frac{[\tau_{i,j}(t)]^{\alpha}[\eta_{i,j}(t)]^{\beta}}{\sum_{t \in N_i^k}[\tau_{i,j}(t)]^{\alpha}[\eta_{i,j}(t)]^{\beta}} \; j \in N_i^k \qquad (1)$$

N_i^k = list of nodes, were not visited by ant
$\tau_{i,j}(t)$ = intensity of trail on edge (*i,j*) at time
α = weight of the trail
$\eta_{i,j}(t)$ = 1/d*ij* is called the visibility
β = weight of the visibility

In this study, the adapted ACO is used to determine the shortest distance of cutting tool movement for holes drilling.

3. RESULTS AND DISCUSSION

The simulation of ACO has been performed in Matlab software. Simulation has been done for five times which different number of ant. Each simulation the number of ants has been set as 30, 60, 90,120 and 158.

Number of ants of 158 is equal to number of hole. The value of α and β is 5 and 4, respectively. Figure 2 shows the best route obtains by the ACO. Table 1 shows the value of tool path length based on different number of ants. Based on Table 3.1, the shortest tool path length (average) is 976.58 mm due to number of ants 158.

Table 3.1 Tool path length due to different nu. of ant

Number of ants	Tool path length (mm)
30	989.59
60	990.51
90	995.75
120	984.89
158	976.58

Figure 3.1 demonstrate the tool path route based on shostest tool path length. Compared to the average result obtained by Genetic Algorithm proposes by [9], ACO can reduce 13.5 % of average of tool path in drilling process.

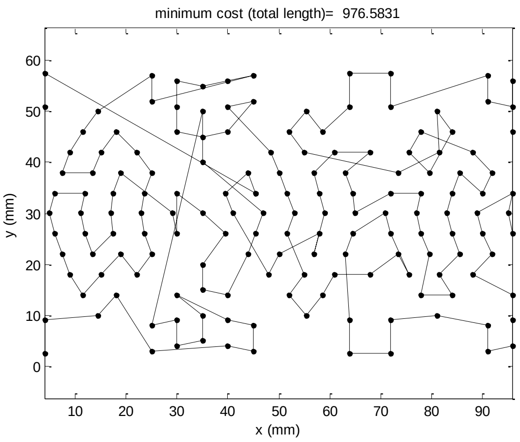

Figure 3.1 Minimum tool path length based on ACO

In ACO method, the shortest path is determined based on the pheromone left by ants. The first ants leave a pheromone trail and the next ants will follow the trail which has stronger pheromones. If the number of ants through the shorter path increases, the effect of the pheromone trail left behind will stronger. Thus, the number of ants must also consider in producing a shorter travel distance. The more ants, the more the solution is formed. In the case of drilling, each ant will be required to form a sequence in drill holes that need to generate the shortest path.

4. SUMMARY

This paper presented a comparison of ACO and GA due to performance of tool path length in drilling process. Based on simulation results, it can be ascertained that ACO method performed better performance compared to the GAin generating tool path. However, these techniques need to be further explored to find their suitability to certain applications.

REFERENCES

[1] M. Solimanpur, A. Foroughi, and M. Mohammadi, "Optimum route selection in hole-making operations using a dynamic programming-based method," *Cogent Eng.*, pp. 1–13, 2016.

[2] E. H. Guiotoko, H. Aoyama, and N. Sano, "Optimization of hole making processes considering machining time and machining accuracy," *J. Adv. Mech. Des. Syst. Manuf.*, vol. 11, no. 4, pp. JAMDSM0048-JAMDSM0048, 2017.

[3] D. Pezer, "Efficiency of tool path optimization using genetic algorithm in relation to the optimization achieved with the CAM software," *Procedia Eng.*, vol. 149, no. June, pp. 374–379, 2016.

[4] A. Adam *et al.*, "A Particle Swarm Optimization Approach to Robotic Drill Route Optimization," in *International Conference on Mathematical/Analytical Modelling and Computer Simulation*, 2010, pp. 1–5.

[5] W. Chen, E. Lim, G. Kanagaraj, and S. G. Ponnambalam, "PCB Drill Path Optimization by Combinatorial Cuckoo Search Algorithm," *Sci. World J.*, vol. 1, no. 1, pp. 1–11, 2014.

[6] A. T. Abbas, M. F. Aly, and K. Hamza, "Optimum drilling path planning for a rectangular matrix of holes using ant colony optimisation," *Int. J. Prod. Res.*, vol. 49, no. 19, pp. 5877–5891, Oct. 2011.

[7] H. Abdullah, R. Ramli, D. A. Wahab, and J. A. Qudeiri, "Simulation approach of cutting tool movement using artificial intelligence method," *J. Eng. Sci. Technol.*, vol. 10, pp. 35–44, 2015.

[8] K. D. Narooei, R. Ramli, M. Nizam, A. Rahman, F. Iberahim, and J. A. Qudeiri, "Tool Routing Path Optimization for Multi-Hole Drilling Based on Ant Colony Optimization," *World Appl. Sci. J.*, vol. 32, no. 9, pp. 1894–1898, 2014.

[9] D. Pezer, "Efficiency of tool path optimization using genetic algorithm in relation to the optimization achieved with the CAM software," *Procedia Eng.*, vol. 149, no. June, pp. 374–379, 2016.