OPTIMIZATION OF MULTI-HOLES DRILLING PATH USING PARTICLE SWARM OPTIMIZATION

NAJWA WAHIDA BINTI ZAINAL ABIDIN

MASTER OF SCIENCE

UNIVERSITI MALAYSIA PAHANG

SUPERVISOR'S DECLARATION

We hereby declare that We have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.

(Supervisor's Signature)

Full Name : DR. MOHD FADZIL FAISAE B. AB. RASHID

Position : ASSOCIATE PROFESSOR

Date : 12 JANUARY 2022

(Co-supervisor's Signature)

Full Name : IR. DR. HAJI NIK MOHD ZUKI BIN NIK MOHAMED

Position : ASSOCIATE PROFESSOR

Date :12 JANUARY 2022

STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

(Student's Signature)

Full Name : NAJWA WAHIDA BINTI ZAINAL ABIDIN

ID Number : MMM16030

Date : 12 JANUARY 2022

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

College of Engineering

UNIVERSITI MALAYSIA PAHANG

JANUARY 2022

ACKNOWLEDGEMENTS

Thank Allah S.W.T for giving me the opportunity to complete this study. I would like to thank my supervisor, Assoc. Prof. Dr. Mohd Fadzil Faisae Bin Ab. Rashid and co-supervisor, Assoc. Prof. Ir. Dr. Haji Nik Mohd Zuki Bin Nik Mohamed for all the suggestions, knowledge, advice and guidance that have been given to complete this study. Many thanks also to the beloved family members who have given a lot of support, encouragement and financial assistance until this study was successfully completed. Not forgetting the friends who have helped a lot in completing this study. Many thanks.

I would also like to express my sincere appreciation to all parties involved either directly or indirectly contributing to the success of this project. This accomplishment would not have been possible without them. Hopefully this study brings benefits to all parties in the future. Thank you.

ABSTRAK

Penggerudian berbilang lubang adalah proses pembuatan yang biasa digunakan dalam industri. Dalam proses ini, pergerakan dan peralihan alat rata-rata memerlukan 70% dari keseluruhan masa pemesinan. Terdapat banyak aplikasi penggerudian berbilang lubang seperti dalam pembuatan acuan dan papan litar bercetak *(PCB)*. Salah satu cara untuk meningkatkan penggerudian berbilang lubang adalah dengan mengoptimumkan pemprosesan laluan alat. Tujuan penyelidikan ini adalah untuk memodelkan dan mengoptimumkan masalah penggerudian berbilang lubang menggunakan algoritma *Particle Swarm Optimization (PSO)*. Penyelidikan dimulakan dengan memodelkan masalah penggerudian berbilang lubang menggunakan konsep *Traveling Salesman Problem (TSP).* Fungsi objektif ditetapkan untuk meminimumkan jumlah jarak laluan alat. Kemudian *PSO* dirumuskan untuk meminimumkan jarak keseluruhan dalam pengerudian berbilang lubang. Masalah utama pada peringkat ini adalah menukar pengekodan berterusan dalam *PSO* kepada permutasi seperti dalam penggerudian berbilang lubang. Untuk tujuan ini, prosedur penyusunan topologi berdasarkan nilai partikel terbesar telah dilaksanakan. Algoritma diuji menggunakan 15 masalah ujian dimana julatnya antara 10 hingga 150 lubang yang dijalankan secara rawak. Prestasi *PSO* kemudiannya dibandingkan dengan algoritma meta-heuristik lain termasuk *Genetic Algorithm (GA), Ant Colony Optimization (ACO), Whale Optimization Algorithm (WOA), Ant Lion Optimizer (ALO), Dragonfly Algorithm (DA), Grasshopper Optimization Algorithm (GOA), Moth Flame Optimization (MFO)* dan *Sine Cosine Algorithm (SCA)*. Kemudian, eksperimen pengesahan telah dilakukan dengan mengaplikasikan laluan alat yang dihasilkan oleh *PSO* berbanding dengan laluan yang dihasilkan oleh perisian *CAD-CAM* komersial. Pada peringkat ini, masa pemesinan direkodkan. Hasil dari eksperimen berkomputer menunjukkan bahawa algoritma *PSO* yang dicadangkan mendapat penyelesaian terbaik dalam 10 daripada 15 masalah ujian. Sementara itu, hasil eksperimen pengesahan membuktikan bahawa laluan alat yang dihasilkan *PSO* memberikan masa pemesinan yang lebih cepat berbanding dengan laluan *CAD-CAM* komersial sebanyak 5% secara purata. Hasilnya jelas menunjukkan bahawa *PSO* berpotensi besar untuk diterapkan dalam proses penggerudian berbilang lubang. Penemuan dari penyelidikan ini dapat memberi manfaat kepada industri pembuatan untuk meningkatkan produktiviti mereka menggunakan sumber yang sedia ada.

ABSTRACT

Multi-hole drilling is a manufacturing process that is commonly used in industries. In this process, the tool movement and switching, on average, take 70% of the total machining time. There are many applications of multi-hole drilling, such as in mould, die-making and printed circuit board (PCB). One way to improve the multi-hole drilling is by optimising the tool path in the process. This research aims to model and optimise multi-hole drilling problems using Particle Swarm Optimisation (PSO) algorithm. The study begins by modelling the multi-hole drilling problems using the Travelling Salesman Problem (TSP) concept. The objective function was set to minimise the total tool path distance. Then, the PSO was formulated to minimise total length in multi-hole drilling. The main issue in this stage was to convert the continuous encoding in PSO to permutation problems as in multi-hole drilling. For this purpose, a topological sorting procedure based on the most prominent particle rule was implemented. The algorithm was tested on 15 test problems where between 10 to 150 holes were randomly generated. The performance of PSO was then compared with other meta-heuristic algorithms, including Genetic Algorithm (GA) and Ant Colony Optimisation (ACO), Whale Optimisation Algorithm (WOA), Ant Lion Optimiser (ALO), Dragonfly Algorithm (DA), Grasshopper Optimisation Algorithm (GOA), Moth Flame Optimisation (MFO) and Sine Cosine Algorithm (SCA). Then, a validation experiment was conducted by implementing the PSO generated tool path against the commercial CAD-CAM path. In this stage, the machining time was measured. The results from the computational experiment indicated that the proposed PSO algorithm came out with the best solution in 10 out of the 15 test problems. In the meantime, the validation experiment result proved that the PSO generated tool path provides faster machining time compared with the commercial CAD-CAM path by 5% on average. The results clearly showed that PSO has a great potential to be applied in the multi-hole drilling process. The findings from this research could benefit the manufacturing industry to improve their productivity using existing resources.

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