OPTIMIZATION OF ASSEMBLY LINE BALANCING WITH ENERGY EFFICIENCY BY USING TIKI-TAKA ALGORITHM

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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.

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ABSTRAK

Assembly line balancing (ALB) could be translated as the activity that is applied to optimize the layout of an assembly line by distributing a balance workload assembly among workstations. Based on the previous research conducted by researchers, most of the assembly line model studies focused extensively on the problem models that related to time, space, workers, and a few resources. However, there is a shortage of studies that considers the utilization of electrical energy in assembly line design. This situation stimulates this research to further investigate the Assembly Line Balancing with Energy Efficiency (ALB-EE). This research aimed to establish a computational model that represents the ALB-EE, propose a new Tiki-Taka Algorithm (TTA) to solve and optimize the ALB-EE and validate the developed model through a real-life case study. In the modeling phase, all the ALB-EE optimization objectives are presented in a mathematical form to earn line efficiency and energy utilization. Then, the TTA is developed before undergoing functionality tests by benchmarking with Particle Swarm Optimization (PSO), Grey Wolf Optimization (GWO), Genetic Algorithm (GA), and Whale Optimization Algorithm (WOA). Lastly, a study of the industrial case was performed as a validation of the developed model and algorithm. An automotive company is selected, and the collected actual data is used for validation purposes. As a result, the Optimized TTA performs best compared to PSO, GWO, GA, and WOA in most of the test problems. Meanwhile, the case study validation activity resulting an increase in line efficiency from 92.7% to 95.1% by task arrangement with the utilization of TTA. Through the improved line efficiency, the total energy consumed is also reduced to 3,305,478.46 J from the initial figure of 3,374,329.46 J. This is a clear indication that the developed TTA algorithm is reliable and could be used in optimizing a real-life problem by the re-sequence of the assembly task, thus reducing the cycle time and could reduce the total energy consumption by machinery.

ABSTRACT

Assembly line balancing (ALB) boleh diertikan sebagai aktiviti yang digunakan untuk mengoptimumkan pelan susunan sesebuah rangkaian pemasangan kilang dengan cara pengagihan dan penyusunan tugas kerja pemasangan disetiap stesen kerja. Berdasarkan kepada kajian-kajian terdahulu yang dilakukan oleh penyelidik, kebanyakan kajian model rangkaian pemasangan berfokus sepenuhnya hanya kepada permasalahan yang berkaitan dengan masa, ruang, pekerja dan juga beberapa sumber. Bagaimanapun, terdapat kekangan kajian yang menggunakan penggunaan tenaga elektrik dalam sebuah pelan rangkaian pemasangan. Situasi ini menggalakkan kerja kajian ini untuk menyiasat Assembly Line Balancing with Energy Efficiency (ALB-EE). Kajian ini bertujuan untuk memperkenalkan model pengiraan yang mewakili ALB-EE, mencadangkan Tiki-Taka Algorithm (TTA) yang baru untuk menyelesaikan dan mengoptimumkan ALB-EE, dan mengesahkan model yang telah diperkenalkan melalui situasi sebenar kes kajian. Dalam fasa permodelan, kesemua masalah ALB-EE dalam objektif kajian ini dipersembahkan dalam cara matematik untuk mendapatkan rangkaian yang efisien. kemudian, TTA itu akan diuji keberkesanannya melalui perbandingan antara Particle Swarm Optimization (PSO), Grey Wolf Optimization (GWO), Genetic Algorithm (GA), dan Whale Optimization Algorithm (WOA). Akhirnya, sebuah kajian kes industri akan dilakukan untuk menguji model dan algoritma yang telah dibangunkan. Sebuah syarikat automotif telah dipilih, dan data kajian yang telah dikumpul akan digunakan untuk tujuan pengujian. Sebagai rumusan, model Optimized TTA berfungsi dengan terbaik jika dibandingkan dengan PSO, GWO, GA, dan WOA dalam kebanyakan permasalahan kajian. Manakala, aktiviti pengujian kajian kes memberikan keputusan peningkatan kadar efisien rangkaian dari 92.7% kepada 95.1% dengan cara penyusunan kerja melalui aplikasi TTA. Melalui peningkatan kadar efisien, penggunaan tenaga keseluruhan dapat dikurangkan kepada 3,305,478.46 J dari jumlah asal iaitu 3,374,329.46 J. Hal ini menunjukkan bahawa algoritma TTA yang dibina adalah berkesan dan boleh digunakan dalam menyelesaikan masalah situasi sebenar dengan cara penyusunan semula kerja pemasangan, lantas mengurangkan masa pemsasngan dan dapat mengurangkan penggunaan tenaga yang diperlukan oleh mesin-mesin.

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