



## IMPROVING MANUFACTURING AGILITY THROUGH OPTIMAL PRODUCTION SCHEDULING SYSTEM

Moch Saiful Umam\*

Magister Program of Information System  
Diponegoro University  
Indonesia  
[itgov@yandex.com](mailto:itgov@yandex.com)

Mustafid

Department of Statistics  
Diponegoro University  
Indonesia  
[mustafid55@gmail.com](mailto:mustafid55@gmail.com)

Suryono

Department of Physics  
Diponegoro University  
Indonesia  
[suryonosur@gmail.com](mailto:suryonosur@gmail.com)

\*Corresponding Author email: [itgov@yandex.com](mailto:itgov@yandex.com)

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Office # 6, First Floor, A & K Plaza, Near D Watson, F-10 Markaz, Islamabad, Pakistan,

[editor@readersinsight.net](mailto:editor@readersinsight.net)

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## ABSTRACT

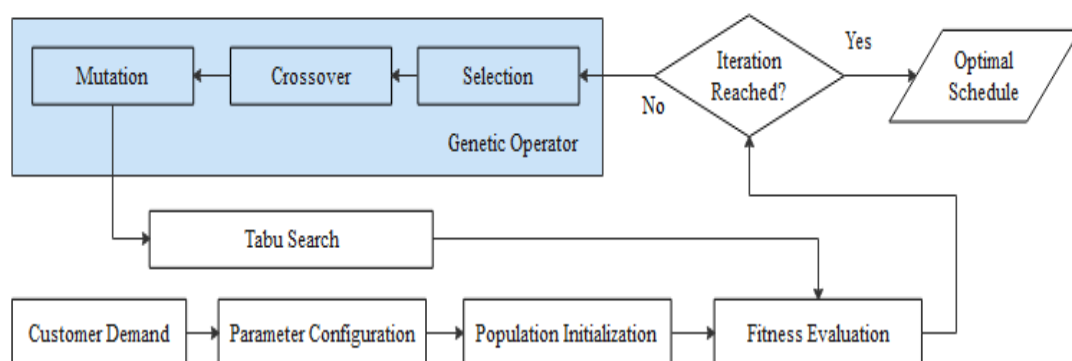
The garment industry is a global industry that requires high agility in response to changing market demands that are quickly changing. Short product cycles with unpredictable demand often make the industry unable to meet consumer needs. In increasing the agility of production to deliver products to customers as fast as possible, the production scheduling system must be designed optimally. Recently algorithm hybridization is used because the combination of more than one algorithm is more optimal. Genetic Algorithm (GA) is a metaheuristic algorithm is applied in various production scheduling and its power can be improved by combining it with the Tabu Search (TS). The GA is the best metaheuristic algorithm to output the optimal scheduling with less execution time but has the disadvantage—easily trapped in local optimum (early convergence is faster). The TS algorithm works as a local search algorithm with a faster computation time than GA. This study aims to minimize the total time to complete the work (minimizing makespan) by combining TS into GA in conducting local searches to increase industrial agility. The results obtained are GA-TS hybridization can provide a more optimal solution for the production scheduling in the garment so that agility can increase.

**Keywords:** *Manufacturing Agility, Scheduling, Genetic Algorithm, Tabu Search*

## RESEARCH HIGHLIGHTS

The garment industry is a worldwide industry with strict competition because it has short product cycles, rapid-changing in demand, and information technology innovation. Conditions like this force the industry to have high agility to fulfil consumer needs (Mustafid et al., 2018). Agility is the industry's ability to respond to fast consumer demand as one of the pillars of success to ensure the implementation of fast action plans in companies and the suggested plans have been implemented (Islam et al., 2019). The agility can be increased through several aspects including the optimal scheduling system (Kusiak & He, 1998) by modernizing the scheduling system (Guo & Zhang, 2010). GA is a common algorithm for scheduling optimization (Branda et al., 2020) but convergence earlier. To overcome this problem, the local search algorithm is hybridized with TS so that there is a balance between global and local searches in producing a more optimal solution.

## GRAPHICAL ABSTRACT



## Research Objectives

The purpose of this study is to propose the new hybrid GA-TS algorithm in minimizing the completion time for jobs (minimizing makespan) to increase industrial agility so that the industry can deliver the product to the consumer at an earlier time. The GA algorithm is widely known to be more effective than other heuristic algorithms in solving flow shop scheduling problems because of its superiority in producing solutions that are more effective and also faster in exploring global searches. Unfortunately, there is a weakness of GA which makes it fall into a local optimum and the execution time slows down when finding a solution area that is close to the optimum result. To cover this deficiency, the TS algorithm is used as the optimum local search to avoid GA stuck at the local optimum and increase the speed of GA in seeking solutions.

## Methodology

For this work, the hybrid GA-TS was proposed by inserting TS into the GA in order to provide more effective scheduling results, there are several things that need to be considered, such as the string encoding technique which is adopted from (Ramezani et al., 2010) and the decoding technique using Job-Precedence (JP) from (Wang & Wang, 2019). Next, it is necessary to determine the parameters and methods used by genetic operators in reproducing. This job uses a population size of 100 and stops reproducing when it reaches 1.000 turns. The elitist selection method applies the method of (Rani et al., 2019) by storing the best chromosomes in the elitist table and also tournament selection is used from (Kılıç & Yüzgeç, 2019) by selecting 5 chromosomes randomly. In order to produce a more converging crossover, the two-point crossover method (Koohestani, 2020) was used by randomly selecting two-parent chromosome positions. This study uses a crossover rate of 0.5 and an introduced mutation rate of 0.1 from (Gotshall & Rylander, 2002) to balance searching. Furthermore, the neighborhood framework which includes move attributes, neighborhood structure and tabu list from (Deroussi et al., 2012) was employed to guide GA so as not to be trapped in a local optimum.

## Results

An experiment was conducted and the results have been proven that the makespan needed in production using the proposed hybrid GA-TS algorithm is superior to using the single of GA and TS algorithms so that products can be delivered to customers faster and this increases the value of industrial agility. From the experiment, it can also be concluded that the proposed hybrid GA-TS is able to solve the flow shop scheduling problem with a more optimal solution and more efficient computing time. There are two reasons why this can happen, first is that the combination is carried out on algorithms that are superior in their respective fields, the GA excels on exploration and the TS excels on exploitation so that the combination can balance the results of the solution and make GA not stuck at a local optimum. Second, the important configuration for selecting the encoding-decoding method, genetic operator and neighborhood structure must be correctly chosen for the flow shop scheduling problem as presented in this work.

## Findings

The hybridization of GA-TS in this study provides a new colour in increasing industrial agility through a more optimal makespan of production scheduling. GA is used to explore solutions through defined parameters, evaluate fitness values, and use optimal genetic operators for the selection, crossover and mutation methods. Furthermore, the performance of GA is improved through local tracing by TS to avoid GA being trapped in a local optimum so that a more optimal solution is obtained with a faster computation time. With a more optimal solution makes the production schedule completed earlier automatically and results in higher agility.

## References

- Branda, A., Castellano, D., Guizzi, G., & Popolo, V. (2020). Metaheuristics for the Flow Shop Scheduling Problem with Maintenance Activities Integrated. *Computers & Industrial Engineering*, 106989. <https://doi.org/10.1016/j.cie.2020.106989>
- Deroussi, L., Gourgand, M., & Norre, S. (2012). *New Effective Neighborhoods for the Permutation Flow Shop Problem*. <https://hal.archives-ouvertes.fr/hal-00678053/document>
- Gotshall, S., & Rylander, B. (2002). Optimal Population Size and the Genetic Algorithm. *Proceedings On Genetic And Evolutionary Computation Conference*, 1–5.
- Guo, Q. lin, & Zhang, M. (2010). An Agent-Oriented Approach to Resolve Acheduling Optimization in Intelligent Manufacturing. *Robotics and Computer-Integrated Manufacturing*, 26(1), 39–45. <https://doi.org/10.1016/j.rcim.2009.02.003>
- Islam, T., Khan, S. A., Elahi, S., Sharif, M. N., & Mollik, M. M. (2019). An attempt to increase agility of garment industry. *Journal of Textile Engineering & Fashion Technology*, 5(3). <https://doi.org/10.15406/jteft.2019.05.00196>
- Kılıç, H., & Yüzgeç, U. (2019). Improved Antlion Optimization Algorithm via Tournament Selection and its Application to Parallel Machine Scheduling. *Computers and Industrial Engineering*, 132, 166–186. <https://doi.org/10.1016/j.cie.2019.04.029>
- Koohestani, B. (2020). A Crossover Operator for Improving the Efficiency of Permutation-Based Genetic Algorithms. *Expert Systems with Applications*, 151, 113381. <https://doi.org/10.1016/j.eswa.2020.113381>
- Kusiak, A., & He, D. W. (1998). Design for Agility: A Scheduling Perspective. *Robotics and Computer-Integrated Manufacturing*, 14(5–6), 415–427. [https://doi.org/10.1016/s0736-5845\(98\)00017-9](https://doi.org/10.1016/s0736-5845(98)00017-9)
- Mustafid, Karimariza, S. A., & Jie, F. (2018). Supply Chain Agility Information System with Key Factor for Fashion Industry Competitiveness. *International Journal of Agile Systems and Management*, 11(1), 1–22. <https://doi.org/10.1504/ijasm.2018.091352>
- Ramezani, R., Aryanezhad, M. B., & Heydari, M. (2010). A Mathematical Programming Model for Flow Shop Scheduling Problems for Considering Just in Time Production. *International Journal of Industrial Engineering & Production Research*, 21, 97–104.
- Rani, S., Suri, B., & Goyal, R. (2019). On the Effectiveness of Using Elitist Genetic Algorithm in Mutation Testing. *Symmetry*, 11(9), 1145. <https://doi.org/10.3390/sym11091145>

Wang, J., & Wang, L. (2019). Decoding Methods for the Flow Shop Scheduling With Peak Power Consumption Constraints. *International Journal of Production Research*, 57(10), 3200–3218. <https://doi.org/10.1080/00207543.2019.1571252>

### **Author's Biography**



**Moch Saiful Umam** received received his Bachelor's in Computer Science from AKI University in Information Technology in 2012. He is finalizing his Master in Information Systems from the Diponegoro University, Indonesia in 2020. His main research interests include information retrieval, supply chain, and industrial informatics and he had been teaching at Telkom's vocational school.



**Mustafid** received his Master and PhD in Information Engineering from Hiroshima University, Japan in 1987 and 1990 respectively. He is a Professor of Statistics and Information Systems at the Faculty of Science and Mathematics, Diponegoro University, Indonesia. His research focuses on subjects linked to Six Sigma, business intelligence, supply chain agility, supply chain information systems.



**Suryono** is registered as a senior lecturer and researcher in Department of Physics, Science, and Mathematics Faculty of Diponegoro University, Semarang, Indonesia since 1998. A doctoral degree is achieved from Gadjah Mada University in 2011. He is a professor in 2020. His research focuses area: physical instrumentation, wireless sensor network, sensor and application, and sensor and instrumentation.