APEM journal

Advances in Production Engineering & Management
Volume 18 | Number 2 | June 2023 | pp 250–262
https://doi.org/10.14743/apem2023.2.471

ISSN 1854-6250
Journal home: apem-journal.org
Original scientific paper

Simulation and Genetic Algorithm-based approach for multi-objective optimization of production planning: A case study in industry

Bojic, S.[a], Maslaric, M.[a,*], Mircetic, D.[b], Nikolicic, S.[a], Todorovic, V.[c]

[a]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
[b]Institute for Artificial Intelligence Research and Development of Serbia, Novi Sad, Serbia
[c]Science and Technology Park Novi Sad, Novi Sad, Serbia

ABSTRACT

To stay competitive on the constantly changing and demanding market, production systems need to optimize their performance daily. This is particularly challenging in labour-intensive industries, which is characterized by highly volatile customer demand and significant daily variability of available workers. The Uncertainty related to the key production parameters in the industry is causing disruptions in long-term production planning and optimization, which leads to the long lead production times, operational risks and accumulation of inventory. To address these challenges, production systems need to ensure adequate operational production planning and optimization of all variables that are influencing the productivity of their systems on a daily basis. To tackle the problem, this study elaborates the application of discrete event simulations and genetic algorithm, using the Tecnomatix Plant Simulation software, to support decision-making and operational production planning and optimization in the industry. The simulation model developed for this purpose considers: customers demand changes, variable production times, operationally available resources and production batch size, to provide an optimal production sequence with the highest number of produced pieces and the lowest total work in process (WIP) inventory per day. To demonstrate the efficiency of the methodology and prove the benefits of the selected optimization approach, a case study is conducted in the textile factory.

ARTICLE INFO

Keywords:
Discrete event simulation (DES);
Genetic algorithm (GA);
Production planning;
Multi-objective optimization;
Textile industry;
Tecnomatix Plant Simulation software

**Corresponding author:*
marinko@uns.ac.rs
(Maslaric, M.)

Article history:
Received 18 May 2023
Revised 8 June 2023
Accepted 28 June 2023

References

[1] Bhardwaj, V., Fairhurst, A. (2010). Fast fashion: Response to changes in the fashion industry, *The International Review of Retail, Distribution and Consumer Research*, Vol. 20, No. 1, 165-173, doi: 10.1080/09593960903498300.

[2] Mak, L.C.L. (2016). *Modelling of apparel production system and optimization of lot size scheduling in apparel industry,* PhD. thesis, Hong Kong Polytechnic University, Hong Kong.

[3] Ahmad, S., Miskon, S., Alabdan, R., Tlili, I. (2020). Towards sustainable textile and apparel industry: Exploring the role of business intelligence systems in the era of Industry 4.0, *Sustainability*, Vol. 12, No. 7, Article No. 2632, doi: 10.3390/su12072632.

[4] Ekren, B.Y., Ornek, A.M. (2008). A simulation based experimental design to analyze factors affecting production flow time, *Simulation Modelling Practice and Theory*, Vol. 16, No. 3, 278-293, doi: 10.1016/j.simpat.2007.11.016.

[5] Kincade, D.H., Kim, J., Kanakadurga, K.S. (2013). An empirical investigation of apparel production systems and product line groups through the use of collar designs, *Journal of Textile and Apparel, Technology and Management*, Vol. 8, No. 1, 1-15.
[6] Pirola, F., Zambetti, M., Cimini, C. (2021). Applying simulation for sustainable production scheduling: A case study in the textile industry, *IFAC-PapersOnLine*, Vol. 54, No. 1, 373-378, doi: 10.1016/j.ifacol.2021.08.041.
[7] Ramesh, V., Sreenivasa Prasad, K., Srinivas, T. (2009). Study on implementation of one-piece lean line design using simulation techniques: A practical approach, *Journal of Industrial Engineering International*, Vol. 5, No. 8, 20-36.
[8] Brahmadeep, Thomassey, S. (2014). A simulation based comparison: Manual and automatic distribution setup in a textile yarn-rewinding unit of a yarn-dyeing factory, *Simulation Modelling Practice and Theory*, Vol. 45, 80-90, doi: 10.1016/j.simpat.2014.04.002.
[9] Wang, C.-N., Cheng, Z.-H., Phan, N.K.P., Nguyen, V.T. (2021). Scheduling optimization modelling: A case study of a woven label manufacturing company, *Computer Systems Science and Engineering*, Vol. 38, No. 2, 239-249, doi: 10.32604/csse.2021.016578.
[10] Jung, W.-K., Kim, H., Park, Y.-C., Lee, J.-W., Suh, E.S. (2020). Real-time data-driven discrete-event simulation for garment production lines, *Production Planning & Control*, Vol. 33, No. 5, 480-491, doi: 10.1080/09537287.2020.1830194.
[11] Sime, H., Jana, P., Panghal, D. (2019). Feasibility of using simulation technique for line balancing in apparel industry, *Procedia Manufacturing,* Vol. 30, 300-307, doi: 10.1016/j.promfg.2019.02.043.
[12] Grznar, P., Gregor, M., Gola, A., Nielsen, I., Mozol, S., Seliga, V. (2022). Quick workplace analysis using simulation, *International Journal of Simulation Modelling*, Vol. 21, No. 3, 465-476, doi: 10.2507/IJSIMM21-3-612.
[13] Ištoković, D., Perinić, M., Borić, A. (2021). Determining the minimum waiting times in a hybrid flow shop using simulation-optimization approach, *Tehnički Vjesnik – Technical Gazette,* Vol. 28, No. 2, 568-575, doi: 10.17559/TV-20210216132702.
[14] Li, G.Z., Xu, Z.G., Yang, S.L., Wang, H.Y., Bai, X.L., Ren, Z.H. (2020). Bottleneck identification and alleviation in a blocked serial production line with discrete event simulation: A case study, *Advances in Production Engineering & Management,* Vol. 15, No. 2, 125-136, doi: 10.14743/apem2020.2.353.
[15] Yang, S.L., Wang, J.Y., Xin, L.M., Xu, Z.G. (2022). Verification of intelligent scheduling based on deep reinforcement learning for distributed workshops via discrete event simulation, *Advances in Production Engineering & Management,* Vol. 17, No. 4, 401-412, doi: 10.14743/apem2022.4.444.
[16] Man, K.F., Tang, K.S., Kwong, S., Ip, W.H. (2000). Genetic algorithm to production planning and scheduling problems for manufacturing systems, *Production Planning & Control,* Vol. 11, No. 5, 443-458, doi: 10.1080/ 095372 80050051942.
[17] Alhijawi, B., Awajan, A. (2023). Genetic algorithms: Theory, genetic operators, solutions, and applications, *Evolutionary Intelligence*, Vol. 16, doi: 10.1007/s12065-023-00822-6.
[18] Lee, C.K.H. (2018). A review of applications of genetic algorithms in operations management, *Engineering Applications of Artificial Intelligence*, Vol. 76, 1-12, doi: 10.1016/j.engappai.2018.08.011.
[19] Ferro, R., Cordeiro, G.A., Ordóñez, R.E.C., Beydoun, G., Shukla, N. (2021). An optimization tool for production planning: A case study in a textile industry, *Applied Science*, Vol. 11, No. 18, Article No. 8312, doi: 10.3390/app11188312.
[20] Parven, I., Mia, M.A., Ali, M.S., Rafsun-Ul-Hasan, K., Rahman, M.M., Mahmud, M.I., Cho, H.M. (2019). Implementation of JIT to increase productivity in sewing section of garment industry, In: *Proceedings of the International Conference on Industrial Engineering and Operations Management*, Bangkok, Thailand, 618-629.
[21] Yin, R.K. (2010). Case study research: Design and methods, 4th edition, Sage, Los Angeles, USA.
[22] Elgazzar, S. (2013). *Enhancing the company's financial performance through the performance of supply chain operations: A case study of an Egyptian manufacturing company,* Doctoral thesis, University of Huddersfield, Huddersfield, United Kingdom.
[23] Ellram, L.M. (1996). The use of the case study method in logistics research, *Journal of Business Logistics*, Vol. 17, No. 2, 93-138.
[24] Jeon, S.M., Kim, G. (2016). A survey of simulation modelling techniques in production planning and control (PPC), *Production Planning & Control,* Vol. 27, No. 5, 360-377, doi: 10.1080/09537287.2015.1128010.
[25] Law, A.M., Kelton, W.D. (1991). *Simulation modelling and analysis*, 2nd edition, McGraw-Hill, New York, USA.
[26] Nyemba, W.R., Mbohwa, C. (2017). Modelling, simulation and optimization of the materials flow of a multi-product assembling plant, *Procedia Manufacturing*, Vol. 8, 59-66, doi: 10.1016/j.promfg.2017.02.007.
[27] Güner, M.G., Ünal, C. (2008). Line balancing in the apparel industry using simulation techniques, *Fibres & Textiles in Eastern Europe*, Vol. 16, No. 2, 75-78.
[28] Fozzard, G., Spragg, J., Tyler, D. (1996). Simulation of flow lines in clothing manufacture, Part 1: Model construction, *International Journal of Clothing Science and Technology*, Vol. 8, No. 4, 17-27, doi: 10.1108/09556229610123982.
[29] Kursun, S., Kalaoglu, F. (2009). Simulation of production line balancing in apparel manufacturing, *Fibres & Textiles in Eastern Europe*, Vol. 17, No. 4, 68-71.
[30] Ivatury, V.M.K., Bonsa, K.B. (2022). Productivity improvement of a garment assembly line using simulation and model driven decision support system, *ARPN Journal of Engineering and Applied Sciences*, Vol. 17, No. 4, 407-415.
[31] Rashidi, Z., Rashidi, Z. (2016). Evaluation and ranking of discrete simulation tools, *Journal of Electrical and Computer Engineering Innovations*, Vol. 4, No. 1, 69-84, doi: 10.22061/jecei.2016.562.
[32] Butrat, A., Supsomboon, S. (2022). A Plant Simulation approach for optimal resource utilization: A case study in the tire manufacturing industry, *Advances in Production Engineering & Management,* Vol. 17, No. 2, 243-255, doi: 10.14743/apem2022.2.434.

[33] Silberholz, J., Golden, B. (2010). Comparison of metaheuristics, In: Gendreau, M., Potvin, J.Y. (eds.), *Handbook of metaheuristics, International series in operations research & Management science,* Vol. 146, Springer, Boston, USA, 625-640, doi: 10.1007/978-1-4419-1665-5_21.
[34] Sivanandam, S., Deepa, S. (2008). Genetic algorithm optimization problems, In: *Introduction to genetic algorithms,* Springer, Berlin, Germany, 165-209, doi: 10.1007/978-3-540-73190-0_7.
[35] Janeš, G., Ištokovic, D., Jurković, Z, Perinić, M. (2022). Application of modified steady-state genetic algorithm for batch sizing and scheduling problem with limited buffers, *Applied Science*, Vol. 12, No. 22, Article No. 11512, doi: 10.3390/app122211512.
[36] Wong, W.K., Guo, Z.X., Leung, S.Y.S. (2013). *Optimizing decision making in the apparel supply chain using artificial intelligence (AI): From production to retail (Woodhead publishing series in textiles),* 1st edition, Woodhead Publishing Limited, Cambridge, USA, doi: 10.1533/9780857097842.
[37] Al-Zuheri, A., Luong, L., Xing, L. (2016). Developing a multi-objective genetic optimisation approach for an operational design of a manual mixed-model assembly line with walking workers, *Journal of Intelligent Manufacturing*, Vol. 27, 1049-1065, doi: 10.1007/s10845-014-0934-3.
[38] Berthier, A., Yalaoui, A., Chehade, H., Yalaoui, F., Amodeo, L., Bouillot, C. (2022). Unrelated parallel machines scheduling with dependent setup times in textile industry, *Computers & Industrial Engineering*, Vol. 174, Article No. 108736, doi: 10.1016/j.cie.2022.108736.
[39] Man, K.F., Tang, K.S., Kwong, S., Ip, W.H. (2020). Genetic algorithm to production planning and scheduling problems for manufacturing systems, *Production Planning & Control*, Vol. 11, No. 5, 443-458, doi: 10.1080/09537280050051942.
[40] Kämpf, M., Köchel, P. (2006). Simulation-based sequencing and lot size optimisation for a production-and-inventory system with multiple items, *International Journal of Production Economics*, Vol. 104, No. 1, 191-200, doi: 10.1016/j.ijpe.2006.02.008.

APEM journal

Advances in Production Engineering & Management
Letnik 18 | Številka 2 | Junij 2023 | Strani 250–262
https://doi.org/10.14743/apem2023.2.471

ISSN 1854-6250
Spletna stran: apem-journal.org
Izvirni znanstveni članek

Pristop s simulacijo in genetskim algoritmom za večkriterijsko optimizacijo načrtovanja proizvodnje: študija primera v industriji

Bojic, S.[a], Maslaric, M.[a,*], Mircetic, D.[b], Nikolicic, S.[a], Todorovic, V.[c]

[a]Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia
[b]Institute for Artificial Intelligence Research and Development of Serbia, Novi Sad, Serbia
[c]Science and Technology Park Novi Sad, Novi Sad, Serbia

POVZETEK

Da bi ostali konkurenčni na nenehno spreminjajočem se in zahtevnem trgu, morajo proizvodni sistemi vsak dan optimizirati svojo zmogljivost. To je še posebej zahtevno v delovno intenzivnih panogah, za katere je značilno zelo spremenljivo povpraševanje strank in velika dnevna spremenljivost razpoložljivih delavcev. Negotovost, povezana s ključnimi proizvodnimi parametri v industriji, povzroča motnje pri dolgoročnem načrtovanju in optimizaciji proizvodnje, kar vodi v dolge proizvodne čase, operativna tveganja in kopičenje zalog. Za reševanje teh izzivov je treba v proizvodnih sistemih zagotoviti ustrezno operativno načrtovanje proizvodnje in optimizacijo vseh spremenljivk, ki vsakodnevno vplivajo na produktivnost. Za rešitev te težave in za podporo odločanju ter operativnemu načrtovanju in optimizaciji proizvodnje je v tej študiji obravnavana uporaba simulacije diskretnih dogodkov in genetskega algoritma v programskem okolju Tecnomatix Plant Simulation. Simulacijski model, razvit v ta namen, upošteva: spremembe povpraševanja kupcev, spremenljive proizvodne čase, operativno razpoložljive vire in velikost proizvodne serije s ciljem zagotoviti optimalni potek proizvodnje z največjim številom proizvedenih kosov in najnižjo količino nedokončane proizvodnje na dan. Da bi potrdili učinkovitost metodologije in preverili prednosti izbranega optimizacijskega pristopa, je izvedena študija primera v tekstilni tovarni.

PODATKI O ČLANKU

Ključne besede:
Simulacija diskretnih dogodkov (DES);
Genetski algoritem (GA);
Načrtovanje proizvodnje;
Večkriterijska optimizacija;
Tekstilna industrija;
Programska oprema Tecnomatix Plant Simulation

**Kontaktna oseba:*
marinko@uns.ac.rs
(Maslaric, M.)

Zgodovina članka:
Prejet 18. maja 2023
Popravljen 8. junija 2023
Sprejet 28. junija 2023