



Worker Assignment in Dual Resource Constrained Systems Subject to Machine Failures: A Simulation Study

N. O. Fernandes^{a,b}, M. Thürer^c, F. Rodrigues^d, L. P. Ferreira^{d,e}, F. J.G. Silva^{d,e,*}, P. Ávila^{d,f}

^a Instituto Politécnico de Castelo Branco, Av. do Empresário, 6000-767 Castelo Branco – Portugal;

^b ALGORITMI Research Unit (University of Minho), Campus de Gualtar, 4710-057 Braga, Portugal;

^c Jinan University, School of Intelligent Systems Science and Engineering, Jinan University (Zhuhai Campus), 519070 Zhuhai, PR China;

^d ISEP - School of Engineering, Polytechnic of Porto, Rua Dr. António Bernardino de Almeida, 431, 4200-072 Porto, Portugal;

^e INEGI - Instituto de Ciência e Inovação em Engenharia Mecânica e Engenharia Industrial, Rua Dr. Roberto Frias, 400, 4200-465 Porto, Portugal;

^f INESC TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Campus da FEUP, Rua Dr. Roberto Frias, 4200 - 465 Porto, Portugal

References

- [1] M. Treleven, “A Review of the Dual Resource Constrained System Research”, *IIE Transactions*, 21(3), 279–287, 1989.
- [2] V.B. Gargeya and R.H. Deane, “Scheduling research in multiple resource constrained job shops: a review and critique”, *International Journal of Production Research*, 34(8), 2077-2097, 1996.
- [3] E.B. Edis, C. Oguz, and I. Ozkarahan, “Parallel machine scheduling with additional resources: Notation, classification, models and solution methods”, *European Journal of Operational Research*, 230(1), 449-463, 2013.
- [4] M. Thürer and M. Stevenson, “Order Release, Dispatching and Resource Assignment in Multiple Resource Constrained Job Shops: An Assessment by Simulation”, *International Journal of Production Research*, (in print), 2022.
- [5] D.A. Elvers and M.D. Trevelen, “Job-shop vs. hybrid flow-shop routing in a dual resource constrained system”, *Decision Sciences*, 16(2), 213-222, 1985.
- [6] J.S. Morris and R.J. Tersine, “A simulation comparison of process and cellular layouts in a dual resource constrained environment”, *Computers & Industrial Engineering*, 26(4), 733-741, 1994.
- [7] S.I. Satoglu and N.C. Suresh, “A goal-programming approach for design of hybrid cellular manufacturing systems in dual resource constrained environments”, *Computers & Industrial Engineering*, 56, 560-575, 2009.
- [8] M. Hamed, G.R. Esmailian, N. Ismail, and M.K.A. Ariffin, “Capability-based virtual cellular manufacturing systems formation in dual-resource constrained settings using Tabu Search”, *Computers & Industrial Engineering*, 62, 953–971, 2012.
- [9] H. ElMaraghy, V. Patel, and I.B. Abdallah, “Scheduling of manufacturing systems under dual-resource constraints using genetic algorithms”, *Journal of Manufacturing Systems*, 19(3), 186-201, 2000.
- [10] Ö.U. Araz and L. Salum, “A multi-criteria adaptive control scheme based on neural networks and fuzzy inference for DRC manufacturing systems”, *International Journal of Production Research*, 48(1), 251-270, 2010.
- [11] D. Lei and X. Guo, “Variable neighbourhood search for dual-resource constrained flexible job shop scheduling”, *International Journal of Production Research*, 52, 9, 2519-2529, 2014.
- [12] D. Lei and X. Guo, “An effective neighbourhood search for scheduling in dual-resource constrained interval job shop with environmental objective”, *International Journal of Production Economics*, 159, 296-303, 2015.
- [13] J. Li, Y. Huang, and X. Niu, “A branch population genetic algorithm for dual-resource constrained job shop scheduling problem”, *Computers & Industrial Engineering*, 102, 113-131, 2016.
- [14] X.L. Zheng and L. Wang, “A knowledge-guided fruit fly optimization algorithm for dual resource constrained flexible job-shop scheduling problem”, *International Journal of Production Research*, 54(18), 5554-5566, 2016.
- [15] J. Zhang, W. Wang, and X. Xu, “A hybrid discrete particle swarm optimization for dual-resource constrained job shop scheduling with resource flexibility”, *Journal of Intelligent Manufacturing*, 28, 1961-1972, 2017.
- [16] A. Costa, V. Fernandez-Viagas, and J.M. Framiñan, “Solving the hybrid flow shop scheduling problem with limited human resource constraint”, *Computers & Industrial Engineering*, 146, 106-545, 2020.

- [17] P. Renna, M. Thürer, and M. Stevenson, "A game theory model based on Gale-Shapley for dual-resource constrained (DRC) flexible job shop scheduling", *International Journal of Industrial Engineering Computations*, 11(2), 173-184, 2020.
- [18] M.Y. Jaber and W.P. Neumann, "Modelling worker fatigue and recovery in dual-resource constrained systems", *Computers & Industrial Engineering*, 59, 75-84, 2010.
- [19] N. Berti, S. Finco, O. Battaia, and X. Delorme, "Ageing workforce effects in Dual-Resource Constrained job-shop scheduling", *International Journal of Production Economics*, 237, 108-151, 2021.
- [20] R. T. Nelson, "A simulation of labour efficiency and central assignment in a production model", *Management Science* 17(2) 97-106, 1970.
- [21] P. M. Bobrowski and P. S. Park, "An evaluation of labor assignment rules when workers are not perfectly interchangeable", *Journal of Operations Management*, 11(3), 257-268, 1993.
- [22] H. V. Kher, "Examination of flexibility acquisition policies in dual resource constrained job shops with simultaneous worker learning and forgetting effects", *Journal of the Operational Research Society*, 51(5), 592-601, 2000.
- [23] J. Xu, X. Xu, and S.Q. Xie, "Recent developments in Dual Resource Constrained (DRC) system research", *European Journal of Operational Research*, 215 (2), 309-318, 2011.
- [24] H.V. Kher and T.D. Fry, "Labour flexibility and assignment policies in a job shop having incommensurable objectives", *International Journal of Production Research*, 39 (11), 2295-2311, 2001.
- [25] M. K. Malhotra and H. V. Kher, "An evaluation of worker assignment policies in dual Resource constrained job shops with heterogeneous resources and worker transfer delays". *International Journal of Production Research*, 32(5), 1087-1103, 1994.
- [26] J.A.C. Bokhorst, J. Slomp, and G.J.C. Gaalman, "On the who-rule in Dual Re-source Constrained (DRC) manufacturing systems", *International Journal of Production Research*, 42(23), 5049-5074, 2004.
- [27] M. Thürer, H. Zhang, M. Stevenson, F. Costa, and L. Ma, "Worker assignment in dual resource constrained assembly job shops with worker heterogeneity: an assessment by simulation", *International Journal of Production Research*, 58 (20) 6336-6349, 2020.
- [28] M.K. Malhotra, T.D. Fry, H.V. Kher, and J.M. Donohue, "The Impact of Learning and Labor Attrition on Worker Flexibility in Dual Resource Constrained Job Shops", *Decision Sciences*, 24 (3), 641-664, 1993.
- [29] T.D. Fry, H.V. Kher, and M.K. Malhotra, "Managing worker flexibility and attrition in dual resource constrained job shops", *International Journal of Production Research*, 33(8), 2163-2179, 1995.
- [30] V.R. Kannan and J.B. Jensen, "Learning and labour assignment in a dual resource constrained cellular shop", *International Journal of Production Research*, 42(7), 1455-1470, 2004.
- [31] H.V. Kher, M.K. Malhotra, P.R. Philipoom, and T.D. Fry, "Modeling simultaneous worker learning and forgetting in dual resource constrained systems", *European Journal of Operational Research*, 115, 158-172, 1999.
- [32] N. Mirzaei, M.G. Nejad, and N.O. Fernandes, "Combining Line Balancing Methods and Discrete Event Simulation: A Case Study from a Metalworking Company", *International Journal of Industrial Engineering and Management*, 12(1), 14-24, 2021.
- [33] M. Ebrahimi, M. Mahmoodjanloo, B. Einabadi, A. Baboli, and E. Rother, "A mixed-model assembly line sequencing problem with parallel stations and walking workers: a case study in the automotive industry". *International Journal of Production Research*, Ahead-Of-Print, 1-20, 2022, DOI: 10.1080/00207543.2021.2022801
- [34] D. Lei, Y. Yuan, J. Cai, and D. Bai, "An imperialist competitive algorithm with memory for distributed unrelated parallel machines scheduling", *International Journal of Production Research*, 58 (2), 597-614, 2020.
- [35] Y.-I. Kim and H.-J. Kim, "Rescheduling of unrelated parallel machines with job-dependent setup times under forecasted machine breakdown", *International Journal of Production Research*, 59(19), 5236-5258, 2021.
- [36] D. Xu, L. Xu, Z. Xu, and X. Yu, "A note on scheduling on uniform parallel machines with unavailability constraints", *International Journal of Production Research*, 59 (16), 5083-5086, 2021.
- [37] L. D. Fredendall, S. A. Melnyk, and G. Ragatz, "Information and Scheduling in a Dual Resource Constrained Job Shop", *International Journal of Production Research* 34 (10): 2783-2802, 1996.
- [38] M. Thürer, M. Stevenson, and P. Renna, "Workload control in dual-resource constrained high variety shops: an assessment by simulation", *International Journal of Production Research*, 57(3), 931-947, 2019.
- [39] A. Portioli-Staudacher, F. Costa, and M. Thürer, "The use of labour flexibility for output control in workload controlled flow shops: A simulation analysis", *International Journal of Industrial Engineering Computations* 11(3):429-442, 2020.
- [40] S. Carmo-Silva, N. Fernandes, M. Thürer, and L.P. Ferreira, "Extending the POLCA production control system with centralized job release". *Production*, 30, e20190159, 2020, DOI: 10.1590/0103-6513.20190159.
- [41] D. L. McWilliams and E.G. Tetteh, "Managing lean DRC systems with demand uncertainty: an analytical approach". *International Journal of Advanced Manufacturing Technology*, 45, 1017-1032, 2009.
- [42] C.H. Glock, "The machine breakdown paradox: How random shifts in the production rate may increase company profit", *Computers & Industrial Engineering*, 66(4), 1171-1176, 2013.
- [43] W.J. Hopp, N. Pati, and P.C. Jones, "Optimal inventory control in a production flow system with failures", *International Journal of Production Research*, 27 (1), 1367-1384, 1989.
- [44] S.M.R. Iravani and I. Duenyas, "Integrating maintenance and production control of a deteriorating production system", *IIE Transactions*, 34 (1), 423-435, 2002.
- [45] C.H. Glock and M.Y. Jaber, "A multi-stage production-inventory model with learning and forgetting effects, rework and scrap", *Computers and Industrial Engineering*, 64 (1), 708-720, 2013.
- [46] J.B. Jensen, "The impact of resource Flexibility and staffing decisions on cellular and departmental shop performance", *European Journal of Operational Research* 127 (1) 279-296, 2000.
- [47] M. Thürer, "Dual Resource Constrained (DRC) Shops: Literature Review and Analysis", In: Moon I., Lee G., Park J., Kiritsis D., von Cieminski G. (eds) *Advances in Production Management Systems. Production Management for Data-Driven, Intelligent, Collaborative, and Sustainable Manufacturing APMS 2018. IFIP Advances in Information and Communication Technology*, vol 535. Springer, Cham, 2018.
- [48] M.J. Land, M. Stevenson, M. Thürer, and G.J.C. Gaalman, "Job Shop Control: In Search of the Key to Delivery Improvements". *International Journal of Production Economics* 168 (1), 257-266, 2015.