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Micro downtimes management in the Lean perspective: An empirical research in a production bottleneck

P. Lacerda^a (D) 0000-0002-1592-9782, M. C. Guedes Ramos^a (D) 0000-0003-0652-6444,

R. Odebrecht de Souza^{b,*} (D) 0000-0002-2186-6183, A. Bonamigo^a (D) 0000-0002-6670-9755,

F. A. Forcellini^b (D) 0000-0003-2851-6028

^a Fluminense Federal University, Volta Redonda, Rio de Janeiro, Brazil;

^b Federal University of Santa Catarina, Florianópolis, Santa Catarina, Brazil

References

- Associação Nacional da Indústria de Pneumáticos, "Vendas de pneus fecham 2023 com queda de 8,2%, aponta balanço da ANIP" [Online]. Available: https://www.anip.org.br/releases/vendas-de-pneus-fecham-2023-com-queda-de-82-aponta-balancoda-anip/. [Acessed: 26-Apr-2024].
- [2] Estadão, "Venda de pneus de caminhão recua 15% em 2023" [Online]. Available: https://estradao.estadao.com.br/caminhoes/ venda-de-pneus-de-caminhao-recua-15-em-2023/ [Accessed: 26-Apr-2024].
- [3] Allied Market Research, "Brazil Automotive Tire Market Outlook 2020 2027" [Online]. Available: https://www.alliedmarketresearch.com/ [Accessed: 26-Apr-2024].
- [4] J. P. Womack, D. T. Jones, and D. Roos, The Machine That Changed the World: The Story of Lean Production. New York, USA: Simon and Schuster, 2007.
- [5] R. Odebrecht de Souza, H. A. Ferenhof, and F. A. Forcellini, "Systematic for Process Improvement Using Cyber-Physical Systems and Toyota Kata," in Product Lifecycle Management. Green and Blue Technologies to Support Smart and Sustainable Organizations, O. Canciglieri Junior, F. Noël, L. Rivest, and A. Bouras, Eds. Cham: Springer, 2022, vol. 639, pp. 447-460, doi: 10.1007/978-3-030-94335-6_32.
- [6] F. T. S. Chan, H. C. W. Lau, R. W. L. Ip, H. K. Chan, and S. Kong, "Implementation of total productive maintenance: a case study," Int. J. of Prod. Econo., vol. 95, no. 1, pp. 71-94, 2005, doi: 10.1016/j.ijpe.2003.10.021.
- [7] A. Acharya, D. Garg, N. Singh, and U. Gahlaut, "Plant Effectiveness Improvement of Overall Equipment Effectiveness using Autonomous Maintenance Training: A Case Study," Int. J. Mech. Prod. Eng. Res. Dev., vol. 9, no. 1, pp. 103–112, 2018, doi: 10.24247/jipperdfeb201911.
- [8] I. Zennaro, D. Battini, F. Sgarbossa, A. Persona, and R. D. Marchi, "Data collection, analysis and impact on OEE in bottling lines the San Benedetto case study," Int. J. Qual. Reliability Manag., vol. 35, no. 4, pp. 965-995, 2018, doi: 10.1108/IJQRM-11-2016-0202.
- [9] A. Athanasopoulou and M. De Reuver, "How do business model tools facilitate business model exploration? Evidence from action research," Elec. Mark., vol. 30, pp. 495–508, 2020, doi: 10.1007/s12525-020-00418-3.
- [10] M. Ingaldi and K. Knop, "Influence of the Modernity of the Dosing Machine on the Stability of the Packing Process," AIP Conference Proceedings, vol. 2503, no. 050069, pp. 1-8, Oct. 2022, presented at the International Conference on Modern Trends in Manufacturing Technologies and Equipment 2021 (ICMTMTE 2021), Sevastopol, Russia, Sep. 6-10, 2021, doi: 10.1063/5.0099503.
- [11] N. Basán, L. Ramos, M. Coccola, and C. A. Méndez, "Modeling, simulation and optimization of the main packaging line of a brewing company," in Proc. 25th European Modeling and Simulation Symposium (EMSS 2013), Athens, Greece, Sep. 25-27, pp. 551-560, 2013.
- [12] D. Battini, A. Persona, and A. Regattieri, "Buffer size design linked to reliability performance: A simulative study," Comput. Ind. Eng., vol. 56, no. 4, pp. 1633-1641, 2009, doi: 10.1016/j.cie.2008.10.020.

- [13] D. Battini, R. Manzini, A. Persona, and A. Regattieri, "TPM approach and new buffer design paradigm in plant layout," in Proc. 11th ISSAT International Conference on Reliability and Quality in Design, San Francisco, CA, USA, Aug. 4-6, 2005, pp. 299-305.
- [14] A. F. da Silva, F. A. S. Marins, P. M. Tamura, and E. X. Dias, "Bi-Objective Multiple criteria data envelopment analysis combined with the overall equipment effectiveness: An application in an automotive company," J. Clean. Prod., vol. 157, pp. 278-288, 2017, doi: 10.1016/j.jclepro.2017.04.147.
- [15] S. Nakajima, Introduction to TPM Total Productive Maintenance. Productivity Press, 1988.
- [16] D. Powell, M. C. Magnanini, M. Colledani, and O. Myklebust, "Advancing zero defect manufacturing: A state-of-the-art perspective and future research directions," Comput. Ind., vol. 136, p. 103596, 2022, doi: 10.1016/j.compind.2021.103596.
- [17] G. Lanza, J. Stoll, N. Stricker, S. Peters, and C. Lorenz, "Measuring global production effectiveness," Procedia CIRP, vol. 7, pp. 31–36, 2013. doi: 10.1016/j.procir.2013.05.006.
- [18] J. Basulo Ribeiro, M. Amorim, and L. Teixeira, "How To Accelerate Digital Transformation in Companies With Lean Philosophy? Contributions Based on a Practical Case," Int. J. Ind. Eng. Manag., vol. 14, no. 2, pp. 94–104, 2023, doi: 10.24867/ IJIEM-2023-2-326.
- [19] B. Resta, S. Dotti, P. Gaiardelli, and A. Boffelli, "Lean Manufacturing and Sustainability: An Integrated View," Adv. Prod. Manag. Syst. Initiat. a Sustain, 2016, pp. 659–666, doi: 10.1007/978-3-319-51133-7_78.
- [20] C. Cimini, A. Lagorio, D. Romero, P. Gaiardelli, and G. Tortorella, "On Job Profiles Enlargement and Enrichment when Lean and Industry 4.0 Paradigms Meet," Int. J. Ind. Eng. Manag., vol. 15, no. 4, pp. 338–347, 2024, doi: 10.24867/IJIEM-2024-4-367.
- [21] B. Zhou, "Lean principles, practices, and impacts: A study on small and medium-sized enterprises (SMEs)," Ann. Oper. Res., vol. 241, no. 1–2, pp. 457–474, 2016, doi: 10.1007/s10479-012-1177-3.
- [22] M. Godinho Filho, G. M. D. Ganga, and A. Gunasekaran, "Lean manufacturing in Brazilian small and medium enterprises: implementation and effect on performance," Int. J. Prod. Res., vol. 54, no. 24, pp. 7523-7545, 2016, doi: 10.1080/00207543.2016.1201606.
- [23] M. C. Rodríguez, M. M. Vázquez, H. Tslapatas, C. V. de Carvalho, T. Jesmin, and O. Heidmann, "Introducing lean and agile methodologies into engineering higher education: The cases of Greece, Portugal, Spain and Estonia," in Proceedings of the 2018 IEEE Global Engineering Education Conference (EDUCON), Tenerife, Spain, 17–20 April 2018, pp. 720–729, doi: 10.1109/ EDUCON.2018.8363302.
- [24] M. F. Suárez-Barraza and F. G. Rodríguez-González, "Cornerstone root causes through the analysis of the Ishikawa diagram, is it possible to find them?," Int. J. Qual. Serv. Sci., vol. 11, pp. 302-316, 2019, doi: 10.1108/IJQSS-12-2017-0113.
- [25] M. Savković, D. Ćirić Lalić, B. Lalić, U. Marjanović, T. Vučković, and M. Petrović, "A glance into holistic project success with organisational agility and project resilience," Teh. Vjesn., vol. 31, no. 4, pp. 1030–1039, 2024. doi: 10.17559/TV-20230411000523.
- [26] S. Sá, L. P. Ferreira, F. Silva, J. C. Sá, M. Teresa, and G. Santos, "The Importance of Subcontracting and Its Relationship With Lean Philosophy in Automotive Industry," Int. J. Ind. Eng. Manag., vol. 13, no. 3, pp. 186–193, 2022, doi: 10.24867/ IJIEM-2022-3-311.
- [27] P. T. Ross, E. Abdoler, L. Flygt, R. S. Mangrulkar, and S. A. Santen, "Using a modified A3 lean Framework to identify ways to increase students' reporting of mistreatment behaviors," Acad. Medicine: J. Assoc. Am. Med. Colleges, vol. 93, no. 4, pp. 606–11, 2018, doi: 10.1097/ACM.00000000002033.
- [28] N. Mohd Saad, A. Al-Ashaab, M. Maksimovic, L. Zhu, E. Shehab, P. Ewers, and A. Kassam, "A3 thinking approach to support knowledge-driven design," Int. J. Adv. Manuf. Technol., vol. 68, no. 5-8, pp. 1371-1386, 2013, doi: 10.1007/s00170-013-4928-7.
- [29] S. Nallusamy and G. Majumdar, "Enhancement of Overall Equipment Effectiveness Using Total Productive Maintenance in a Manufacturing Industry," Int. J. Performability Eng., vol. 13, no. 2, pp. 173-188, 2017.
- [30] S. Nallusamy, V. Kumar, V. Yadav, U.K. Prasad, and S.K. Suman, "Implementation of total productive maintenance to enhance the overall equipment effectiveness in medium scale industries," Int. J. Mech. Prod. Eng. Res. Dev., vol. 8, no. 1, pp. 1027-1038, 2018, doi: 10.24247/jijmperdfeb2018123.
- [31] M. Kumar, J. Antony, R. K. Singh, M. K. Tiwari, and D. Perry, "Implementing the Lean Sigma framework in an Indian SME: A case study," Prod. Plan. Control, vol. 17, no. 4, pp. 407-423, 2006, doi: 10.1080/09537280500483350.
- [32] P. Marinho, D. Pimentel, R. Casais, F. Silva, J. C. Sá, and L. P. Ferreira. "Selecting the Best Tools and Framework To Evaluate Equipment Malfunctions and Improve the OEE in the Cork Industry," Int. J. Ind. Eng. Manag., vol. 12, no. 4, pp. 286–298, 2021, doi: 10.24867/IJIEM-2021-4-295.
- [33] S. J. Benjamin, M. S. Marathamuthu, and U. Murugaiah, "The use of 5-WHYs technique to eliminate OEE's speed loss in a manufacturing firm," J. Qual. Maint. Eng., vol. 21, no. 4, pp. 419-432, 2015, doi: 10.1108/JQME-09-2013-0062.
- [34] A. Dresch, D. R. Veit, P. N. de Lima, D. P. Lacerda, and D. C. Collatto, "Inducing Brazilian manufacturing SMEs productivity with lean tools," Int. J. Prod. Perform. Manag., vol. 68, no. 1, pp. 69-87, 2019, doi: 10.1108/IJPPM-10-2017-0248.
- [35] R. Domingo and S. Aguado, "Overall environmental equipment effectiveness as a metric of a lean and Green manufacturing system," Sustainability, vol. 7, no. 7, pp. 9031-9047, 2015, doi: 10.3390/su7079031.
- [36] C. Anusha and V. Umasankar, "Performance Prediction Through OEF-Model," Int. J. Ind. Eng. Manag., vol. 11, no. 2, pp. 93-103, 2020, doi: 10.24867/IJIEM-2020-2-256.
- [37] I. Antoniolli, P. Guariente, T. Pereira, L. Pinto, and G. Silva, "Standardization and optimization of an automotive components production line," Procedia Manuf., vol. 13, pp. 1120-1127, 2017, doi: 10.1016/j.promfg.2017.09.173.
- [38] P. M. Gibbons and S.C. Burgess, "Introducing OEE as a measure of lean Six Sigma capability," Int. J. Lean Six Sigma, vol. 1, no. 2, pp. 134-156, 2010, doi: 10.1108/20401461011049511.
- [39] N. A. B. Aminuddin, J. A. Garza-Reyes, V. Kumar, J. Antony, and L. Rocha-Lona, "An analysis of managerial factors affecting the implementation and use of overall equipment effectiveness," Int. J. Prod. Res., vol. 54, no. 15, pp. 4430-4447, 2016, doi: 10.1080/00207543.2015.1055849.
- [40] S. Raedemaecker, C. Handscomb, S. Jautelat, M. Rodriguez, and L. Wienke, "Lean management or agile? The right answer may be both," McKinsey & Company [Online]. Avalable: https://www.mckinsey.com/ [Acessed: 26-Apr-2024].
- [41] J. Ren, Y. Y. Yusuf, and N. D. Burns, "The Effects of Agile Attributes on Competitive Priorities: A Neural Network Approach," Integr. Manuf. Syst., vol. 14, no. 6, pp. 489-497, 2003, doi: 10.1108/09576060310491351.

- [42] T. Dingsøyr, S. Nerur, V. Balijepally, and N. B. Moe, "A decade of agile methodologies: Towards explaining agile software development," J. Syst. Softw., vol. 85, pp. 1213–1221, 2012, doi: 10.1016/j.jss.2012.02.033.
- [43] D. Lj. Bjelica, M. Mihić, K. Kavčič, and D. Gošnik, "Relationship between project success factors, project success criteria and project success in SME: Evidence from selected European transitional economies," Int. J. Ind. Eng. Manag., vol. 14, no. 4, pp. 297–310, 2023, doi: 10.24867/IJIEM-2023-4-340.
- [44] L. E. De la Cruz-Perdomo, D. S. Pastor-Mendoza, M. F. Collao-Diaz, and E. A. Del Solar-Vergara, "Service Model Based On Lean Service And Agile Methods To Increase The Service Level In A SME In The Mining Sector," in Proc. LACCEI Int. Multiconf. Entrepreneurship, Innovation and Regional Development, LEIRD, pp. 217, 2023, doi: 10.18687/LEIRD2023.1.1.217.
- [45] Manifesto for Agile Software Development, "Agile Manifesto," [Online]. Avalable: https://agilemanifesto.org. [Acessed: 23-May-2024].
- [46] J. Pócsová, D. Bednárová, G. Bogdanovská, and A. Mojžišová, "Implementation of Agile Methodologies in an Engineering Course," Educ. Sci., vol. 10, no. 333, pp. 1–12, 2020, doi: 10.3390/educsci10120333.
- [47] A. Al-Refaie, G. Abbasi, and H. Al-shalaldeh, "Lean and agile practices to improve the performance of filling process via simulation and data envelopment analysis," SN Appl. Sci., vol. 1, no. 1131, pp. 1-12, 2019, doi: 10.1007/s42452-019-1199-4.
- [48] J. S. Bravo-Paliz and S. V. Avilés-Sacoto, "Characterizing the Integration of BRC Food Safety Certification and Lean Tools: The Case of an Ecuadorian Packaging Company," TQM J., vol. 35, pp. 872–892, 2023, doi: 10.1108/TQM-05-2021-0120.
- [49] K. Srinivasan, S. Muthu, N. K. Prasad, and G. Satheesh, "Reduction of paint line defects in shock absorber through Six Sigma DMAIC phases," Procedia Eng., vol. 97, pp. 1755–1764, 2014, doi: 10.1016/j.proeng.2014.12.327.
- [50] M. Smetkowska and B. Mrugalska, "Using six sigma DMAIC to improve the quality of the production process: a case study," Procedia - Soc. Behav. Sci., vol. 238, pp. 590–596, 2018, doi: 10.1016/j.sbspro.2018.04.039.
- [51] R. R. D. Prado, P. A. Boareto, J. Chaves, and E. A. P. Santos, "Agile DMAIC cycle: incorporating process mining and support decision," Int. J. Lean Six Sigma, vol. 15, no. 3, pp. 614–641, 2023, doi: 10.1108/IJLSS-04-2022-0092.
- [52] P. Acosta-Vargas, E. Chicaiza-Salgado, I. Acosta-Vargas, L. Salvador-Ullauri, and M. Gonzalez, "Towards Industry Improvement in Manufacturing with DMAIC," in Int. Conf. Syst. Inf. Sci., Cham, Switzerland, pp. 341–352, 2020, doi: 10.1007/978-3-030-59194-6_28.
- [53] S. A. Villacís and P. S. Burneo, "UAVs' Efficient Assembly: Lean Manufacturing Implementation in an UAVs' Assembly Company," Int. J. Ind. Eng. Manag., vol. 11, no. 4, pp. 237–252, 2020, doi: 10.24867/IJIEM-2020-4-268.
- [54] P. K. P. Paranitharan, R. Babu, P. Pandi, and D. Jeyathilagar, "An empirical validation of integrated manufacturing business excellence model," Int. J. Adv. Manuf. Technol., vol. 92, no. 5-8, pp. 2569–2591, 2017, doi: 10.1007/s00170-017-0271-8.
- [55] R. R. Delgadillo, K. Medini, and T. Wuest, "A DMAIC framework to improve quality and sustainability in additive manufacturing - A case study," Sustainability, vol. 14, no. 1, article no. 581, 2022, doi: 10.3390/su14010581.
- [56] A. Al-Hussain and H. Al-Ahmed, "Role of Lean Principles and 5S Programs in Increasing Maintenance Productivity," in Proceedings of the 2022 International Petroleum Technology Conference, Riyadh, pp. 21-23, 2022, doi: 10.2523/IPTC-22107-MS.
- [57] S. K. Kim and J. Mont, "Agile project management for root cause analysis projects," in Proceedings of the 19th International Conference on Engineering Design, vol. 5, DS75-05, pp. 71-80, 2013, doi: 10.978-190467048-3.
- [58] S. Krishnan, K. Mathiyazhagan and V. R. Sreedharan, "Developing a Hybrid Approach for Lean Six Sigma Project Management: A Case Application in the Reamer Manufacturing Industry," IEEE Trans. on Eng. Manag., vol. 69, no. 6, pp. 2897-2914, 2022, doi: 10.1109/TEM.2020.3013695.
- [59] J. De Mast and J. Lokkerbol, "An analysis of the Six Sigma DMAIC method from the perspective of problem solving," Int. J. Prod. Econ., vol. 139, no. 2, pp. 604–614, 2012, doi: 10.1016/j.ijpe.2012.05.035.
- [60] D. J. Wheeler, The Six Sigma Practitioner's Guide to Data Analysis. Knoxville, Tennessee, USA: SPC Press, 2005.
- [61] J. A. Garza-Reyes, A. Flint, V. Kumar, J. Antony, and H. Soriano-Meier, "A DMAIRC Approach to Lead Time Reduction in an Aerospace Engine Assembly Process," J. Manuf. Technol. Manage., vol. 25, no. 1, pp. 27–48, 2014, doi: 10.1108/JMTM-05-2012-0058.
- [62] R. S. McLean, J. Antony, and J. J. Dahlgaard, "Failure of continuous improvement initiatives in manufacturing environments: A systematic review of the evidence," Total Qual. Manag. Bus. Excellence, vol. 28, no. 3-4, pp. 219–237, 2017, doi: 10.1080/14783363.2015.1063414.
- [63] M. Shamsuzzaman, M. Alzeraif, I. Alsyouf, and M. B. C. Khoo, "Using lean six sigma to improve mobile order fulfilment process in a telecom service sector," Prod. Planning Control, vol. 29, no. 4, pp. 301–314, 2018, doi: 10.1080/09537287.2018.1426132.
- [64] R. Pinedo-Cuenca, P. G. Olalla, and D. Setijono, "Linking six sigma's critical success/hindering factors and organizational change (development)," Int. J. Lean Six Sigma, vol. 3, no. 4, pp. 284–298, 2012, doi: 10.1108/20401461211284752.
- [65] S. J. Raval and R. Kant, "Study on Lean Six Sigma frameworks: A critical literature review," Int. J. Lean Six Sigma, vol. 8, no. 3, pp. 275–334, 2017, doi: 10.1108/IJLSS-02-2016-0003.
- [66] I. Azhar, S. Ahmad, and M. K. Sein, "Action research as a proactive research method for construction engineering and management," J. Constr. Eng. Manag., vol. 136, no. 1, pp. 87–98, 2010, doi: 10.1061/(ASCE)CO.1943-7862.0000081.
- [67] Z. Heng, L. Aiping, X. Liyun, and G. Moroni, "Automatic Estimate of OEE Considering Uncertainty," Proceedia CIRP, vol. 81, pp. 630–635, 2019, doi: 10.1016/j.procir.2019.03.167.
- [68] G. Pinto, F. J. G. Silva, A. Baptista, N. O. Fernandes, R. Casais, and C. Carvalho, "TPM implementation and maintenance strategic plan – a case study," Procedia Manufacturing, vol. 51, pp. 1423–1430, 2020, doi: 10.1016/j.promfg.2020.10.198.
- [69] N. Torre, C. Leo, and A. Bonamigo, "Lean 4.0: An analytical approach for hydraulic system maintenance in a production line of steel making plant", Int. J. Ind. Eng. Manag., vol. 14, no. 3, pp. 186–199, 2023., doi: 10.24867/IJIEM-2023-3-332.
- [70] A. Bonamigo, P. Mendonça, L. F. Conrado, and N. Pereira, "Development of a method for evaluation of internal processes in Brazilian Emergency Care Units (ECUs) through Toyota Kata and Single Minute Exchange of Die (SMED)," Meta Avaliação, pp. 23-23, 2023, doi: 10.22347/2175-2753v0i0.4051.