APEM journal

Advances in Production Engineering & Management
Volume 18 | Number 2 | June 2023 | pp 163–174
https://doi.org/10.14743/apem2023.2.464

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

Hybrid forecasting modelling of cost and time entities for planning and optimizing projects in the die-cast aluminium industry

Muñoz-Ibañez, C.[a], **Chairez, I.**[a], **Jimenez-Martinez, M.**[b], **Molina, A.**[a], **Alfaro-Ponce, M.**[a,*]

[a]Tecnologico de Monterrey, Institute of Advanced Materials for Sustainable Manufacturing, Mexico City, Mexico
[b]Tecnologico de Monterrey, School of Science and Engineering, Puebla, Mexico

ABSTRACT

The techniques employed to manage an industrial project are based on tools that aim to achieve the objectives set by an organization. Most of these techniques consider the development of operative and predictive models. The difficulty in developing project planning models relies on estimating large sets of parameters and the need to include model sections of poorly identifiable, that increase costs and time. This work develops a hybrid forecasting model for all the phases that make up die-casting projects through a series of parameters and sub-models that contemplate the particularities of each case, thereby achieving greater precision in the forecast. The model identifies the cost and time factors that affect project planning, specifically in the die-casting industry, and intends to predict their future behaviour when certain initially given conditions are modified. To estimate the parameters of the hybrid model, several factors in the processes were considered that interact in this industry, such as primary matter costs and activities associated to the process. The considered processes that have a substantial economic impact on the implementation of the project were selected. The criteria for this selection considered identifying the relevant parts of the design and manufacturing in the die-casting industry. Process factors such as the Cost of aluminium and its related activities, whose processes will be grouped into cost and time entities to build a set of metrics that allow better control over them. Finally, the proposed model is based on analytical, parametric, and analog methods that achieve accuracy greater than 85 % in predicting the time and Cost of the process.

ARTICLE INFO

Keywords:
Hybrid models;
Entity modelling;
Project planning;
Forecasting models;
Aluminium die-casting;
Cost factors;
Time factors;
Optimization

**Corresponding author:*
marielalfa@gmail.com
(Alfaro-Ponce, M.)

Article history:
Received 5 May 2023
Revised 17 June 2023
Accepted 19 June 2023

References

[1] Campero, M., Alarcón, L.F. (2018). *Administración de proyectos civiles*, Tercera edición, Ediciones UC, Valparaíso, Chile.
[2] Gido, J., Clements, J., Baker, R. (2003). *Administración exitosa de proyectos*, Cengage Learning Editores, Santa Fe, México, from *https://dspace.scz.ucb.edu.bo/dspace/bitstream/123456789/13442/3/9947.pdf,* accessed April 26, 2023.
[3] Turner, J.R. (2009). *Handbook of project-based management: Leading strategic change in organizations,* 3rd edition, Mc Graw Hill, New York, USA.
[4] Wan, J. (2022). Demand prediction and optimization of workshop manufacturing resources allocation: A new method and a case study, *Advances in Production Engineering & Management,* Vol. 17, No. 4, 413-424, doi: 10.14743/apem2022.4.445.
[5] Amaya Amaya, J. (2016). *Toma de decisiones gerenciales: Métodos cuantitativos para la administración,* 2nd edition, Ecoe Ediciones, Bogotá, Colombia, from Link, accessed April 26, 2023.
[6] Heizer, J.H., Render, B. (2004). *Principles of Operations Management*, 5th edition, Pearson Educación, Ciudad de México, Mexico, from Link, accessed April 26, 2023.

[7] Kerzner, H. (2013). *Project management: A systems approach to planning, scheduling, and controlling,* John Wiley, New York, USA, from Link, accessed April 27, 2023.
[8] Goodpasture, J.C. (2004). *Quantitative methods in project management,* J. Ross Publishing, Fort Lauderdale, Florida, USA, from Link, accessed April 27, 2023,.
[9] Saunders, M., Lewis, P. (2017). *Doing research in business and management*, 2nd edition, Pearson, Harlow, United Kingdom, from *https://research.birmingham.ac.uk/en/publications/doing-research-in-business-and-management,* accessed April 27, 2023.
[10] Kramar, D., Cica, D. (2021). Modeling and optimization of finish diamond turning of spherical surfaces based on response surface methodology and cuckoo search algorithm, *Advances in Production Engineering & Management,* Vol. 16, No. 3, 326-334, doi: 10.14743/apem2021.3.403.
[11] Turk, M., Pipan, M., Simic, M., Herakovic, N. (2020). Simulation-based time evaluation of basic manual assembly tasks, *Advances in Production Engineering & Management,* Vol. 15, No. 3, 331-344, doi: 10.14743/apem2020.3.369.
[12] Kan, S.H. (2004). *Metrics and models in software quality engineering* , 2nd edition, Pearson Education, New York USA, from Link, accessed April 27, 2023.
[13] Bryde, D., Broquetas, M., Volm, J.M. (2013). The project benefits of Building Information Modelling (BIM), *International Journal of Project Management*, Vol. 31, No. 7, 971-980, doi: 10.1016/J.IJPROMAN.2012.12.001.
[14] Ofori, G. (2010). Indicators for measuring construction industry development in developing countries, *Building Research & Information,* Vol. 29, No. 1, 40-50, doi: 10.1080/09613210150208787.
[15] Ward, Y., Graves, A. (2007). Through-life management: The provision of total customer solutions in the aerospace industry, *International Journal of Services, Technology and Management*, Vol. 8, No. 6, 455-477, doi: 10.1504/IJSTM.2007.013942.
[16] Burgess, T.F., McKee, D., Kidd, C. (2005). Configuration management in the aerospace industry: A review of industry practice, *International Journal of Operations and Production Management*, Vol. 25, No. 3, 290-301, doi: 10.1108/01443570510581880.
[17] Martínez Sánchez, A., Pérez Pérez, M. (2005), Supply chain flexibility and firm performance: A conceptual model and empirical study in the automotive industry, *International Journal of Operations & Production Management,* Vol. 25, No. 7, 681-700, doi: 10.1108/01443570510605090.
[18] Han, X., Zhao, P.X., Kong, D.X. (2022). A bi-objective optimization of airport ferry vehicle scheduling based on heuristic algorithm: A real data case study, *Advances in Production Engineering & Management,* Vol. 17, No. 2, 183-192, doi: 10.14743/apem2022.2.429.
[19] Vukelic, D., Simunovic, K., Kanovic, Z., Saric, T., Doroslovacki, K., Prica, M., Simunovic, G. (2022). Modelling surface roughness in finish turning as a function of cutting tool geometry using the response surface method, Gaussian process regression and decision tree regression, *Advances in Production Engineering & Management,* Vol. 17, No. 3, 367-380, doi: 10.14743/apem2022.3.442.
[20] Blair, M., Hartong, A. (2012). Multidisciplinary design tools for affordability, In: *Proceedings of 41st Structures, Structural Dynamics, and Materials Conference and Exhibit,* Atlanta, USA, 350-360, doi: 10.2514/6.2000-1378.
[21] Qian, L., Ben-Arieh, D. (2008). Parametric cost estimation based on activity-based costing: A case study for design and development of rotational parts, *International Journal of Production Economics,* Vol. 113, No. 2, 805-818, doi: 10.1016/J.IJPE.2007.08.010.
[22] Wang, H.S., Wang, Y.N., Wang, Y.C. (2013). Cost estimation of plastic injection molding parts through integration of PSO and BP neural network, *Expert Systems with Applications,* Vol. 40, No. 2, 418-428, doi: 10.1016/J.ESWA.2012.01.166.
[23] Verlinden, B., Duflou, J.R., Collin, P., Cattrysse, D. (2008). Cost estimation for sheet metal parts using multiple regression and artificial neural networks: A case study, *International Journal of Production Economics,* Vol. 111, No. 2, 484-492, doi: 10.1016/J.IJPE.2007.02.004.
[24] Lallemand, H. (1999). Méthodes de chiffrage et indicateurs de la fonction devis, *Travail et méthodes,* No. 545, 35-44.
[25] Madan, J., Rao, P.V.M., Kundra, T.K. (2007). System for early cost estimation of die-cast parts, *International Journal of Production Research,* Vol. 45, No. 20, 4823-4847, doi: 10.1080/00207540600789016.
[26] Sung, B.S., Kim, I.S. (2008). The molding analysis of automobile parts using the die-casting system, *Journal of Materials Processing Technology,* Vol. 201, No. 1-3, 635-639, doi: 10.1016/J.JMATPROTEC.2007.11.185.
[27] Srivastava, A., Joshi, V., Shivpuri, R. (2004). Computer modeling and prediction of thermal fatigue cracking in die-casting tooling, *Wear*, Vol. 256, No. 1-2, 38-43, doi: 10.1016/S0043-1648(03)00281-3.
[28] Tsoukalas, V.D. (2008). Optimization of porosity formation in $AlSi_9Cu_3$ pressure die castings using genetic algorithm analysis, *Materials & Design,* Vol. 29, No. 10, 2027-2033, doi: 10.1016/J.MATDES.2008.04.016.
[29] Kim, D.-H., Kim, H.-G., Kim, H.-S. (2015). Design optimization and manufacture of hybrid glass/carbon fiber reinforced composite bumper beam for automobile vehicle, *Composite Structures,* Vol. 131, 742-752, doi: 10.1016/J.COPSTRUCT.2015.06.028.
[30] Singh, R., Sahay, A., Karry, K.M., Muzzio, F., Ierapetritou, M., Ramachandran, R. (2014). Implementation of an advanced hybrid MPC–PID control system using PAT tools into a direct compaction continuous pharmaceutical tablet manufacturing pilot plant, *International Journal of Pharmaceutics,* Vol. 473, No. 1-2, 38-54, doi: 10.1016/J.IJPHARM.2014.06.045.
[31] Liou, F., Slattery, K., Kinsella, M., Newkirk, J., Chou, H., Landers, R. (2007). Applications of a hybrid manufacturing process for fabrication of metallic structures, *Rapid Prototyping Journal,* Vol. 13, No. 4, 236-244, doi: 10.1108/13552540710776188.
[32] Rojek, I., Jagodziński, M. (2012). Hybrid artificial intelligence system in constraint based scheduling of integrated manufacturing ERP systems, In: Corchado, E., Snášel, V., Abraham, A., Woźniak, M., Graña, M., Cho, S.B. (eds.), In:

Hybrid artificial intelligent systems, HAIS 2012, Lecture notes in computer science, Vol. 7209, Springer, Berlin, Germany, 229-240, doi: 10.1007/978-3-642-28931-6_22.
[33] Liu, N., Zhang, Y.F., Lu, W.F. (2015). A hybrid approach to energy consumption modelling based on cutting power: A milling case, *Journal of Cleaner Production*, Vol. 104, 264-272, doi: 10.1016/J.JCLEPRO.2015.05.049.
[34] Hao, Q., Shen, W. (2008). Implementing a hybrid simulation model for a Kanban-based material handling system, *Robotics and Computer-Integrated Manufacturing,* Vol. 24, No. 5, 635-646, doi: 10.1016/J.RCIM.2007.09.012.
[35] Langmaak, S., Wiseall, S., Bru, C., Adkins, R., Scanlan, J., Sóbester, A. (2013). An activity-based-parametric hybrid cost model to estimate the unit cost of a novel gas turbine component, *International Journal of Production Economics,* Vol. 142, No. 1, 74-88, doi: 10.1016/J.IJPE.2012.09.020.
[36] Zhu, Z., Dhokia, V.G., Nassehi, A., Newman, S.T. (2013). A review of hybrid manufacturing processes – state of the art and future perspectives, *International Journal of Computer Integrated Manufacturing,* Vol. 26, No. 7, 596-615, doi: 10.1080/0951192X.2012.749530.
[37] Shehab, E.M., Abdalla, H.S. (2001). Manufacturing cost modelling for concurrent product development, *Robotics and Computer-Integrated Manufacturing,* Vol. 17, No. 4, 341-353, doi: 10.1016/S0736-5845(01)00009-6.
[38] Shooter, S.B., Simpson, T.W., Kumara, S.R.T., Stone, R.B., Terpenny, J.P. (2005). Toward a multi-agent information management infrastructure for product family planning and mass customisation, *International Journal of Mass Customisation*, Vol. 1, No. 1, 134-155, doi: 10.1504/IJMASSC.2005.007354.
[39] Montgomery, D.C., Jennings, C.L., Kulahci, M. (2008). *Introduction to time series analysis and forecasting,* 2nd edition, Jonh Wiley & Sons, Hoboken, New Jersey, USA, doi: 10.1111/jtsa.12203.
[40] Rosato, D.V., Rosato, D.V., Rosato, M.G. (2012). *Injection molding handbook,* 3rd edition, Kluwer Academic Publishers, Norwell, Massachusetts, USA, doi: 10.1007/978-1-4615-4597-2.