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EDITED AND REVIEWED BY  
Björn Johansson,  
Chalmers University of Technology,  
Sweden

\*CORRESPONDENCE  
Amit Kumar Jain,  
amitkumar.jain@gcu.ac.uk

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# Editorial: Life cycle engineering in the era of Industry 4.0

Amit Kumar Jain<sup>1\*</sup>, Sandeep Kumar<sup>2</sup> and Shubham Tayal<sup>3</sup>

<sup>1</sup>Department of Mechanical Engineering, School of Computing, Engineering and Built Environment, Glasgow Caledonian University, Glasgow, United Kingdom, <sup>2</sup>IILM Graduate School of Management, IILM University, Greater Noida, India, <sup>3</sup>Department of Electronics and Communication Engineering, SR University, Warangal, India

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## Editorial on the Research Topic

### Life cycle engineering in the era of Industry 4.0

In today's sustainability debate, industries are working to modernise their life cycle engineering strategies. Identifying a sustainable competitive edge in the era of Industry 4.0 is the most critical problem. Consequently, researchers and industry experts worldwide have optimised product life cycle by integrating machine learning, modern computing technologies, information management, and other multifaceted technologies, viz., semantic interoperability. Nevertheless, there are gaps between life cycle engineering and evolving Industry 4.0 technologies. Therefore, it is crucial to optimise the product life cycle *via*. digitalisation, innovation, resilience, and sustainability. This will allow for more value throughout the whole product's life cycle design and resource planning to environmentally friendly production, unrestricted operational availability, and full recycling or reusability. In light of this, this Research Topic aims to assemble articles highlighting innovations in life cycle engineering motivated by Industry 4.0.

Three research articles and one review article are among the papers on this Research Topic that have been published. A sound maintenance plan is crucial for optimising life cycle engineering. The research work by [Alamri and Mo](#) used the failure mode and consequences analysis to build novel preventive maintenance (PM) schedule for a complex system. Their methodology mainly relies on mean-time-to-failure (MTTF) information derived from Industry 4.0 system feedback data. If new MTTF data becomes available, the technique makes it simple to change the PM schedule. The case study findings show that over 90% system reliability has been reached while ensuring that related costs are kept to a minimum. The technical, environmental, and economic effects of maintenance choices throughout the product life cycle are considered in this approach.

Information management has pushed digital manufacturing to discover more effective ways to link and share data throughout different system stages. One of the cornerstones of Industry 4.0 is the horizontal and vertical integration of intelligent and self-adaptive systems. To develop an intelligent manufacturing system, [Pereira et al.](#) tackled the problem of semantic interoperability. This study provided a conceptual

framework based on semantic technologies to address semantic integration and interoperability issues. The architecture put forth is called MANUMATE, and it comprises two processes—ontology specialisation and information application, along with three artefacts—reference ontologies, requirements, and application ontologies. For beverage industry product life cycle optimisation, the system has been validated.

West et al. explored the research question in the smart factory environment through an integrative literature review: “What are the effects on product lifecycle management (PLM) when bundling assets with diverse operational lifespans in digitally enabled product-service systems?”. In addition, this study introduces the concept of nested lifecycles, which examines subsystems with different lifespans that must be handled holistically by other actors with different perspectives. Nested lifecycles take a systems perspective on asset management. Additionally, by enabling the nested lifecycles to be precisely recognised and handled, this study offers a framework for determining methods for lifespan management. The concept of nested lifecycles provides a fresh perspective to the asset management and PLM research community from a theoretical standpoint. From a managerial standpoint, the proposed paradigm will assist managers in understanding why and where collaboration between various actors may provide challenges because of their disparate perspectives and backgrounds.

Finally, to increase sustainability, Sarwatula et al. focused particularly on energy concerns in life cycle engineering. This study suggested the use of statistics and machine learning in the production of metal, electrical, food, and plastic to achieve sustainability at the industrial level. Herein, energy consumption prediction models are created utilising machine

learning methods like the random forest regressor, the extreme gradient boost regressor, etc. The machine learning models could help compare the energy usage of factories and locate areas for energy efficiency improvement.

The papers gathered in this Research Topic can be seen as a “taster” for what is to come because the field of digital transformation of the engineering life cycle is constantly growing. More intriguing outcomes are expected in the future. Many thanks to all of the researchers that contributed to this Research Topic.

## Author contributions

AJ drafted the editorial. SK and ST proofread it.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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