© Universiti Tun Hussein Onn Malaysia Publisher's Office

IJIE

Journal homepage: http://penerbit.uthm.edu.my/ojs/index.php/ijie
ISSN : 2229-838X e-ISSN : 2600-7916

The International Journal of Integrated Engineering

Step and Step-Nc as a Tool for Big Data in Cloud Manufacturing

N. Kassim[1]*, J. Jaafar[2], M.S.A. Mat Roseh[3], M.H. Mohamed Ali[1], R. Roslan[1], I.A. Bahrudin[1], S. Mat Yasin[1], J. Mohamed[1], A.H. Omar[1], M.F. Mohamed Nor[1], M.H. Jofri[1] , M. Abdul Hamid[1], M.R. Azhar[4]

[1]Center for Diploma Studies,
Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, MALAYSIA

[2]Software Engineering, Malaysian Institute of Information Technology,
University Kuala Lumpur, MALAYSIA

[3]Faculty of Engineering Technology,
University Malaysia Pahang, MALAYSIA

[4]Empire Tech Vision Network, Damansara, Kuala Lumpur, MALAYSIA

*Corresponding Author

DOI: https://doi.org/10.30880/ijie.2021.13.02.023
RReceived 1 January 2020; Accepted 3 December 2020; Available online 28 February 2021

Abstract: The terms big data, cloud manufacturing, predictive and additive manufacturing, and Internet of Things (IoT) are being most commonly used in the manufacturing industry nowadays. These terms are related to the fourth industrial revolution that emphasizes automation and data exchange between manufacturing tools/elements. Communication occurs between machines, products and even technicians or operators through various technologies while creating records of each interaction resulting in rapid growth of amount of data to be stored. Data acquisition is not a major issue since a structure or framework can properly connect these data in improving manufacturing efficiency. However, lack of effort in collecting and storing manufacturing data in the whole product life cycle process has made integration to be almost difficult to achieve. In this study, the adoption of STEP-NC method/technique was demonstrated in suiting the current explosion of big data in the industrial and manufacturing sector. The proposed methodology was developed through a study of an entity file structure and hierarchical concept in STEP and STEP-NC in gathering manufacturing data in a unified database. The challenge would be in making sense of the data, revealing the patterns in it and using them for operational improvements. The outcome of this study will be useful to support strategic decision making in product manufacturing.

Keywords: Manufacturing, Internet of Things (IoT), Communication

1. Introduction

Smart manufacturing is about putting priorities of the explosion in big data evolution by connecting and integrating it with cyber and physical capabilities of manufacturing operation [1]. Predictive manufacturing through big data and similar technologies like the Internet of Things, Cloud Manufacturing, Augmented Reality and Advanced human-machine interference is revolutionizing the way data and information is being viewed and generated as well as made

*Corresponding author: noordiana@uthm.edu.my

significant. The vast information explosion nowadays is expected to play a major role in the process of decision making in the manufacturing process, especially in terms of product life cycle. It will be highly advantageous when industrial decision-making practices are being done based on informed, filtered and novel data. Therefore, systematic and computerized analysis on big data has increased awareness on how it can be beneficial for the research and innovation process [2]. It is undeniable that the recent explosion of technological advancement has created a strong applicability of big data in every industry, particularly in manufacturing. However, regardless of the huge technological and business opportunities offered, its implementation in the actual manufacturing process is still in the early stages [3].

At every step of the chain, manufacturing generates massive amount of data, often from thousands of sources. To work with it, the volume, velocity and variety of big data need to be handled [4] – [6]. The power of big data varies. With the right analytic platform, different types of data can be combined for manufacturing for better impact through finding relationships and causes, predicting problems and improving efficiency.

The manufacturing sector is being pushed to its next transformation through globalization of global economies and has been forcing the local industries to face major challenges like predictive manufacturing. With the interest of becoming more competitive, industrial major players need to entwine modern upcoming technologies like advanced analytics or any cyber-physical system-based approaches in order to improve production efficiency, adaptability and productivity. Industry 4.0 has emphasized an aggressive push towards the concept of integrating Big Data, the Internet of Things and Additive Manufacturing, where data has become widely accessible and more universal, contributing to an influx of data. This scenario has emphasized the importance of finding and developing the right tools and approach towards managing data in the manufacturing sector [7]. The current advances of information and technology have shown that big data undoubtedly offers various tremendous advantages towards smart and advanced manufacturing. Although its adoption is still in the early stages, but its benefits and importance could not simply be ignored. This study aims to identify significant factors that could help in the integration of big data in the physical and cyber aspects of manufacturing by focusing on using STEP or STEP-NC as a tool to integrate all data including CAD as well as CAM activities like tool rotations, federate or workpiece clamping positions as shown in Figure 1. In this study, the structure and capability of STEP and STEP-NC files are highlighted through the process of manufacturing Example 1 ISO 14649 Part 11. The process helps to bring out a successful tool that can integrate manufacturing big data and design under a cloud platform as shown in Figure 2.

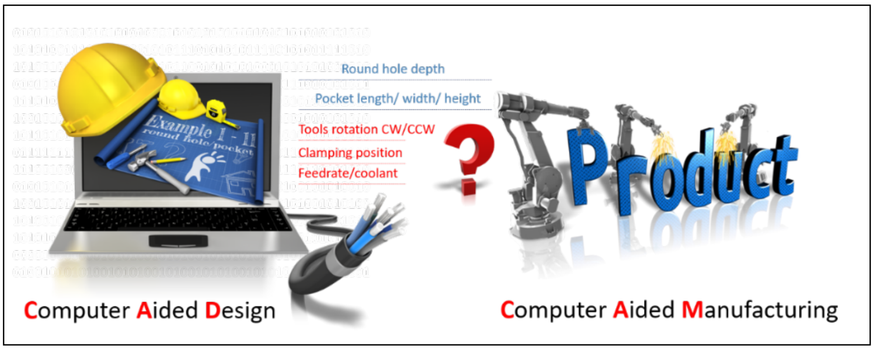


Fig. 1 - Current structure of data dysconnectivity in product life cycle

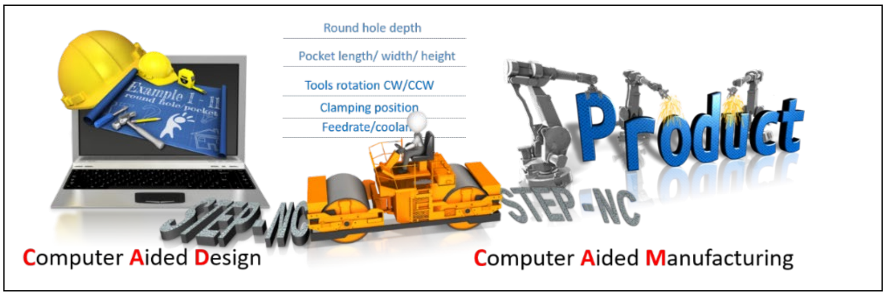
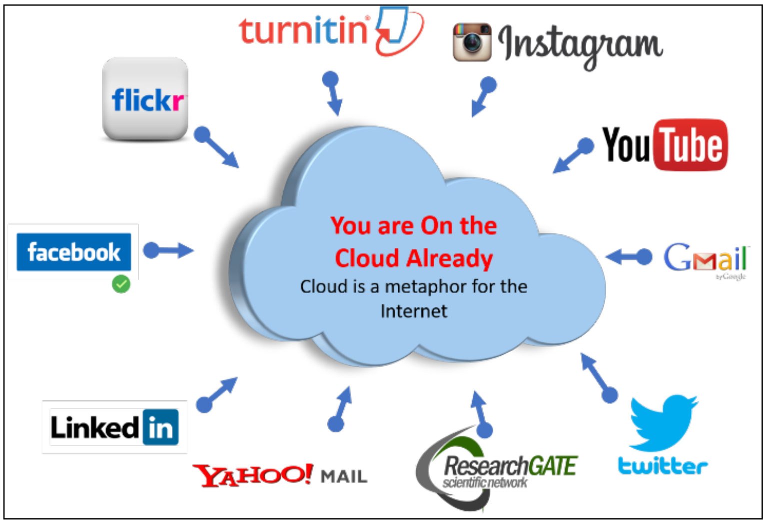


Fig. 2 - STEP-NC providing connectivity between CAD and CAM

2. Cloud Manufacturing

The concept of cloud technologies in manufacturing is taken from cloud computing on sharing network as well as varieties of configurable resources related to computerized environment that puts minimal effort and requirement on interaction with technology providers. It can be viewed as making full use of the internet for all the activities that can be done by the computer. Cloud concept is used in daily activities frequently like twitter, Instagram, Gmail, ResearchGate,



Scopus, LinkedIn and Facebook, as shown in Figure 3

Fig. 3 - General cloud concept utilization

Nowadays, product designers, production planners and manufacturers are not bound by their locations to conduct production and business globally. The whole life cycle of developing and manufacturing a product can be done regardless of the locations of operators, designers or manufacturers, as they are able to get themselves connected to each other through cloud technologies. This helps in reducing various costs that come from the needs to be at the same locations at the same time in order for product development to proceed as well as minimizing product lead time [8]. Cloud manufacturing plays a very important role in the utilization and integration of big data as seen in rapid prototyping [9], management system architecture and scheduling [10], service composition [11] and many other technologies enabled business [12]. Cloud manufacturing has leverage manufacturing process to new heights and hierarchy as needed in industries 4.0 by creating new paradigm on how manufacturing runs its business. It has been recognized as a new paradigm that will shift the future of manufacturing.

2.1 Big Data in Cloud Manufacturing

The data generated every day in manufacturing is transforming industrial data into a pool of information explosion that requires proper management and verification, especially with the internet access being made available almost globally by anyone [13]. Big data analytics have been employed to extract useful information and can derive effective manufacturing intelligence [14] as intelligence comes from data. Big data in manufacturing requires a unified analysis and integration that could benefit all parties and players involved [15]. Most tools to fully realize the concept of cloud manufacturing like Big Data, cyber physical system and information technology (IT) infrastructure have already been made available through current technological advancement, but there seems to be lack of integration and customization in various manufacturing aspects like manufacturing domain, cloud architecture and algorithms to computerize the whole product manufacturing process [16]. Data volume is exploding. With passing times, it is unavoidable to see the increase in piles of data being generated and accumulated. Why do we need all these connected devices? What is the purpose and the overall benefits of all these data? And the big question for the industry is, how do we turn big data into small and smart data, and create value? This is because being connected in an IOT world is essential nowadays.

2.2 STEP and STEP-NC as a Tool for Big Data

The emergence and current popularity of big data has brought with it new and unforeseen demands and challenges [17]. Big data can be found in various aspects and categories in the entire product lifecycle, starting from product design to the actual process of manufacturing and product service. It was found that current research on product data lifecycle in manufacturing puts more focus on physical products rather than virtual models. When information and data available in the product lifecycle are mostly scattered and disintegrated due to low integration procedures between physical and virtual aspects of a product, it will be useless for industries. These lead to low level of efficiency and intelligence in every vital phase of product development [18]. STEP and STEP-NC have always been known for its information richness, where from several researches, it has shown its capabilities in keeping manufacturing and design data of the whole process of the product management life cycle [19]–[24]. The process of integrating manufacturing data from design until production has been ongoing since 1950s. Some of the recent data integration that is close to modern manufacturing era can be summarized in Figure 4, where the International Standard Organization is working on integrating basic to advanced data under one flat file with relationships that can connect different data together.

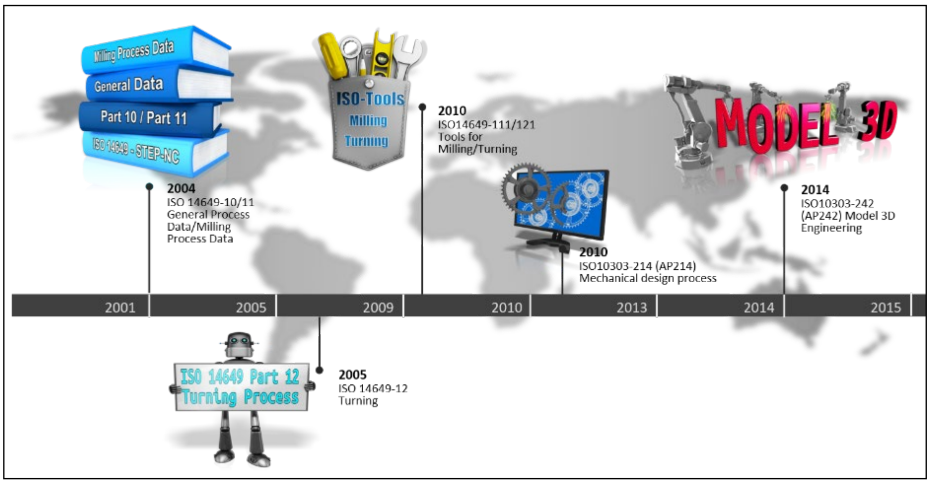


Fig. 4 - Data integration progress through the years

The STEP and STEP-NC physical structures allow data to be expandable and connected through an entity relationship as shown in Figure 5. These structures create a relationship between fields and entities in between tables that is similar to a tree structure in the database management system. All the data and information that are involved in the development of a product from design to actual manufacturing will be stored in one database to allow a detailed study on each entity to emphasize on its connections and relationships to other entities or fields.

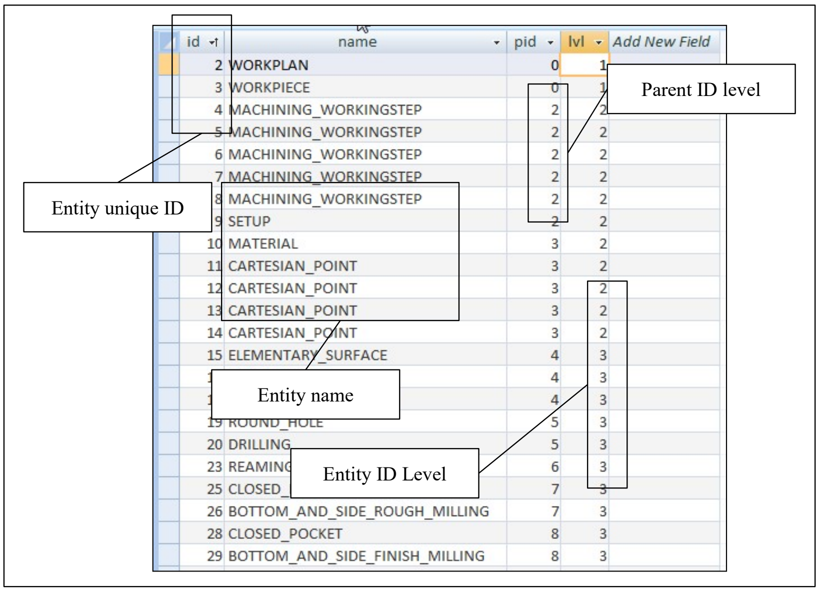


Fig. 5 - Data view of entity tree hierarchy

In order to have a better understanding on the tree structure of data relationships, one can also view it in terms of a parent to child relationship, by connecting data to a multilevel hierarchy. This multilevel hierarchy will highlight the integration between data, and how it will be grouped and categorized. The categorization of data will help in easing the process of arranging them into similar and relatable system tables and records. Figure 6 shows the sample of a file for the bottom and side rough milling, and Figure 7 shows the interface connected to it, where is shows the simplicity of the connectivity between data itself, and at the same time allowing it to be opened to other machining or configuration possibilities.

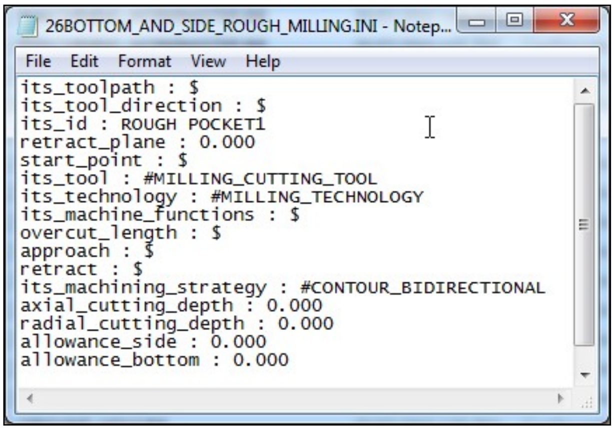


Fig. 6 - Configuration for bottom and side rough milling

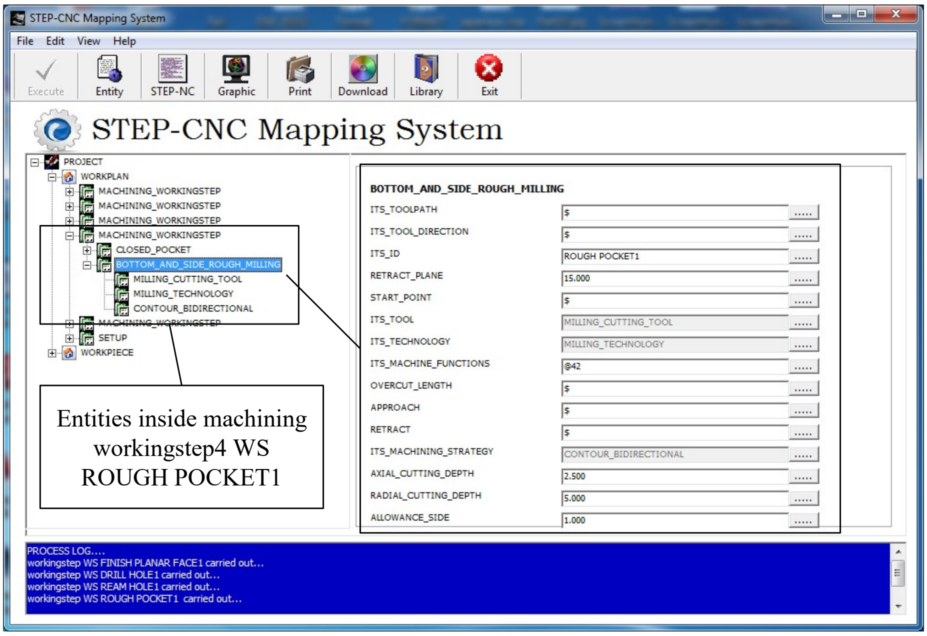


Fig. 7 - Interface for bottom and side rough milling

3. Conclusion

Big data emphasize on details, cloud providing connectivity between the data and STEP-NC provide structure on how interconnected data can be used in product manufacturing. Big data is not magic, it is just a way to see more, and STEP and STEP-NC are providing the platform and structure on how data in the whole process of product development life cycle can be stored under one big database and not be lost to floor or production technicians. Using big data can help us achieve greater efficiency, fewer defects, and greater profitability. STEP-NC is moving towards providing a common standard for manufacturing data that will ensure no loss of data to occur in the whole process of product development by creating a path that helps data integration in various aspects of manufacturing to happen. The data file structure in STEP-NC shows high level of data intelligence and standardization that it is trying to achieve, making it one of the best tools for integration of isolated and fragmented data in manufacturing in industries. As a tool that is known to provide richer information and data capabilities, rather than providing geometry information, STEP-NC also creates possibilities and space to provide and keep process plan of information.

Acknowledgment

The work presented in this paper was supported by University Tun Hussein Onn Malaysia, Research Management Centre (RMC) under Grant TIER1 U927.

References

[1] J. Moyne and J. Iskandar, "Big Data Analytics for Smart Manufacturing: Case Studies in Semiconductor Manufacturing," Processes, vol. 5, no. 4, pp. 39, 2017

[2] T. Niebel, F. Rasel and S. Viete, "BIG data–BIG gains? Understanding the link between big data analytics and innovation," Econ. Innov. New Technol., vol. 28, no. 3, pp. 296–316, 2019

[3] E. Yadegaridehkordi, M. Hourmand, M. Nilashi, L. Shuib, A. Ahani, and O. Ibrahim, "Influence of big data adoption on manufacturing companies' performance: An integrated DEMATEL-ANFIS approach," Technol. Forecast. Soc. Change, vol. 137, no. July, pp. 199–210, 2018

[4] M.D. Assunção, R.N. Calheiros, S. Bianchi, M.A.S. Netto and R. Buyya, "Big Data computing and clouds: Trends and future directions," J. Parallel Distrib. Comput., vol. 79–80, pp. 3–15, 2015

[5] C.K. Emani, N. Cullot and C. Nicolle, "Understandable Big Data: A Survey," Comput. Sci. Rev., vol. 17, pp. 70–81, 2015

[6] S.F. Wamba, S. Akter, T. Coltman, and E.W. Ngai, "Information Technology-Enabled Supply Chain Management," Prod. Plan. Control, vol. 26, no. 12, pp. 933–944, 2015

[7] J. Lee, E. Lapira, B. Bagheri, and H. Kao, "Recent advances and trends in predictive manufacturing systems in big data environment," Manuf. Lett., vol. 1, no. 1, pp. 38–41, 2013

[8] N. Kassim et al., "An Overview of Cloud Implementation in the Manufacturing Process Life Cycle," IOP Conf. Ser. Mater. Sci. Eng., vol. 226, no. 1, 2017

[9] Y. Cao, L. Huang, Y. Bai and Q. Fan, "FDM Rapid Prototyping Technology of Complex-Shaped Mould Based on Big Data Management of Cloud Manufacturing," Complexity, vol. 2018, pp. 1–14, 2018

[10] X. Li, J. Song and B. Huang, "A scientific workflow management system architecture and its scheduling based on cloud service platform for manufacturing big data analytics," Int. J. Adv. Manuf. Technol., vol. 84, no. 1–4, pp. 119–131, 2016

[11] F. Xiang, G.Z. Jiang, L.L. Xu and N.X. Wang, "The case-library method for service composition and optimal selection of big manufacturing data in cloud manufacturing system," Int. J. Adv. Manuf. Technol., vol. 84, no. 1–4, pp. 59–70, 2016

[12] J. Bughin, M. Chui and J. Manyika, "Clouds, big data, and smart assets: Ten tech-enabled business trends to watch," McKinsey Q., pp. 75–86, 2010

[13] D. Mourtzis, E. Vlachou and N. Milas, "Industrial Big Data as a Result of IoT Adoption in Manufacturing," Procedia CIRP, vol. 55, pp. 290–295, 2016

[14] M. Khakifirooz, C.F. Chien and Y.J. Chen, "Bayesian inference for mining semiconductor manufacturing big data for yield enhancement and smart production to empower industry 4.0," Appl. Soft Comput. J., vol. 68, no. December, pp. 990–999, 2018

[15] Q. Qi and F. Tao, "Digital Twin and Big Data Towards Smart Manufacturing and Industry 4.0: 360 Degree Comparison," IEEE Access, vol. 6, pp. 3585–3593, 2018

[16] R.F. Babiceanu and R. Seker, "Big Data and virtualization for manufacturing cyber-physical systems: A survey of the current status and future outlook," Comput. Ind., vol. 81, pp. 128–137, 2016

[17] M.L. Song, R. Fisher, J.L. Wang and L.B. Cui, "Environmental performance evaluation with big data: theories and methods," Ann. Oper. Res., vol. 270, no. 1–2, pp. 459–472, 2018

[18] F. Tao, J. Cheng, Q. Qi, M. Zhang, H. Zhang and F. Sui, "Digital twin-driven product design, manufacturing and service with big data," Int. J. Adv. Manuf. Technol., vol. 94, no. 9–12, pp. 3563–3576, 2018

[19] N. Kassim, Y. Yusof, H.M. Noor, M.N. Janon, and H. Masandig, "Cloud manufacturing framework based on step-nc machine tool for capturing design and manufacturing data," J. Phys. Conf. Ser., vol. 1150, no. 1, 2019

[20] N. Kassim et al., "An Overview of Cloud Implementation in the Manufacturing Process Life Cycle," IOP Conf. Ser. Mater. Sci. Eng., vol. 226, no. 1, pp. 0–9, 2017

[21] N. Kassim, Y. Yusof and M.Z. Awang, "REVIEWING ISO 14649 THROUGH ISO10303," ARPN J. Eng. Appl. Sci., vol. 11, no. 10, pp. 6599–6603, 2016

[22] N. Kassim et al., "The Development of New STEP-NC Code Generator (Milling STEP Coder)," Appl. Mech. Mater., vol. 465–466, pp. 667–671, 2014

[23] N. Kassim et al., "Information Structure of STEP Convertor of STEP-CNC Mapping System," Appl. Mech. Mater., vol. 773–774, pp. 38–42, 2015

[24] N. Kassim, Y. Yusof, M. Abd, H. Mohamad, M.N. Janon, and R.M. Hanifa, "Development of STEP-NC Based Machining System for Machining Process Information Flow," Appl. Mech. Mater., vol. 315, pp. 278–282, 2013