Type of contribution:
▶ Editorial
Research Paper
Case Study
Review Paper
Report of Tech. Application

mesi
e-issn. 2798-5245

Mechanical Engineering
for Society and Industry
Vol. 1, No. 1 (2021) pp 3-6
https://doi.org/10.31603/mesi.5309

Industry 4.0: Challenges of Mechanical Engineering for Society and Industry

Muji Setiyo[1]*, Tuessi Ari Purnomo[2], Dori Yuvenda[3], Muhammad Kunta Biddinika[4], Nor Azwadi Che Sidik[5], Olusegun David Samuel[6], Aditya Kolakoti[7], Alper Calam[8]

[1] Department of Automotive Engineering, Universitas Muhammadiyah Magelang, **Indonesia**
[2] Department of Industrial Engineering, Universitas Muhammadiyah Magelang, **Indonesia**
[3] Department of Automotive Engineering, Universitas Negeri Padang, **Indonesia**
[4] Faculty of industrial technology, Universitas Ahmad Dahlan, **Indonesia**
[5] Department of Mechanical Engineering, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, **Malaysia**
[6] Department of Mechanical Engineering, Federal University of Petroleum Resource, **Nigeria**
[7] Department of Mechanical Engineering, Raghu Engineering College, **India**
[8] Department of Automotive Engineering, Gazi University, **Turkey**
✉ muji@unimma.ac.id

Abstract
Today, in the industry 4.0 era, the boundaries of scientific disciplines are blurred, everything seems to be interrelated and shows the ability to be combined. Intelligent sensors combined with Artificial Intelligence (AI) have demonstrated their ability to influence processes, design, and maintenance in manufacturing systems. Mechanical engineering tasked with solving complex engineering problems must be able to adapt to this transformation, especially in the use of digital and IT to combine the principles of physics and engineering mathematics with materials science to design, analyze, manufacture, and maintain mechanical systems. On the other hand, mechanical engineering must also contribute to a better future life. Therefore, one of the keys to consistently playing a role is to think about sustainability, in order to provide benefits for society and industry, in any industrial era.

Keywords: Mechanical engineering, Complex engineering problems, Industry 4.0

1. Introduction

In recent years, new technologies such as artificial intelligence, 3D printing, and robotics have emerged with the potential to have a transformative impact on the industry, the economy and society as a whole [1,2]. In fact, the speed and scope of technological transformation are exponential, with unlimited potential and unlimited opportunities. On the other hand, there is a delay in preparing human resources to be resilient and adaptive in mastering technology, predicting markets, and the ability to transfer skills [3]–[6].

Now, we are at the edge of a technology revolution that will drastically alter the way we live, work, and communicate [7]–[9]. The shift was unprecedented in terms of scale, scope, and complexity, so everyone has never had a similar adequate experience. As a result, we don't know what the future expectations and risks will be, but wise solutions to these changes must be integrated and comprehensive, engaging all stakeholders from global to local governments, public and commercial sectors, academia, and civil society.

2. From Industry 1.0 to 4.0

The illustration of the stages to the industrial revolution (RI) 4.0 is presented in Figure 1. The IR began in the 1800s. In the 1700s, the IR was started by the commercial steam engine and the mechanical era. It was known as Industry 1.0. IR was followed by electricity and mass production in the early 20th century, applied to production lines (goods). Industry 2.0 started in the 1900s. Then, IR continued to evolve into the computerized era in the 1970s known as Industry 3.0. At this point, everything started to go digital, and the elements of manufacturing shifted to automation

Publisher
Universitas Muhammadiyah Magelang

and robotics. The use of electronics, information technology, and the internet is the beginning of the information age. At that time, Industry 4.0 was introduced, which was the beginning of digital supply chains, digital products and services, and business models. Data-driven analysis and decision-making started as a core competency. As a key feature, IR 4.0 is characterized by a combination of technologies that obscure physical, digital, and biological disciplines [10,11]. At the very least, there are three causes for the current change, which is more than just an extension of the third industrial revolution: speed, scope, and system effect. This shift represents the transformation of an industry's whole production, management, and governance structure, wherever the industry is developed and what goods are produced [12].

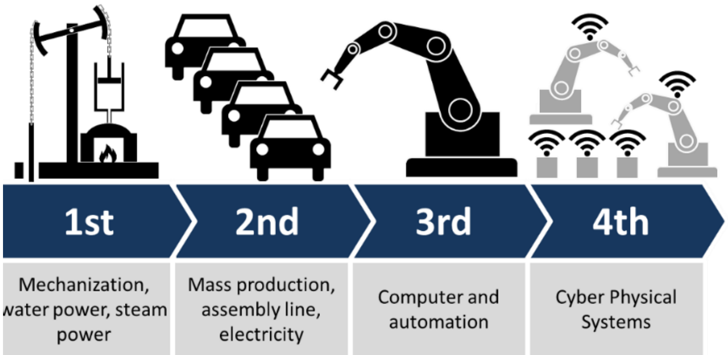

Figure 1. Stages to the industrial revolution 4.0 (source: link)

The fourth industrial revolution, like the other revolutions, has the potential to raise global income levels and enhance the quality of life for people all around the world. Now, those who can afford to acquire and access the digital world have benefited the most from it. Technology has enabled the development of new goods and services that improve efficiency. Ordering a cab, booking a flight, purchasing a product, making a payment, coordinating production systems, and management meetings are all now possible from a distance. So, long-term efficiency and productivity will be enhanced through technological innovation in the future. Transportation and communication costs will fall, global logistics and supply chains will become more efficient, trade prices will fall, open up new markets, and promote economic growth.

At the same time, as economists Erik Brynjolfsson and Andrew McAfee have pointed out, the fourth industrial revolution is likely to result in increase inequality, notably in labor market competitiveness. As a substitute for automation for labor in all sectors of the economy, the massive shift from workers to machines with automated systems can exacerbate the gap between the capital return and labor costs [13]. Those concerns were answered, in 2015, an electronics factory in Dongguan City-China announced that it was replacing 650 employees at the factory with intelligent robots and leaving 60 employees. This transformation can increase production up to 162% and reduce production defects from 25% to below 5% [14].

Then, what exactly is the definition of the industrial revolution? There may be hundreds of references that talk about it, but the industrial revolution refers to a significant and fundamental shift in the way people manufacture products. This huge shift has been documented three times, and we are now in the midst of the fourth industrial revolution. Each of these major changes is always followed by major changes in the economic, political, even military, and cultural fields. As a result, millions of old jobs are disappearing and millions of new ones appearing [15].

Especially in the discipline of mechanical engineering and production engineering, by paying attention to the main area of Industry 4.0 as presented in Figure 2, the presence of IoT will significantly change the work methods for engineers and production systems in factories. Workplaces, production schedules, and rest hours may have to be redefined. IoT will be widely applied to manufacturing systems, design, maintenance, and production control. On the manufacturing side, the shift will be seen at least in the presence of robots that replace human work, an intelligent collaboration between humans and machines, training through Augmented Reality, coordination of working hours via the internet, and remote control of production equipment with intelligent sensors. On the manufacturing side, the shift will be seen at least in the presence of robots that replace human work, the intelligent collaboration between humans and machines, training through Augmented Reality, coordination of working hours via the internet, and remote control of production equipment with intelligent sensors. On the design side, computer-based simulations and the widespread use of cloud-computing and crowdsourcing will affect the speed and accuracy of the design. In the maintenance section, at least it will be characterized by a remote-controlled maintenance system and extensive use of sensors to monitor the state of production equipment. At the production control stage, it is marked by paperless logistics, product and process traceability, RFID, product digital memory, and production optimization with big data.

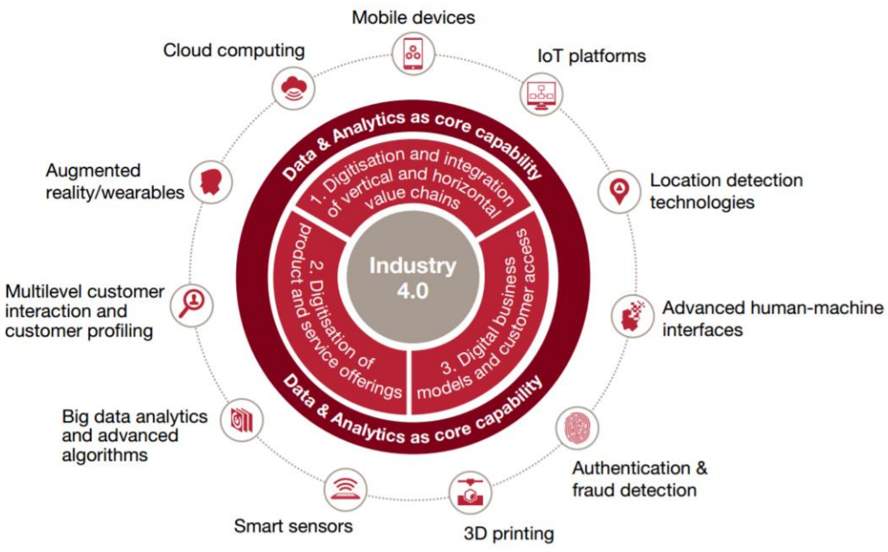

Figure 2. The main area of Industry 4.0 (source: link)

3. Conclusion

Although Artificial Intelligence (AI) is developing very rapidly, there is something that should not be forgotten, behind AI, human intelligence is a masterpiece. In facing industry 4.0, researchers, students, and mechanical engineering engineers must be able to: 1) respond to the needs of Industry 4.0, where humans and machines unite to be ready for new possibilities; 2) harness the potential of digital technology, personalization of data, open access content, and a new globally connected social life; and 3) setting a blueprint for the future of learning (lifelong learning) from childhood school to graduate school for continuous learning in the workplace and for taking on a better role in society. Whatever, the industrial revolution occurs, mechanical engineering disciplines must be able to solve complex problems in society and industry. Theoretical concepts of natural science, application of engineering mathematics, special and unique materials science, theoretical principles of engineering design, production, renewable energy, energy conversion, or industrial mechatronics/automation must continue to play an important role in contributing to a cleaner and more sustainable environment.

Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

Funding – No funding information from the authors.

Availability of data and materials - All data are available from the authors.

Competing interests - The authors declare no competing interest.

Additional information – No additional information from the authors.

References

[1] V. Sima, I. G. Gheorghe, J. Subić, and D. Nancu, "Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review," *Sustainability (Switzerland)*, vol. 12, no. 10, 2020, doi: 10.3390/SU12104035.

[2] A. T. C. C. Finance, *Industry 4.0 Challenges and Solutions for the Digital Transformation and Use of Exponential Technologies*. Zurich: Finance, Audit Tax Consulting Corporate, 2015.

[3] Y. Vereycken, M. Ramioul, S. Desiere, and M. Bal, "Human resource practices accompanying industry 4.0 in European manufacturing industry," *Journal of Manufacturing Technology Management*, 2021.

[4] N. Dhanpat, Z. P. Buthelezi, M. R. Joe, T. V. Maphela, and N. Shongwe, “Industry 4.0: The role of human resource professionals,” *SA Journal of Human Resource Management*, vol. 18, p. 10, 2020, doi: 10.4102/sajhrm.v18i0.1302.

[5] F. Hecklau, M. Galeitzke, S. Flachs, and H. Kohl, “Holistic Approach for Human Resource Management in Industry 4.0,” *Procedia CIRP*, vol. 54, pp. 1–6, 2016, doi: 10.1016/j.procir.2016.05.102.

[6] J. Vrchota, M. Mařiková, P. Řehoř, L. Rolínek, and R. Toušek, “Human resources readiness for industry 4.0,” *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 6, no. 1, pp. 1–20, 2020, doi: 10.3390/joitmc6010003.

[7] S. Saniuk, S. Grabowska, and B. Gajdzik, “Social expectations and market changes in the context of developing the industry 4.0 concept,” *Sustainability (Switzerland)*, vol. 12, no. 4, 2020, doi: 10.3390/su12041362.

[8] G. Spöttl and L. Windelband, “The 4th industrial revolution–its impact on vocational skills,” *Journal of Education and Work*, vol. 34, no. 1, pp. 29–52, 2021, doi: 10.1080/13639080.2020.1858230.

[9] H. Kuper, “Industry 4.0: changes in work organization and qualification requirements—challenges for academic and vocational education,” *Entrepreneurship Education*, vol. 3, no. 2, pp. 119–131, 2020, doi: 10.1007/s41959-020-00029-1.

[10] A. Rojko, “Industry 4.0 concept: Background and overview,” *International Journal of Interactive Mobile Technologies*, vol. 11, no. 5, pp. 77–90, 2017, doi: 10.3991/ijim.v11i5.7072.

[11] L. Da Xu, E. L. Xu, and L. Li, “Industry 4.0: state of the art and future trends,” *International Journal of Production Research*, vol. 56, no. 8, pp. 2941–2962, 2018.

[12] K. Schwab, “The Fourth Industrial Revolution: what it means, how to respond,” *World Economic Forum*, 2016. https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/ (accessed Dec. 12, 2019).

[13] E. Brynjolfsson and A. McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies*, 1st Editio. New York: W. W. Norton & Company, 2014.

[14] C. Forrest, “Chinese factory replaces 90% of humans with robots, production soars,” *Tech Republic.[Online] July*, 2015. https://www.techrepublic.com/article/chinese-factory-replaces-90-of-humans-with-robots-production-soars/ (accessed Jun. 20, 2021).

[15] M. Susanto, “Apa Itu Revolusi Industri 4.0?,” *Zenius.net*, 2019. https://www.zenius.net/blog/21104/revolusi-industri-4-0 (accessed Dec. 12, 2019).