Industrial Revolution 4.0 in Chemical Engineering

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Abstract — Generally, Industry 4.0 targets on the development of an open, smart manufacturing platform for the application of industry-network information. Therefore, a skill set is required for chemical engineers in order to adapt to fulfill industrial needs with the concept of Industrial Revolution 4.0 (IR4.0) in mind. This paper discusses the knowledge and skillset required of a chemical engineer. It also presents a short discussion on how palm oil industry can be improved with the idea of IR 4.0.

Keywords — Industrial Revolution 4.0 (IR4.0); Chemical Engineering; Palm Fiber Oil; Refinery Process

1. Introduction

Industry 4.0 is a strategic initiative introduced which was first published in an article by the German government in November 2011 (Drath & Horch, 2014; Zhou, Taigang, & Lifeng, 2015). This idea was introduced with the aim of developing and transforming the manufacturing technologies in terms of cyber-physical systems (CPS), Internet of Things (IoT) and cloud computing hence resulting in the formation of intelligent factories (Zhong, Xu, Klotz, & Newman, 2017). Industrial revolution refers to industrial development that has caused much changes to our society and economy. For instance, the term "development" indicates some tardiness in the context of the word "revolution", which represents rapid and fundamental changes (Bloem et al., 2014). In this case, IR 4.0 is expected to bring a great transition in the future, after the introduction of steam engine, mass production, electronics and IT (robots and programmable logic controllers) during the first, second and third industrial revolution (Branke, Farid, & Shah, 2016).

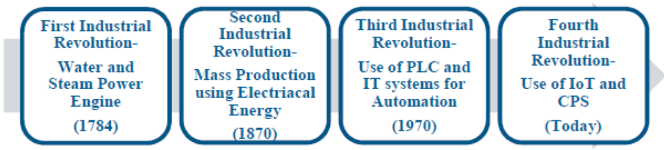

Fig. 1: Four Industrial Revolution (Vaidya, Ambad, & Bhosle, 2018)

2. Literature Review

II A. Needs of Industry 4.0 in Chemical Engineering

In the chemical industry, the application of IR 4.0 is highly required as this application would help ensure safety in plants or working stations. Typically, most workers in a chemical plant carry out their duty under either high temperature or pressure, with some being exposed to radioactive materials or processes. Based on the statistic done, there are over 130 incidents in chemical plants during the past 20 years (Doyle, 2018). Although some of these incidents have happened due to natural disasters such as earthquake and volcano explosion, it is to improper maintenance and inappropriate operation are among the contributing factors. Therefore, IR4.0, which promotes the use of autonomous robots and artificial intelligent (AI), could help reduce untoward incidents through precise operation, especially at places where human beings are denied access (Vaidya et al., 2018). With the acceptance of IR4.0, the human can work safely with the cooperation of robots and AI in the working places (Rüßmann et al., 2015).

Next, the concept of IR 4.0 is also offers a new idea called cloud computing, which has been widely utilized by industries to keep or store their information (Lasi, Fettke, Kemper, Feld, & Hoffmann, 2014). In chemical industries, data plays an important role as it shows the efficiency of a process, errors or issues that may occur and suggests methods to manipulate or improve the processes. Therefore, technologies that are able to collect and evaluate huge data from different sources of production equipment and system are necessary to ease or simplify the work of process engineers and also manufacturing engineers (Koumoutsakis, 2018; Rüßmann et al., 2015). Therefore, the introduction of industrial revolution 4.0 is a good news for those who are involved in the tasks mentioned above. The concept of IR4.0 flags the utilization of self-aware and self-learning machines in the industries, whereby they are able to collect data or information from every equipment and control systems and at the same time, analyze or evaluate the data. to the analyses could then be used to identify the threats occur in the processes and to forecast and prevent potential or repeating issues (Bagheri, Yang, Kao, & Lee, 2015).

Generally, all the equipment in a chemical plant or industry has to undergo regular maintenance at least once a year. Such maintenance method might not be able to ensure the productivity and efficiency of the equipment throughout the year. In other words, the uptime duration of the equipment cannot be guaranteed. In this case, the involvement of IR 4.0 in the chemical engineering industry would prove useful. For example, a new smart technology called smart sensor from the general idea of “smart factory” can be introduced to the industry (Bahrin, Othman, Azli, & Talib, 2016; Brown & John, 2018). This smart sensor is used to monitor the condition from every angle of the plant with the diagnostic, predictive and prescriptive capabilities (Brown & John, 2018). The smart sensor is able to identify the issues and then access cloud database in order to find out the effects of these issues found. In the end, the smart sensor will come out with a solution for the identified issues. With this smart technology, the production line can be upgraded to a smart production line which can perform constant self-monitoring and stay sensitive to all detected or anticipated issues, as well as resolving the problems themselves. Plant technicians can monitor and interact with the machines remotely and at the same time increase the uptime duration and reduce the cost of maintenance for the equipment installed (Branke et al., 2016).

II B. Skill Required for Chemical Engineer to be a Part of Industrial Revolution 4.0

Currently, there are more and more young engineers who have been brought up along the development of IR4.0. All the future engineers should be well educated on and exposed to IR4.0 However, there are skills that are required of them in order to implement IR4.0. First of all, young engineers will have to keep up with the rapid advancements in technology and devices (Javier, 2015; NewEngineer, 2018). Continuous improvement on the current technologies is inevitable. Hence, young engineers need to have a strong adaptability to ensure that they could catch up with the rapid growth of technologies (Aulbur, CJ, & Bigghe, 2016).

Besides, engineers should have good communication skills. With the adoption of smart technologies, socialization skills are still very important. Engineers can easily access and obtain the most updated information and knowledge as the global network is expected to expand continuously and bring more industries to be a part of digital revolution (NewEngineer, 2018). With technology advancement, an engineer can easily “hand-on” with the newly introduced technologies and be able to analyze or understand the data obtained from the equipment and system (Javier, 2015).

Critical thinking is-is the other skill that an engineer should have. Engineers deal with obstacles or problems, such as manufacturing costs, disruptions, quality issues, and others almost every day (Javier, 2015). Therefore, An engineer oughts to seek for solutions to fulfil everyone’s needs (NewEngineer, 2018). For that, engineers should be well versed with every process stage processes and the available alternatives.

II C. Contributions of Chemical Engineers in Industrial Revolution 4.0

The first contribution of IR4.0 in the chemical engineering field is to transform the regular process control and management system into a fully digitalized machine or set-up. In earlier days, engineers or technicians in a petroleum platform have to walk around the control room installed with analog controllers along the walls in order to manually record the data and manipulate the operation of the plant. With digital involvement, data can be collected automatically through the connected system and presented to the operators for manual review, which save time and man power. Real time analysis and automated control are also the technologies that fall under IR4.0 to enable greater control over consistency and quality. (Wibowo, 2019)

Besides, chemical engineers can introduce autonomous robots in the manufacturing industries. Simple, convenient and less-expensive products are generally what people are looking for now. This is a great challenge to the manufacturing industries as human workers have limited abilities to achieve so. For example, in the biopharmaceuticals field, autonomous robots that have been utilized in the manufacture of biopharmaceutical products for cell and gene therapies for better job precision and accuracy. Besides, the use of autonomous robots has been experimented and the study showed that the patients that used biopharmaceutical production or underwent operation by robots did not show any symptoms of negative impact on their body and daily life. (Branke et al., 2016)

In year 2017, a new technology named blockchain was introduced to the society as a contribution of chemical engineers toward IR 4.0. Blockchain is a type of distributed, electronic database which can hold any information or data and able to set rules on the update of the information (Sikorski, Haughton, & Kraft, 2017). In simple words, it is an electronic cloud database that collects, analyzes and evaluates all the information and data automatically based on the pre-set database. With the use of this blockchain technology, the process engineers in the chemical manufacturing plant can easily monitor the operating condition of all the equipment and control systems in the plant by just accessing the blockchain database. With this, engineers will be able to identify and rectify the issues occurred. Furthermore, the cloud database also allows process engineers to modify the production process in order to obtain the products with better efficiency and quality.

II D. Industrial Revolution 4.0 and Palm Oil Industry

Palm-pressed mesocarp fiber (PPMF) is one of the residues besides palm kernel and palm oil mill effluent (POME) from the crude palm oil (CPO) extraction process by using mechanical screw press technique (Noorshamsiana et al., 2017; Phoon, Ng, Zakaria, Yim, & Mokhtar, 2018). According to statistic reported in year 2017, the oil palm industry in Malaysia had processed approximately 103.94 million tons of fresh fruit bunches (FFB) into 19.92 million tons of CPO and at the same time generated 14.55 million tons of PPMF as the by-product (Sulihatimarsyila, Lau, Nabilah, & Azreena, 2019). Traditionally, the PPMF collected is recycled and utilized as a solid fuel to generate heat and energy for the palm oil mills or the power generation plants (Abdullah & Sulaiman, 2013; Lau, Choo, Ma, & Chuah, 2008; Teoh, 2002). However, the PPMF has been found to be retaining 5 – 7% of residual oil after the extraction process of CPO (Lau et al., 2008; Sulihatimarsyila et al., 2019). From the residual oil, it is found that PPMFO is containing high concentration of phytonutrients such as carotene (4000 – 6000 ppm), vitamin E (2400 – 3500 ppm), sterols (4500 – 8500 ppm) (Choo et al., 1996; May, 1994; Zou, Jiang, Yang, Hu, & Xu, 2012).

In order to extract the residual oil from the PPMF, a Soxhlet apparatus set-up with the use of n-hexane as the solvent is recommended as the extraction method for the PPMFO (Kupan, Hamid, Kulkarni, & Yusoff, 2016; Phoon et al., 2018). Accordingly, the first step is PPMF is fully filled in the extractor and this process is left for 6 hours with the presence of n-hexane. After that, the solution obtained undergoes filtration, rotary evaporation, and pump-drying processes to remove solvent and impurities. On the other hands the refinery process is a combination of water degumming, acid degumming, bleaching, deacidification and deodorization processes (Sulihatimarsyila et al., 2019). At different stages, the PPMFO sample is heated to a certain temperature before necessary materials such as distilled water, phosphoric acid, natural bleach earth (NBE) are added (Sharma, Yadav, & Upadhyay, 2019; Silva et al., 2014). Meanwhile, the PPMFO sample goes through c centrifugation, filtration and nitrogen blowing process during the whole refinery process to remove the unwanted products.

The smart sensor, which was mentioned earlier in Section IIA, can be utilized in the PPMFO extraction process. It is especially suitable for the commercial PPMFO extraction plant located in Lekir Palm Oil Mill, Perak, Malaysia. Specifically, this smart sensor can be used to maintain the temperature of n-hexane at 68°C, which is required for commercial PPMFO extraction process Besides that, the workers in the palm oil industry mostly perform data recording and analysis manually. This can be replaced with cloud database or cloud computing technique. This technique can automatically analyze and compare all the data throughout the global network. With the assistance of this technology, the workers can save their time and effort, enabling them to carry out more tasks to improve the productivity of the chemical plant.

3. Conclusion

Industrial revolution 4.0 represents a significant advancement in technologies and a transition from IR 3.0. With the implementation of the new technologies under the umbrella of IR 4.0, we are looking at an era with - high efficiency, both productivity and cost wise.

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