Review of industry 4.0 with focus on products

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Abstract. The primary aim of this article is to review industrial revolutions. It reveals that the industry 4.0 interconnected with product designs. This article, by reviewing the existing online information, explains that with the help of industrial revolution, worthy product can be designed and produced. Nowadays, in industry 4.0, people should get design and quality conscious for products. Industry 4.0 will provide better flexibility in product manufacturing and designing with higher quality, lower cost, and/or higher speed. Furthermore, as discussed in this paper, attractions of industry 4.0 are considerable for industrialists. This article will provide a deeper understanding of Industry 4.0 for practitioners and researchers.

1. Introduction

Industrial revolution is a process, which had changed the agrarian and handicraft economy to be dominated by machine and industrial manufacturing [1, 2]. Revolution occurs when a society starts either to use apparatus to make products or utilize new sources of energy such as coal to generate the industrial machines. The revolution started in Great Britain in 18th century and later spread all over the world. Before industrialization, pre-industrial Europe suffered the lack of factories and steam engines therefore it did not have static economy [1].

With the help of revolution, the societies changed quickly and made them more urban and industrialized. A series of innovation is made to enhance the effectiveness and productivity of labours. Advances in organization and technology help the average worker to work more efficiently. For example, a low-skilled worker could produce hundred times of the spin threads using steam-powered machine. This means the manpower could be saved by the help of innovation and makes our life getting better.

The first industrial renovation is introduced at the end of 18th century, which is called mechanization era. In this period of time, steam-powered engines, telegraph, cotton gin, steamboat and etc invented. James Watt was the one, who created the first reliable steam engine [1]. He added a separate condenser to the steam engine, which significantly improved its efficiency [1], therefore, a great saving of energy occurred by keeping the condenser and cylinder permanently cold and hot, respectively [3]. This was beneficial to a lot of machines/factories and it brought a huge part of British economy at that time. Over 1870 to 1914, the second industrial revolution was introduced. It is known as Industry 2.0 or electrification, which was mostly focused on mass production. Cincinnati slaughterhouses were the first production line in 1870 and thereafter the pre-existing systems such as railroads and telegraphs inverted into the industries. Moreover, During the American revolution, by help of Industry 2.0, the development of bridges and railroads was encouraged using cheaper steel prices [4]. However, the second revolution
marked the end at the start of World War I. Here came to the Information era, Industry 3.0 Automatization. The revolution came into the digital technologies in production from 1950 to 1970 by electronics and IT to further automated production. It was mostly focused on the development in digital systems, rapid advances in computing power and communication technologies [5].

In 2011, the industry 4.0 (IR 4.0) was introduced by a group of representatives from different fields of study such as politics, academia and business. It is also known as digitization era. It enhanced German competitiveness in manufacturing industry and chain production to meet the challenges in 21st century. It also provides an opportunity to Germany to strengthen the responsibility of producers and suppliers in IT business. On the other hand, this revolution introduced flexible and customized mass production technologies, which in return the automation of manufacturing processes hit to a new level. With regard to the high technologies of mass production, the machines will operate itself independently and cooperate with humans. For example, the machines will be able to work solely by collecting data, analysing data and advising upon it. Moreover, the implementation of smart technologies in workplaces or factories could make decisions autonomously [6]. It is also could impact all industries, disciplines and economies [6,7]. The biggest difference between IR 3.0 and 4.0 are the big data, internet of services, internet of things, and integrated industries. Moreover, industrial revolution 4.0 creates intelligent machines with independent information exchange. Existence of smart factory could create an identifiable and information product. It also strengthens in controlling and optimization in real-time. In business processes, new and more efficient business models produce through applications using image processing systems. In the other words, it is self-organized production and automated based on visually identified information and extensive data collection. Therefore, in operational processes, more effective and efficient products produce through extensive network of visions systems. Regarding the interaction between human and technology, IR 4.0 plays an important role on it. It is a platform that connects people, systems and objects. In IR 4.0, there are 4 components of fundamental conceptual approaches, which are internet technology, cyber-physical systems, components as information carriers, holistic security and safety including knowledge and privacy protection. These 4 approaches help smart system in practical ways. In a nutshell, Industrial Revolution 4.0 has brought efficiency, optimising and quality to the process by cooperated with intelligent cyber-physical systems. Through Industrial Revolution 4.0, there are some significant changes that we are seeking for namely self-driving logistics vehicles, robot-assisted production, production line stimulation, predictive maintenance and machines as a service [8].

The industrial revolutions are related to product design. Helping the industrial revolution, good product design can be made. IR 4.0 will provide better flexibility in manufacturing and designing with appropriate quality, cost and speed. Besides, Quality control and management are the main focus areas in industrial 4.0. Nowadays, as people are getting quality conscious, they would rather pay more in order to a product with sustainable goods. Quality is a competitive marker for brands, that can improve customers’ satisfaction, greater profits and consequently customer retention. With good product design, IR 4.0 brings a lot of benefits such as increased efficiency and productivity, reduced production cost, manpower saving, improved product quality, increased customer satisfaction, providing a better work place and improved communication skills.

2. Benefits of Industry 4.0

Industrial revolution 4.0 allows the companies to implement the smart technologies to create products more agile and flexible. It is usually related to the idea of a smart factory. Industrial revolution 4.0 can facilitate the interaction between people and technology providing information [9]. It is a horizontal process that makes industrial production fully automated and interrelated [10]. An intelligent management system is formed when the machinery, personnel, and devices communicate to each other [10].

Fourth industrial revolution is not only a method of using the latest technologies, also basically changes the manufacturing equation [11]. It provides better flexibility in manufacturing and designing
products with good quality, speed, and cost. This will enable the firm to innovate faster and earn more income [11]. In addition, the impact of digitization on the product design provides many advantages:

**Increased efficiency and productivity:** Due to the high demand in the industrial sector, it is essential to implement digital technologies to produce more raw-materials and reduce the production of energy-intensive products as this can increase efficiency, flexibility, and also produce more sustainable products [12]. IR 4.0 offers manufacturers the opportunity to integrate intelligent equipment and materials over the process of designing [12]. This will help to produce the products in streamlined processes, make more diverse production decisions, and always improve the income of the companies [12]. As automation increases and company staff decreases, the managers can make decision faster and maintain the higher efficiency [11]. Automation also tends to maintain high quality, therefore it can further increase the efficiency [11]. Higher efficiency can be observed when different products are created at higher quality and speed with improved supply chain and distribution facilities, as well as faster decision-making throughout the process [13].

**Lower costs:** The smart technologies help the designers to have the informative data to create the products that meets the customers’ requirements. The designers use computer-aided design (CAD) system to create, modify and analysis the design of a product [14]. CAD software creating a database for manufacturing, increases the designer’s productivity and improves design quality [14]. Virtual reality technology is a technological tool that can improve the design process by understanding, communicating and validating the design with the help of a stereoscopic image and a wide field-of-view. The usage of 3D printer aids the designers to develop an interactive 3D model of a product from the basic CAD data. It allows people to ‘see’ the finished design before a physical model is built. This will lead to fewer quality problems and less material waste.

**Improved product quality:** The operations of the design process can be performed with minimum human force and higher reliability when the smart equipment is optimized. The workflow automation, assets synchronization, tracking progress and scheduling could not only enhance the output, operating time and quality also decrease the expense and waste.

**Increased customer satisfaction:** People and smart devices are efficiently connected through the internet; therefore, the products are created according to the customer specifications [15]. Clients’ information is collected through smart products, which gives the designers a deeper understanding about the requirements of customers and provides a better service for them [11]. The designers can invent a new product by using the data that are collected from the connected operations and production systems [16]. They always adapt and grow along with the various demands of the customers [16]. Due to the powerful computing and analytical skills, new products can be developed and extended to new markets, plus new processes and technologies can be integrated easily [16]. The operation of fourth industrial evolution can offer the clients an output with higher quality, affordable price and vast availability [13]. Fast resolution of the problems and excellent service ensure that the customers are satisfied with the provided services [13]. IR 4.0 allows the manufacturing companies to customise a product that meet the demands of an individual consumer while still applying mass production techniques [12]. The new products can be manufactured and distributed to the marketplace in a short time using new digital technologies [12].

**Rapid innovation:** The potential of 3D design can be used to carry out the experiments and prototyping a new product [13]. This will reduce the production cost and ensure the product quality. The process of the entire design and production require the participation of customers, suppliers, and employees to obtain a better decision result [13].

**Increased revenues:** Great amount and better quality products are produced and supplied to a larger market. A good quality and a continuous supply of products will make the customer to continue purchasing the product and this will eventually increase the income of the company. Besides, the information from the interconnected system can improve the strategies of direct selling and marketing. This also allows the companies and their partners to offer post-sales communications with customers to strengthen the relationship with customers [15].
Better workplace: The employees will feel appreciated and assisted if the smart technology is applied to their functional operations [13]. Well-designed workstations, intensive training and cooperation make the employees feel reliable and secure to perform their jobs [13].

Improved Communication: Collecting, storing, processing and sharing large quantity of detailed data will offer the designers a useful information on each step of the planning and production phases [13]. A good flow of information helps to schedule properly and prevent downtime or failures. It also develops a tighter work environment [13].

3. Attractions of Industry 4.0

The Industry Revolution 4.0 has brought much effect not only on technologies but also to the lifestyle of human being [17, 18]. The alteration, in the way the technologies perform their task, brings impact to the transformation of the way human live all this long time. Indirectly, in the aspect of product design, it has shown the big influences from this revolution. How can be said so, lets discuss about this in more detail. This is much more related on how Industry Revolution 4.0 had given attraction to human nowadays. In many aspects of life, the IR4.0 had given the attraction to, but in the below it will be discussed that what kind of attraction IR4.0 had given to human, which slowly influences the product design.

Human are being created intelligently to comes out with new ideas and products. It has gone through the steps of evolution and innovation, which can always be seen on the product itself [19]. By years through years, more advanced products such as drone, virtual assistants, 3-D printing, self-driving car and self-cleaning kits can be easily achieved anywhere at any time all over the world [17] The innovation of these products had given rise the popularity amongst world population. This is due to the benefits and conveniences that the products are able to provide.

This popularity has captured the attention of businessmen, entrepreneurs, designers and engineers. By introducing the technique into a product that draws so much attention, engineers are more keen to comes out with more advanced and convenience technique to improve previous technology. In this way, the demand for engineers had been increased to meet the world’s needs. This would attract youngers for exploring into the field to discover more source, which brings the industry into a new digital segment [20]. This is accomplished with the designer, wherever designer has to design for the outer look of the technology created with the small and advanced parts in a device [20]. Design study is important since that particular details on the external look would be one of the selling points in future. Most importantly, people would demand an advanced device with modern look, easy to carry and user-friendly. The characteristic that an entrepreneur requires is independent thinking. They have to always thinking out of the box for innovation and know what the world needs? [21]. With the introduction of revolution in digital manufacturing, obviously there is high encouragement for many people to invest themselves as an entrepreneur. Various products made with high technology have widen the market for business purpose.

Growing of these 4 fields would attract more youngers to take part and explore themselves in the manufacturing field. On our point of view, this revolution has brought the population’s conservative mind set to the other level. Especially in Asian countries, people are lacking in confidence and are conservative when come to do business part but through this revolution, people are finally having the opportunities and attracted by advanced technologies and finally end up working in the area that haven’t been created yet for serving customer for existence need [20].

There is also some attractions in this area, which has not been emphasized obviously such as telemedicine, gene editing and synthetic biology [22,23]. This revolution that happens in medical area is not obviously seen by public but in fact the health care section now is improving and transforming fast by the aid of the technology. Professions, which are in touch with health care area will definitely been attracted to the innovation of advanced technology [23].

Secondly, the revolution has brought much impact on the product that currently exists. The improvement of function and usefulness in certain objects had successfully attracted people attention
especially the younger to explore the items and seems the response to this improvement is quite good and well-received. Products such as 3-D printer, which are able to provide printing in three dimension, has improved the way of printing from prototyping to actual production of real object [24,25]. This function has attracted much more people since it has made the manufacturing process easier and quickly, which is only the transformation of a digital file into a real life object [24,25].

In services section, both of the quality of service and efficiency of service have been improved by the aid of advanced technology. For example, the invention of apps and websites for food ordering has become popular amongst people living in urban area since the lifestyle of people in this era is mostly connected by mobile device [26]. Nowadays, younger generation are looking for services which are fast and time saving, therefore the introduction of several apps or machines through the revolution, which are able to collect and analyse data on its own and do not need to rely on human are so common. This is the point where human get attracted to implement this invention. The invention makes people life easier. Even at certain restaurant, the ordering process have been replaced with digital methods, where it provides convenience to the customer to shorten the waiting time for waitress to take order. This revolution has attracted to those business owner in beneficial their profit in a visible way.

4. Conclusions
In conclusion, Industrial Revolution 4.0 is the digital of manufacturing sector, which improve in transferring digital instruction, astonishing in data volumes emergence of analytic and business-intelligence capabilities and improve in human-machine interaction. It is also closely related to product design. With IR 4.0, several benefits in product design is provided; namely, increased efficiency and productivity, lower production cost, saved manpower, improved product quality, increased customer satisfaction, providing a better work place and improved communication skills. In the other hand, there are some challenges we can find in the product design with IR 4.0. One of the challenges is that the privacy of products details is not fully protected, as there are many hackers. Next, facility is not completely equipped, so there is no variety in products to be produce in a process and finally there are not environmentally friendly products.

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