IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IMPLEMENTATION OF INDUSTRY 4.0 IN PROCESS INDUSTRY

AUTHOR :- MAKARAND M DESHPANDE

GUIDED BY :- DR.S.A.MESHRAM,

PROFESSOR AT G.H.RAISONI UNIVERSITY AMRAVATI, MAHARASHTRA, INDIA

Abstract: The industry 4.0 is a group of digital technologies that can create cyber--physical systems (CPS). These systems can redefine the rules of the industrial production, creating more wealth than ever before, while transforming the factory ecosystem (Schwab, 2016). In the car and aerospace industry different prototypes of CPS have been developed in factories and end products. However, in the process industry, in particular Oil and Gas, Food & Beverage, Construction or Chemicals, it is not clear yet what could be the impact of these digital technologies and what methodology should be used to design cyber--physical systems (PwC, 2016). For all these reasons, this thesis focus on analyzing the impact that the industry 4.0 might have in the process industry. In this analysis, a categorization of the i4.0 technologies was develop based on the phenomenological qualitative approach. It was determined that sensors, artificial intelligence(AI), cloud computing are in the category "KEY", which means they have a high impact and technological maturity. With the "KEY" technologies mentioned before, the next step was to make a design of a CPS based on a methodology called the 5C level architecture, following the special requirements and boundary conditions of the process industry. After this design and methodology, it is concluded that it is possible to build up and asses a CPS in the process industry, by following the criteria mentioned in the document. At last, based on the information gather in the previous steps, it was concluded that process factories will tend to shrink by reducing inventories and redundancies. This, by enhancing software and hardware elements in the structure and operation, embedding AI in their process, and shifting from pushing to pulling production processes.

1. Introduction

DIGITALIZATION GAP FOR THE PROCESS INDUSTRY

According to PwC "2016 Global Industry 4.0 survey "of the 600 process industry firms interviewed, 72% of them want to achieve digitalization and automation in the processes, within the next five years. However, only 33% of the respondents have already found out how to reach this digitalization and automation (PwC, 2016). This gap of 39% represents the fact that, even though companies in the process industry want to achieve digitalization, not all of them have a methodology on how to apply digital technologies to their processes and business cases. For this reason, the purpose of this report is to foresee the impact that the Fourth Industrial Revolution might have in the process industry in the next five years and propose a methodology to develop digitalization.

2 Data and Sources of Data

The data collected will determine the I4.0 technologies that should be prioritize by companies in the process industry. However, due to the lack of trustworthy information in the literature, it was opted to follow a qualitative methodology based on the book "Qualitative Inquiry and Research Design: Choosing among five approaches" by John W. Creswell(John W. Creswell, 2013). Given the fact that the primary research goal is to foresee the impact of the I4.0 technologies in the process industry, it was opted to choose a phenomenology research approach in which each technology in the process industry will be treated as an event or phenomena (John W. Creswell, 2013). Herewith, these 14 technologies will be explained profoundly by the 32 interviewees in different isolated opinions, after these interviews, the phenomenology methodology suggests compiling the information gather in the interviews, in a coherent and narrative manner, pointing out the characteristics of the phenomena and the views from the experts. Following this approach, the assessment will describe the opinion of the experts on each technology, insights about limitations and challenges of the techniques, and finally, it will give 32 experts were interviewed in a period of one month between September and October of 2016. These interviews were semi structured with some fix questions and some other customized, based on the interviewee expertise. In figure 16, it can be seen the different types of experts that were chosen for the interviews.

3. Theoretical framework

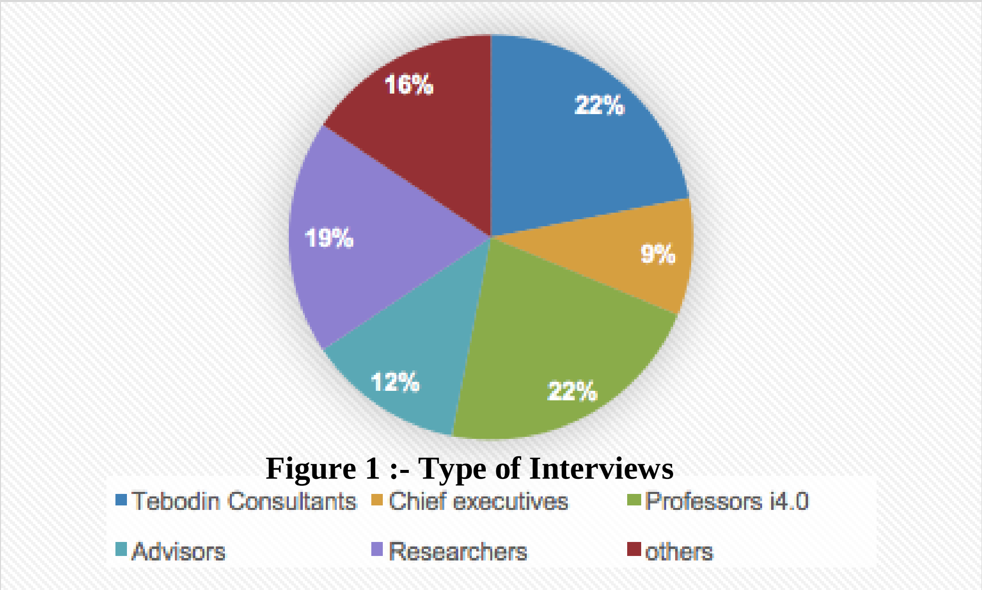

Figure 1 :- Type of Interviews

The goal of these interviews was to have a clear idea about the limitations of the technologies for process applications, and an opinion of the possible impact that the technology could have in a factory in the near future. Furthermore, in order to get an acceptable overview on all the technologies, at least 2 interviewees were found to describe each one of the i4.0 technology.

4. RESEARCH METHODOLOGY

In figure, a sketch is illustrated to show, step by step, how-to go from the Fourth Industrial Revolution to the impact on the process installations.

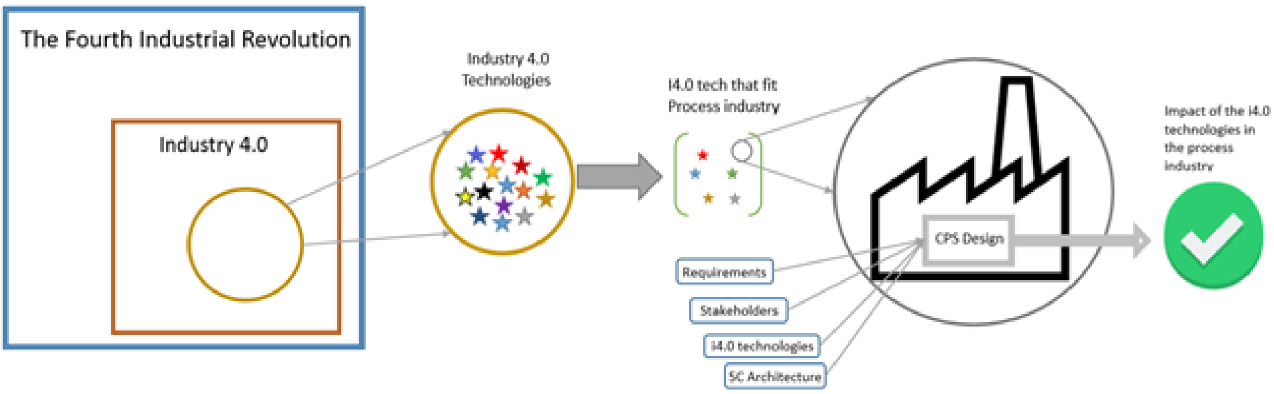

Figure 2 :- Research Method

In primary phase, there is a definition of the purpose and scope of the research, defining the concept of Fourth Industrial Revolution, Industry 4.0, cyber--physical systems and the process industry. In chapter 2 there will also be a more profound definition of each of the technologies that belong to the Industry 4.0. In figure 1, the blue square represents the content of that chapter, which implies the broad scope of the second chapter. It is important to mention that the technologies chosen in this chapter are those that have a high potential in the manufacturing industry and not for the process industry.

Next thing is to focus on assessing the technologies described in chapter 2. This assessment will be done by a *phenomenological qualitative approach* (John W. Creswell, 2013) based on the opinions of 32 experts. The outcome of this chapter will also give some hints about the possible impact of the Industry 4.0 in the process industry. In figure 1, this chapter is represented by the stars, which show the technologies that might have a big potential in the process industry in the short term, and the two green parentheses, that represent the context of the process industry. After that the, focus on the design of a cyber--physical system for a particular process installation based on the *5C level architecture* (Jay Lee, 2014). This design methodology will be assessed with a *validation square* (Karolyn C. Seepersad, 2005) that will identify the impact of the CPS on the stakeholders and the boundary conditions identified, based on the paper "*Evaluation in Design--Oriented research*" (Hartog, 2005). In figure 1, this chapter is represented by the image of the factory. Finally, discussion on the trends that factories might have in the next five years in the process industry. In this chapter, a focus will be given to the form and shape of the factories and the outcome of the *validation square*. (Karolyn C. Seepersad, 2005).

5. Theoretical framework

In table 1 there is a list of experts that chose to talk about each i4.0 technology.

I4.0 Technology	# of interviewees
Drones	5
Autonomous vehicles	3
Additive manufacturing	10
Robots	7
Big Data analytics	8
Routing and devices	2
Artificial intelligence	10
Data transmission	3
Sensors	12
Digital products	4
Cloud computing	9

Social network	3

Table 1 : - Type of Interviews

Finally, the semi structured interview had some fix questions that allowed each technology to have sufficient background to give a proper qualitative score. In this interview the following questions were asked to all interviewees.

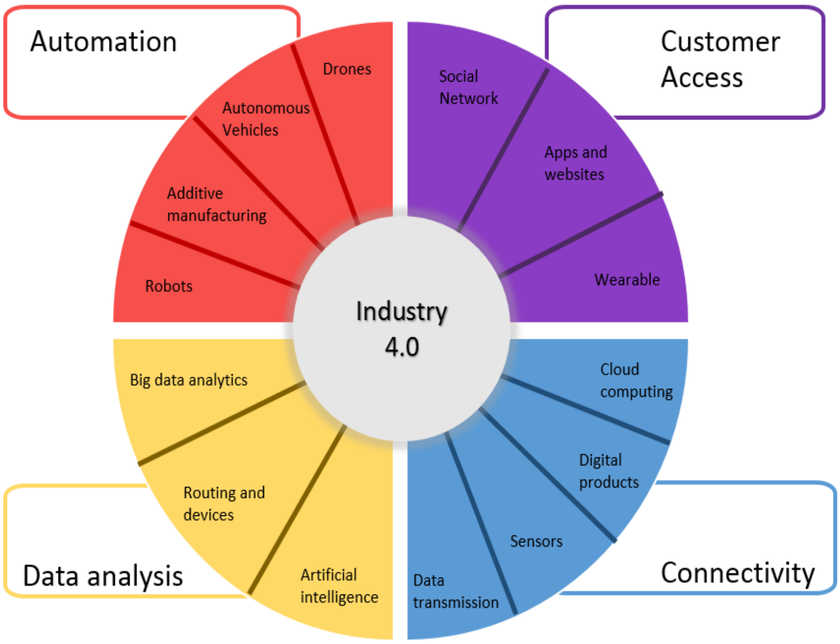

Figure 3 :- Overview Chart

On the above figure there is an overview of the i4.0 technologies, which one of the technologies are you an expert on? What type of research are you involved on?

1. Based on the technology the interviewee chose: which is the biggest limitation that this technology has and why?
2. Based on the technology the interviewee chose: which is the current level of maturity of this technology (concept, prototypes, first commercial products, few competitors, mature product).
3. Which applications have you seen of this technology in process installations? In your opinion when do you expected this technology to have an impact in the industry? What steps are need to reach that impact level?
4. Categorize the technology in (disruptive, important, interesting, non-- operational and useless) based on the impact that might cause in 5 years to the process industry?

6. Problem Definition

The Verschuren and Hartog suggest, there has to be few main elements drive the design of a system or structure (Hartog, 2005). Hence, in this step, there will be a definition and explanation of the main problems that will drive the design process. This definition was also made based on the expertise of Tebodin's senior project engineer. For this case study, it was decided to select three main problems based on the focus level. One operational (machine level), one control problem (factory level), One strategic problem (company level).

According to the senior project engineer, the high noise level is the major operational challenge that the company has been facing for the last couple of years. The vibration of the machinery produces a low--frequency sound that resonates through the entire building. This high level of noise makes the company unable to invest in more machinery, only because it will add more noise and the environmental authorities will probably sue them or even stop their production. To prevent this high noise problem, the company is using painting and dampening devices that managed to reduce the noise. However, they still have problems because these passive reducers are not capable to reduce dramatically the levels of noise that they have been reaching.

The second major problem is the lack of reliable information for maintenance and quality checks. Currently, support and quality are done in periodical checks, and the company has no data management systems. Therefore, the maintenance and quality team cannot learn from their previous failures. For that reason, the senior project engineer believes that a tool that helps them store and analyze quickly failure modes will improve factory's availability. Finally, from a strategic perspective, there is a significant disconnection between the suppliers, the production process, and the customers. The senior engineer stated that currently, the customer places an order, via email, and then the sales employee put the order in their internal system. Ones the request is in the system, the operation engineers read the order and verify if it is possible to make it. Finally, after they check that the order is possible, they placed it on the production line. On the supplier's side, the company requests the raw material from overseas suppliers by email. However, in case the content doesn't fit the quality standards, the company has to send back the raw material to the provider and use the inventory of end--products to cope with the demand. In conclusion, even though the production process is highly automated, the connection with customer and suppliers is made entirely by Human-to-Human communication.

7. RESULTS AND DISCUSSION

7.1 Theoretical Validation

According to Seepersad et al (Karolyn C. Seepersad, 2005), a methodology has a valid theoretical structure if the model is consistent, which means that theoretically the design process and design outcome are align and coherent. In this case the methodology was clear, consistent and fluent, with step-by-step procedures. The outcome of this methodology is a design of a cyber physical, using the KEY and important technologies of the industry 4.0.

7.2 Structural Validation

Based on the paper by Seepersad et al (Karolyn C. Seepersad, 2005) the empirical structural validity relies on the representativeness of the case study chosen. In other words, how well does the examples used in the methodology represent the context. For this validity, the case study chosen was a bulk production process factory, for this case study the requirement was set up clear and the needs for a design that solves noise, stakeholder connectivity and better information were set up. However, this example will only be representative for the mineral production process and in particular for factories that have machines connected to the slab of the structure.

7.3 Empirical Performance Validity

The empirical performance validity based on Seepersade et al (Karolyn C. Seepersad, 2005) focus on two main aspects. The first one is the usefulness of the output in each example, which means that the design output solves a problem or need accurately. In this research, the output of the design of the CPS using the 5C level methodology is well aligned with the boundary conditions, goals and requirements of the company, which means it is useful. The second aspect is the usefulness of the method: this aspect defines whether the case was good enough to deliver certain outputs. For this topic, the case study had enough information to deliver a valid output. However, the integrated validity can’t be stablished because there was only one example, and therefore, there was not possibility to compare outputs between examples. Finally, to analyse the usefulness, a group of examples must be analysed and compared. Unfortunately, in this research there was only one example and therefore it is impossible to analyse properly the integrated usefulness of the method.

7.4 Theoretical Performance Validity

The last category on the validation square is the theoretical performance validity: this category explains the usefulness of the methodology beyond the examples. In other words, how useful a methodology could be in other cases regardless of the case study chosen. In this research, it is possible to see that the 5C level architecture modified in this report could be applied in the entire process industry. This leap of faith is based on the argument that cyber--physical systems have so many different applications and components that is not difficult to think that other process installations will require the design of CPS. Moreover, it is stated that the process industries have converging trends and challenges, especially regarding innovation, digitalization and automation. Therefore, it is probable that the 5C level architecture could be applied in different industries and applications, within the process industry. Finally, based on the categorization of the technologies and the application of them in the CPS, it is possible to foresee that the outcome of the methodology could solve several problems in a process factory.

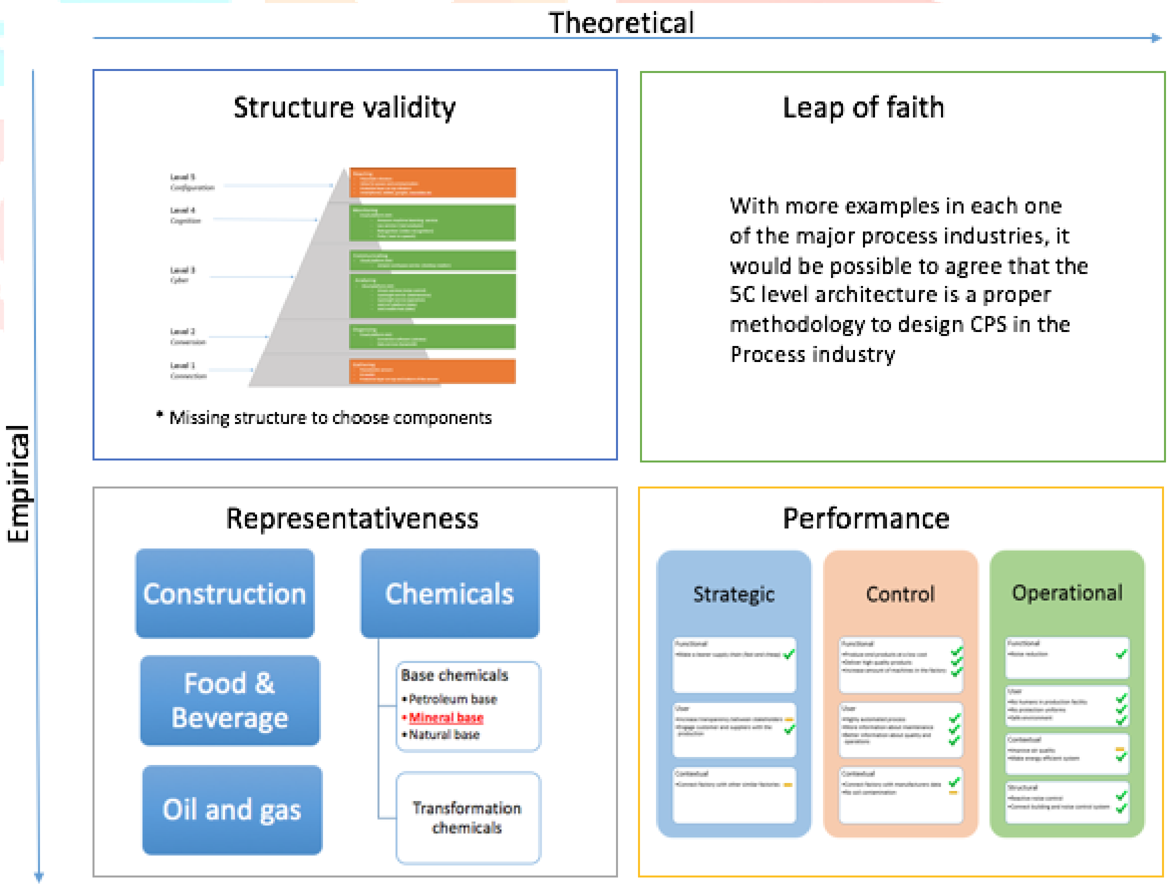

Figure 4 :- Validation Square for 5C Methodology

8. Conclusion

This document has the purpose of showing the possible impact that cyber--physical systems (combination of i4.0 technologies) might have in the process industry and how can they be applied in a process installation. During the entire document, there were five major conclusions that were derived from the literature study, interviews and design process:

The first conclusion is that in the process industry, in the next 5 years, out of the fourteen technologies listed in industry 4.0, only three of them (sensors, artificial intelligence and cloud computing) have the potential and the technological maturity to be placed in process installations. Additional to these KEY technologies, other five technologies were considered as IMPORTANT, which means that they have a technological maturity but their application in the process industry is limited to certain tasks.

The second conclusion is that cyber--physical systems can disrupt the process industry. However, the design and execution of these systems should be fully customized to the case and managed by engineers and IT professionals able to choose the technologies, connect the components and maintain the system. This conclusion is important because it means that, in order to design CPS, there will always have to be an assessment and design process that can't be avoid with standard methodologies.

The third conclusion is that the methodology used to design a cyber--physical system (5C level architecture) could be valid for the process industry, however, more case studies and designs should be developed, in order to assure that the methodology is adequate in other process industries.

The fourth conclusion is that design and engineering companies, like Tebodin, should use the methodology shown in this report as a design philosophy rather than a methodology. In fact, every time that a client asks for a design of a factory, building, machine, pump, vessel, etc., the approach of the design/engineering team should always be to create an object that acts as a CPS (gathering, organizing, analysing, monitoring, communicating and reacting towards the environment). By using the 5C level architecture as a design philosophy the added value to the client should be higher than the single inert object. As for the design/engineering firm, the added value of making a CPS should also rise because the new system will require additional services like asset management control, sustainable consulting and CPS management, in order to work efficiently and adequately.

9. **Figures and Tables**

Sr no.	Figure / Table number	Name of Figure / Table.
1	1	Type of Interviews
2	2	Research Method
3	3	Overview Chart
4	4	Validation Square for 5C Methodology
5	Table 1	Type Of Interviews

10. ACKNOWLEDGMENT

- I would like to express my gratitude to my primary supervisor, Dr.S.A.MESHRAM who guided me throughout this project. I would also like to thank my friends and family who supported me and offered deep insight into the study.

- I wish to acknowledge the help provided by the technical and support staff in the MECHANICAL DEPARTMENT OF G.H.RAISONI UNIVERSITY .

- I would also like to show my deep appreciation to my supervisors who helped me finalize my project.

11. REFERENCES

i. ABB NORWAY. (2013). OIL AND GAS PRODUCTION OUTLOOK. ABB, NORWAY. OSLO : ABB GROUP.

ii. American Chemical Society. (2013). The Chemical industries in the UK. Retrieved from The Environment

http://the--environment.org.uk/bristish_isles/history_chemical_industry_UK.html

iii. Association for unmanned vehicle systems international. (2013). The economic Impact of unmanned aircraft systems integration in the United States. Global: AUVSI.

iv. Azhar, S. (2011). Leadership Management. Atlanta.

v. Bell labs Consulting. (2016). Advising the industry on the path to network 2020.New Jersey: Nokia

vi. Bhargav. D , S. Kubler . (2016). Opportunities for enhanced lean construction management using internet of things standards. In S. K. Bhargav Dave, Automation in Construction (pp. 86--97). Elsevier.

vii. Bose. (2016, 121). Bose Retrieved

from: //www.bose.com/en_us/products/headphones/noise_cancelling_headphones.html

viii. Boston Consulting Group . (2016). The Future of productivity and growth in manufacturing industries. Global: BCG .