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Design of line Twin and its Implementation

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Abstract--In this work our main focus will be on designing of digital twin for a physical asset "Line" inside an industry. This concept of line twin is design of an A.S for the line inside the industry. Having this digitized representation of a line inside internet cloud and continuously updating data from the physical asset will be the major goal. The different sub models inside the line twin executing expected functionality from a line inside industry would be focused. For instance as a beginning proof of concept this line twin in this master thesis will be calculating the "Line OEE (Overall equipment efficiency)" based on its connected machines and the underlying infrastructure of machines with the line. So at the internet cloud we would be able to get the information of product development at the shop floor even and so this could also lead to a better order related acquaintance of the customer. Furthermore, other functionality that is expected from a Line in industry will also be focused and how the proposed solution can also help us in different organization types will also be highlighted up to some extent.

Keywords: **Line OEE; digital twin; IoT cloud; AS; OPE**

1. Introduction

In the context of the Internet of Things concept, the research presented concepts such as smart grids, smart homes, and smart industries. Industry 4.0 is a German vision for the future smart sector, which is the subject of major concerns of the German government and many successful commercial entities. The government is investing heavily in this industrial stimulus. I4.0 is the most systematic and innovative approach for different industrial sectors that has a significant positive impact on product production, efficiency, mass customization, quality improvement, lower costs, easy access and product traceability throughout its useful life. Several multinational industries are participating in industry 4.0 research to target challenges of an intelligent future. Research on Industrial 4.0 in the automation sector focuses mainly on manufacturing industries. To meet the challenges of the connected sector, investigate in this field, it mainly focuses on providing Internet access to industry, machines, lines and even manufactured products. In search I4.0, the word resource is used for each inventory within a factory and even the factory itself. In order to allow all resources within the sector to be intelligent enough to meet the expectations and requirements of I4.0, allowing the former to communicate their status throughout the production life cycle and do so more solid diagnoses and global process traceability. The research proposes digitization through the introduction of the concept of architecture industry reference 4.0 (RAMI4.0) for the industry 4.0 components (activities). RAMI4.0

is a three-dimensional coordinate system, a model that brings together the most important aspects for sector 4.0 technologies in a very dichotomous approach by offering a model layered in each coordinate [1]. Research teams for industry 4.0 in Germany proposed the Management Shell concept for compliance with the requirements for the Industry 4.0 component presented by RAMI4.0. ZVEI (die electro industries). The main aim of our work is to find the overall effective efficiency for an industry. OEE is the most important and significant key performance indicator (KPI) in regard or optimizing overall factory performance. OEE gives the performance indication of different equipment inside an industry. This performance indication of equipment helps in diagnostics in industry; also comparison of different equipment inside a firm becomes easy. Improving the performance of individual equipment inside firm results in improvement of performance of the overall industry. In literature it has been observed that most of big enterprises has been investigating a lot in improvement of their enterprise performance in which OEE calculation has been a mile stone in improvement of factory production, reducing the cost of production and as a result incrementing the overall performance of the factory. Different literature has been referring to OEE calculation in different ways which results in several options of calculation of OEE. Here in this section we will focus upon some important research papers and then explain the calculation of OEE in general, further followed by calculation of OEE in case of simple Asynchronous lines, asynchronous POOL production and also the explanation of how the calculation of Line OEE can help us in calculating the overall factory performance

2. State of Art

Normally we have a scenario in which, we have some machines and for these machines some solutions have been developed in some software. Now, to make this communication between the solution and the physical machines possible, we must have a certain implementation of the concepts of machines or a certain middleware, a platform that can map the different aspects or properties of the machines to the interfaces provided by the software solution. This platform we call implementation in this article could be used as the basis for interaction between the machine and the previous solution. Here on this topic, the different possibilities of organizing the machines with the previous solutions and how they are presented first. As a result, it is ultimately shown that the way in which Line is an important aspect to consider when organizing machines the concept of two machines from 2 different suppliers, one from Siemens and one from Panasonic were considered as depict in figure 1.

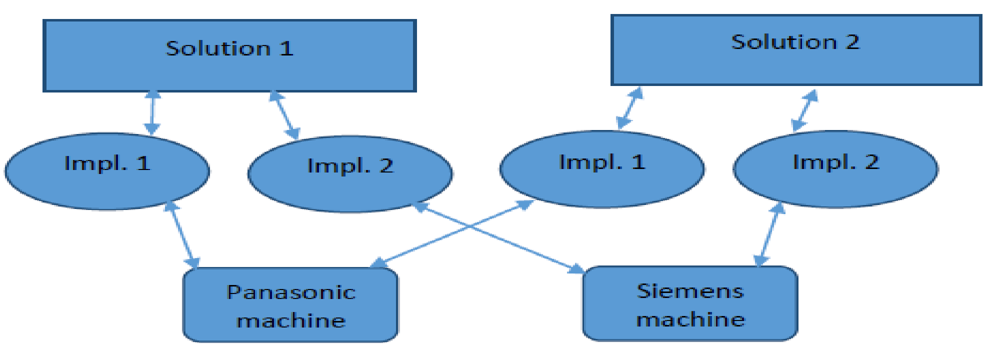

Figure 1: Relation between machines and solutions

Each machine needs its separate implementation mapping for each piece of solution. Such a relation could be called n:m. That means- n represent the number of Implementations and m represent the number of solutions. This number of implementation for mapping machine to the solution depends mainly on the number of solutions that uses the specific machine. This traditional method is too expensive and time taking as the implementation of mapping each machine takes a long time to complete.

3. The Digital Twin

The first time, when a "Twin" of a physical entity was created, dates from several years ago to NASA's Apollo program. There were built at least two identical space craft's for mirroring the condition of the one spacecraft, which is currently in space with the one on earth – the craft on the earth was called "the twin" [4]. Since then until now there are several kinds of definitions have been established for the meaning scope of the "Digital Twin". For example, the automobile manufacturer "TESLA" is planning to develop a Digital Twin for each vehicle and to synchronize information exchange between the vehicle and the factory. The technology company "PTC" is aiming to create a link between the physical entity and the virtual model to enhance the production processes [5]. The software company "Assaults System" is focusing on product design performance. The conglomerate "General Electric" planning to create Digital Twins from their product to predict the health and performance over a lifetime [6]. Also regarding some scientists, there are small or more significant differences in the view of the benefit and scope of the Digital Twin. Regarding to the first scientist, who spoke about the Digital Twin "A Digital Twin is an integrated multiphysics, multiscale simulation of vehicle or system that uses the best available physical models, sensor updates, fleet history, etc., to mirror the life of its corresponding flying twin [7]. According to Michael Grieves, who is one of the pioneers in this task, the Digital Twin is "a set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level [8]. To combine all the different definitions of a Digital Twin, it could be said, that a Digital Twin of a real distributed product is a virtual reflection, which can describe the exhaustive physical and functional properties of the product along the whole life cycle and can deliver and receive product information. The following figure shows the development process of the Digital Twin integrated into the three phases of every products life cycle, design, production and service.

4. Overall Equipment Efficiency

Overall equipment efficiency or efficiency (OEE) is a measure that has been accepted in the semiconductor industry. The OEE is simple and clear and standards and guidelines have been developed. As the OEE does not have an adequate framework, the effectiveness of the team (E) was developed on the basis of a systematic team approach. And consider the effectiveness of the equipment in terms of availability, speed and quality losses. Unlike OEE, E is a measure of performance for independent equipment, isolated from the environment. In addition, E uses the available response time as the basis in contrast to the OEE, which uses the total time as the basis for the measurement. Finally, due to the fact that E is measured directly from the time of production and operation, it does not depend on the use of the equipment, unlike the OEE. OEE is the most important and significant key performance indicator (KPI) in regard or optimizing overall factory performance. OEE gives the performance indication of different equipment inside an industry. This performance indication of equipment helps in diagnostics in industry, also comparison of different equipment inside a firm becomes easy. Improving the performance of individual equipment inside firm results in improvement of performance of the overall industry. In literature it has been observed that most of big enterprises has been investigating a lot in improvement of their enterprise performance in which OEE calculation has been a mile stone in improvement of factory production, reducing the cost of production and as a result incrementing the overall performance of the factory. Different literatures have been referring to OEE calculation in different ways which results in several options of calculation of OEE. Here in this section we will focus upon some important research papers and then explain the calculation of OEE in general, further followed by calculation of OEE in case of simple Asynchronous lines, asynchronous POOL production and also the explanation of how the calculation of Line OEE can help us in calculating the overall factory performance. In literature generally the OEE is calculated based on the following equation [11]:

$$OEE = \frac{valuable\ operating\ time}{loading\ time} \quad (1)$$

Where Valuable Operating time (VOT) is the time in which the equipment for which OEE is calculated is producing valuable products at its full efficient performance. Loading time is the total time in which the machine is scheduled to produce continuously in certain period of time for example in a shift, in one day, in one week etc. In this equation the description of how much actual output an equipment providing out of the expected output from the same equipment. OEE does not only provide the efficiency of equipment but it also focus and considers the different losses that are expected to occur in a certain factory. Out of these losses information provided by the OEE KPI, a firm can better grape the opportunity to focus on these losses and improvement of the losses results in improvement of performance factor of industry.

5. Results and Discussion

In this section we discuss the result performance after implementing in MATLAB 2016a. The entire setup works with the internet, each of the devices connected with the server has its own IP address. The main IP address is assigned to the server and the remaining addresses can be assigned to each of the devices connected to it. The connected devices, which in this case are the printers, also have a MAC address like other devices which are connected to the internet. In the Simulation setup, there are two printing devices connected to the server namely **'HP LaserJet'** and **'Cannon Dot Matrix'**. For the simplicity we have considered only two devices in the simulation implementation. Other such devices can also be connected to the server. Each of the printing device or the printer has some specified number of pages that can be printed within the available limit of the toner. The step wise statistics of printing done per day and remaining pages are discussed in the upcoming section of this document. The figure 2 describes the working scenario

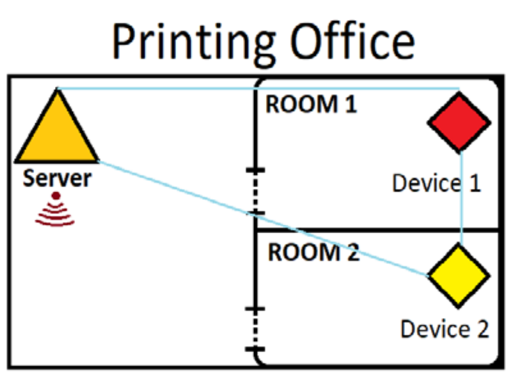

Figure 2: Working scenario

The simulation displays overall 14 Graphs (7 for each device) 7 of the graphs have been explained below whereas the other 7 work on the same criteria. In figure 3, the prints are taken by the device per minute. The small blocks show the exact number of prints taken in any specific minute which are all connected by lines. The overall time is 480 minutes which is taken from 8 times 60. In figure 4, a maximum number of prints are taken for a single minute which is 12 and minimum is 1. This is the result of Dot Matrix Printer.

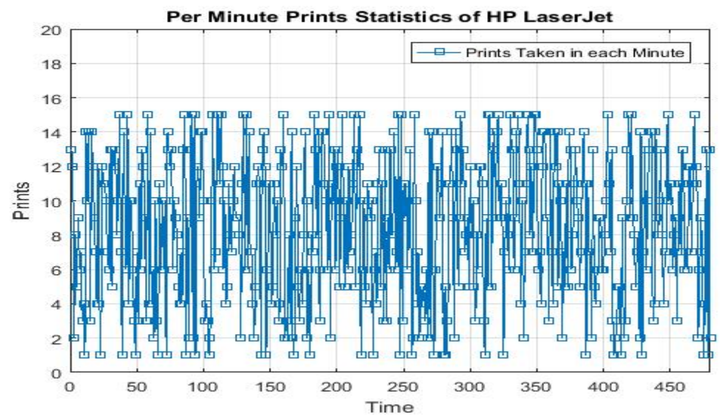

Figure 3: Per minute statistics

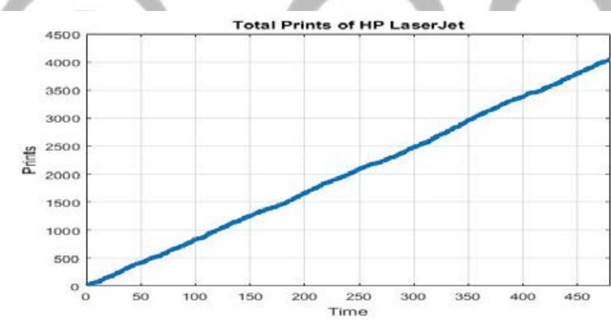

Figure 4: Maximum prints of Cannon DotMatrix

The figure 4 shows total prints taken in each minute. The difference between figure 3 and figure 4 is that figure 3 shows the prints in each minute individually whereas in figure 4, the value of each print in each minute is added up in the next minute. This means that if the printer has printed 10 prints in first minute and 15 prints in the second minute, the value shown against the second minute will be 10 + 15 = 25 page which is this graph increases linearly.

Figure 5 shows the temperature statistics of the device or the printer. The normal room temperature is assumed to 15 degrees centigrade so when the printer is idle, the temperature gradually falls back to 15 degrees. This graph can be compared with figure 3 and it can be seen that the time when the prints are maximum, the temperature will also be maximum. This would help us to understand the operating temperature of the device to the user so that to handle temperature varies with the time of operation

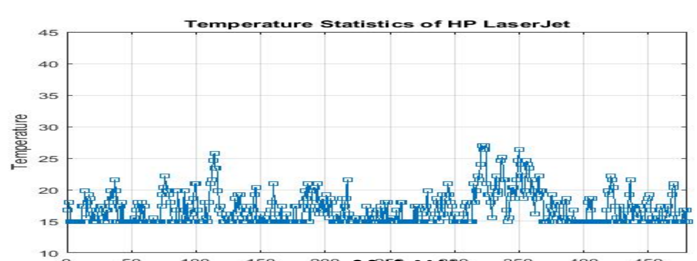

Figure 5: Temperature statistics of Cannon DotMatrix

. As in figure 5 the maximum temperature reached to 25 degrees centigrade. The cut off threshold of the temperature is 35 degrees as discussed earlier that means if temperature reaches to 35, the printer will shut down and the error message will be sent to the server.

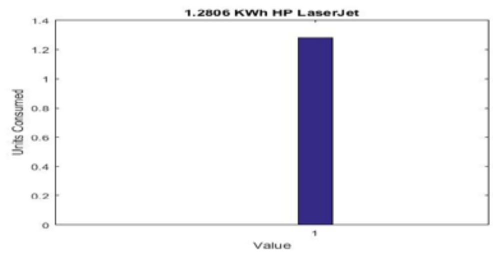

Figure 6: power consumption by Cannon DotMatrix

As per the power of the device, figure 5.5, calculates the total electrical energy units consumed in the entire day. In the case shown above, the dot matrix printer consumes about 1.2806kw units of electrical energy.

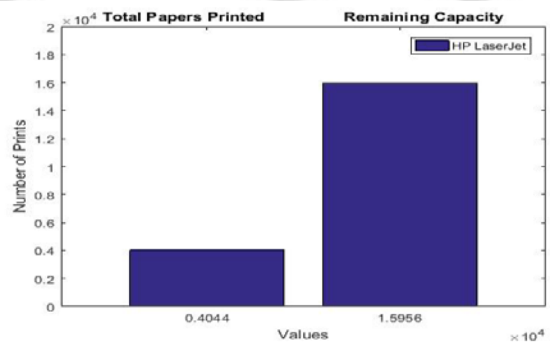

Figure 7: Printing capacity

Figure 7 simply counts the total number of prints and displays that how many papers have been printed so far and how many more papers can be printed within the same toner capacity.

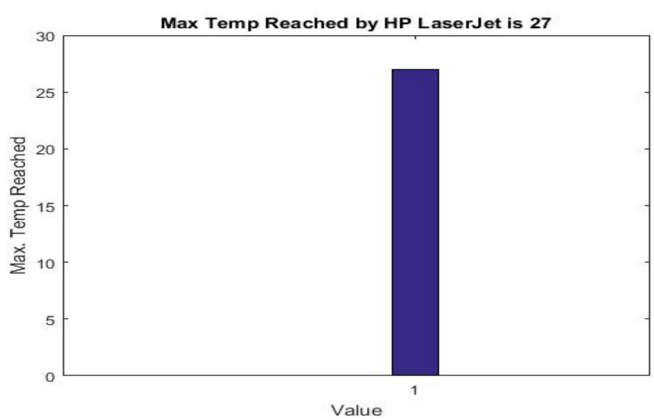

Figure 8: Temperature Effect by Cannon DotMatrix

Figure 8 shows the maximum temperature reached by the device in the entire day.

6. Conclusion

The importance of information exchanges between stakeholders in a product life cycle is constantly increasing, leading to the need for virtual products that describe the physical entity completely in the virtual world. This type of virtual product is called Digital Twins and offers many new possibilities and advantages in the future field of product documentation. This paper presents Digital Twin in the context of the two printing devices connected to the server, namely "**HP LaserJet**" and "**Cannon Dot Matrix**". Between the state of the art and the fundamental issues to consider, there are also some steps necessary to implement a digital Twin in the process of printing development. In addition, users of a Digital Twin are determined and their use cases and benefits are also mentioned in the results chapter. In the future, there will be more arguments, which should be considered for the implementation of a sustainable and convenient digital twinning process. One of the main issues, which should be considered, is the need for a data layer, an IoT platform or a cloud that allows the twins to remain in constant contact with the respective physical entity. In addition, the methods and processes for creating a digital twin should consider that the digital twin must be prepared for archiving throughout life. Another point that should be reflected is the method for 3D visualization of the harness that represents a product with a great variety. It is necessary to determine the benefits of creating unique views for digital twins, which depend on the parties involved. For example, marketing departments do not need the same content view as the development department. Finally, the necessary methods must be created and validated to allow a continuous exchange of information between the "As Mained" phase and Digital Twin

References

[1] Beck, T., Reichmann, C. and Schaeuffele, J. (2016), “Modellbasierter Ansatz vom Architekturentwurf bis zur Serienreife”, ATZ elektronik, Vol. 6, pp. 58-63.

[2] Bogner, R., Hoyer, P.-J., Kyriazis, J. and Urban, G. (1998), “VOBES – Das Volkswagen-Bordnetze Entwicklungssystem”, Elektronik im Kraftfahrzeug, Electronic Systems for Vehicles, Tagung, Baden-Baden, Germany, October 8-9, 1998, VDI-Verlag, Düsseldorf, pp. 1085-1100.

[3] Bortolazzi, J., Garthe, M. and Menrad, B. (2004), “Elektronik und Vernetzung”, Motortechnische Zeitschrift, Vol. 65, pp. 106-115.

[4] Eigner, M. (2017), “Workshop: Digital Model & Digital Twin”, Proceedings of the ProSTEP iViP Symposium2017, Essen, Germany, May 17-18, 2017

[5] Iqbal Amjad, Shah Syed, M. Amir, "Adaptive Investigating Universal Filtered Multi-Carrier (UFMC) Performance Analysis in 5G Cognitive Radio Based Sensor Network (CSNs)", *International Journal of Engineering Works Kambohwell Publisher Enterprises*, vol. 4, no. 1, pp. 5-9, January 2017, ISSN 2409-2770.

[6] Grieves, M. and Vickers, J. (2017), “Digital Twin: Mitigating Unpredictable, Undesirable Emergent Behavior in Complex Systems”, In: Kahlen, J., Flumerfelt, S. and Alves, A. (Eds.), Transdisciplinary Perspectives on Complex Systems, Springer.

[7] P. Spicer, Y. Koren, M. Shpitalni, and D. Yip-Hoi, “Design Principles for Machining System Configurations,” CIRP Annals - Manufacturing Technology, vol. 51, no. 1, pp.275–280, 2002.

[8] Y. Dallery and S. B. Gershwin, “Manufacturing flow line systems: A review ofmodels and analytical results,” Queueing Syst, vol. 12, no. 1-2, pp. 3–94, 1992.

[9] Gruender, W.T. (2017), “Systems Engineering Requires Digital Twins of Machine Elements”, CONAT 2016 International Congress of Automotive and Transport Engineering, pp. 227-233.

[10] Neckenich, J., Winter, R. and Vielhaber, M. (2015), “Digital Support of wiring harness development (Based on the 3D Master Method)”, Proceedings of the ICED15 / International Conference on Engineering Design, Milano, Italy, July 27-30, 2015, pp. 1-10.