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A New Approach to MES System Deployment

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Abstract: The manufacturing sector requires prompt company's responsiveness to optimize their competitiveness and improve their performance. In this context, the Manufacturing Execution System (MES) is a growth lever for Small and Medium-size Industries (SMI) that aim to implement a real-time base production management system in order to respond, properly and at the short term. It is also a guarantor to industries wishing to engage in the future industry. This system oversights all the events occurring during the production cycle. However, it has no systemic process to ensure its deployment within the SMI. In this paper, we propose a systemic approach to the MES deployment. Our approach is based on the BPMN modeling to ensure smooth communication among employees regardless of their profiles. In our approach, we will determine the appropriate MES functions based on the production value-added chain. Then, we develop a guideline that highlights a detailed requirements of workstation in harmony with its environment. The approach aims to measure the impact of MES on the company's performance.

Keywords: MES, real-time production, traceability, Lean manufacturing, BPMN modeling, UML.

I. Introduction

In the manufacturing sector, competitiveness is a pillar to companies 'sustainability. Therefore, companies should be more responsive and efficiently monitor their operational process in real time, in order to remain competitive and to conquer new markets. To achieve this goal, companies have to optimize the production management, both at the strategic and operational levels to respectively upgrade their practices and enhance data collection. Companies must be able to react on timely basis to the events that may occur during the production cycle; to cope with unpredictable events and to eliminate any time deficiency. Thus, they ought to accurately assess the different costs (procurement, possession, manufacturing, outsourcing, etc.), which depend on production statements (consumption, work in progress, maintenance operations, etc.). The statements need to be accurate and reliable.

In the presence of constraints that influence the production function, companies must adopt the workshop control systems. Among the tools that ensure the workshop control is the Manufacturing Execution System (MES) [1] [2], it optimizes the production and simultaneously connects the workshops to other enterprise information systems such as ERP, WMS, SCADA, etc.

The MES is a real-time control system, it ensures at once the coherent feed of ERP [3] [4]. This tool, as rapidly changing technology, is adapted to all sectors; In this sense, the SMI planning to adapt the production real-time control should implement the MES solution. However, this system does not cover all deployment process (precondition, post-condition and evaluation) [5] [6].

Therefore, the objective of this article is to provide a systemic approach to the deployment of the MES solution in the SMI. To address this issue, we review all deployment phases, targeting the development of a state based on BPMN modeling for a smooth and standardized description of the infrastructure of production; we will determine later, customized and proper functions of MES system based on value added in the production chain. Then, we develop a guideline document that transcribes detailed requirements for each function in perfect harmony with its workstation environment. Finally, we assess the impact of MES on the company's performance.

This article is structured as follows: the second section presents the state of the art of the tools deployed to drive our approach; in the third section, we propose our approach framework. For the approach illustration, we present in the fourth section a case study that is developed into a SMI in plastics industry. In conclusion, we review the work assessment of work and present our research perspectives.

II. Presentation of MES and business process tools

In this section, we present the state of the art of the tools deployed to direct our approach, namely the concept of Manufacturing Execution System, some tools of Lean and BPMN modeling.

*II.1.*Manufacturing Execution system

According to MESA International (Manufacturing Enterprise Solutions Association) [7], the MES provides the necessary information to the optimization of production activities from manufacturing order to finished product. MES guides, initiates, responds to the workshop activities as they progress, and provides reports on these activities. It has high responsiveness to production condition changes, and aims to cut off low added value activities. By supplying a bidirectional flow of information, the MES provides the company and its supply chain, in real-tile basis, with critical data.

Figure 1 illustrates the role of MES to the company's information production system. According to MESA standard [4] [7], MES fulfills 11 functions, namely: management resources, scheduling, tracking products and lots, document management, data collection and acquisition, quality management, process management, maintenance management, product traceability and genealogy, performance analysis and management personnel. MES creates a bridge between two levels that cannot properly communicate with each other mainly:

the first level is the management system (ERP, MIS, WMS, etc.) and the second level is the automation (Supervision, SCADA, etc.).

Fig. 1. Core functions of a Manufacturing Execution System [7]

II.2. The Lean tools and BPMN

The concept of Lean, inspired from Toyota Production System [8] is based on the elimination of waste in the production process. Waste is an activity that does not realize any added value to the customer; In contrary, it generates additional costs. Generally, Lean basic defines seven types of waste, the "Muda" [8] namely:

-Waiting time: when parts, equipment, information and people are not available at the right time.

-Unnecessary transport: the unnecessary transportation information or materials from one place to another.

-Over processing: achieving more steps or use more resources to do the job.

-Stock: "muda" exists if the plant keeps more material and components as the minimum necessary to carry out the work.

-Unnecessary movement: it concerns any employee move that do not directly contribute to the finished product added value.

-Defects: any activity resulting from errors.

-Overproduction: Doing the work in advance or as more as required.

For the effectiveness of the production improvement, we need to monitor and collect measurements to trace, in timely basis, in order to be able to analyze and control instantly the production data. Therefore, we need an effectively reliable data that are properly collected by various sensors on each workstation. After then, the data is injected into a responsive MES system to prepare appropriate decisions at the right time. The MES is monitoring guarantor to continuous improvement, waste traceability reduction, time response optimization. It is a tool that drives waste and brings added value, namely: saving time, Overall Equipment Effectiveness (OEE) calculation, availability of resources, etc. The implementation of a MES aims to increase the proportion of value-added operations.

The Business Process Model & Notation (BPMN) [9] is a process model that represents the business processes of an organization. BPMN provides a standard to ensure an easily understandable notation by all company's managers. It provides a better understanding of the mechanisms of corporate activity and good communication among peer employees. BPMN notation is based on different graphic symbols and standards; it aims to avoid any ambiguity or interpretation induced by a textual description.

III. Overview of the Approach

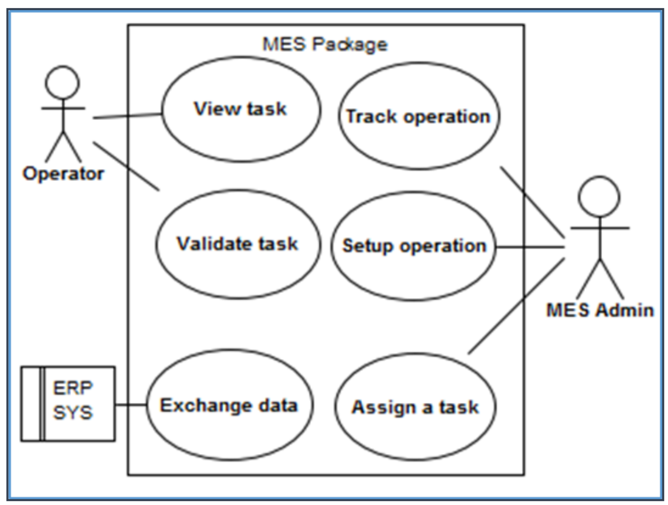
In this section, we provide the general framework of our approach based on expected key functions of a MES system. The use case diagram is the appropriate tool to present the services provided by MES. At the first stage, we identify all the actors who will use the system. According to the specifications of a MES cited above (§ II.A), we refer the following actors: ERP system, manufacturing operator and administrator of MES. The use case diagram contains three actors and six use cases, namely:

-ERP system: it needs to exchange data such as manufacturing orders, schedules, delivery or receipt vouchers, etc.

-Manufacturing operator: it provides inbound and outbound with the operators; the system collects the data by specific sensors for each activity.

-MES Admin: is the system conductor, it acts a pivotal role in the configuration of consecutive operations for each manufacturing order. Thus, it provides in real time monitoring to evaluate the progress of sequenced tasks.

Fig. 2. Diagram use case of MES system



To fulfill the settled objectives of the use case diagram, we organize the process deployment of the MES solution associated with this approach in three phases, namely: the analysis, the design and the implementation and control. The general flow diagram that summarizes these phases and activities of our approach is shown in Figure 3.

In the first phase of analysis, the responsible of MES project focuses on three key activities, in the first activity, he must define the scope of the project, thereafter, for each workstation in the first phase, he should describe the operation process with BPMN diagram, each BPMN diagram is revisited with Lean tools to identify all acts of waste. The deliverable of this phase is a document regardless of any specific technologies. This

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document contains the descriptive diagrams of each workstation with each location points and types of waste.

The second phase is based on the available results of the previous stage. At this point, we identify waste to eliminate according to the company's perspectives and specify monitoring indicators to each improvement. Subsequently, we select applying MES features to eliminate covered waste while compiling a graphic illustration according to Deployment Process of MES solution in figure 3.

At the end of this phase, we integrate the proposal resulting from the production system for a more harmonious global integration.

In the third phase, we aim to implement the system based on the deliverables from the previous phase. For this, we physically specify the software and hardware requirements to achieve desired results. Thereafter, we move towards the establishment of system software and hardware required (sensor, industrial PC, acquisition terminal, etc.).

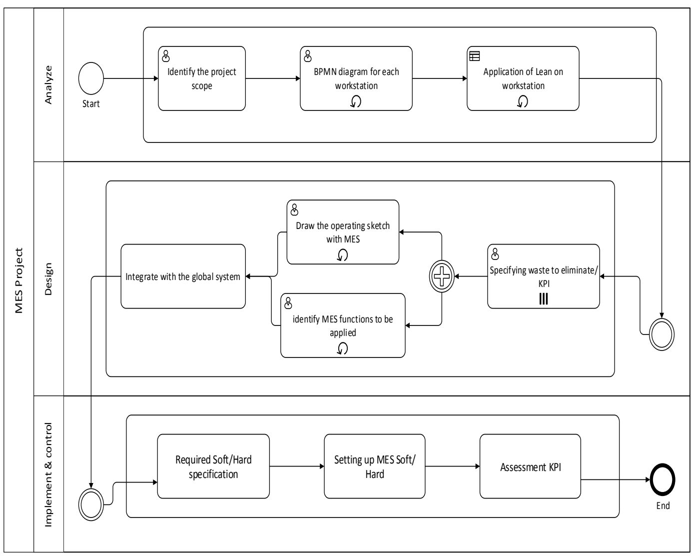

Fig. 3. Deployment Process of MES solution

At the end of this phase, we take indicators measuring productivity to compare with the initial indicators; this comparison capitalizes improvement and aims other iterations of continuous improvement based on the indicators previously identified.

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IV. Approach description

To illustrate our approach, we chose a case study of a company of plastics. For the sake of simplicity, we focus on a few diagrams to validate the approach.

IV.1. The analysis phase

The first activity in this phase is to define the scope of the project and the objectives to be attained. In this sense, and for more efficiency, the implementation of MES should be limited to lines of homogeneous products within the same physical site. Thereafter, to understand about what will run the future system, it is relevant to go through an analysis of production monitoring process since the launch of the manufacturing order to the finished product. This analysis is transcribed into BPMN diagrams detailing the activities carried out, the different people in charge and the resulting documents to complete a manufacturing order.

In our illustrative case, monitoring of the progress in production is scheduled by manufacturing orders, such monitoring is performed by paper, the person responsible for this mission provides information in production file, which is then collected and processed manually. We are going to study carefully each document used to address the data collection and processing. The collected data are input into the system. The performance indicators are calculated at the ERP. A production report is created by the system after entering data, it gives the status of each manufacturing order and indicators (OEE, scrap rates, not quality rate, deceleration rate) by each workstation. For example, Figure 4 shows the mapping process of injection operation.

In the third activity, based on the BPMN process diagram, we could assess the current production tracking state. We detected existing weaknesses based on the concept of waste. Such weaknesses are as follows:

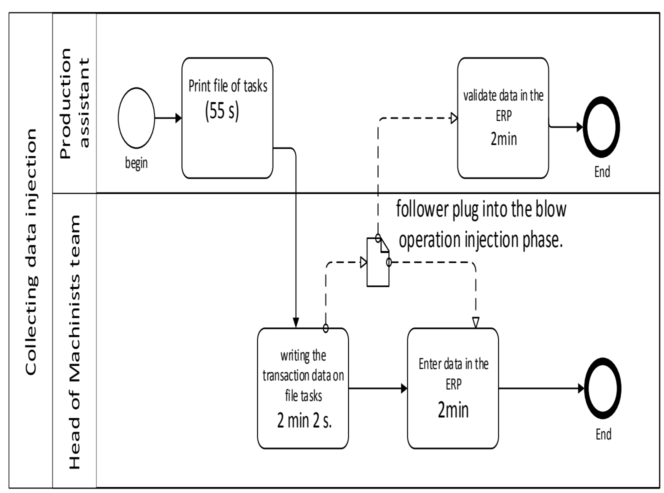

Fig. 4. Diagram BPMN for the injection operation

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-Unnecessary movement: operators have to print out the task file from another service, and also to transfer it to another service.

-Errors and defects: the operators still make errors in the production data acquisition (production quantity, opening time, etc.) in the information system. Based on the collected data, we found that for each month, the operators commit almost 30 average entry errors. Incorrect production data have a significant risk that refrains from obtaining reliable analysis, because the calculated performance indicators are based on collected data of operator's failure

- Multiple inputs: for each manufacturing order, operators spend time to collect data, print task file, type in the task file and re-enter in the information system.

IV.2. The design phase

Based on the previous phase results, we specify the waste points to be eliminated according to the project objectives and the available resources. For each selected waste point, we specify at least one functionality from the 11 criteria for MES (cf.§§ 2.1.) At the same time, we draw a diagram to illustrate the suggested solution. In our case, we will propose several schemes of implementation of MES in production workshops. The guide document contains two parts. The first part, outlines the detailed features of the system, the second presents an illustration of the MES solution.

Concerning the illustration, it describes the data to be entered into the database by the operators, the data relevant for managers and operators, calculated indicators, represented graphs, etc. This will be useful when installing the tool, which allows supplier to know position needs and features. For this, we will identify the system input and output, equipment for data acquisition. In our case study, the workshop contains multiple equipment; we will limit our analysis to only two machines. Figure 5 describes the future state of the workshop of injection and below after the implementation of the MES.

IV.3. The phase of implementation and control

The implemented solution has to resolve the weaknesses identified in the analysis phase, and it must adapt now to the environment, namely: data source, equipment, protocols and standards, etc. In this phase, we aim the implementation of the system based on the deliverable of the previous phase, to do this, we physically specify the software and hardware requirements to achieve expected results. Afterward, we aim the implementation of system software and hardware required (sensor, industrial PC, acquisition terminal, etc.). Finally, we determine performance measurement indicators to compare with the starting values. This comparison capitalizes improvement and intends other continuous improvement iterations based on reliable data. In Table 1, we present some improvement indicators provided by the MES system on the company's performance of our case studies.

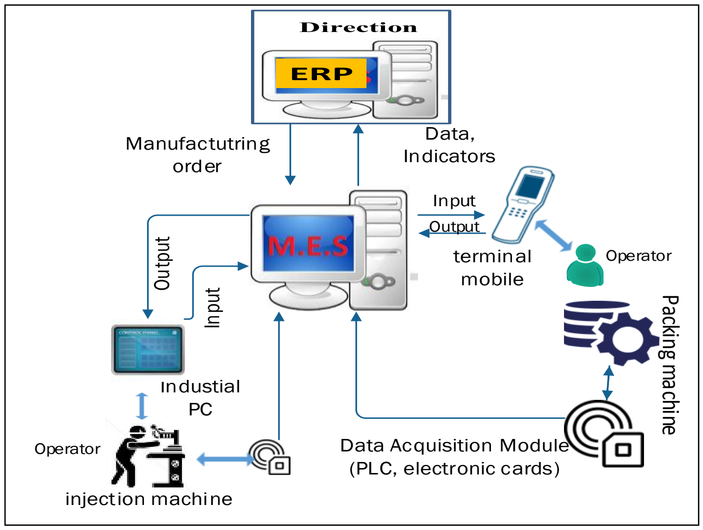

Fig. 5. Illustration of solution MES in injection workshop

V. Conclusion and perspectives

In the connected industry, the information system has a crucial role in real-time production, it increases the management responsiveness using collected data and dispatched it to all workstations through the MES system. Nevertheless, the SMI has no systematic approach to ensure their deployment. In this paper, we have developed a systemic approach to implement a MES system in a SMI. The approach is based on the evaluation of the production line using the BMPN modeling, in order to implement MES system in detected waste points.

TABLE. 1. IMPACT OF MES SYSTEM ON THE PERFORMANCE

Indicator	Impact
Reliability of data	The automatic or manual data acquisition replaces the multiple input. So the production service will avoid errors in the collection and data entry.
Going Paperless in monitoring production	The paperless make a real reduction in costs (paper, ink, printers). The Production Service will avoid the consumption of: ++ 1030 task file per month on average; ++ 405 control file per month on average.
	It will eliminate time losses such as shifts to the printers.
	It reduce the time of exchanges information
Information in real time	The information is handled early.
	Better responsiveness to risks.
	Analysis of real-time performance of all workshops.
Alleviating staff	Alleviate the people from entering manually data.
	simplify entering in the assembly workshops and recycling.
	People focus on production.
Improvement	The implementation of MES will help of good manufacturing practices.

In our approach, we presented the necessary tools, namely: the MES system in a production company, Lean and BPMN modeling. Subsequently, we introduced the process frame which is based on three phases, namely: the analysis phase, the design and the implementation and control one. Each phase ends with a deliverable that ensures the access to the next phase. To explain our approach, we illustrate with a case study in the SMI of plastics. The proposed approach will be complemented with other improvements such as the establishment of the correspondence between the features of MES and types of waste, and the integration of MES as part of Big Data to process large amounts of collected data. Our focus is also on how to automate the collaboration between the MES and ERP.

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