A METHOD TO SUPPORT SMES TO OPTIMIZE THEIR MANUFACTURING OPERATIONS

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Abstract:

In the last decades the gap between enterprise systems, like Enterprise Resource Planning (ERP), and process control systems has been filled with the development of software systems, commonly referred to as Manufacturing Operations Management (MOM). The ISA-95 standard provides a detailed functional description of this intermediate layer in the CIM pyramid. This standard supports manufacturing companies, system integrators and software vendors by using the same terminology in their communication for integrating their enterprise and control systems. Most of the time, these software systems address bigger companies which are convinced of the strategic advantages for their MOM projects: reduction of risks, costs and errors. This paper introduces an analysis and justification method that reduces the barriers to adoption of MOM systems for small and medium enterprises (SMEs). By applying the method an SME gets an idea of the possible improvements for the materials and information flow required for the production of goods or services.

Keywords:

MOM, ISA-95, manufacturing execution system, SME, technology adoption.

INTRODUCTION

The Computer Integrated Manufacturing (CIM) pyramid presents the entire manufacuring process as a layered structure (Figure 1). It contains three main layers. On top is the administration layer which handles the incoming orders and supplies the deliveries through enterprise systems, like ERP. At the bottom of the pyramid is the layer with the materials and information flow for controlling the production process. MOM systems are the supporting link between both layers. Most of the time those systems are not present at SMEs or are often replaced by Microsoft Office tools. If MOM systems are integrated, the different production steps are not always executed in an efficient way. The intermediate MOM layer is important for the synchronization between the enterprise systems and the real-time production process.

Next to that, MOM systems are built according to the structures described in the ISA-95 standard (ISA-95, 2000). ISA-95 is the international standard which describes the gap between the enterprise and control systems layer. ISA-95 consists of models and terminology which can be used to determine which information has to be exchanged between the different business systems. This information is structured in Unified Modeling Language (UML) models, which are the basis for the development of standard interfaces between ERP, MOM systems and the work floor. The ISA-95 standard can be used as a guide for the definition of user requirements, for the selection of Manufacturing Execution Systems (MES) suppliers and as a basis for the development of MES systems and databases (Scholten, 2007). Most SMEs do not know the ISA-95 standard. If the ISA-95 standard is known, there is a lack of knowledge and expertise about what exactly it

describes. It is not clear to SMEs how to apply the standard. Neither can they analyze their current situation, nor can they discover their “bad habits” and consequently their needs and requirements.

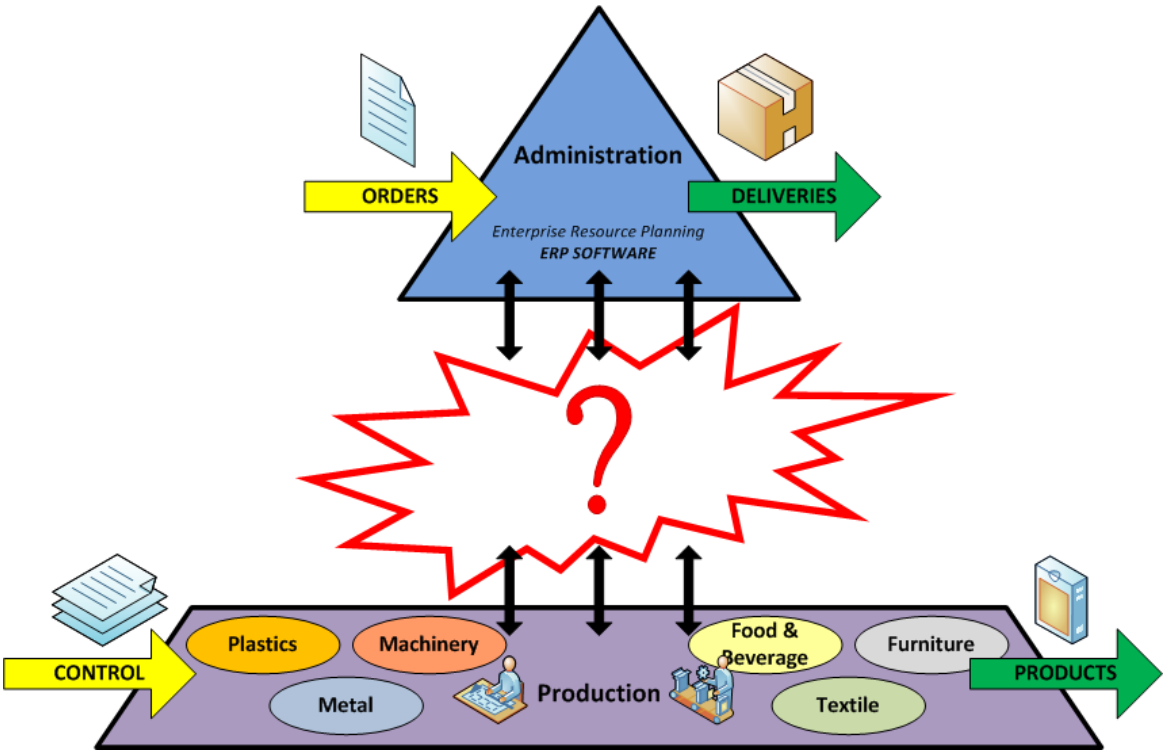

Figure 1 – Gap between administration and production layer within the Computer Integrated Manufacturing (CIM) pyramid

At last, the production pressure at SMEs doesn’t leave any room for experimenting with MOM systems on the work floor. “The production process is running fine” and “Never touch a running system” are the catchphrases. Change is often feared. SMEs don’t have the time to execute such experiments or there is no IT-responsible available to guide the MOM project. Consultancy often comes in to play, which is costly in hours for making changes or improvements. Because the justification for the investment is missing, the MOM system seems not affordable.

To investigate the experienced thresholds at SMEs, the research project started with the investigation of a group of approximately twenty Belgian SMEs from different industrial branches (metal, furniture, nutrition, machine construction and textile) and with different sizes ranging from ten to two hundred employees. A miniscan, a quick situation scan, was introduced to achieve this goal. To be able to compare the SMEs afterwards, the ISA-95 standard has been used as a guideline and as a reference.

During a meeting of maximum two hours with the company owner, IT-manager and/or production responsible, the physical assets, business functionalities, the production process and the software systems were mapped to the different models described in the ISA-95 standard. The presence or absence of the four pillars (production, quality, inventory and maintenance) of the manufacturing operations management model were revealed. For each activity of the manufacturing operations layer became visible which steps are executed manually and which are partly or completely supported by some kind of software.

The miniscans confirmed that SMEs do experience several thresholds with the introduction of MOM inside their company walls. These thresholds match with the typical barriers that have to be overcome with the adoption of new technologies (Estrin et al, 2003).

A list of the experienced thresholds:

1. Ignorance about ISA-95 standard

   SMEs barely know the ISA-95 standard neither by name, nor by its content. The layered structure of business, MOM and control systems are unfamiliar to them.

2. A lack of knowledge about MOM

   The new technology is not really known to them. If it is known, the SMEs have no idea what kind of software is available on the market to help improve the efficiency of their manufacturing operations. Because there is no expertise about MOM systems inside the company, the SMEs rather discard the new technology than embracing it.

3. Misconception about MOM systems

   MOM systems are often wrongly considered to be business software systems, like ERP. Microsoft Office tools are a big help in supporting the production process but also cannot be considered as MOM systems. The MOM software systems also seem very expensive to them.

4. No integration between the production and administrative systems

   The different production steps are executed manually. MOM software is rarely used for controlling or following up the production process. It is often replaced by the Microsoft Office tools. Also, the synchronization between the enterprise system and the work floor is frequently paper based.

5. Feasibility of MOM systems

   Because of the size, cost and complexity of such systems, SMEs do think those systems are only suited for bigger companies.

6. Unbalance between supply and demand of MOM systems

   Most of these systems are not customized to their needs and requirements. The software systems contain too much functionality compared to their needs and are too complex to start with. The MOM systems should be rather small, simple, configurable and easy-to-use. Moreover, SMEs do like a step-by-step approach in order to prevent possible resistance on the work floor.

The purpose of this paper is to investigate a small group of SMEs to see what keeps them away from using MOM systems. Second, an analysis and justification method will be constructed based on the ISA-95 standard and the results of the inquiry. By applying the method the SMEs can analyze their current situation. By comparing the AS-IS situation with a possible TO-BE situation, improvements are calculated in a financial gain or in a percentage. Totalizing the gains will help SMEs to decide if MOM is feasible or not.

CASE STUDIES

A first goal of the case study is to execute a more detailed inquiry of the AS-IS situation compared to the miniscan. All functionalities for the manufacturing process are investigated. The analysis and justification method is further fine tuned. The ISA-95 standard is scaled down and translated to a methodology suitable for SMEs.

The second goal of the case study is to improve the analysis and justification method. It must also be extended with the production, quality, inventory and maintenance pillar of the MOM layer. After each session, the method is tested on usefulness, reliability and correctness. In this way, it is validated step-by-step.

A case study consists of four consecutive interview sessions spread over a longer period of time. The sessions of approximately two hours are held with the corresponding responsible persons of the SME. Each session had its own specific purpose (Table 1).

Session	Actions
1	Double checking the information delivered during the miniscan. Deeper analysis of AS-IS situation. Processing new information.
2	Inquiry based on the manufacturing operations management model of ISA-95. Focus on links between the business, MOM and control layer.
3	Comparison of the AS-IS with the TO-BE situation. Define the wastes, manual and semi-automatic steps and possible improvements.
4	Review of the findings.

Table 1: Actions of case study sessions

Five companies out of the group of twenty from the miniscans were selected for a case study. The criteria on which the companies were selected are:

- The willing of the SME to cooperate;
- The presence of improvements points;
- Different industrial sectors;
- Different types of production strategy:

The case studies had to be executed on a representative amount of SMEs and within the time limits of the research project.

All the information gathered during the case study sessions are mapped to the models of the ISA-95 standard. The AS-IS situation is written down on paper.

After session four of the case study, the SME receives a detailed report. It contains a thorough description of the functionalities of the manufacturing operations management model. Also, the status of the production, quality, inventory and maintenance pillars is mentioned. Each activity is defined by the necessary consecutive steps and how they are carried out, i.e. manual, semi-automatic or automatic. By describing the AS-IS situation in this way, an idea of possible improvements comes forward. The delivered report can be helpful to the SMEs in their future negotiation with MOM vendors or integrators.

METHODOLOGY

1. General

The analysis and justification method consists of two main parts:

- The analysis: a workflow diagram to follow;
- The justification: a calculation of the gains;

2. Analysis method

The analysis method has been set up in accordance with the ISA-95 standard. It is strongly related to the manufacturing operations management model of the ISA-standard (Figure 2). The model makes clear that manufacturing companies carry out twelve main functions. The standard describes point by point the tasks of each function (Scholten, 2007). The functions work together by exchanging information through flows indicated by thin arrows. The thick dotted line in the model depicts the boundary between the administration layer and underlying layers of the CIM pyramid (Figure 1).

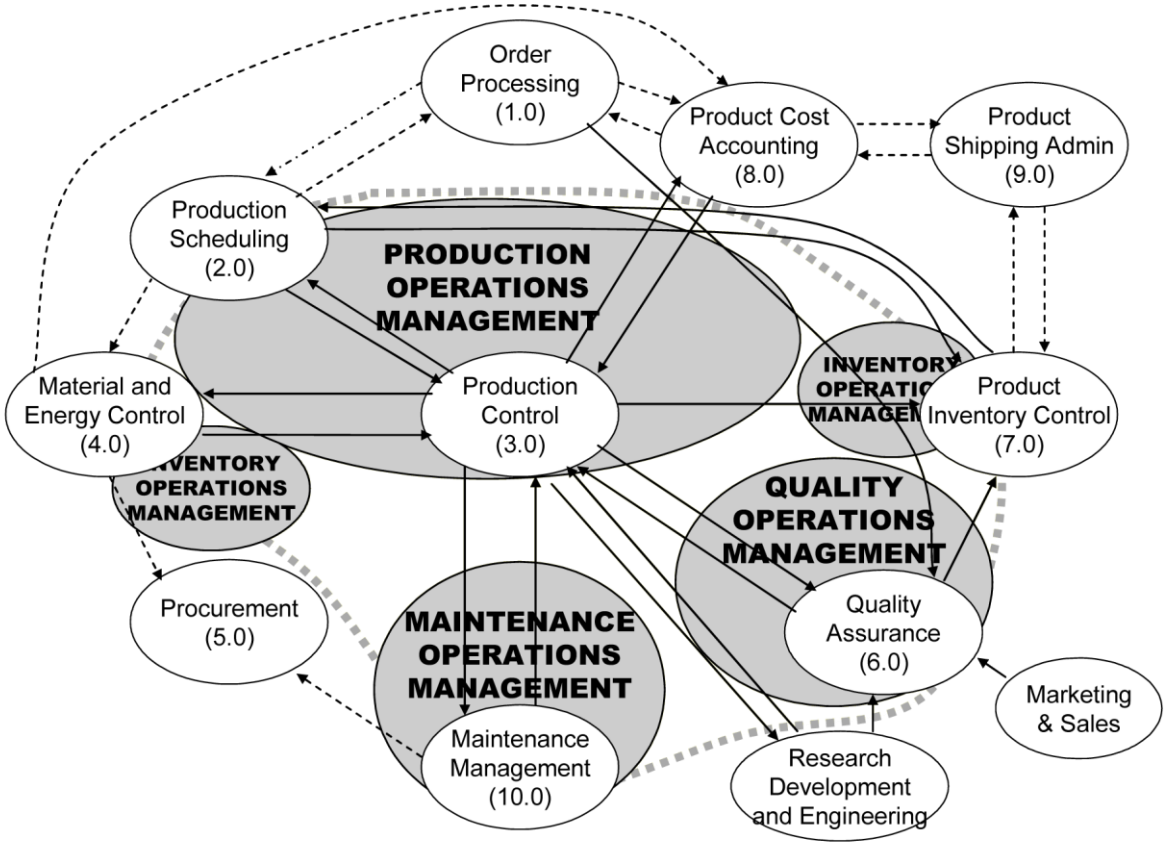

Figure 2: ISA-95 The Manufacturing Operations Management model.

As mentioned before, not all functions are always present in an SME and not all the described steps of the standard appear in each and every company. Therefore, the analysis method concentrates on the ten numbered functions in ellipses (Figure 2). Marketing & Sales and Research Development & Engineering are not taken into consideration. The functions are marked with a serial number from 1.0 till 10.0. These numbers return in the workflow diagram of the analysis method (Figure 4). Each function is represented as a big rectangle where the processing steps are denoted as a smaller rectangle and the decisions are presented as a diamond. Remark that not all tasks of each function are integrated in the flowchart as the descriptions in volume three of the ISA-95 standard have been filtered according to the way-of-working at the SMEs.

The operations management ellipses for production, quality, inventory and maintenance (Figure 2) correspond with the four supporting pillars of the MOM layer. Zooming in on these ellipses reveals eight functionalities for each pillar. Figure 3 shows the functionalities for the production pillar. Volume three of the ISA-95 standard describes in detail what actions are contained in the eight functionalities. Parts of the sentences used in the standard return in the workflow of the analysis method. The more extensive the description of the pillar is, the longer the corresponding part in the workflow is.

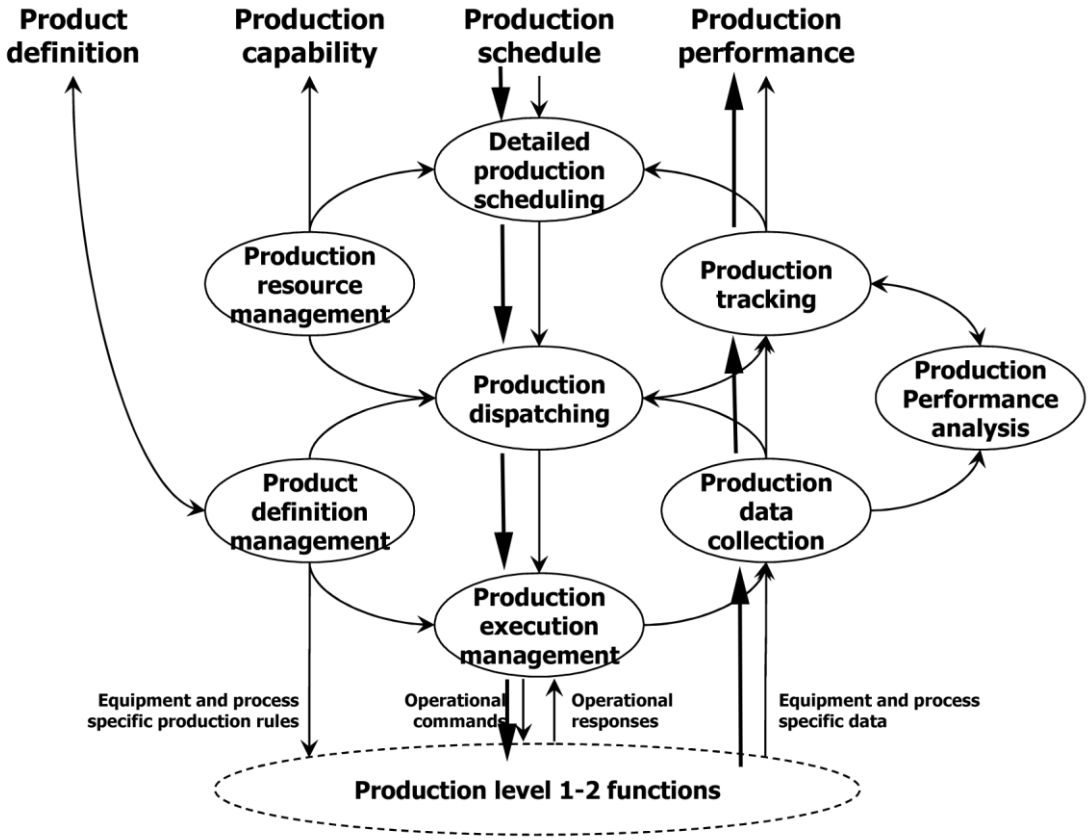

Figure 3: ISA-95 The activity model of Production Operations Management

On Figure 2 and 3 the thick arrows present an example of information flow from the enterprise layer to and from the MOM and control layer. Processed orders are scheduled into a long-term planning. The production scheduling ellipse overlaps both the enterprise and underlying layers. The boundary between the layers is equal to the top of Figure 3. The long-term planning is refined into a detailed production scheduling. It is dispatched and executed on the work floor. Data about the progress and status of the orders is collected. This information is returned to the enterprise layer. The flows between the ellipses have been studied and integrated as best as possible in the analysis method.

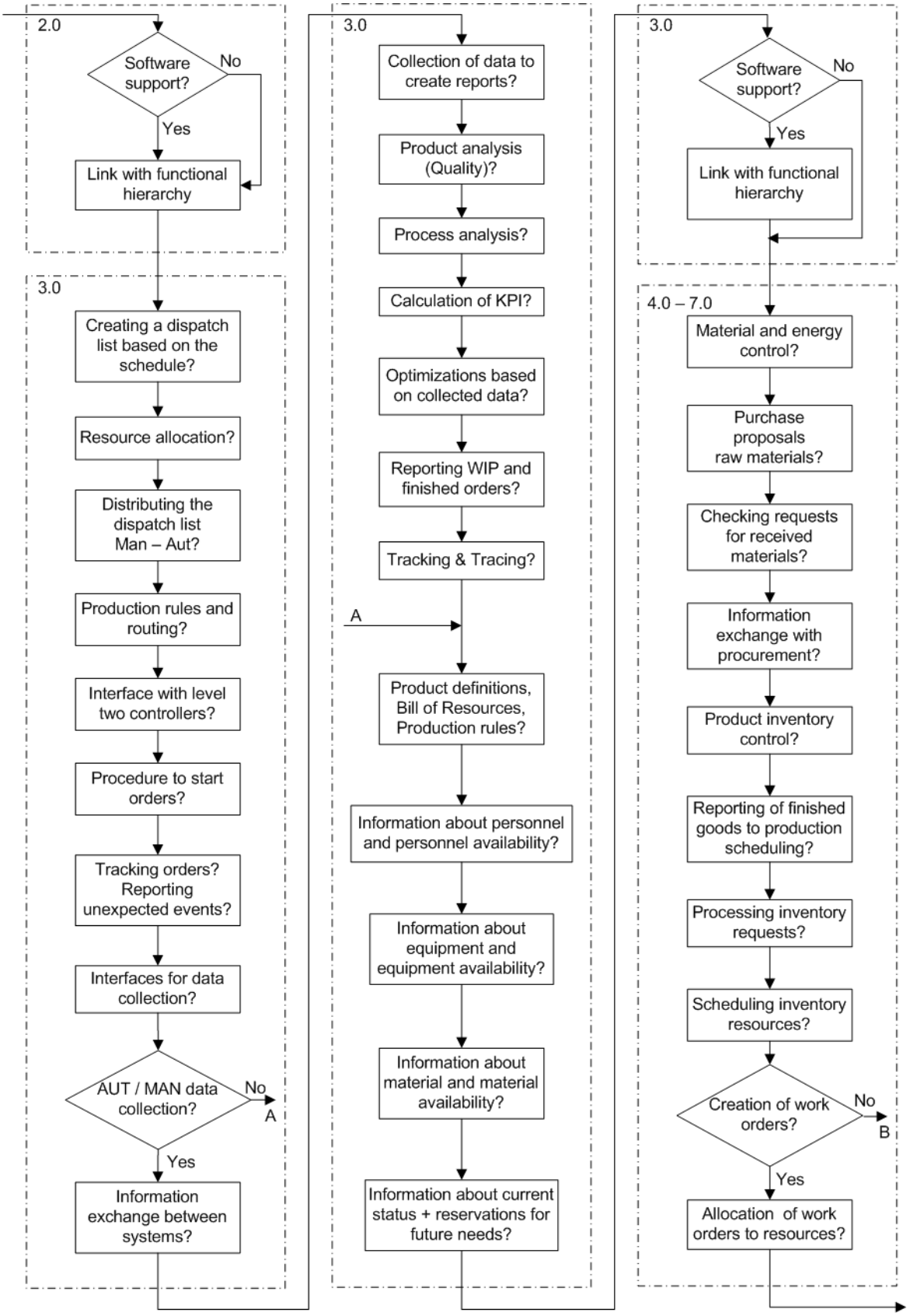

Figure 4: The workflow for Production Scheduling (2.0), Production Control (3.0), Material and Energy Control (4.0) and Product Inventory Control (7.0) as part of the analysis method

The analysis of the AS-IS situation can be started at the left top of the flowchart. It should be advanced from left to right and from top to bottom. In this way, each of the ten functions of the ISA-95 standard are investigated and the four pillars of the MOM layer are treated. By answering the questions and delivering the necessary information the SME gets an idea of the AS-IS situation. Important here is to concentrate on how each step is executed without any support of a MOM system. The delivered information is then poured into a overview drawing of the production process with an emphasis on the production and information flow. An example of a part of the production process in the metal industry is given in Figure 5.

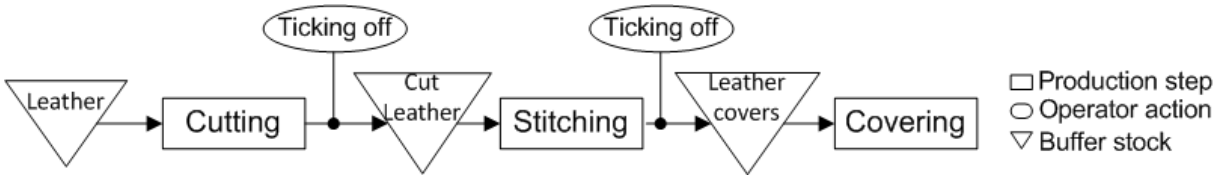

Figure 5: Information and production flow of a part of the production process in the furnish industry

Making a workflow drawing of the production process is a big help in defining the current situation of the SMEs. Starting from the AS-IS situation, a more “ideal” situation with additional MOM support could be thought of. The TO-BE situation concentrates on how actions can be done in a more efficient way and where time can be saved. Comparing both situations produces a list of improvements.

3. Justification method

Nowadays, vendors and integrators of MOM systems try to sell their software to SMEs by justifying the investment based on benefits expressed in percentages in their brochures, e.g. the quality will improve by five percent. The SME can only have confidence in these published figures. The justification method tries to hand over a better calculation of the benefits.

By comparing the AS-IS with the TO-BE situation the SME gets an idea of how the different steps of the processes can be improved by automating them by MOM software. A list of possible improvements can be generated from this comparison. For each functionality linked to an improvement the necessary time to perform the action is known in the current situation. In the TO-BE situation the execution time is not known. It can be defined in two ways. The future time will be estimated as best as possible or it will actually be measured on the spot. Equation (1) calculates the gained time (GT) which is the difference between the current time (CT) and the future time (FT) of the actions. The calculated time must be converted to a time on a yearly basis. This time is then converted to a number of man-days.

$$GT = CT - FT \quad (1)$$

Example: An operator must fill in several data (start, stop, name, work step,…) on an order paper. It takes him 5 minutes of his work time to fill in the data. Automating this task requires him only to click on a operator screen when he starts and stops the order. In the new situation he needs 1 minute for these actions. The total gained time by automating this task is then 4 minutes. The operator gets an average of 10 orders per day. The total time gained on a annual basis is calculated with an estimated 216 working days per year (2). The total time of 8640 minutes is equal to 18 man-days (MD) (3).

$$Total\,Gain = 4\,\text{min} \times 10\ orders\ per\ day \times 216\ working\ days\ per\ year = 8640\,\text{min} \quad (2)$$

$$MD = 8640\,\text{min} / 60\,\text{min}\ per\ hour / 8\ hours\ per\ day = 18\ days \quad (3)$$

The total amount of man-days (TMD) totalizes all the individual calculated man-days (4) for each listed improvement. In this way, the SME gets an idea of the total amount of man-days that can be saved by automating several processes.

$$TMD = \sum_i MD_i \quad (4)$$

If the SME plans to invest in a MOM system for automating his production processes, it can now figure out the return time (RT) based on the total amount of saved man-days and the price of the MOM system (5). Remark that the saved man-days must be converted to a sum of money which can easily be done by multiplying the wage costs of the operators with the amount of saved man days.

$$RT = Cost\ of\ MOM\ in\ dollars / Cost\ of\ Employees\ in\ dollars\ per\ year \quad (1)$$

The cost of a MOM system is vendor or integrator specific. The cost of the employees are specific for each SME. The return time figure can help the SME in its decision to adopt a MOM system or not.

Most improvements contribute in defining a return time figure because a financial gain could be calculated. But a lot of other benefits are not measurable but do have an impact on the financial performance, the corporate mission and on day-to-day operations. Some examples of those benefits are categorized into different lists (MESA International, 5/1997):

- Benefits to shop floor operation: reduction of manufacturing cycle time, reduction of ordering processing errors, reduction of set-up times,…
- Benefits to planning process: allows flexibility to respond to customer demands, fulfills customer orders quickly,…
- Business benefits: fast ROI/payback, improves customer services,…

Customer and operator satisfaction, easier way-of-working and better quality are additions to the list of the survey of MESA International. Benefits which cannot be calculated in a financial gain, are expressed in percentage figures: e.g. wrong products decreased by 20%.

4. Simulation of optimization opportunities

Simulation is a last step in the investigation of an SME. The execution of it depends on whether the company was willing to deliver production data of at least several consecutive days. By changing process parameters and decision rules, the possible optimizations are revealed through third party software. The SME gets the visibility of extra gains regarding the quality, the cost and the delivery of the end products. By limiting the work in process (WIP) the lead times are shorter and delivery dates are better achieved. Fine tuning the order priority brings forth a higher efficiency of the production process. Consequence is that the SME has a better overview, less orders on the work floor and has less stock in the intermediate buffers.

CONCLUSION

SMEs do experience several thresholds for the adoption of a new technology. The investigation of a group of Belgian companies by executing miniscans and case studies revealed those thresholds. SMEs don’t know the ISA-95 standard at all, nor can they clearly

distinguish the business, MOM and control layer. SMEs are not acquainted with the four pillars production, quality, inventory and maintenance supporting the MOM layer. The different models of the ISA-95 standard are completely unknown.

MOM as abbreviation is not always known. MOM systems are often confused with business systems. Moreover the SMEs have no idea of how the MOM systems can help them optimize their processes or improve their way-of-working. Also, the SMEs are not convinced about the return on investment with the adoption of an MOM system.

By offering an analysis and justification method, the thresholds for the SMEs can be lowered. By comparing the AS-IS with the TO-BE situation a list of possible improvements can be set up. Based on this list the SMEs can calculate the total gain in time or money. The SMEs get an idea of the total gain. Next to that, the none-measurable improvements (better quality, higher customer satisfaction,…) can contribute to the optimization of the processes. Through simulation of the production process further optimizations can be revealed by changing process parameters and decision rules.

FUTURE WORK

The intention is to put the analysis and justification method at the disposal of SMEs in the first place. The future plan is to implement the method as an online tool. A first step is to convert the workflow diagram of the analysis into a question and answer tool.

The justification will become an online calculation of the possible gains that can be achieved. The SME will be able to change dynamically the figures according to their situation.

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