

Production planning and control in Finnish manufacturing companies – Current state and challenges

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ABSTRACT

In today's highly dynamic manufacturing environment smooth information flow between different operational levels, especially planning and shop floor-level, is essential to ensure rapid reaction to changes. Unfortunately, the manufacturing companies are facing challenges with their manufacturing operations and management practices and associated information systems. This came clear during the interviews conducted among 25 Finnish manufacturing companies between the late fall 2013 and spring 2014. This paper discusses the results from those company interviews, highlighting the current practices and challenges of manufacturing operations management in Finnish manufacturing companies. The main findings are the following. The production planning and control on the factory floor level are not widely supported by proper IT-tools. Utilisation of Manufacturing Operations Management (MOM) systems, including Manufacturing Execution Systems (MES) and Advanced Planning and Scheduling (APS) systems, is still rare. The detailed production scheduling, dispatching and operations control are commonly performed by various MS Excel spreadsheets and paper documents, which are not integrated with other company IT-systems and do not support rapid reaction to changes and disturbances.

1. INTRODUCTION

Today's manufacturing environment is characterized by rapidly changing requirements in terms of customized products, fluctuating and unpredictable demand, and small batch sizes. The manufacturing systems and networks have to flexibly and competitively adapt to these frequent changes, disturbances and other events that can not be foreseen, at least not in detail. The operations should be run in a Lean way, minimizing the waste and targeting to continuous improvement. In such a dynamic environment, the information systems are becoming more and more important. The manufacturing operations information needs to be effectively collected, managed and served in a way which supports the production planners, managers and operators in their daily tasks, and facilitates rapid decision making and fast reaction to changes. Manufacturing Operations Management (MOM) systems, such as Manufacturing Execution Systems (MES) and Advanced Planning and Scheduling (APS) systems, aim to help with these challenges [1][2][3].

MES, as indicated by its name, is targeted to the production execution and monitoring and is therefore part of the operative activities. APS, on the other hand, is used for production planning and detailed scheduling before the actual manufacturing operations take place. In the markets there are pure MES and pure APS-systems and combinations of those. The yearly survey among the MES providers [1] shows wide variety of functionalities provided by the IT-systems referred as MES. There is no clear distinction of the functionalities of MES and other manufacturing IT systems. Therefore, the term MES is often used (e.g. in [1]) to refer to systems providing any MOM functionalities, such as APS. According to the ISA-95 standard part 3, "the activities of manufacturing operations management (MOM) are those activities of a manufacturing facility that coordinate the personnel, equipment, material and energy in the conversion of raw materials and/or parts into products. They include activities of managing information about the schedules, use, capability, definition, history and status of all the resources within and associated with the manufacturing facility." [4] In general, MOM activities include the production planning and scheduling, as well as information collection and reporting from the production floor [2].

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According to Meyer [5], MES allows constant monitoring of the production status and quality, and therefore facilitates rapid reaction in case of failure, deviation from target requirements or other problems. MES also provides transparency of information to all who need it and reduces the waste of time used for searching information or doing the same things multiple times. [5] According to [6] MES can trigger, feed or validate Lean decision-making process by providing useful information, e.g. by tracing and performance monitoring, visual management screens, and KPI (Key Performance Indicator) generators. Kletti [2] highlighted that MES provides information to the workers on all levels of organization allowing them to measure their own success and to improve their work performance and make continuous improvements to the production processes. MES eliminates the waste of reporting and recycling/transporting those reports from one organization level to others (needing a lot of manual work prone to errors). [2]

This paper will summarize the main findings of the interviews conducted among Finnish manufacturing companies during the late fall 2013 and spring 2014. The aim of the interviews was to map the current status, encountered challenges, and needs of manufacturing companies regarding the manufacturing operations management practices and associated tools. The results will be utilized in a national LeanMES-project (2013-2017), which goal is to create a lean, scalable and extendable concept for a new type of MES that supports human operator in a dynamically changing environment. Section 2 will shortly describe the research methodology, while the results of the interviews are presented in Section 3. The discussion and conclusions are presented in Section 4.

2. RESEARCH METHODOLOGY

The presented research is qualitative and is based on interviews conducted among 25 Finnish manufacturing companies from piece goods, mainly machine building, industry. Both Original Equipment Manufacturers (OEM) and sub-contracting companies were interviewed. The division of the companies is shown in Table 1.

Table 1: Interviewed companies.

Company size	Type	Amount
SME (< 250 persons)	OEM (Own product)	8
SME (< 250 persons)	Sub-contracting	9
Large (> 250 persons)	OEM (Own product)	8

The interview had about 80 standardized open-ended questions, divided into four categories and related topics indicated in Table 2. The interview session consisted of plant tour and interview of three types of personnel: 1) plant or production manager; 2) production worker and 3) main user of the production planning and execution system or IT manager. The production manager was asked all questions, while from the other two personnel types, only the relevant questions for them, were asked. The purpose was to find out any differences between their perceptions of the situation.

Table 2: Question categories and related topics [7].

Production planning and control practices and tools	Shop floor level production control	Key performance indicators (KPIs)	Lean practices and their implementation status
<ul style="list-style-type: none"> Overall process and IT-tools from production planning to factory floor level control Integration level of IT-systems used for production management and control Communication in the production network Management of resources and capacity Quality control and maintenance Challenges in current production planning and control practices and tools Future MOM 	<ul style="list-style-type: none"> Demand forecasting and reacting to fluctuation Control of the WIP and inventories Control and traceability of material and product flows Management of the change and problem situations Flexibility of the production Challenges and development targets in the current shop floor level production control practices 	<ul style="list-style-type: none"> Currently followed KPIs in different work steps Collection of the metrics data Analysis and utilization of the metrics data Future KPIs 	<ul style="list-style-type: none"> Familiarity of Lean philosophy in the company Utilization of Lean practices and tools Material control and flow Standardized processes and work instructions Respect, involvement and motivation of the personnel Current IT-system support for Lean

The interviews were recorded and later transcribed. The results of the interviews were analysed by the Affinity Wall method [8]. The purpose was to rise up the most important findings from the interviews, and to categorize and compress the results into more manageable form. In this paper the results are organized under the main categories recognized during the affinity wall exercise, namely: 1) Production planning and control; 2) Digitalization and data collection; 3) Information management and transparency; 4) Quality monitoring and quality issues; 5) Utilization of Lean-principles; 6) Skills, motivation and worker inclusion.

3. RESULTS OF THE INTERVIEWS

3.1. PRODUCTION PLANNING AND CONTROL

At the time of the interviews, only two of the companies had some sort of MES in use, and one company was preparing for a MES pilot implementation. All of these companies were large OEMs. None of the interviewed companies had a true APS-system, capable of simulating different schedule scenarios. Instead, the production is planned, scheduled and controlled purely with the help ERP, various Excel spreadsheets and paper and pen. Figure 1a illustrates the share of different tools used in production planning and scheduling. The challenge in scheduling with ERP is that it does not support capacity restricted (finite capacity) planning [[2]]. Also, especially the spreadsheets used for detailed scheduling are often highly personified, which means that there is usually only one or two “gurus” in the company, who can update and interpret it. This involves a great personnel risk.

Majority of the interviewed companies controls the production on the shop floor level with paper work orders. Those companies, who have MES-functionality available, shows the job queue on computer displays. Controlling the production with paper work orders (e.g. allocating the work to specific workstations by distributing the work order papers to those stations) does not enable the collection of history information (e.g. on which machine the work was done and how long the processing took?). In sub-contractor companies the most disturbances on the factory floor, are caused by the surprising rush orders from the customers, and machine breakdowns. In OEM-companies the main disturbances are due to the unavailability of the needed components and quality defects coming from the supplier. Due to these disturbances, the orders need to be re-scheduled, which is very arduous process in ERP and Excel. E.g. in ERP it is not possible to re-schedule all the phases of one order at the same time, but all the phases need to be re-scheduled separately. In addition, because ERP and the various excel spreadsheets are not integrated with each other and they include overlapping information, the changes done in one system need to be updated manually to other systems. Therefore the change situations are often handled on the production floor level, and they do not leave any mark to the upper level information systems and cannot thus be utilized to support later production planning phases. Learning from the actual realized processes and causes and their consequences is missing. Majority of the interviewed companies were hoping to get rid of the unconnected excel sheets.

Based on the interviews, the “detailed scheduling” is most commonly done at the level of one day. Many of the interviewed companies were hoping to increase the planning accuracy from the day level to shift level or even hourly level. This would support lead time reduction. Increasing the planning accuracy is not possible in ERP, but proper scheduling tool would be required. Because of the lack of reliable history data, the workload planning is usually done based on some average loads, not based on the actual load of the specific order. In those companies, assembling complex project-based products, there are high variations in the processing times, due to the project orientation and customization. For basic systems the assembly times can be known accurately, but the customized parts and options are difficult to estimate. In addition, it was emphasized that the process times are strongly dependent on the worker who performs the task. This cause challenges especially in companies with a lot of labour intensive production, such as assembly and machine settings. The proactive maintenance of the machines is not usually scheduled to the production plan, which means that the capacity reduction caused by the service break was not taken into account while planning the production. Many of the interviewees mentioned that recording the time stamps (setoffs) of the start and finish of the jobs are done vaguely – one does not always remember to do it, sometimes the start and finishing are recorded simultaneously or all the setoffs are done at the end of the day. Therefore reliable information of the status of the orders or history data of the duration of the jobs is not acquired. It was complained that recording the time stamps to the ERP-system is often too arduous and time consuming task for the operators. More efficient collection of history data from the production floor, and especially more systematic utilization of it, was seen as a target in multiple companies.

Most of the interviewed companies have multiple strategies to the material management. Bulk items and in many cases also the often repeated items, are commonly in pull control, which is implemented either directly to ERP as alarm limits or visually. Visual methods were e.g. 2-box system (common for bulk items, such as bolts and nuts) or empty storage place indicating the need for replenishment. Especially in OEMs the components and materials are commonly

replenished based on material requirements planning (MRP) calculated in ERP based on the orders. However, the components having long delivery time need to be ordered based on forecasts. In small subcontractor machine shops a common method to material management is that the worker tells to the production supervisor when he/she notices that some material is in short supply.

Majority of the interviewed companies manage the material balances in ERP-system. However, several companies reported to have problems with the management of inventory balances, in terms of faulty balances. The cause for the faults are e.g. that in case the product is rejected, new raw material may be retrieved from the inventory without recording that to the ERP. Some of the companies said that there is a room for improvement regarding the common procedures, e.g. the inventory balances are not up-to-date and material may be missing, because the recordings are not done systematically and immediately when the material is acquired, but randomly when remembered. In many companies the confusing material and part storing strategy was causing troubles on the factory floor. For instance multiple different items may be stored on the same deck, or same items may be stored in multiple different locations, which make the material management and finding the right items difficult. Similar challenges were encountered with the management of work in progress (WIP).

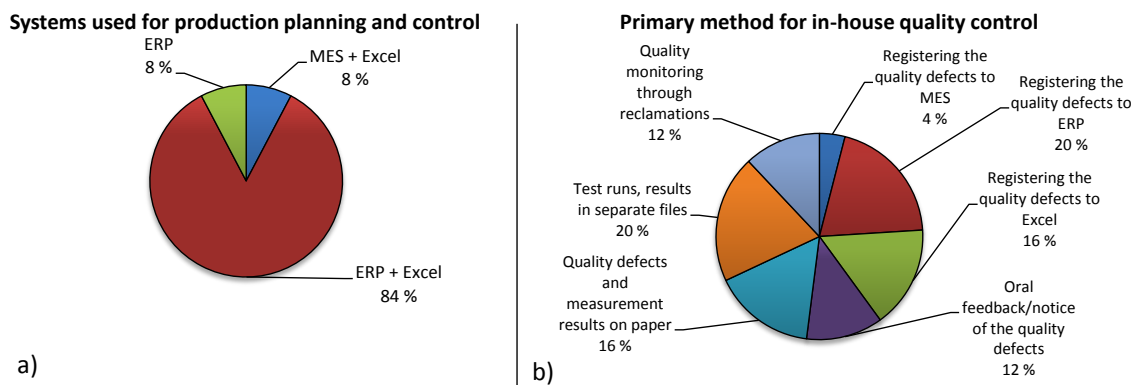


Figure 1: a) Usage of different systems for production planning and control activities; b) The primary method for in-house quality control.

3.2. DIGITALIZATION AND DATA COLLECTION

The usage of paper documents in data collection (e.g. time stamps, quality data, information of disturbances) was seen problematic, because the data usually stays on those papers, it is not linked to the item data and can not be easily found and utilized later on e.g. to support the production planning and control. It neither allows real time reaction to disturbances. In some companies the information on paper documents is manually typed to the information system. This causes double work in information input and is prone to human errors. In many companies the production managers and other managerial level people hold the opinion that digitalization should definitely be increased on the production floor level, while the production workers were more satisfied with the current methods and tools. It was recognisable, that the production workers are afraid that their work load would increase if new IT-tools were introduced on the factory floor. Therefore, it is crucial to carefully consider, what is the most painless way for the operator to accomplish the required tasks, and what is the best interface to represent and collect the information to/from the human. For example, if one needs to recall and type project or serial numbers to the system in order to access to certain information, or accessing to the information requires several clicks, the information may not even be searched for or the necessary recordings (setoffs) will not get done. Bar codes were commonly used in inventory and material management. In large companies the utilization of RFID-tags has increased in material and product tracking within the past few years.

The increasing demand on product and material traceability has been recognised in all types of companies. The information systems used to collect the traceability related information are often insufficient or non-existing. For example, the serial, batch or heating number may be entered to a separate excel-document and it may never be linked with the product information in ERP (or it is manually typed). Few interviewees mentioned potential in reading e.g. serial or heat numbers with bar code readers, in order to avoid error prone manual typing when collecting data related to traceability. Some companies also utilized bar codes in making electronic setoffs. In those companies, which use personal codes to record the setoffs, it can be accurately traced who has performed each individual step and when. This has been noted to increase the quality of work.

None of the interviewed companies utilize any mobile platforms, like tablet devices or smart phones, in their production. However, few companies had seriously considered of introducing mobile devices for displaying the work instructions, orders, and job schedules, as well as for recording setoffs and writing failure notifications. Currently the work instructions, if they even exist, are most commonly in paper folders. There are several drawbacks related to paper instructions, e.g. it takes time to look for them, the folders are often lost, updating the instructions is arduous and sometimes old versions of the instructions are used to perform the work. Almost all the interviewed companies mentioned digital work instructions as their future development target. Also, a desire to have all the information needed by the worker, e.g. job queue, drawings, instructions, NC-programs, setoffs, one place in digital format, was emphasized. In addition, it was highlighted, that the tacit knowledge of the worker should be collected to digital form.

3.3. INFORMATION MANAGEMENT AND TRANSPARENCY

All of the interviewed companies had recognized the need to increase the transparency in their production network. Majority of the interviewed large OEMs offer their closest sub-contractors and suppliers visibility to their own ERP-system, for example through a common extranet. In small OEM companies this was uncommon. The transparency in the production network is one-directional, meaning that the OEMs do not have any visibility to their suppliers or sub-contractor's systems. The communication to this direction happens mainly by email and telephone. The lack of real time information e.g. of the status of the order was seen problematic, because the information about changes (e.g. delays in the orders) is got when it is already too late to react efficiently. In most of the companies, the most common way to receive orders is through phone calls or email. This requires manual and error prone typing of the orders to the own ERP-system. Majority of the interviewees would like to increase the automation in order handling and start to use electronic orders. The email and telephone communication was seen problematic, because the information stays with the persons involved in the conversation, and it may never reach all the people that should be involved. All the interviewed companies emphasized the importance of the transparency in production network and great majority was hoping to find new tools to support it. For instance, different supplier portals were planned in many of the OEM companies. However, the information security issues were seen as a challenge. Increasing the transparency requires more trust and common rules.

It was repeatedly mentioned in the interviews that different departments, sales, design, production and shipping, for instance, do not work with the same information. Sales department sells without considering the capacity or production produces the products with wrong timing, because the real demand information is not available for production even though sales or shipping department would have it. In order to enhance the information transparency, accessibility and information flows, most of the companies mentioned, they want to get rid of multiple separated systems (e.g. ERP and various excel spreadsheets) and use one system throughout the organisation following common rules. In all types of companies, merely getting the overall picture of just production was considered challenging. This is because, without MES, the real time information of the order status is not visible. The workers do not necessarily see, what is the status of the orders in other workstation (e.g. if the parts needed in welding station have already been cut on the saw) or what kind of jobs are coming next. The desire in many companies was to be able to deliver the production status information (job queue, status of the jobs) to the factory floor workers on real time. Increasing the transparency was seen, by multiple interviewees, as an important tool for motivation and inclusion of the workers. Better transparency and visualization of information is expected to help the workers to better understand their own role and meaning of their work in the whole. The need for MES-systems was clearly visible.

The most common Key Performance Indicators (KPIs) followed by the companies were delivery reliability, quality faults, productivity, line or station specific efficiency and resource utilization rates. In most cases, the delivery reliability was mentioned as the most important indicator, the second being quality. The quality is most commonly reported based on internal quality deviations and customer reclamations. From the large companies, more than half visualize the KPIs on the factory floor either by different displays or traditional notice boards. In SME companies visualizing the KPIs on the factory floor was not that common. One of the main challenges in KPI reporting is the arduous reporting process. The metrics data is usually collected from ERP to Excel and this can take even 1 to 2 days. Only few of the interviewed companies mentioned, that the metrics can be reported directly from ERP without much manual work. Thus, the indicator data is most commonly updated once a month. Only those companies, which have MES-functionality, are able to bring the KPI information on the factory floor in real time. Other significant challenge is that data collected automatically from production resources is saved to a separate system, which is not linked with other company IT-systems, like ERP. Due to the lack of real time metrics, the metrics are not utilized to support the everyday planning, control and management, but provide support for long term planning. Based on the interviewees, not all the production workers are interested in monitoring the metrics. It was clearly recognizable that some of them lacked a deep understanding of the metrics and how to influence them by their own performance.

3.4. QUALITY MONITORING AND QUALITY ISSUES

Various practices were detected in quality monitoring (see Figure 1b). In companies which manufacture large complex products, the systematic quality inspection is limited mainly to test runs. Actual intermediate inspections or measurements are usually not performed, but each assembly worker is assumed to make sure that bad quality is not transferred to the next assembly phase. Unfortunately this does not always come true. Majority of the interviewed companies had a noble goal that the defected products should not move to the next processing step on the production line. However, in reality, many companies are slipping from this goal and the defects are fixed not until reaching the end of the line, e.g. in a specific repair line. It is easier to let the defected product to proceed on the line than to disturb the whole line by stopping it. This approach hides the quality issues and does not support their elimination.

In all types of companies problems related to the systematics of the quality inspections and especially the registrations of quality deviations, were reported. All the workers do not always report about the quality deviations through official channels, which means that not all the quality problems are recorded. All the companies does not even have a “official channel” for reporting about the quality issues, but they may be handled only by word of mouth. In some companies the production management and worker level had very different views on the level of the quality control. It was also visible, that there exists some timidity to report about the quality issues, because some may take it as blaming the workmates. In sup-contractor and supplier side the quality control was clearly more systematic than in OEMs. This is due to the fact that customers require certain measurements and measurement records. However, there were large differences between the companies. In few of the companies it was mentioned that the workers do not do the necessary measurements or report about all the deviations, if they can not get caught of not doing it.

As an information management related challenge was mentioned that the quality data is most commonly collected to a separate system which is not linked with other company systems, such as ERP, and are therefore not directly linked to the product information. Some of the measurements are done manually and the results are written to papers or typed to excel sheets, some of the measurements are done by automated measuring machines which again collects the information to its own system. Therefore the integration of quality data with the product data requires a lot of manual and error prone retyping. In some the companies the quality assurance was challenging, because the workers did not have a clear image of the acceptable quality, for example the requirements relating to the surface quality was not visualized to the workers.

In OEM-companies one of the biggest factor causing disturbances in production floor are the quality defects in the sub-contracted parts. Instead of sending the defected parts and components back to the supplier or sub-contractor, they are usually fixed on the OEM’s assembly line in order to save time. This is particularly problematic, when the order batches are large and same defect applies to the whole batch. In some of the sub-contractors it was mentioned that it has been noted that the design quality of the OEM has been decreasing along the years. Presumably this is because of the outsourced design work. Thus, some of the sub-contractors have adopted a habit to correct the design mistakes by themselves and not to obey customers drawing.

3.5. UTILIZATION OF LEAN PRINCIPLES

Lean operations were considered as important in most of the companies. The lack of resources was seen as a biggest challenge for systematic implementation of Lean principles and tools. 5S was the most common Lean-tool, which almost all the companies claimed to apply. However, the visits on the production floor revealed, the utilization of 5S is not very systematic everywhere. It was clearly recognisable that the fifth S, sustain, was forgotten in many companies and there has been some slipping in the cleanliness and order. Many companies had started different Lean-projects, but had forgotten that, in essence, lean is all about continuous improvement and not only an isolated project. It requires continuous sustenance, follow up and development. Another clear challenge was the lack of engaging and including the personnel to the continuous improvement. Only a few companies had a system for continuous improvement.

Majority of the companies claimed to aim for minimizing the inventories and work in progress. In reality, many companies were holding material and component inventories (commonly worth of one week to three months usage) in order to reduce the probability of delivery reliability problems. The oversized inventories were reported to cause many types of problems. For instance, it may take a lot of time to find the right item from the storage, storages may be blocking the routes and items need to be moved around in order to get access to the needed items or items get obsolete e.g. in conjunction with version updating (it may also cause confusion between different versions).

About three out of four companies mentioned the lead time reduction as one of their important goals, but only a few had used value stream analysis of their production. Especially in large OEM-companies manufacturing large complex and customized products, there was a clear need to be able to shorten the lead time of the whole order delivery process, not only the production lead time. A couple of sub-contractor companies answered paradoxically, that they would like

to reduce the lead time, but at the same time produce in large batches. Just-in-Time thinking was considered as important, especially in large companies. What is challenging is the synchronization of the whole supplier network for JIT. Few companies mentioned that they would like to apply more pull control, but it would require better standardized product platform, which would keep the amount of different items reasonable. Currently, in most of the cases, the products include a lot of customization, which causes variation to the items and process. Therefore implementing continuous flow based on pull control, is very challenging.

3.6. SKILLS, MOTIVATION AND WORKER INCLUSION

Majority of the companies has tried to describe the workers' skills and competences in some way, e.g. through a simple competence matrix built in excel. However, in practice, these competence descriptions are not very commonly utilized in production planning and control, but the tasks are allocated to suitable persons based on the foreman's memory and person knowledge. All the companies considered the versatility (multi-skills) of the workers very important, because it eases up the reaction to different change situations. However, in most of the companies there were challenges hindering the skills versatility development. These were mainly the lack of time resources for training and proper strategy for versatility development. Only a few interviewed companies were practising systematic job rotation. The workers felt that job rotation can help to maintain motivation and vigour, and to increase learning. On the other hand, several interviewees remarked that the willingness to the job rotation depends on the person and his or her personality, and it should not be forced.

Initiative systems were very rare especially in small companies and there was not much systematics in the utilization of personnel's ideas. On the other hand, in small companies, the personnel can affect relatively much to the work planning and development. In bigger companies the initiative systems are more common and good initiatives get rewarded. However, many interviewees stated that these systems produce too few initiatives and development ideas. The companies have not been successful in the inclusion of the workers. Transparency and systematics in the processing of the initiatives and feedback were regarded as challenges. Approximately half of the interviewed companies had some sort of bonus payment system in use in production. In small companies the bonus payment is most commonly paid, in case of good result, to the whole personnel, whereas in bigger companies the bonuses are more commonly tight e.g. to a certain production line and based on certain performance indicators, such as delivery reliability, productivity or efficiency. The desire to move towards personal or team-based bonus payments, based on certain metrics, was mentioned in all types of companies. It was seen that this could cause wholesome competition between the teams and individuals and could motivate the personnel. However, in case of metrics-based rewarding of individuals, teams or production lines, it is important to ensure the metrics used as a basis for the rewarding, are fair, and the personnel can have an effect on those through their own actions. For example, if the materials are delivered to the production line late, it is impossible for the workers on the production line to finish the products before the agreed delivery date. Almost half of the production workers felt, that their motivation can be increased by giving more (positive) feedback. Also openness was seen important.

4. DISCUSSION AND CONCLUSIONS

Differing from the initial assumption, the company type or size had relatively little effect on the challenges faced with the production planning and control. As discussed in more detail in [9] small OEM companies tend to focus on few products which are mostly produced to order, which makes their demand seasonal. Large OEMs, in contrast, often assemble multiple different product variants, and tend to struggle more with inventory issues [9]. In general, the operation of sub-contractors is characterized by having several customers, for which they manufacture wide variety of different products. On the other hand, these products share similar features and are often relatively simple machined, cut, welded and folded parts with relatively short lead time. Biggest challenges of the sub-contractors relate to the difficult and inaccurate forecasting. Even though the OEM would be able to forecast its demand on machine level, it is not able to forecast accurately different customer variations. Thus the forecast can not be broken down to a part level, which means that sub-contractor can not get an accurate forecast. Compared to the OEM companies, the production of the sub-contractors is usually more resource intensive, with a lot of automatic machines. Thus, the machine breakdowns cause a lot more troubles to the interviewed sub-contractors than to the OEMs which focus mainly on manual assembly.

In OEM companies the biggest challenges relate to the synchronization of the supplier network and making sure the right items are at the right place at the right time. Lack of parts and quality defects were those two factors causing most disturbances in the production. On the other hand, in the OEM-companies designing and assembling complex products the biggest challenge from the overall operation viewpoint relate to the management of the entire order-delivery process from the sales all the way to the delivery and installation services. Currently, when the different departments

manage their own schedules in their own spreadsheets, getting an overall picture of the situation is very challenging. Especially changes cause a lot of dealing and communication between different departments.

Particularly interesting in the results of the interviews was that only few of the interviewees actually knew the terms MES and APS. Majority of them thought that ERP system means the same as production planning and control system. However, as defined by the ISA-95 standard [2], ERP systems are targeted to the level 4, meaning to business level operations, whereas MES is targeted to managing and controlling the production on operational level and transferring the information between ERP and the actual production resources. APS on the other hand is targeted to the planning and scheduling of the production before the actual operations take place. Hence, even though most of the companies had recognized the need for certain MES and APS –level functionalities in their operations, they had not had enough knowledge about such systems in order to be able to specify the requirements and look for a correct system. The lack of MES/APS knowledge may be due to the fact that the current MES/APS-markets are very unconsolidated [1][3]. There is no one established definition for the terms MES and APS, and there are hundreds of suppliers on the market offering different MES, APS and MES+APS (MOMS) functionalities, and no dominating actors such as SAP in ERP-markets.

This paper studied the current status and challenges in the manufacturing operations management and control in Finnish manufacturing companies. Large part of the identified challenges is caused by the fact that the companies use wrong tools. Many interviewed companies believe that by more systematic utilization of ERP in all operations, they could attack most of their current production management challenges. This may partly apply, but it will not solve the issues relating to e.g. advanced planning and scheduling (simulation). According to Kletti [2] ERP is only suitable for rough production planning, not detailed planning or production control. This is due to the open loop, which means that the feedback from production floor is not recorded in real time [2]. ERP can not fix e.g. the problems relating to re-scheduling, because it does not take into account the reality on the factory floor, including e.g. machine breakdowns, lost parts, or absenteeism. Therefore MES and APS functionality is needed to take these things into account and provide real-time information of the status of the production and to allow more realistic plans and real time reaction to the actual situations. Obviously, not all the challenges can be solved by IT-systems, such as the fluctuation in demand. However, utilizing appropriate IT-systems helps adapting to the dynamic operation environment, when the real-time information of the changes is always available for all the actors.

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REFERENCES

- [1] J. Snoeij: "MES Product Survey 2013 – The invaluable guide to accelerate the evaluation of your potential MES solution", CGI Group Inc., 673 p, 2013.
- [2] J. Kletti (Ed.): "Manufacturing Execution Systems – MES", Springer, 272 p, 2007.
- [3] B. Scholten: "Governance of Manufacturing IT: Who owns IT systems in the plant"?, Presentation in MES & OPC day, 15th October 2013, Tampere, Finland, Available in: <http://www.automaatioseura.com/jaostot/valmistuksenohjaus/tapahtumat>.
- [4] ANSI/ISA-95.00.03-2005, Enterprise-Control System Integration, Part 3: Models of Manufacturing Operations Management.
- [5] H. Meyer (Ed.): "Manufacturing Execution Systems: Optimal Design, Planning and Deployment", The McGraw-Hill Companies, Inc. 274 p, 2009.
- [6] J. Cottyn, H. Van Landeghem, K. Stockman & S. Derammelaere: "A method to align a manufacturing execution system with Lean objectives", International Journal of Production Research, Vol. 49, Iss. 14, 2011.
- [7] E. Järvenpää, H. Tokola, T. Salonen, M. Lanz, M. Koho & R. Tuokko: "Requirements for Manufacturing Operations Management and Control Systems in a Dynamic Environment", Proceedings of FAIM2014, 20th -23rd May, San Antonio, Texas. 8 p, 2014.
- [8] eHow: "How to Create an Affinity Wall?", Available in: http://www.ehow.com/how_5724234_create-affinity-wall.html (Accessed 5.5.2014).
- [9] H. Tokola, E. Järvenpää, T. Salonen, M. Lanz, M. Koho & E. Niemi: "Shop floor-level control of manufacturing companies: an interview study in Finland, Management and Production Engineering Review, Vol. 6, No. 1, pp. 51-58.