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The MES Experts!

Industry 4.0 disarmed

The reactive factory

Preface by Prof. Dr.-Ing. Jürgen Kletti

On the way to the Smart Factory

With regard to news, specialist press, trade fairs and conventions there is no doubt that Industry 4.0 is still a highly topical subject. And yet opinions tend to differ where important definitions and practical relevance is concerned. For this reason our focus remains the transfer of theory into practice and the fleshing out of the complex topic „Industry 4.0“.

At Hannover Messe 2016 we introduced the four-stage-model „Smart Factory“. Here the main focus was on recommended action for the transparent factory (stage 1). In this white paper we discuss stage 2 - the reactive factory.

Even recognized experts confirm that we are on the right way with the four-stage-model. Just recently I had an exciting discussion with Dr.-Ing. Olaf Sauer from Fraunhofer IOSB. During this discussion it became clear to us that many companies still have some homework to do in order to be able to think about Industry 4.0 at all.

We, MPDV‘s MES experts, will continue to be at the forefront of progress and latest trends. Thus we see ourselves as a competent and reliable partner at your side on your way to Industry 4.0.

Enjoy reading.

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Stage 2 on the way to the Smart Factory

The reactive factory

It is becoming ever clearer that the success of the vision „Industry 4.0“ depends on how flexible and variable production companies are. On the other hand, Industry 4.0 involves tools that make this flexibility possible. To offer the necessary flexibility to the customer the factory must be extremely reactive internally. But what does the term reactivity mean and what preconditions must be met for this?

First of all, it should be noted that neither Industry 4.0 nor the Smart Factory can be implemented overnight. For this purpose, an elaborate roadmap is required. For the systematic way to the Smart Factory MPDV‘s MES experts therefore propagate a simple four-stage-model (Image 1), which has met with great approval already both in the specialist press, on leading Industry 4.0 portals as well as among recognized experts.

Image 1: MPDV‘s four-stage-model „Smart Factory“

In four steps to the Smart Factory

The first stage of the model is the transparent factory. This means that companies have to know promptly what precisely is happening in their production. The reactive factory relies on this knowledge. The recorded data is thus made visible and also usable, so that it quickly becomes identifiable what consequences a change in the shop floor will have. The goal here is to react to deviations from the ideal situation as quickly and targeted as possible. This stage is followed by the self-regulating factory in which one can develop a regulation of production processes based on reactivity. And as the fourth stage the functionally networked factory, which expands the view to neighboring processes such as PLM, energy and building management.[1]

Modern Manufacturing Execution Systems (MES) have proven to be a suitable and partly also indispensable tool to implement the individual stages of this model.

Transparency as basis

Already in the white paper „Industry 4.0 disarmed“[1] it was shown how important reliable data is for production companies. It should be borne in mind that the recorded data has to be correct and up-to-date as well as relevant for the requested evaluations. An MES can only obtain usable information from relevant data. In the next stage, knowledge about coherences and processes can be generated through the further consolidation of information. Transparency and knowledge are the basis for all further stages on the way to the Smart Factory.

Ensuring reactivity

The growing importance of the second stage „reactive factory“ is essentially based on two things: Firstly, everything rarely runs according to plan in production and secondly, customers often

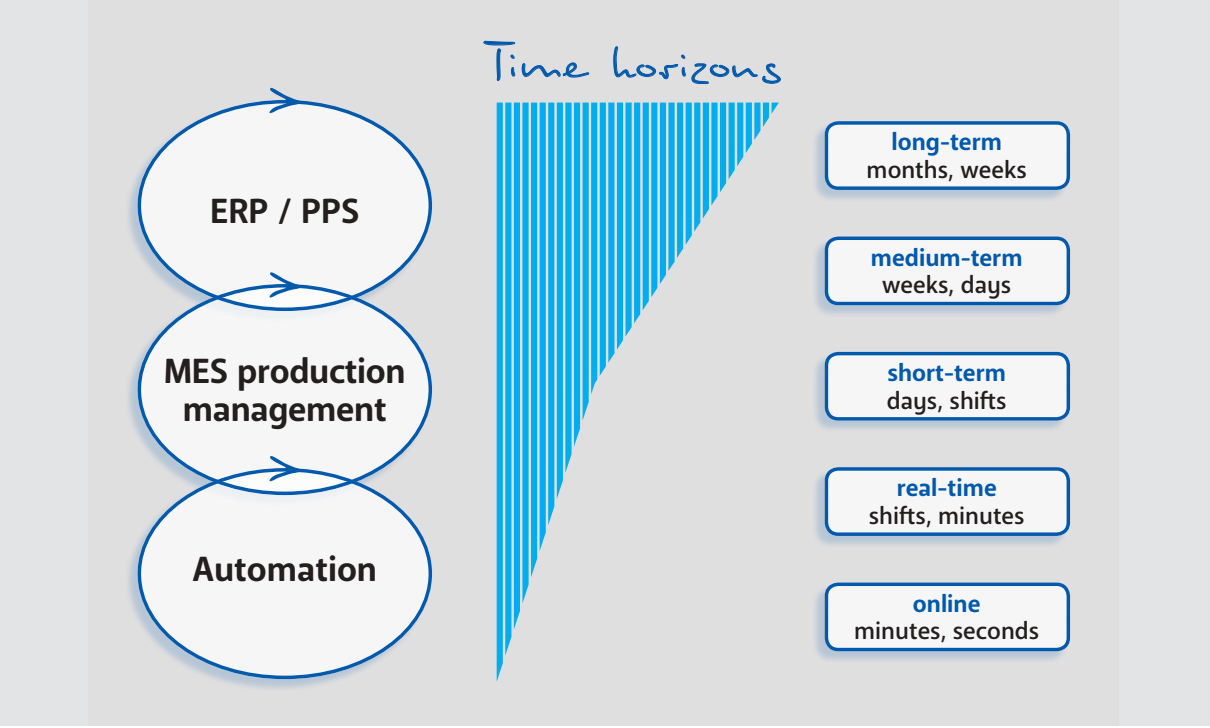
change their requests regarding the article to be produced . Thus, the production must react to unforeseen occurrences. The more quickly and flexibly this is done, the fewer losses will arise. Classical examples of disturbances in production are tool problems, ill employees or wrongly delivered material. Customers mostly have little understanding of this and increase the pressure on the production additionally through change requests at short notice.

Compared to other IT tools or compared to an ERP system, an MES has the advantage that it has an overview of the complete production with all elements involved. Thus, on the one hand, disturbances can be identified at an early stage and on the other hand the MES can show possible alternatives. Without an integrated MES a disturbance or a customer‘s change request often entails numerous telephone calls, emails and meetings convened at short notice. To remain competitive production companies require a tool that reduces such unnecessary wastage to a minimum. Therefore, production companies require an integrated MES, particularly at times when the world is becoming increasingly dynamic.

Planning and control

Based on the knowledge of the current production status, orders usually transferred from an ERP system can now be scheduled in the MES. Unlike a rough planning in the ERP system, against unlimited capacities, production controllers exactly record in the MES on what machine and when precisely the order is to be manufactured. For this purpose, they must know what orders are already scheduled or are currently running and what production progress has already been achieved. This represents planning against real capacities. Image 2 illustrates the different time horizons in which ERP and MES act.

While scheduling the orders one also sets their sequence. This is of great importance especially for the optimization of setup times. Already when planning an order modern MES systems show



Typical time horizons of various levels and IT systems in the production environment.

their strengths. For example. MPDV's HYDRA proposes to modify setup time specified by the ERP if a different time requirement is needed based on empirical values of the past measured from the mean value.

The nearer the target times are to the actual times, the less time buffers will be needed for planning. By closing gaps the efficiency and thus also the productivity can be increased.

If one additionally expands the planning by real-time production data the planning turns into control that can react to current occurrences. A tool breakage or other machine malfunctions are recognized immediately and trigger a correcting shifting of subsequent jobs in the detailed planning. Planners are notified and can react specifically to the new situation. Thus, they have the possibility to reschedule or split time-critical or important orders or create additional capacities, e. g. through special shifts.

Machines, tools and other resources

If previously it was mostly sufficient merely to reserve the capacity of a machine for a job, the necessity of an additional resources planning has become more crucial. The classical wall chart or an Excel sheet are no longer sufficient to handle complex machine connections, tools and equipment. The graphical detailed planning in an integrated MES provides a remedy by managing all required resources in one system. Their availability is shown in a multi-dimensional Gantt chart (Image 3).

In addition to production equipment, consumption materials ideally should also be taken into account in the planning. Besides the material (raw material, semi-finished or final products) energy is meanwhile one of the most important planning factors in many industrial sectors. The connection is simple: Only available material can be processed. In theory, negative stocks are possible but they lead to unnecessary process interruptions (Image 4).

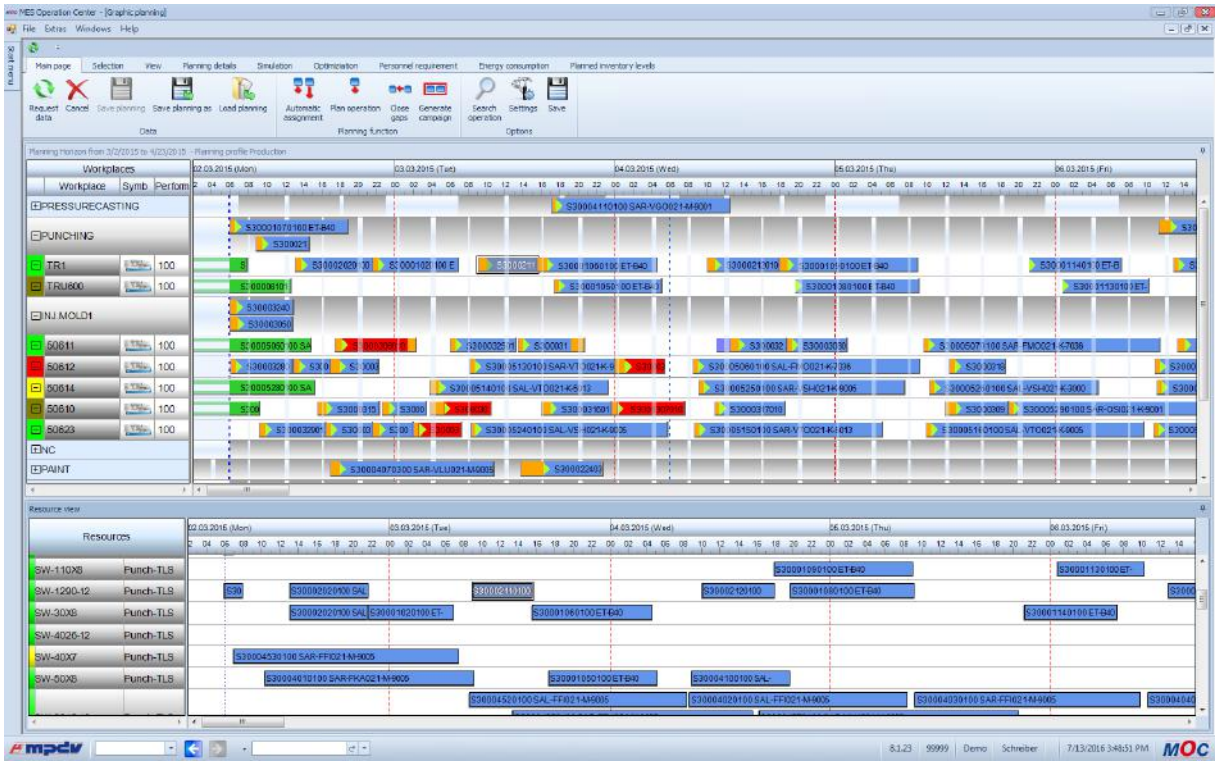


Image 3: Multiple resource planning in HYDRA Shop Floor Scheduling

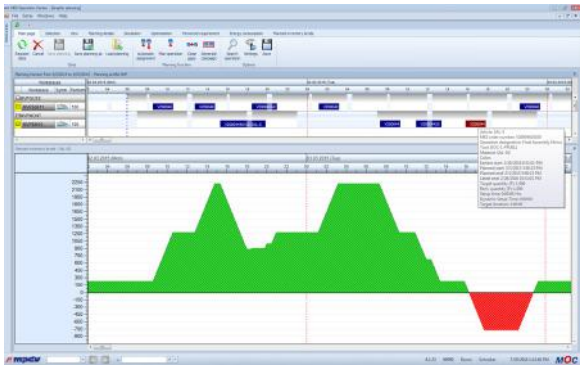


Image 4: Taking into account stocks of materials in the detailed planning using HYDRA Shop Floor Scheduling

Regarding the resource “energy” it is important to avoid load peaks which might lead to increased costs. Also the use of temporary energy quotas can be taken into account already during detailed planning. In this context it is advantageous when the necessary information (material availability or energy budgets) is recorded or collected in an integrated manner and managed in the MES.[2]

Depending on the complexity and production procedure it can also make sense to include the availability of digital information in the planning process. For example the release of the respective NC programs is a mandatory precondition for smooth processes in metal production with many variations on a group of processing centers. Production regulations and drawings also belong to this group of digital information.

The role of people in production

But also the workers, machine operators and other employees on the shop floor must be assigned efficiently and according to their qualifications. For this kind of simple planning of the shift strength, pin-boards or the Excel tables are still used a lot. Here an MES can also effectively support a modern personnel management by digitizing processes through elimination of media disruptions and simplifications. Besides the avoidance of paper (e. g. application of leave) the digitization in production also enables supervisors to access reliable data during shift planning. They also benefit from the transparency that was already established in stage 1 on the way to the Smart Factory.[2] With clearly arranged diagrams and integrated shift strength calculations the shift planning thus becomes a routine task.

Qualification-based personnel scheduling

The more complex the tasks of the individual employees on the shop floor the more relevant their qualification will be. Usually employees have more than one relevant qualification. In a modern MES, qualifications and temporary permits (e. g. forklift truck driver‘s license or welding permit) are recorded, updated and prioritized in the form of a qualification matrix (Image 5). This matrix then serves as the basis for personnel scheduling.

In the simplest variant the personnel requirements are recorded directly at a workplace managed in the MES. The assignment of employees to individual workplaces is consequently done in a Gantt-Chart (Image 6). The respective qualifications of the employees are indicated in color and the planned attendance times are visualized through bars. This prevents that employees are assigned to jobs although they are not available or do not have the necessary qualification. An automatic assignment supports supervisors in the planning process. If supervisors are satisfied with the result, they release the plan. The results are automatically distributed to all employees. They can then see either on a shop floor terminal or on their

Image 5: Qualification matrix for personnel scheduling in MPDV‘s MES HYDRA

smartphone for what workplaces they are planned in the coming days and weeks (Image 6).

Integration of personnel scheduling and production planning

If personnel scheduling is combined with detailed planning and production control, it is possible to consider personnel requirements for specific jobs. This ensures the assignment of qualified employees and is called “job-based personnel scheduling”. At the same time it is irrelevant whether the jobs were planned in the MES or another software tool. Especially in markets with greatly fluctuating demand or in production companies whose product portfolio varies seasonally it is advisable to include the pool of orders into personnel scheduling. Thus, possible overcapacities can be identified at an early stage and working times can be modified accordingly. The available employees are thereby assigned more efficiently, what also enhances employee satisfaction.

Yet another, possible scenario would be to allocate machines with jobs in the MES only when certain employees are available and planned for this workplace. In this case the detailed planning in an MES carries out a personnel availability check or marks times in which no jobs can be dispatched because the employee in question is not available. This scenario is further proof that the ability of an MES to map the complexity of real processes and basic conditions is crucially important for the reactive factory. Especially due to the increasingly higher individualization requirements in many markets, it is evident that production companies in future can no longer do without a modern MES.

Manual or automatic?

The production controllers are still arguing about whether an automatic assignment is better than the manual assignment of jobs to the individual machines. At the same time employees are often subconsciously afraid of losing their jobs since the automatic planning algorithms are getting increasingly better. In the end competent experts are always needed. On the one hand, they manage

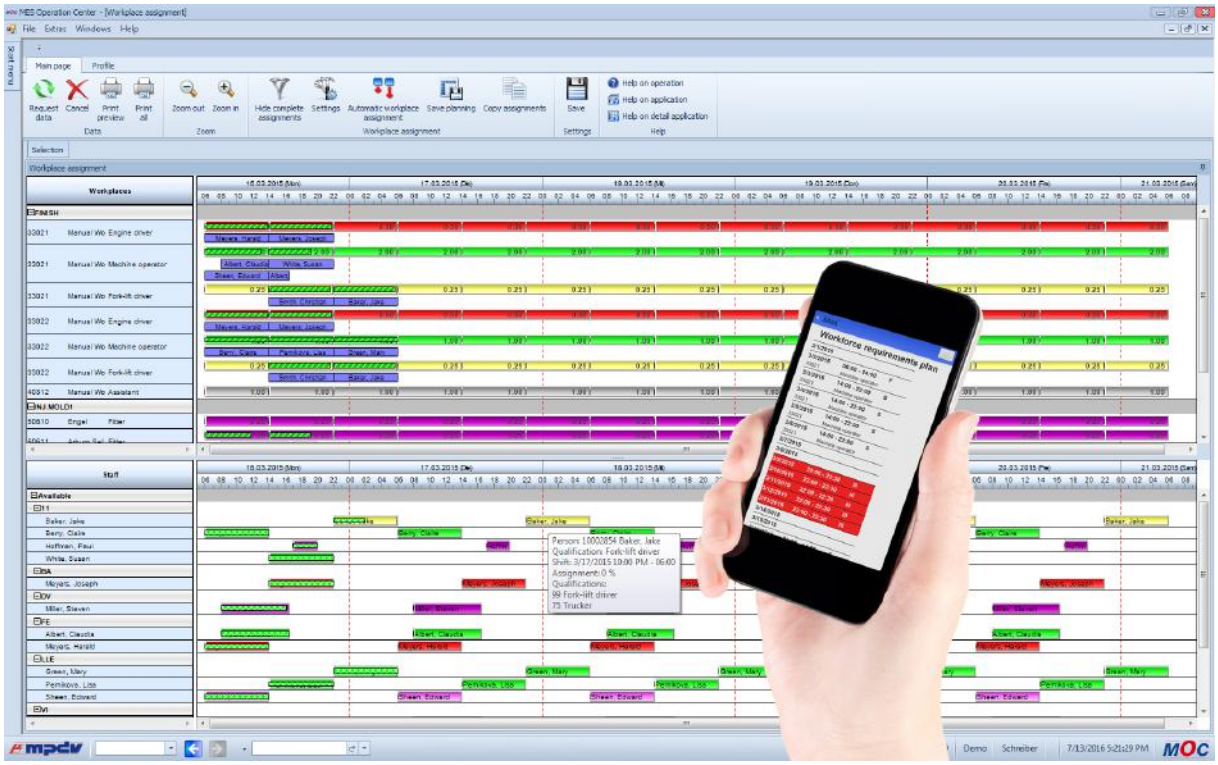


Image 6: Workplace assignment in personnel scheduling with MPDV‘s HYDRA – on a desktop PC or mobile devices

absolutely necessary master data. On the other hand, their vast experience enables them to give planning a final polish or to get involved when the automatic processes do not lead to any meaningful result. Also the assumption of responsibility is and remains a domain of human beings. Thus a company will plan most efficiently when using intelligent automatic processes and employing competent planners, who then get involved manually when it is necessary and profitable,. People in production play an important role not only as assistants in added value but also as directors of planning.

Special case: sequential production with many variations

As a special kind of manufacturing, sequential production with many variations will gain more and more importance in future. With regard to the four-stage-model, sequential production can be found between the second and third stage, i.e. the „autonomous factory“. This manufacturing method uses one production line to produce different variations of a single product. The „One Piece Flow“ method is often applied in this context.

So far, sequential production has mainly been implemented with automotive suppliers. But concepts like „mass customization“ will also force other industry sectors to apply such methods in future. The particular challenge of sequential production is to plan the sequence as exactly as possible but to keep time intervals short to respond immediately to different incidents and events. If quality defects are identified, processes will be locked automatically. Process interlocking prevents damaged items from being processed further and ensures they will be reworked. Consequently, the main issues of sequential production are responsiveness as well as autonomous and decentralized processes.

Until now, companies have tackled such requirements using JIT/JIS systems (Just-in-Time/ Just-in-Sequence). In general, these systems are operated with head controls based on PLC. However, changes had to be programmed with an effort. This method is appropriate to product configurations applicable over longer periods of time. But ever shorter product life cycles will change the situation. In future, companies will need the pace of today‘s JIT/JIS systems and the flexibility of state-of-the-art MES systems. Consequently, the integration of JIT/JIS functions into an MES is imperative.

Outlook

If one looks a little further into the future increasingly more processes will be automated and decentralized. To benefit from these autonomous processes suitable robust control cycles should be established and mapped in the MES. Thus, a self-regulating factory arises successively - stage 3 of the Smart Factory.

Also the dependencies of adjacent sectors, external service providers and other IT systems in the production environment will make it necessary to exchange more relevant information with an MES in future. Stage 4, the functionally linked factory outlines methods and possibilities ensuring that „external“ influences are also taken into account or ideally even benefit is drawn from them.

Recommended Action

MPDV‘s MES experts still recommend to complete the individual stages one after another on the way

to the Smart Factory. It is of course possible to work on selected topics from higher levels earlier if needed. However, it remains important to analyze and as far as possible slim down processes in the course of digitalization. Production does not become more efficient solely through the introduction of an MES. Rather an MES supports companies in discovering and revealing hidden potentials.

In the end production companies need particularly this increase in efficiency in order to counter the new challenges of Industry 4.0 successfully. On the other hand, they also benefit from the technologies and methods of Industry 4.0. While the implementation of a reactive factory according to stage 2 may appear trivial experience has shown that a large part of the production companies is still far removed from this. As a result it makes sense to ensure transparency in a first step and reactivity in the second step. Production companies thereby safeguard and increase their competitiveness in the long term - also and particularly with regard to Industry 4.0 and a constant globalization of the markets.

Bibliography

[1] White Paper „Industry 4.0 - disarmed „Smart Factory“ in four steps “, MPDV Mikrolab GmbH, April 2016, http://mpdv.info/whitepaper

[2] White Paper „Industry 4.0 requires Horizontal Integration MES – but do it the right way!“, MPDV Mikrolab GmbH, August 2015, http://mpdv.info/whitepaper

MPDV Mikrolab GmbH

headquartered in Mosbach/Germany is developing Manufacturing Execution Systems (MES) and is looking back on more than 35 years project experience in the production environment. MPDV's product portfolio comprises of MES products, services, and entire MES solutions for the MES environment. MPDV currently employs 325 people across ten sites in Germany, Switzerland, Singapore, China and USA. More than 930 customers from different industry sectors, ranging from metal processing to medical engineering, benefit from MPDV's MES solutions. These include medium-sized companies to global enterprises. MPDV is one of the most innovative medium-sized companies in Germany being part of the TOP 100 businesses.

MES HYDRA

Manufacturing Execution Systems (MES) support production companies to improve efficiencies in their production processes, increase productivity and thus to secure or enhance their ability to compete. A state-of-the-art MES puts companies in the position to record and evaluate data along the complete value-added chain in real-time. People in charge can therefore react instantly to unforeseen events in the daily production routine and put in suitable measures.

The MES supports on all levels short-term and far-reaching decisions by providing a reliable data basis.

HYDRA, the modular structured MES by MPDV, features an extensive functional range and meets all requirements stated in the VDI guideline 5600. Individual HYDRA applications based on a central MES database can be combined without the use of interfaces. Thus, HYDRA guarantees a 360-degree view on all resources in production and can incorporate overlapping processes. Powerful tools for configuration and customization ensure that HYDRA can be modified in order to cater for company and industry specific requirements. HYDRA can be integrated into existing IT landscapes and is used as a link between production (shop floor) and the management level (e. g. ERP system). Production companies are particular reactive using an MES system like HYDRA and therefore remain competitive - especially looking at Industry 4.0.

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The MES-Experts next to our customers.

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