Application of MES systems for the automation of the shop floor
Brief info

- What is the effective production?
- Can we use information technologies to increase effectiveness of the production?
- What is the MES? Which functions has such systems?
- How MES can help you to control your plant?
What is the effective production?

- All orders are produced timely
- All products have defined quality level
- Lowest level of production expansions
- All manufacturing resources are used in optimal way
- Prices are lower than competitor’s prices
What IT can provide to you?

- Visibility
- Controlability
- Traceability
IT in production control

Enterprise management

Shop floor management

Process control
What is MES?

- MES – Manufacturing Execution System (traditionally)
- MES – Manufacturing Enterprise Solution (new)
- Most of specialist likes traditional version 😊
MES in production management

- Planning of sales, customer relations management, accounting, ...
- Disptatching, scheduling, production tracking, work confirmation
- Control and monitoring of technological process, operator interface, local control, safety

ERP

Process control systems
MES in production management

- Planning of sales, customer relations management, accounting, …
- Dispatching, scheduling, production tracking, work confirmation
- Control and monitoring of technological process, operator interface, local control, safety
MES or MOM?

- MOM – Manufacturing Operations Management
- Term was first used in ISA-95 standard
- Term does not have clear definition
- Term constantly become victim of marketing manipulation 😊
- MOM = MES + (other systems of same control level)
- LIMS, WMS etc can be «other system»
MES in production management

- ERP
- MES/MOM
- Process control systems

Source data for decision

Time of decision
Functions of MES

- Resource Allocation and Status
- Dispatching Production Units
- Data Collection/Acquisition
- Labor Management
- Quality Management
- Process Management
- Product Tracking and Genealogy
- Performance Analysis
- Operations/Detail Scheduling
- Document Control
- Maintenance Management
History and development of MES
Typical structure of MES

- **Business Logic:**
  - data processing
  - order scheduling
  - ...

- **Administration Jobs:**
  - housekeeping
  - user administration
  - ...

- **Online Database**

- **Replication**

- **Archive Database**

- **Reporting**

- **User Interface**
Place of the MES in IT landscape

1. Коммуникационные сети устройств управления
   - Устройства ввода-вывода, приборы, датчики

2. Сети для автоматизации
   - HMI, SCADA, Batch-системы

3. Информационная сеть производственных операций
   - MES, LIMS, WMS, CMM

4. Информационная сеть бизнес-процессов
   - ERP, APO, логистические системы
Examples of MES

- PHARIS (Unis a.s., Czech Republic)
- Simatic IT (Siemens, Germany)
- SAP ME (SAP, Germany)
- IDBox (CIC, Spain)
- MES Software (Wonderware, USA)
- Proficy Plant Applications (GE, USA)
- Hydra (MPDV, Germany)
- Фобос (ИКТИ РАН, Russian Federation)
- ....
MES and other systems: control systems

- Processing data from sensor
- Calculation of control value
- Generation of control signal for actuators (motors, contactors, drives etc)
- Diagnosis of equipment
- Automatical generation of alarms in case of faults and disturbances of technological process
- Support of operator interface

Time of decision – from milliseconds till minutes
Control systems: main components

- Sensors
- Actuators
- Control devices (PLCs)
- SCADA
MES vs. Control systems

- MES manages all production area, control system control separate lines and machines
- MES does not generate control signal for actuators
- MES uses complex analytical tasks and tasks of production scheduling.
- MES uses aggregated data, control systems uses data in real-time
MES and other systems: ERP/MRP

- Management of design and technological specifications and other master data
- Requirements planning for materials and other resources
- Supply planning
- Procurement management
- Sales planning
- Preparation of master plan, capacity planning
- Financial management
- Project management
- …
MES vs. ERP/MRP

- Most of MES systems are domain specific
- MES can exchange data with production machines in real-time
- MES make decisions in relatively short periods of time (from hours till shifts)
- MES always knows what happened in shopfloor
- MES does not solve tasks of financial management
- MES works with specific lines and machines during process of scheduling
MES, ERP and control system must work together!
### MES for different types of production

<table>
<thead>
<tr>
<th></th>
<th>Continuous</th>
<th>Batch</th>
<th>Discrete</th>
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<tbody>
<tr>
<td>Resource Allocation and Status</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Dispatching Production Units</td>
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<td>+</td>
<td>+</td>
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<tr>
<td>Data Collection/Acquisition</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Labor Management</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Quality Management</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Process Management</td>
<td>-</td>
<td>-</td>
<td>+</td>
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<tr>
<td>Product Tracking and Genealogy</td>
<td>+</td>
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<tr>
<td>Performance Analysis</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Operations/Detail Scheduling</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Document Control</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Maintenance Management</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Data exchange with control systems

- OPC (OLE for Process Control)
- Industrial standards and well-known technologies (EUROMAP63, PackML, BatchML, …)
- Protocol of CNC data exchange (Mazatrol, Heidenhein, DNC2, LVC2, …)
- Proprietary technologies of equipment manufacturers
- Data collection using printer port
- Duplication of signals of existing sensor or installation of new sensors
- Manual data input (production terminals)
Manual data input

- Number of non-conformities
- Information about operator
- Downtime reason
- Tool information
- Selection of production order
Production visualization
Work confirmation

- Number of produced parts
- Number of good parts
- Number of non-conformities
- Number of used materials
- …
Data exchange with ERP/MRP

- Web services
- Common database
- Bulk loading
- Message infrastructure
- etc
Production alarms

Message to setter

System alarm

Message to plant manager
Monitoring of production orders
### Coefficients of effectiveness (OEE)

<table>
<thead>
<tr>
<th>Name</th>
<th>Code</th>
<th>Production-center</th>
<th>Overall efficiency of equipment (OEE)</th>
<th>Overall productivity (TEEP)</th>
<th>Load</th>
<th>Utilization</th>
<th>Productivity</th>
<th>Quality</th>
<th>Average time between failures (MTBF)</th>
<th>Average time for repairs (MTTR)</th>
<th>Utilization per cycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNC Bruce Studer 20</td>
<td>62101/2</td>
<td>Metal Machining</td>
<td>0.00%</td>
<td>0.00%</td>
<td>NA</td>
<td>NA</td>
<td>N/A</td>
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<td>CNC Horizontal H42 1</td>
<td>25401</td>
<td>Metal Machining</td>
<td>0.00%</td>
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<td>NA</td>
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<td>CNCК 2000 2 340 SM</td>
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<td>0.00%</td>
<td>0.00%</td>
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<tr>
<td>CNC Gildemeister CTX 420 1</td>
<td>24301</td>
<td>Metal Machining</td>
<td>0.00%</td>
<td>0.00%</td>
<td>NA</td>
<td>NA</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Maintenance management

- Counting of work hours (cycles) of every equipment unit or every tool
- Management of tools
- Setting up of maintenance schedule
- Automatic alarms while reaching date of maintenance
- Blocking of equipment till maintenance
- Management of technical documentation which is needed for maintenance
Maintenance management
What data we need to create production schedule?

- Production orders
- Scheduling module
- Availability of equipment and tools
- Production resources
- Actual efficiency
### Detail production scheduling

<table>
<thead>
<tr>
<th>№</th>
<th>Статус</th>
<th>Процент</th>
<th>Описание</th>
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<tr>
<td>1</td>
<td>25405</td>
<td>52.3%</td>
<td>CNC Horizontka H40 5</td>
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<tr>
<td>2</td>
<td>11206</td>
<td>19.7%</td>
<td>CNC fréza (MCFV 1060) 3</td>
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<tr>
<td>3</td>
<td>61101</td>
<td>92.5%</td>
<td>CNC soustruh S50 2x + CNC soustruh Delcam 2x</td>
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<tr>
<td>4</td>
<td>62101</td>
<td>80.9%</td>
<td>CNC fréza MCFV 1060 + CNC bruška Stukenbrok 3x</td>
</tr>
<tr>
<td>5</td>
<td>24301</td>
<td>29.3%</td>
<td>CNC soustruh Gildemeister CTX 420 1</td>
</tr>
</tbody>
</table>

*Highlight:*
- VP-2012-0000995 - [SOU8-001-US-7] Lathing NC
- VP-2012-0001111 - [SOU8-001-US-7] Lathing NC

**Status:**

**Interval for statistics:** 1 week
### Детали производственного планирования

#### Доступные источники

<table>
<thead>
<tr>
<th>Код</th>
<th>Наименование</th>
<th>Производ</th>
<th>Группа</th>
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<tbody>
<tr>
<td>64403</td>
<td>CNC souchtruh KARUSEL 3</td>
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<td>11205</td>
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#### Текущий выбор

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<th>Производ</th>
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<tr>
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<td>CNC frēžka MCFV 1060 + CNC</td>
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<tr>
<td>5</td>
<td>24301</td>
<td>CNC souchtruh Gildemeister CTX</td>
<td>Metal Machir</td>
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</tbody>
</table>

[Передвинуть вверх](#)
[Передвинуть вниз](#)
[Вставить](#)
[Копировать](#)
**Оптимизатор**

**Состояние службы:** Отключено

**Текущая задача:**

**Задача запущена:**

**Параметры вычислений**

- **Направление планирования:**
  - слева направо
  - справа налево

- **Алгоритм:**
  - генетический
  - примитивный

- **Окончание операций:**
  - определён
  - все постоянные
  - планировать
  - отчёт только о недостаче
  - игнор

- **Материал:**

- **Восстановить доступ:** (опция сбрасывается после начала вычислений)
- **Обновить статус хран.:** (опция сбрасывается после начала вычислений)

- **Начать расчет плана**

**Ход текущих вычислений**

<table>
<thead>
<tr>
<th>Статус вычислений:</th>
<th>Успешно завершено</th>
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<tbody>
<tr>
<td>05.09.2012 11:37:11</td>
<td>Предупреждение - операия выполняется за допустимые времена</td>
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<td>05.09.2012 11:37:11</td>
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<td>Предупреждение - операия выполняется за допустимые времена</td>
</tr>
<tr>
<td>05.09.2012 11:37:11</td>
<td>ExitCode 0 - Оптимизация завершена успешно</td>
</tr>
</tbody>
</table>

[CSV]
Detail production scheduling
Traceability of production

- All production data are recorded during whole production process
- Long-time storing of data in connection with batch code
- One can any data in case of claims or to prove good quality of production processes
Results of implementation of MES

- Decreasing costs of data input
- Decreasing time and number of downtimes
- Production become more flexible
- One can monitor production in realtime
- Significant increase of discipline of workers
- Paperless production
Paperless production

- Production schedule
- Drawings, instructions, specifications, ...
- Production info
- Results of inspection
- Task to operators, additional info
- Operator
- Product
- Inspection of quality

Shift supervisor
Planners
Designers
Paperless production
Paperless production
Most popular initiatives

- 85% - Asset Utilization or OEE Improvement
- 61% - Continuous improvement
- 54% - Six Sigma
- 46% - TPM
- 38% - Lean production
- 38% - Condition-Based Maintenance
- 8% – Implementation of new control systems
Is your plant effective

- Many people think that OEE of their plant has value 80-90%
- Real value is 60%
- OEE of best plants has value 85%
Calculating OEE

**Load** = \( \frac{\text{Scheduled time}}{\text{All time}} \)

**Availability** = \( \frac{\text{Scheduled time} - \text{Downtime}}{\text{Scheduled time}} \)

**Productivity** = \( \frac{\text{Number of produced parts} \times \text{Estimated cycle time}}{\text{Scheduled time} - \text{Downtime}} \)

**Quality** = \( \frac{\text{Number of good parts}}{\text{Total number of parts}} \)

**OEE** = Availability \( \times \) Quality \( \times \) Productivity

**TEEP** = Load \( \times \) Availability \( \times \) Quality \( \times \) Productivity
## Reasons of decreasing of OEE

<table>
<thead>
<tr>
<th>Reason</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td>Scheduling problems and marketing problems</td>
<td>Load</td>
</tr>
<tr>
<td>Major faults and downtimes</td>
<td>Availability</td>
</tr>
<tr>
<td>Setup and setting</td>
<td>Availability</td>
</tr>
<tr>
<td>Short stop (5-10 minutes) and downtimes</td>
<td>Productivity</td>
</tr>
<tr>
<td>Decreasing of speed of work</td>
<td>Productivity</td>
</tr>
<tr>
<td>Scrap during setting and start of production</td>
<td>Quality</td>
</tr>
<tr>
<td>Scrap during production</td>
<td>Quality</td>
</tr>
</tbody>
</table>
Ideal line – OEE=100%

- All of the time it is scheduled
- No time loss for Changeovers, Cleaning, Breakdowns
- Always runs at the full rated speed
- No short stop failures
- Has a 1st pass Yield of 100%
- Does not exist 😊
Example

- OEE = Availability * Productivity * Quality
- OEE = (0.77)\times(0.65)\times(0.98) \times 100\% = 49\%
- For high value of OEE **ALL** coefficients must be high!
World Best Practices

- Availability – 90%
- Productivity – 95%
- Quality – 99.9%
- OEE – 85%
Manual and automatic data collection

**Manual data collection**
- Production: 82.5%
- Setting: 12.5%
- Downtime: 5%

**Automatic data collection**
- Production: 51.5%
- Setting: 21%
- Downtime: 27.5%
## Manual and automatic data collection

<table>
<thead>
<tr>
<th></th>
<th>Manual data collection</th>
<th>Automatic data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of incidents</td>
<td>12</td>
<td>140</td>
</tr>
<tr>
<td>Mean time of incidents</td>
<td>15</td>
<td>&lt;2</td>
</tr>
<tr>
<td>Total downtime</td>
<td>180</td>
<td>280</td>
</tr>
<tr>
<td>OEE</td>
<td>79%</td>
<td>73%</td>
</tr>
</tbody>
</table>
Timeline
IT in production control

Enterprise management

Shop floor management

Process control
MES Selection

**MES requirements**

- Support of *your* kind of industry
- Support of *all required* functions
- Support of data exchange with existing systems (both ERP and control systems)
- Support of IT used in plant
- Qualification and experience of implementation team
Support of **your** kind of industry

- There is no «universal» system
- Every system has own roots and these roots belong to specific kind of production
- Different industry need different sets of MES functions
- It is very difficult to use MES for continuous production in machine building plant and so on
- Do not listen to sellers, watch the list of real implementations of the system! The system is best suited to the industry that has maximum numbers of implementations.
- Try to contact people from these plants. Ask them about suitability of the system and plant.
- Best of all, system integrator must organize your free discussion with people from such plants!
Support of **all required functions**

- Please think about requirements got every function!
- Select only functions that you need. For example if you have small plant you (maybe) does not need optimal scheduler. Don’t waste your money!
- Check the possibility to implement each needed function using selected system. Be careful with promises to implement new function «special for you». You can became «crush test dummy» in the test of new functionality of the system.
- Check the possibility of increasing of functionality of the system after implementation.
- And please don’t try to replace ERP with MES!
Support of data exchange with existing system

- Do you think that MES is thing-in-itself? You are wrong!
- MES needs real-time data from shopfloor, MES needs production definitions and definitions of resources.
- MES must exchange data both with high-level systems (ERP/MRP) and low-level systems (PLC, CNC, SCADA etc)
- Such words as OPC, MODBUS, SOAP, XML, EDI and so on must be familiar to specialists of selected system integrator. Try to tell some of these words and examine faces of such specialists 😊
- Check what information systems you already have. Check communication technologies supported by such systems.
- Ask system integrator to prepare list of equipment and software that must be purchased before beginning of the project.
Support of IT used in plant

- Do you want to have your own zoo? If yes, select systems that use own databases, own report managers and so on. It will be interesting but not very effective.
- Try to select system that use technologies similar to technologies wide used in your enterprise.
- Using of standard software is most cost effective
Implementation team for MES

- Don’t buy just system, buy solution!
- Specialists of system integrator must show you how to use system to solve your problem.
- Such specialists must be familiar with your plant and your kind of industry.
- Specialist must be familiar with selected MES closer than you!
- Specialists must be able to tell you what will happened after implementation of each function.
Thank You!

Questions?