Trends in Production Control

ERP Support for Pull Production

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SINTEF Operations Management
Outline

- Enterprise resource planning (ERP)
- Lean & Just-in-Time: Pull production
- The lean-ERP paradox
- A research framework for ERP in lean production
- Researching ERP support for lean production
- ERP support for pull production: A capability model
- Conclusion
LEAN i NORGE...

Norway, a lean champion

Norway is perhaps more famous for its natural wonders such as fjords, mountains, Northern lights and midnight sun than for its thriving manufacturing industry. Yet, the country boasts a variety of companies drawing on its abundance of natural resources to shape modern products from traditional materials like aluminum and wood. Giants Hydro, Aker Solutions and Norske Skog are major international players, whilst many innovative smaller companies, such as Teeness and Hoca, focus on niche markets to further strengthen a robust sector which has seen consistent rises in both productivity and income.

Daryl John Powell works for the Department of Production and Quality Engineering at Trondheim’s Norwegian University of Science and Technology and for SINTEF Logistikk. He talks about the status of lean in Norway.

SFI NORMAN

This eight-year research programme aims to develop new and multi-disciplinary research on next-generation manufacturing, and create theories, methods, models and management tools that enable Norwegian manufacturers to thrive in the global market. Norman was established by the Research Council of Norway as a Centre for Research-based Innovation in 2007; it’s the result of the collaboration between 16 leading Norwegian manufacturing companies from a wide range of industries, the Norwegian University of Science and Technology and research institution SINTEF.

In 2009, the Norman companies were surveyed to find out the extent to which lean practices had been adopted and applied. A questionnaire was developed that allowed each company to evaluate itself on a Likert scale for the following 10 lean practices:

1. Workplace Organisation
2. Total Productive Maintenance (TPM)
3. Kaizen
4. Total Quality Management
5. Standardised Work
6. Quick Changeovers
7. Heijunka
8. Pull Systems
9. Supplier Relationship Management
10. Customer Relationship Management
Enterprise resource planning (ERP)

Vollmann et al. (2005) Mabert et al. (2001)
Lean & Just-in-Time: Pull Production

- 3 fundamental principles of JIT (Sugimori, 1977):
  - Levelling of production (Heijunka)
  - One piece production and conveyance (Single piece flow)
  - Withdrawal by subsequent process (Kanban)

Levelling of production: Heijunka

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>20,000</td>
</tr>
<tr>
<td>B</td>
<td>10,000</td>
</tr>
<tr>
<td>C</td>
<td>5,000</td>
</tr>
</tbody>
</table>

Product A

Product B

Product C

Estimated production output (monthly)
Number of working days: 20

<table>
<thead>
<tr>
<th>Month</th>
<th>Day</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>50</td>
<td>1,000 units</td>
</tr>
<tr>
<td>Y</td>
<td>30</td>
<td>600 units</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
<td>400 units</td>
</tr>
</tbody>
</table>

Daily production schedule

<table>
<thead>
<tr>
<th>Model</th>
<th>Quantity</th>
<th>One month</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>1,000</td>
<td>50 units per day</td>
</tr>
<tr>
<td>Y</td>
<td>600</td>
<td>30 units per day</td>
</tr>
<tr>
<td>Z</td>
<td>400</td>
<td>20 units per day</td>
</tr>
</tbody>
</table>

Assembly schedule for one day

<table>
<thead>
<tr>
<th>Model</th>
<th>Quantity</th>
<th>One day</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>50</td>
<td>8:00 am to 5:00 pm</td>
</tr>
<tr>
<td>Y</td>
<td>30</td>
<td>9:00 am to 12:00 pm</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
<td>1:00 pm to 4:00 pm</td>
</tr>
</tbody>
</table>

This is still shish-kabob production
One piece production and conveyance: Single piece flow

Monthly output

<table>
<thead>
<tr>
<th>Model</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>X</td>
<td>1,000</td>
</tr>
<tr>
<td>Y</td>
<td>600</td>
</tr>
<tr>
<td>Z</td>
<td>400</td>
</tr>
</tbody>
</table>

Working days in month: 20

Daily output

<table>
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<tr>
<th>Model</th>
<th>Quantity</th>
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</thead>
<tbody>
<tr>
<td>X</td>
<td>1,000 ÷ 20 = 50</td>
</tr>
<tr>
<td>Y</td>
<td>600 ÷ 20 = 30</td>
</tr>
<tr>
<td>Z</td>
<td>400 ÷ 20 = 20</td>
</tr>
</tbody>
</table>

Working minutes in day: 480

Takt time: 4.8 minutes
X: 9.6 minutes
Y: 16 minutes
Z: 24 minutes

Level production

<table>
<thead>
<tr>
<th>Model</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>50</td>
</tr>
<tr>
<td>Y</td>
<td>30</td>
</tr>
<tr>
<td>Z</td>
<td>20</td>
</tr>
</tbody>
</table>

8 am 12 noon 5 pm
X 1 unit every 9.6 minutes
Y 1 unit every 16 minutes
Z 1 unit every 24 minutes

Repeat this production sequence 10 times

Line flow
Withdrawal by subsequent process: Kanban
Customer order decoupling point

ALTERNATIVES
MAKE TO STOCK
ASSEMBLE TO ORDER
MAKE TO ORDER
ENGINEER TO ORDER

Kanban for MTS / ATO, but what about MTO / ETO?!

Customization
Cost efficiency and standardisation
Paired-cell Overlapping
Loops of Cards with Authorisation:

**POLCA**
Why POLCA?

- Kanban requires a minimum amount of inventory to be held between each workstation - LARGE NUMBER OF PRODUCT SPECIFICATIONS?

- Custom designed products? - NO PREDIFINED FINISHED GOODS.

- POLCA for material control in manufacturing environments with high variety or custom-engineered products
What is POLCA?

• Paired-cell Overlapping Loops of Cards with Authorisation (POLCA)

• A Hybrid “Card-based” Push-Pull Strategy

• Controls material flow through the factory (for minimal WIP)
How is POLCA different from Kanban?

• POLCA cards are paired-cell specific, kanban cards are product specific

• POLCA cards are used to control material movements between cells, not within cells

• POLCA cards are a capacity signal, kanban cards are an inventory signal
  - POLCA cards signal production can start if there are orders waiting, kanban cards signal that production must start regardless.
Back to Lean & ERP…

• Lean and ERP consistently rated as the most important strategies for achieving competitive advantage in manufacturing operations (Carroll, 2007)

• In lean, information technology (IT) has often been viewed as non-value adding activity (Sugimori et al., 1977)

• Modern IT can be tailored to support lean production (Riezebos et al., 2009)
Lean Vs. ERP Systems?


Time (not to scale)

Lean (Krafcik, 1988); Machine (Womack et al., 1990); Lean thinking (Womack and Jones, 1996)

Lean IT (Bell, 2006); Lean and ERP (Steger-Jensen and Hvolby, 2008); Lean and IT (Riezebos et al., 2009)

TPS (Sugimori et al., 1977)

MRP (Aggarwal, 1985); MRP II (Higgins et al., 1996); ERP (Davenport, 1998)

ERP support for Lean (Powell et al., 2011); ERP support for Pull (Powell et al., 2012)

ERP route to lean (Davis, 2005); Class A ERP (Sheldon, 2005); IT and Lean (Ward and Zhou, 2006)
Pull vs. Push: The Lean-ERP Paradox

• Lean and ERP have emerged from fundamentally different approaches to production...

Powell and Strandhagen (2011)

• …Potential synergy in combining the two?
(Perceived) Benefits?

**LEAN PRODUCTION**
- Lead time reduction
- Inventory reduction
- Productivity improvement
- Quality improvement
- Customer service improvement
- Performance improvement!

**ERP SYSTEMS**
- Lead time reduction
- Inventory reduction
- Productivity improvement
- Quality improvement
- Customer service improvement
- Performance improvement!

But ERP systems used with “traditional” operating practices:
- Excessive planned lead times = Increased inventory
- Large lot sizes = MORE inventory
- Just-in-case safety stocks = EVEN MORE INVENTORY!!!
A research framework for ERP systems in lean production

Combining lean and ERP for competitive advantage

Methods for the concurrent application of lean and ERP

ERP support for lean production

ERP in Lean Production

Real-time information for intelligent planning and execution

ERP systems for the extended lean enterprise

e-Kanban: a platform for integrating ERP and pull systems
Researching ERP Support for lean Production

- Action Research (Norway)
  - Simultaneous implementation of ERP and lean practices

- Multiple Case Study (Netherlands)
  - ERP support for pull production in SMEs
ERP support for lean production

Value
- CRM
- Automation of necessary non-value adding activities (NNVA)

Value stream
- Process modelling
- Source of WIs
- Information sharing across the supply chain

Perfection
- Root-cause analysis
- Visual management
- Performance measurement

Pull
- Kanban
- Production levelling
- JIT Procurement

Flow
- Synchronized data flow
- Line balancing
- Demand levelling
- Rate-based planning
- Decision support

ERP Support for Lean Production
ERP Support for Pull Production:  
*Case Study Research, NL*
<table>
<thead>
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<th>Overview of Case Studies</th>
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<tbody>
<tr>
<td><strong>Company</strong></td>
</tr>
<tr>
<td><strong>Industry</strong></td>
</tr>
<tr>
<td><strong>Product</strong></td>
</tr>
<tr>
<td><strong>Employees</strong></td>
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<td><strong>Turnover</strong></td>
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<td><strong>Pull System</strong></td>
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<tr>
<td><strong>CODP</strong></td>
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Development of a capability maturity model for ERP support for pull production

- Aims to aid companies in benchmarking the maturity of their operations relative to industry best practice
- Used to compare the findings from each of the cases
## ERP support for pull production capability maturity model

<table>
<thead>
<tr>
<th>Level</th>
<th>Goal</th>
<th>Examples of criteria</th>
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<tbody>
<tr>
<td>Level 1: Initial</td>
<td>There are no goals defined at this unstructured level.</td>
<td>The pull system does not provide feedback to the ERP system. The ERP system does not support the pull system.</td>
</tr>
<tr>
<td>Level 2: Planned</td>
<td>Support for decoupled push and pull practices.</td>
<td>Color coded release lists are available. Push and pull practices are decoupled. Kanban cards are printed from ERP system.</td>
</tr>
<tr>
<td>Level 3: Validated</td>
<td>Feedback between pull system and ERP system.</td>
<td>Pull system provides feedback to ERP system. Kanban requirements and takt times are calculated.</td>
</tr>
<tr>
<td>Level 4: Controlled</td>
<td>The ERP system actively supports the operation of the pull system.</td>
<td>Operator reallocation is supported. E-heijunka is supported. E-kanban is supported. Pull system performance is monitored.</td>
</tr>
<tr>
<td>Level 5: Optimising</td>
<td>The ERP system continuously improves the pull system.</td>
<td>Continuous improvement activities to improve pull production are enabled. Pull system parameters are optimised.</td>
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Challenges and solutions

C: No kanban functionality in the ERP system.
S: Functionality added to the ERP system for printing of kanban cards.

C: Basic ERP System is “only an accounting system”.
S: Bolt-on “PROPOS” system developed to visualise real-time requirements on the shopfloor.

C: The ERP system is too static, and proposes to build batches based on historical batch sizes.
S: Modification made to SAP with regard to parameterization and logic used for the calculation of batch sizes.

C: ERP system is unable to effectively level the demand.
S: Periods of free capacity are utilised to build up stock for promotions by using temporary (green) kanbans.
## ERP support for pull production capability maturity model

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Conclusion & Further Work

- Findings suggest a range of potential ERP support functionality for lean production principles
- Our CMM highlights examples of ERP support functionality for pull production
- Further work should apply the CMM to demonstrate capability in deploying ERP-enabled pull production in Norwegian industry.
Thank You

Questions?

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