The future meat plant
FOURTH INDUSTRIAL REVOLUTION – WHAT’S IN IT FOR YOU?

Holger Dirac, Director Measurement Systems DMRI, pahd@dti.dk
FOURTH INDUSTRIAL REVOLUTION – WHAT’S IN IT FOR YOU?

The future meat plant

- The need for handling many small volume product variants is increasing.
- Digitalizing and using data across the value chain to optimize logistics and production processes and exploiting synergies presents critical opportunities. But how do we realize them?
- Is line production still the future slaughterhouse production paradigm?
Industry 4.0 (Wikipedia)

1st
Mechanization, water power, steam power

2nd
Mass production, assembly line, electricity

3rd
Computer and automation

4th
Cyber Physical Systems
A cyber-physical system (CPS) is a mechanism controlled or monitored by computer-based algorithms, tightly integrated with the internet and its users. In cyber-physical systems, physical and software components are deeply intertwined, each operating on different spatial and temporal scales, e.g., milliseconds, milliseconds, and minutes, and exhibiting multiple and distinct behavioral modalities, and interacting with each other in a myriad of ways that change with context.[1]

Examples of CPS include smart grid, autonomous automobile systems, medical monitoring, process control systems, robotics systems, and automatic pilot avionics.[2]
Industry 4.0 (for butchers)

- Most information is digitalized and accessible (also along the value chain).

- Machines, raw material and products “talk” together.

- Access to information about history, present state, and predictions about the future.

- Automation of not just individual processes but also of how to combine and adapt processes (also to small series), i.e. automated/assisted:
  - Production planning.
  - Contingency/error management.
  - Management of variation/small series.
The future meat plant
It’s all about BETTER BUSINESS

- How can we increase profit?
  - Increase prices
  - Decrease costs
  - Increase volume
Increasing prices
How are we doing?
- Not so well the last 30 years!
More than 300 mio € saved every year
Market segmentation

Same same but different
Enters the “Craft Beer”

Authenticity, heritage, locality, craftsmanship
Industrial “Craft beer”
Mega trends
Major present and future challenges
How to increase prices?

- Increasing the perceived value:
  - Market segmentation: Let affluent/willing costumers pay according to their value perception.
  - Branding & Story telling (the craft beer analogy): Farmer and provenance, animal welfare, food safety, quality, socially sustainable workplace.
How to increase prices?

- The challenges. Segmentation, Branding & Story telling require:
  - B2C business models (more direct market access/impact, B2B tends to be price driven).
  - Documentation of claims (with a brand comes potential brand damage)
    - Traceability.
    - Objective an communicative parameters for: Animal welfare, food safety, and quality.
Industry 4.0 technologies for

- More complex logistics: More product variants, smaller product series, more detailed distribution
- Horizontal integration: Costumer definition of product!
Industry 4.0 technologies for:

- Documentation of claims (with a brand comes potential brand damage)
- Traceability and documentation (from pig to pack (to consumer)).
- Objective and communicative parameters for: Animal welfare, food safety, and quality.
Decreasing cost
How are we doing?

- Pretty well historically.
- But is there still room for more efficiency?
Decreasing cost
New paradigms?
Decreasing cost
Maintain yield (of high value products)!!!
New paradigms?
Fewer but bigger plants running 24/7

- Why?
  - Less fixed cost
  - Fewer building plots and buildings
  - Better utilization of capital equipment

- Will require (Industry 4.0 technologies for):
  - More automation (labor cost nightshift)
  - Cleaning in Place (CIP) – contained cells
  - Flexibility and redundancy in production
  - Scheduled maintenance
New paradigms?
More streamlined plants

- Less handling. No buffers. Direct from:
  - Truck to stunner.
  - FIFO in equalizing chill room.
  - Cutting to boning to packaging.

- But maintaining:
  - Optimum usage of carcasses.
  - Product/market diversity.
  - And even more and smaller product series.
New paradigms?
More streamlined plants

- Less handling. No buffers.
- But maintaining: Optimum usage of carcasses and Product/market diversity.

- Will require Industry 4.0 technologies for
  - Measurement
  - Traceability
  - Automatic sorting
  - Flexible smart production (automatic and manual)
A new production paradigm. What do we need?

Increasing product price:
- Traceability and documentation (from pig to pack (to consumer)).

24/7:
- More automation (labor cost nightshift)
- Cleaning in Place (CIP) – contained cells
- Flexibility and redundancy in production
- Scheduled maintenance

More streamlined plants:
- Traceability
- Automatic sorting
- Flexible smart production (automatic and manual)
New paradigms: Flexible automatic production
Are the smart robots coming?
Potential benefits of REDUNDANT ROBOT CELL PRODUCTION PARADIGM

- The industrial robot is available, stable, reasonably affordable and flexible (planning and tooling).
- Reduced time for transport.
- Fewer complete production stops and room for CIP and scheduled maintenance.
Will we save transport time with the robot cell?

<table>
<thead>
<tr>
<th>Current draw chain process</th>
<th>Sec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process time</td>
<td>6</td>
</tr>
<tr>
<td>Transport time</td>
<td>4</td>
</tr>
<tr>
<td>Total time pr. process</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Robot cell</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Process time</td>
<td>6</td>
</tr>
<tr>
<td>Tool change time</td>
<td>3</td>
</tr>
<tr>
<td>Transport time</td>
<td>4</td>
</tr>
<tr>
<td>Number of processes</td>
<td>4</td>
</tr>
<tr>
<td>Total time pr. process</td>
<td>10</td>
</tr>
</tbody>
</table>
Robot Cell

Robot 1: operate

Robot 2: hand over tools

Saw machine

Tool center

Robot 1 operation
- Tenderloin
- Foretoe
- Head

Robot 2 Handling over tool
- Tool tenderloin -> tool foretoe
- Tool foretoe -> tool head
- Tool head -> tool tenderloin

Saw machines
Cutting & Backtoe
Robot cell redundancy: Fewer production stops

- Two lines equals full capacity (= 1)
- $2 \times 6 = 12$ cells
- Each circle represents a cell with four processes per cell

- One cell (the green processes) needs service/cleaning/reparations
- What do we do?
Robot cell redundancy

\[ \frac{1}{2} \text{ capacity} \]

\[ \approx \frac{1}{2} + \frac{1}{2} \times \frac{1}{2} \]

\[ = \frac{3}{4} \text{ capacity} \]

\[ \approx \frac{1}{2} + \frac{3}{4} \times \frac{1}{2} = \frac{7}{8} \text{ capacity} \]

Dynamic allocation: \[ \approx \frac{11}{12} \]

What now?
Challenges for robot cell production paradigm

- Will they be able to do boning?
  - Better yields?
  - New ways to cut and bone?
- The industrial robot is available, stable and affordable. But how about:
  - The tools?
  - The speed?
  - The footprint?
- Reduce time used for transport:
  - Many operations in each cell.
  - Fast tool changing.
  - Fast transit between cells.
- Fewer complete production stops and room for scheduled cleaning and maintenance:
  - More redundancy.
  - Flexibility of cell utilization: Many different tools and fast change of tasks in each cell.
  - Inexpensive tooling (or investment will be too high).
  - Complex planning task, especially in contingency situations: IT planning tools.
The future Industry 4.0 meat plant

The core technologies

- Digital twin
- Online 3D measurement (CT).
- Human-data-machine interaction (AR).
- Hyper flexible smart robots (cells and co-worker) and inexpensive tools.
- Complete traceability from pig to pack.
Digital twin
A real time digital plant equivalent

- Design and commissioning.
- Production planning.
- Forecasting and contingency management.
- Maintenance.
Digital twin
Valid data for optimizing PM
Digital revolution
Digital production - Optimum utilization
Online 3D measurement (CT)

Reconstruction: 4 sec; Picture analysis 2.5 sec; 600 products/hour; 17 slice helix; GPU picture generator
Measure and control
Augmented Reality (AR)
Communication of 3D information
Robots as colleagues

Moving stock around
Supervising the robot
Working together
Complete traceability
From pig to pack
Complete traceability
From pig to pack?
Advanced sensors
Augmented reality
Hyper flexible production
Digital twins
Augmented reality
Advanced sensors
Hyper flexible production
Digital twins
Industry 4.0 (for butchers)

- Most information is digitalized and accessible (also along the value chain).
- Machines, raw material and products “talk” together.
- Access to information about history, present state, and predictions about the future.
- Automation of not just individual processes but also of how to combine and adapt processes (also to small series), i.e. automated/assisted:
  - Production planning.
  - Contingency/error management.
  - Management of variation/small series.
Thank you for your attention!