Production Scheduling in an Industry 4.0 Era

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ENGIE

ENGIE automates plants
Content Presentation

• Scheduling in animal-feed plants
• Research approach
• Results
• Concluding remarks
Scheduling in Animal-Feed Plants

- World-wide: $10^{12}$ kg
- 120 plants in Holland
- Production aspects:
  - Customer order due dates
  - Contamination
  - Changeover times
  - ...
Production Scheduling Problem

Trends: ‘big data’ & mass-customization (industry 4.0)

Goal: How to efficiently schedule orders to meet due dates?

Current situation: planners ‘schedule by hand’ ...

As a result: time-consuming and opportunity loss (inflexible and ‘big data’ unused)
Research Approach:

Mixed integer linear programming (MILP):

\[
\begin{align*}
\min_{x,y} & \quad z = c^T x + d^T y \\
\text{s.t.} & \quad Ax + Ey \begin{cases} \leq & \quad b \\ = & \quad \end{cases} \\
& \quad x_{\min} \leq x \leq x_{\max}, \quad y \in \{0,1\}^{ny}
\end{align*}
\]

MILP implementation:

Simplification:

Schedule advice:

Accuracy testing:

Solve MILP:

“Common sense”

(Darwin)
MILP solving strategies:

For **small** instances:  
(max. 3 hour time horizon)

For **medium** instances:  
(max. 6 hour time horizon)

For **large** instances:  
(> 6 hour time horizon)

Evolutionary computing on bottleneck production area*

* By extending the ideas from “Expanding from Discrete Cartesian to Permutation Gene-pool Optimal Mixing Evolutionary Algorithms” from Bosman et al. (2016) to flexible flowshops
Results:

Example of a realized schedule:

From 2017-02-11 00:00:00 to 2017-02-11 02:45:00 (18706.425)
Results:

Optimized schedule: Solved for 180 seconds, 23 minutes earlier finished (7.5%)
Results (Efficiency Gain):
Comparison to realized schedules for 267 instances (5h) when solving for 180 seconds (all found schedules respect the due dates)

WED: solving MILP with “common sense”

MILP
(mean = 2.11%)  
WED
(mean = 6.48%)
Concluding Remarks

• Model is implemented in a pilot plant in Limburg (for testing w.r.t. accuracy and optimization gain)

• Further research:
  – Model extension (transport and finished product silos)
  – Further development of (tailored) heuristics
  – Taking stochastic nature into account:
    ▪ Robust optimization
    ▪ Efficient rescheduling (emergency order, machine breakdown)
Thanks for your attention!

Any questions?

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