Factory operations modelling / scheduling /implementation

An industrial case study

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Based on ESCAPE 17-18-19 contributions by Bakker & Bongers
Unilever in a glance!
You may not know “Unilever”...
But you know our products!
UNILEVER

Our mission is to add vitality to life

We meet everyday needs for nutrition, hygiene, and personal care with brands that help people feel good, look good and get more out of life
Unilever – the Vitality Company!

- 150 million times a day, in over 150 countries, people are using our products at key moments of their day… that’s 150 million opportunities to make a positive difference to people’s lives.
Unilever R&D organisation

- 6000 employees
- 900 million Euros (2.3% turnover; 2006)
- 6 Global Research centres
- 15 Global Product Development centres
- Regional & country centres
Agenda

- Motivation
- Classical process & challenges
- Scheduling Model design
  - Factory structure
  - Material flow
  - Constraints / change-overs
  - Multi-stage scheduling model
- Results and concluding remarks
Motivation

- Operational scheduling is
  - Production when needed
Operational scheduling is
- Flexibility in production
Motivation

- Operational scheduling is
  - Choose when/where to produce
In spite of the fact that during this last decade many companies have made large investments in the development as well as in the implementation of scheduling systems, not that many systems appear to be used on a regular basis. Systems, after being implemented, often remain in use for only a limited amount of time; after a while they often are, for one reason or another, ignored altogether.

The GAP between theory and practice

- **Complexity**
  - The real world aspects/constraints/rules/assumptions that are relevant for the scheduling problem, and the relationships between those.

- **Robustness**
  - Robustness avoids nervousness in scheduling in situations with uncertainty. Nervousness should be avoided as much as possible.

- **Organizational embedding**
  - Alignment of the scheduling decisions with the business.

- **Availability and accuracy of data**
  - If this condition is not met, the scheduling model will be incorrect.

- **Interaction with human scheduler**
  - It is recognized by many authors that the human scheduler will remain an indispensable factor in the scheduling process. However, many techniques do not account for interaction with the human scheduler.
Case study
Ice cream production plant
Complexity

- 12 packing lines
- Limited availability of staff
- Constraints on auxiliary equipment
  - Fruit feeders, secondary packers
- Buffer tanks per line vary in number and size
- Packing lines share buffers
- Two process lines to feed all packing lines
  - Different capabilities
- 146 SKUs
  - SKU’s can be produced at multiple lines
- 150 recipes
  - Fresh dairy ingredients (shelf life)
  - In-house cone production (as well as bought-in)
- Stringent cleaning regime on process
  - Allergens
- Minimum and maximum standing time in buffers
- Mandatory Cleaning In Place
  - 24 hour cycle on process
  - 72 hour cycle on all other equipment
We want to be here

Minimize capital
Increased flexibility

Why beyond engineering rules

Engineering rules or rules-of-thumb

Low (<50%) utilisation
- Single stage production (dedicated resources)
- Single product

High (>70%) utilisation
- Multi stage production (shared resources)
- Complex product mix

Large capacity margin for future growth
- De-bottle necking existing site
- OR rationalisation many plants into only one

“Guesstimate” inventory, storage & delivery

“Guesstimate” inventory, storage & delivery

Controlled inventory, storage & delivery

Modelling (Multi-stage Scheduling)
## Overview commercial scheduling software

<table>
<thead>
<tr>
<th>Vendor or Product Name</th>
<th>Comment</th>
<th>Web-page</th>
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<tbody>
<tr>
<td>1 SAP APO PP/DS</td>
<td>The Production Planning and Detailed scheduling component of the SAP Advanced Planning and Optimizer</td>
<td><a href="http://help.sap.com/saphelp_apo/helpdata/en/7e/63fc37004d0a1ee1000009b38f8c8frameset.htm">http://help.sap.com/saphelp_apo/helpdata/en/7e/63fc37004d0a1ee1000009b38f8c8frameset.htm</a></td>
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<td>In 2006 acquired by the JDA software group</td>
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### Necessary conditions to enable successful implementation

- The model of the plant need to be a sufficient accurate representation of the real situation.

- The graphical user interface for the plant scheduler needs to be intuitive and represent the plant.

- The software should be usable by the plant scheduler, who, in general does not have an academic grade.

- The solution, or schedule, need to be robust rather than optimal to the last decimal digit. One important item of the robustness is that the same schedule is generated even if there are small changes in the inputs.

- The schedule of the complete plant need to be generated in a relative short period of time (faster than appr. 15 min. or one cup of coffee) in order to deal with decisions on the factory floor.

- The software need to be able to deal with break-down of the equipment, and that buffer vessels might be partially full.

- Communication with the other factory software, such that master data is only stored in one location to prevent errors. Master data contains information such as specific capacities, bill of materials, routing, alternatives, etc.
Why look outside SAP PP/DS

- SAP is leading and there is only ONE plan!
  - Everything that is critical within 24 hours has to be handled outside SAP PP/DS:
    - The material requirements in SAP are generated for a complete run OR 24 hours (which ever is the shortest should be selected)
  - Some processes are not suitable for SAP PP/DS:
    - Buffer vessels or intermediate buffers
    - Shared resources
      » Retorts, mixers, mechanics, CIP, …
    - Multiple manufacturing levels
      » Packing, ageing, pasteurising, pre-mixing, …
  - Everything that is non-operational has to be handled outside SAP
    - Scenario’s, Change-of-plans
Scheduling complexity

Increased scheduling complexity

Buffer vessels at level

Shared resources at level

SAP-PP/DS
Reduced complexity model to evaluate commercial scheduling software

Process Line
4500 lph

8000 kg
F1
Packing Line 1

4000 kg
F2
Packing Line 2
### SKU information

<table>
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<tr>
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<th>composition</th>
<th>Packing rate [kg/hr]</th>
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### Mix information

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**Mix**

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So far only INFOR could produce a feasible schedule.
Methodology Multi-Stage Scheduling

- **Input Sources:**
  - Interviews
  - SOPs
  - Change-over Structure
  - Production Plan
  - Inventory
  - Purchase Orders

- **System Structure:**
  - Factory Structure
  - Systems theory, modelling, process engineering
  - Material Flow Structure
  - 'meta'-model
  - Constraints

- **Sourcing Unit Model:**
  - BoM
  - Routing
  - Change-over data
  - BoM
  - Routing
  - Change-over data

- **Sourcing-Unit Simulation Model:**
  - Production Schedule
  - Intermediate Schedules
  - Ingredient Call-off Schedule

- **Data Sources:**
  - 'paper'-model
  - Software implementation

- **Methodology:**
  - Multi-Stage Scheduling Specifications
  - Interviews
  - Analysis
  - BoM
  - Routing
Factory structure

Constraints on Packing

- Hardening Tunnel
- Glue machines
- Fruit feeder
- Secondary packing machine

Ingredients storage

PA1 6000lph

PA2 4500lph

F30  F300
ILF1, ILF2, Viking1

F70  F700
ILF2

mini Vien

F530

F550

F540

F630  F630
Viking1, ILF1, Vien

F790  F790
Viking2, ILF1

F650  F650
F670  F670
F680  F680
F660  F660
SL1  SL1

F570  F570
Rollo1
Rollo2
Rollo3

F580  F580
SL2

F590  F590
F610  F610
Viking1, ILF1, Vienn

F620  F620

F640  F640

mini Vienn.

F530  F530
Rollo1
Rollo2
Rollo3

F750  F750
SL3

Rollo4

Rollo4
## Change-over information

- **Pasteuriser**
  - **Colour, allergens**

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## Packing lines

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Factory model overview

- Pre-mixers
- Pasteuriser
- Ageing tanks
- Production lines

Time axis:
- Production order or batch
- Change-over
- Shift pattern

Non-working time:
- Emptying
- Waiting
- Filling
- Ageing

Shift pattern:
- 2011-09-29/PMB Unilever Confidential
Conclusions

- Implementation of operational multi-stage scheduling leads to:
  - Feasible route to reduced cost/tonnes manufactured products by:
    - raw material waste reduction
    - increased available capacity (upto 30% on factory level)

- In CONTROL of MAKE
Barriers / challenges

- **General**
  - Problems occur at the interfaces
  - Factory data is not reliable, in-consistent, or non-existent
    - Specifications, Flow diagrams, line-speeds, shift variations, ...

- **Operational implementation**
  - BSc level needed for running the system
  - Cultural change necessary
    - Packing line operators no longer “in charge”
    - Master data maintenance (also now in SAP)
Thanks!