

TACIT

Modelling the Ovako Domain

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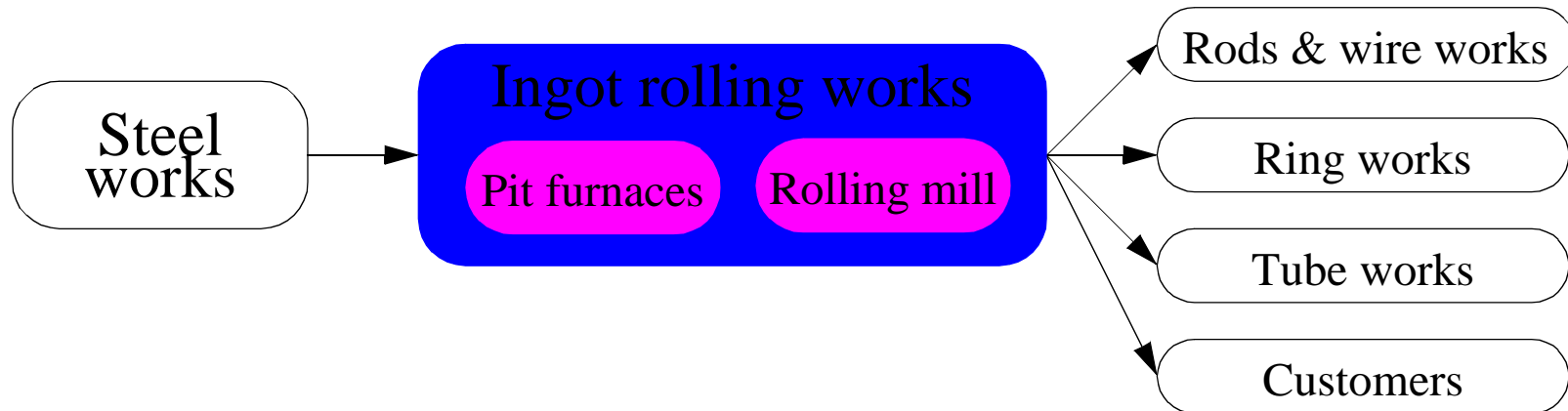
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Introduction & Background

The Swedish TACIT group has chosen to model a central part of the Ovako production facilities.



The focus of the project has been the production planning of pit furnaces and ingot rolling works.

- Today the pit furnaces can only supply the rolling mill with ingots about 70% of the time
- This limits the throughput of the entire plant and is recognised as an important problem, especially since demand is expected to increase in the coming years

The Domain

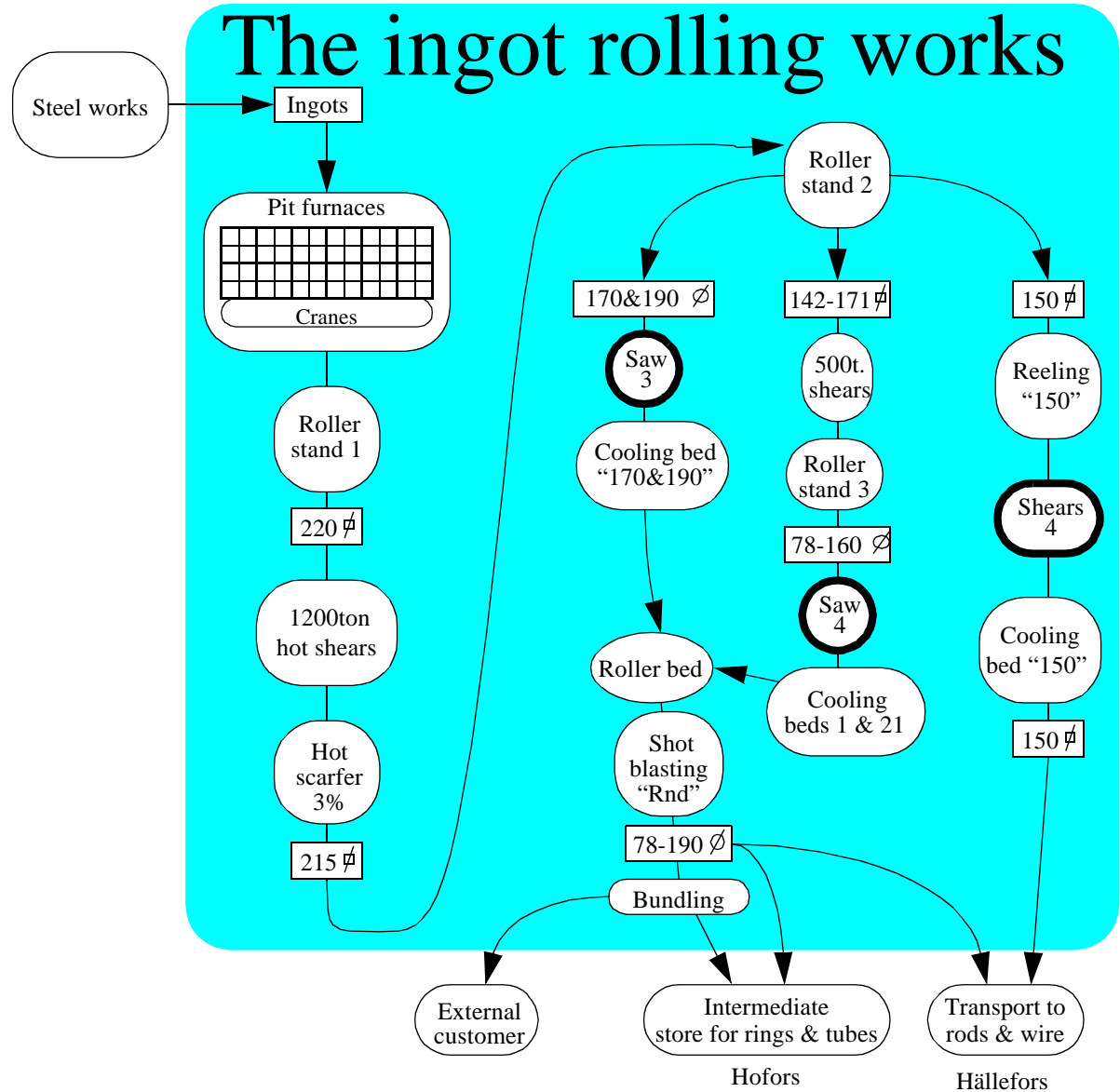
There are *two main parts* of the Ovako domain that in certain ways have different properties

- The pit furnaces and equipment for charging and discharging them with ingots
 - Here the time perspective is 10-20 hours and the variance in heating and soaking times is very large
 - Model includes simplified crane logistics, cooling and heating rates and mechanisms to predict heating times

- The rolling facilities
 - Here the time perspective is 2-3 minutes between decharging of individual ingots and 15-25 minutes of machining from decharging to cooling beds
 - The material flow is split into three separate lines sharing some central resources
 - For each ingot it has to be decided which line it should traverse, what dimension to produce and what order to assign it to
 - Today these decisions are made in real time, frequently only minutes before decharging starts

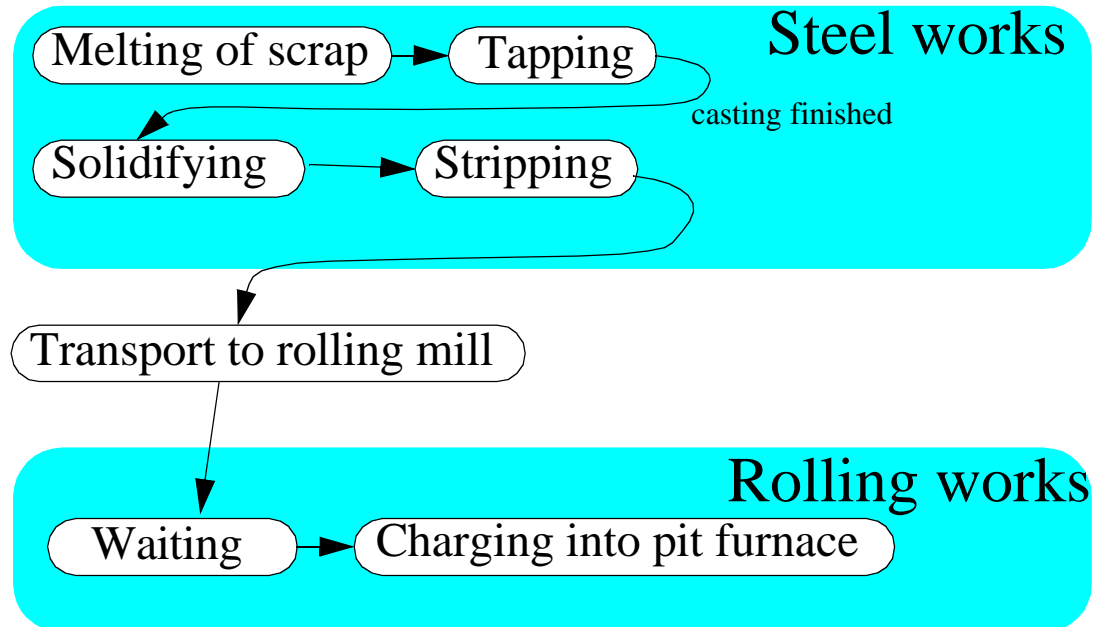
The material flow

- 1 slow process
- 1 central flow divides into 3 lines
- 2 of these merge
- 1 line involves setup times



Some time parameters

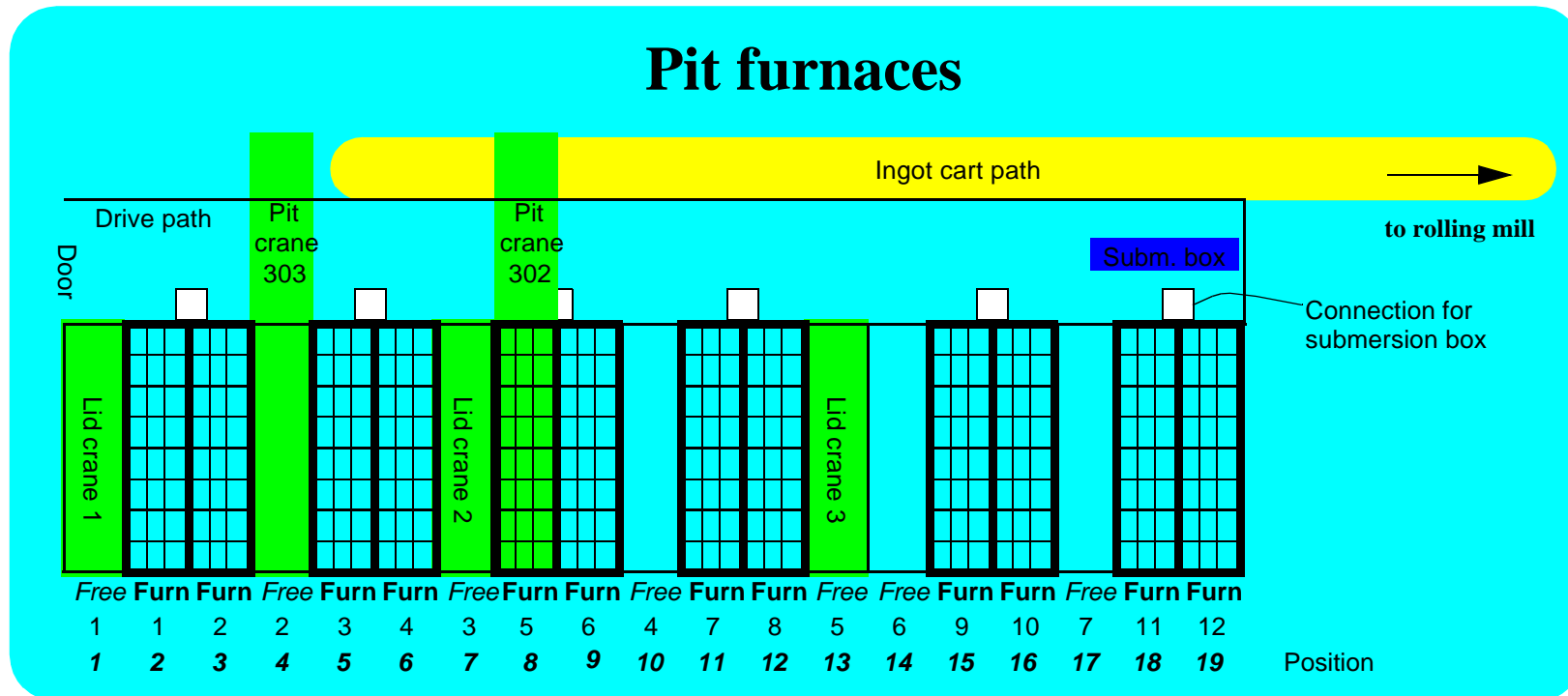
Track times



- Track time = Solidifying + Stripping + Transport to pit furnaces + Waiting time + Charging time

- Track times influence heating time in the furnaces
- Thus processing time in furnaces can increase with delays in upstream processes
- There are upper and lower bounds on track times for different types of material
- If upper bounds are exceeded the material may be ruined or have to go through a special pre-heating phase

The pit furnaces



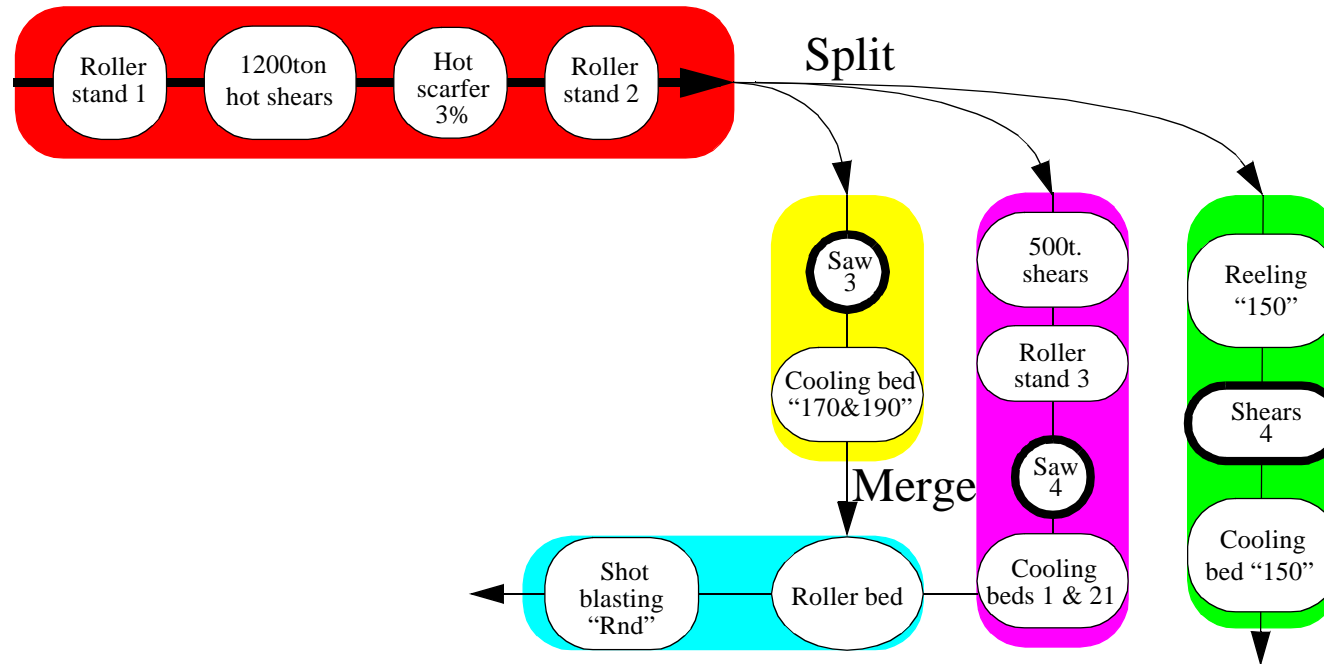
- 12 furnaces, with 4 cells each holding 6 ingots
- No simult. charging/decharging of adjacent furnaces

- The batch size of the steel works is one “charge” consisting of 21-24 ingots
 - Charging the pit furnaces is done one complete batch at the time
 - Usually, the whole batch is charged into a single furnace; this may be suboptimal
 - A batch consists of a number of jobs (suites) of ingots, each assigned to a single order
 - The flow through a given line consists of a sequence of unbroken jobs

- Heating time depends on the temperature of and number of charged ingots, desired end temperature and on the individual furnace used
- Prediction of total heating time is better the closer we get to end temperature
- Heating time is probably a (non linear) function of track time but no reliable data on this function is currently available

- End temperature varies with type of material
- Soaking times varies with type of material and heating history of ingots
- Heating and soaking can be suspended or interrupted in order to use the furnaces as a material buffer
- After soaking time is completed, it is possible (but undesirable) to keep material in furnaces for a limited additional time

Rolling facilities



- Flow is unrestricted through Shears 4
- Flows through Saw 3 and "Saw 4" merge but tonnage through Saw 3 is typically small

- In the flow through Saw 4, Roller stand 3 requires reconfiguration when the dimension of the produced material changes
- Sometimes the roller stand limits throughput of this line, sometimes the saw does
- Where limit lies depends on dimensions and number of cuttings, i.e. lengths of materials
- Sometimes the merging point limits flow through Saw 3

- The Swedish TACIT application will generate
 - simple assignment of materials to orders
 - time schedules for furnaces and rollers
 - setup time schedule for one line in the roller workswith the goal to consistently increase throughput and balance availability of materials from the furnaces.

Input data to the planner consists of

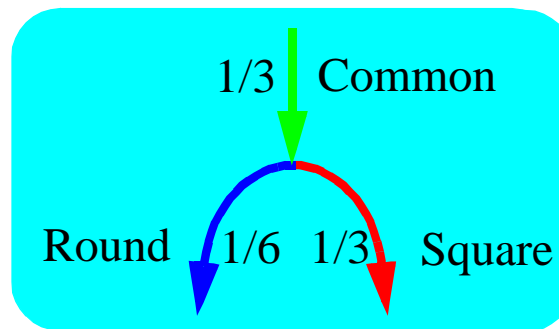
- a preliminary plan (charge queue) for the steel works
- a corresponding set of orders
- the current state of furnaces and the production facilities of the roller works
- partial assignment of material to orders

We describe a detailed model of the production facilities that is used as a basis for the implementation of a planning and decision support tool.

Simplifications

- Manual assignment of ingots to orders is supported in the GUI
 - This gives planners the opportunity to investigate plans resulting from different assignments
 - A fully automatic assignment is probably not desirable but the planning tool will complete a partial manual assignment
 - On a gross scale the assignment is already decided when generating the plan for the steel works

- Black box model
 - Since the focus of the application is on the furnaces, the rolling facilities are modelled in a comparatively simple way
 - Instead of explicitly modelling the various production steps, the flow is considered as:



- Capacity constraints on all arcs ensure that the flow will not stall
- The flow through the Round arc involves sequence dependent reconfiguration events
- The black box model sequentialises the heavy and medium round lines; however, in practice this potential parallelism is rarely exploited
- In this way we avoid having to deal with constraints modelling the two merging lines

- Batches are currently charged into furnaces at the time of delivery from the steelworks but this (too strong) restriction will be lifted
- A batch is always charged into a single furnace
- Instead of modelling a complex heating rate function we reschedule frequently taking changes in the furnace state into account