

Five use case ideas to inspire data driven innovation



Content

Introduction3

Use Case 1

Avoid rejects for mechanical properties and optimize alloying concept
.....3

Use Case 2

Optimize the production schedule
.....5

Use Case 3

Optimize the width along the entire process chain to increase yield
.....6

Use Case 4

Increase scrap input in steel making process
.....8

Use Case 5

Avoid cobbles in hot strip mills
.....9

Introduction

SAS® as a vendor for AI and Machine Learning software and services sees great added value in the usage of AI in the steel industry. The use cases below should inspire you to take a moment and think about data driven innovation in your company. No matter at which stage you currently are. Maybe you have already started with using AI or you are still in the beginning of your digital journey?

Use Case 1

Avoid rejects for mechanical properties and optimize alloying concept

Challenge

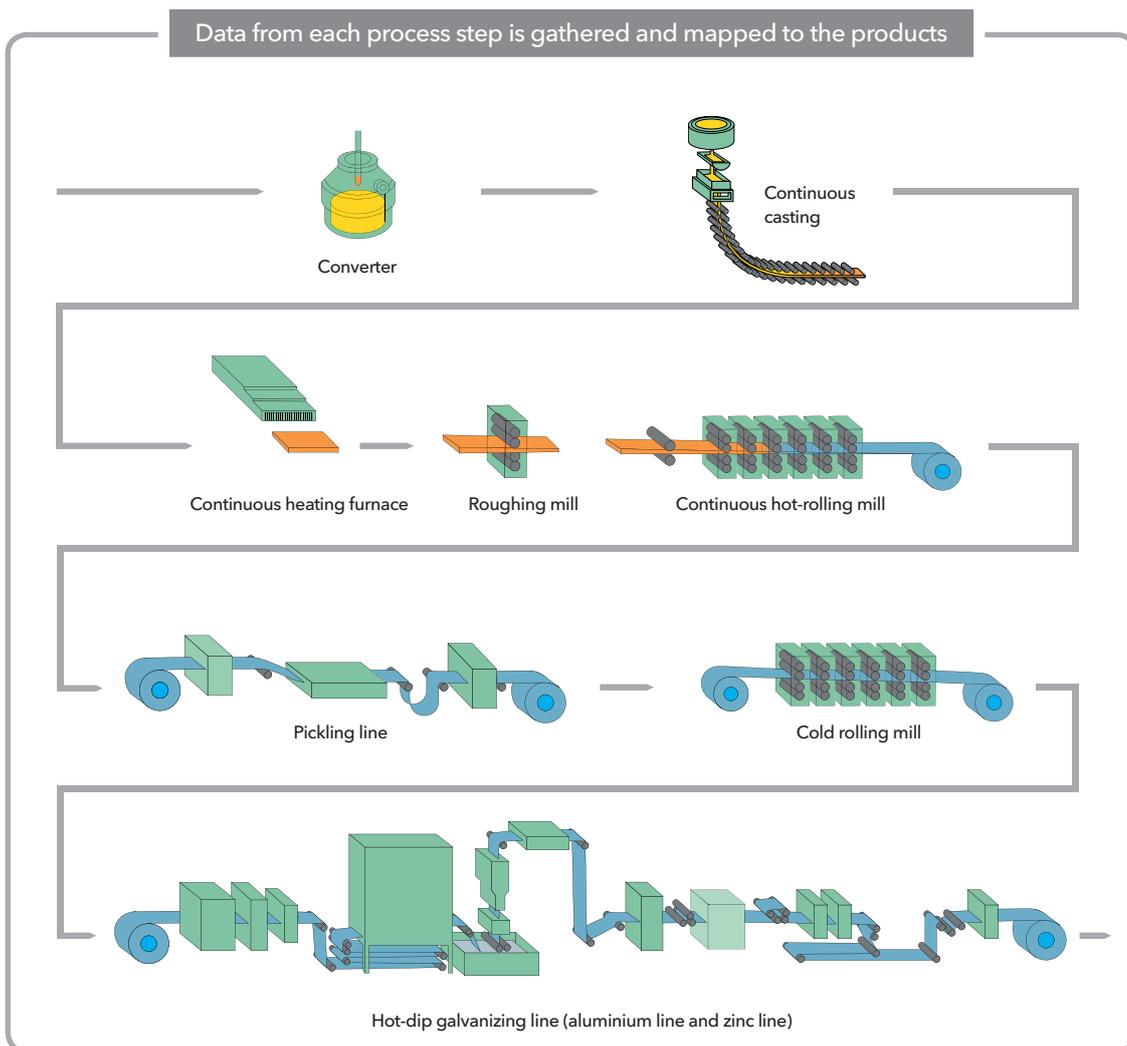
The mechanical properties like Tensile Strength, Yield Strength, Elongation, r-values etc. are an important part of an end-customer's specification. One of the problems is that mechanical properties can only be measured after the finished product (coil, heavy plate, etc.) was produced.

Solution

With data analytics it is possible to predict early on, if a product is likely not to meet the specified mechanical properties. In the steel making plant the alloying chemistry is already set. Using the actual chemistry and the planned set-up values for all downstream processes like hot rolling, cold rolling, annealing the final mechanical properties can be predicted. A warning can be sent to the MES or scheduling system early on, that a product will not reach the specified properties with the given process parameters.

This prediction model has other uses too. The model learns the impact of alloying chemistry and process parameters like reductions and temperatures for each individual steel plant. It can be used to find the root causes for fluctuations of mechanical properties or why some products failed to achieve the mechanical properties. This analysis can be easily made accessible to quality or process engineers using a graphical user interface. This root cause analysis can be done in a matter of minutes and helps engineers to stabilize the process where it has the biggest impact on mechanical properties.

The model "knows" the impact of the alloying chemistry on the product properties. Therefore, the model can also be used to optimize the costs of alloying chemistry. The goal of the optimization is to reduce expensive alloying elements like Niobium, Titanium or Molybdenum and increase the use of strengthening mechanisms like accelerated cooling and cold reduction. The optimizer of course takes the technological limits of each individual plant into account.



Value added

- Up to 30 times better prediction accuracy compared to existing metallurgical-heuristic prediction models
- Detect problems with the mechanical properties early and re-adjust process parameters to minimize rejects (avoid waste of personnel, energy, maintenance and capital costs)
- Make informed decisions to ship or block a product due to property predictions
- Faster root cause analysis in case of deviations of the mechanical properties
- Minimize alloying costs required to meet target mechanical properties

Use Case 2

Optimize the production schedule

Challenge

Production planning is a complex task. The customer requirements concerning on-time delivery, product diversity, product quality and delivery capability are increasing while the sales prices are falling. Therefore, it gets more and more complex to create production schedules. The schedule must take several constraints into account:

- Order book and backlog
- Delivery due dates
- Matching of orders to heats in steel plant
- Heat sequence in the steel plant and on continuous caster
- Thickness, width sequence in hot and cold rolling plants
- Temperature strategy in annealing and galvanizing lines
- Width strategy in galvanizing line
- Etc.

The schedule is a living document - urgent orders or cancelled orders require changes in all schedules. Also new, temporary restrictions e.g. taking a mill-stand out of service in the hot strip mill can have unexpected impact on the production schedule.

Solution

Planning tools available in the market rely heavily on rule sets and need a lot of human input. SAS can create optimization models that are customized to a particular production process. Using these optimization models a global optimum of this multi-dimensional, dynamic optimization problem can be achieved, using all available production capabilities and considering multiple constraints. Different factors can be optimized such as throughput times, production cost or inventory levels.

Value added

- Find the global optimum for the production schedule, in near real time
- Minimize the need for manual work to increase efficiency in optimization of planning process
- Flexibly and quickly align optimization target e.g. equipment utilization, throughput, quality or energy costs to the current business need
- Minimize the capital tied up by work in progress and buffer inventory

Use Case 3

Optimize the width along the entire process chain to increase yield

Challenge

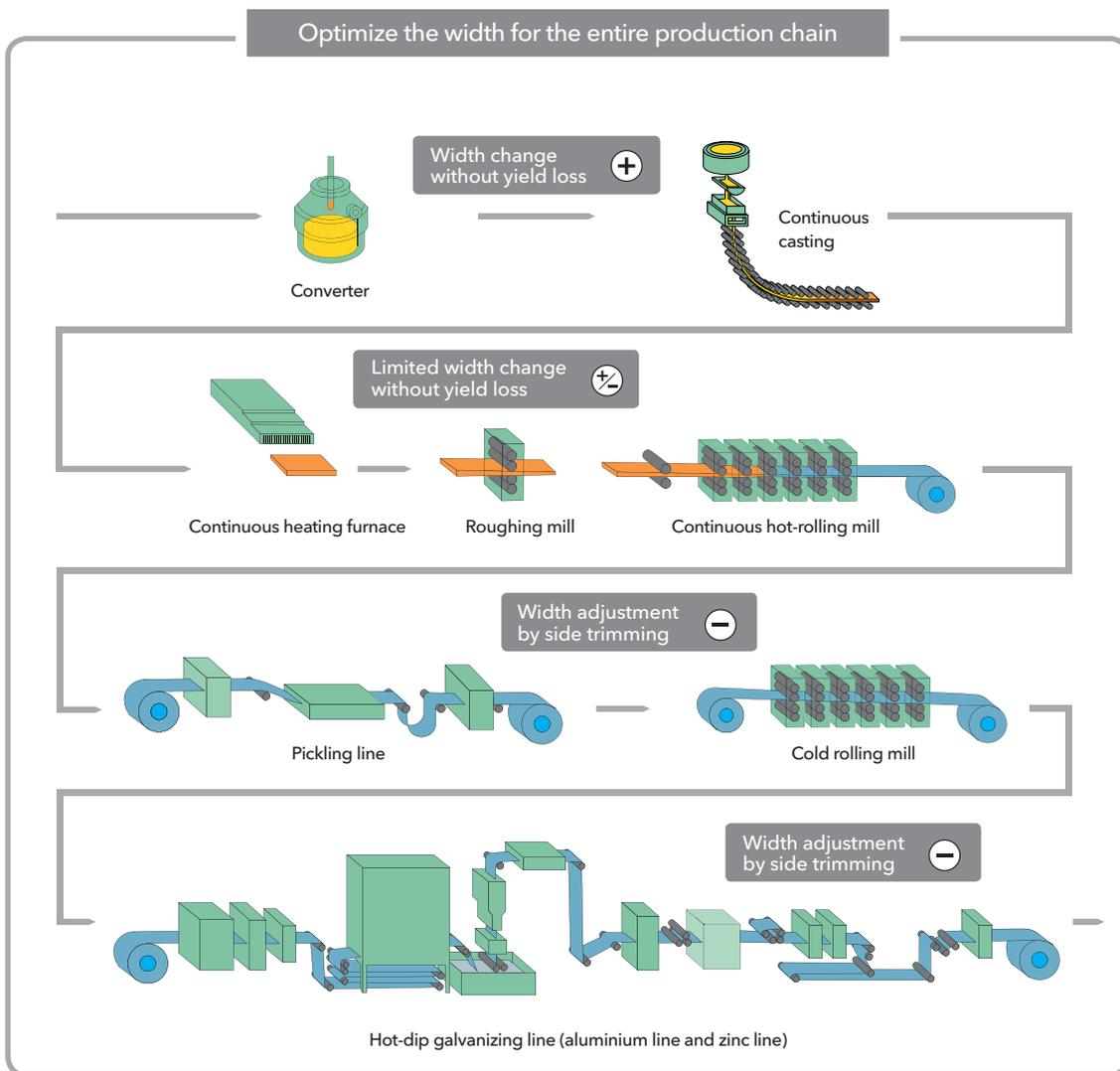
Side trimming in cold rolling, annealing or galvanizing processes carries potential savings for many steel producers. In casting the width can be set without yield losses by changing the mold width. In the hot strip mill the width can be adjusted limited by the capability of the vertical edger, also without yield loss. On the cold rolling mill, annealing and galvanizing lines the product needs to be side trimmed, resulting in a yield loss.

Solution

The challenge is to adjust the width in continuous casting and on the hot strip mill to a value that minimizes side trimming in downstream processes. This challenge can be successfully tackled using machine learning algorithms. These algorithms can consider following inputs (depending on the available sensors and data):

- Steel grade alloying chemistry
- Width changes in continuous casting from mold to the finished slab
- Width adjustment in vertical edging in the hot strip mill
- Necking in the hot strip mill
- Necking in the cold rolling mill
- Shrinking and necking in the annealing or galvanizing line
- Minimum side trimming necessary for certain applications e.g. galvanized automotive strip

The machine learning algorithm is then used to optimize the slab width, hot coil width and tensions in order to optimize the yield. The algorithm takes into account the behavior of different steel grades.



Value added

- Optimize side trimming and width strategy and save millions of Euros (depending on the current width strategy)
- Improve yield through overall optimized width additions for each production step
- Increase understanding of width influences across product groups. Thereby, achieve the target width of the final product with a minimum of overwidth along production chain
- Improve energy costs, CO₂ balance by reducing side trimming scrap

Use Case 4

Increase scrap input in steel making process

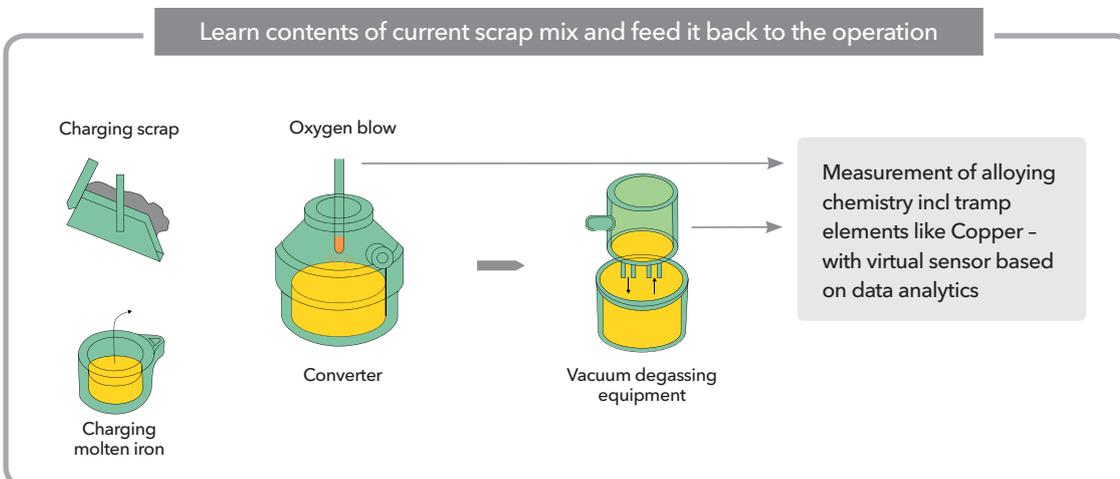
Challenge

There is a push in the steel industry to use more scrap. On the one hand scrap input in the converter process decreases the CO₂ output. On the other hand, a direct cost improvement can be achieved if the scrap prices are low compared to the hot metal prices.

The challenge with using scrap is that it can cause an increase of tramp elements in the liquid steel. Certain scrap types carry for example copper which has a negative impact on the quality of the steel. Even in the best sorted scrap yards the contents of the scrap cannot be determined accurately.

Solution

By analyzing the effects of the scrap continuously in terms of tramp elements, process problems etc. an analytics algorithm can learn the specifics of a current scrap type. This supports the steel plant by providing a prediction of the resulting level of tramp elements, giving warnings if certain elements like copper are predicted too high. The model can also be used to generate recommendations for steel treatment. This can be used to fine-tune the physical process models that exist in most steel plants.



Value added

- Get 30% more accurate set-up parameters, adjusted to current scrap conditions
- Avoid quality problems while steel plants can use more scrap flexibly without exceeding the specified limits for tramp elements
- Increase process stability and throughput
- Improve CO₂ balance

Use Case 5

Avoid cobbles in hot strip mills

Challenge

Cobbles can cause significant downtimes and can cause considerable damage to the equipment. In Hot Strip Mills cobbles can occur in several locations.

Cobbles can have plenty of root causes, among others:

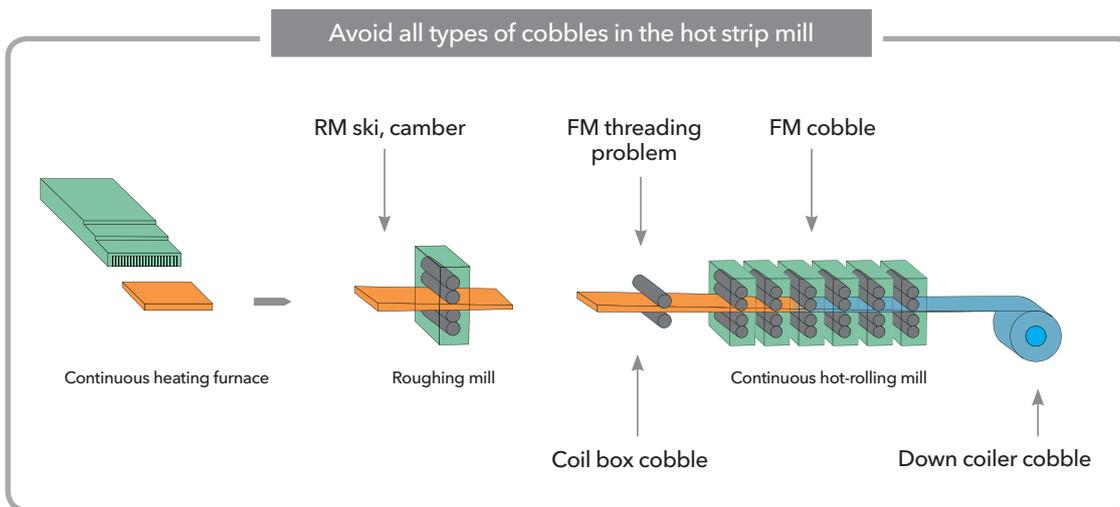
- Too large changes in rolling schedule such as product thickness, width or hot yield strength
- Un-uniform heating in the reheating furnace: head to tail, OS - DS or skid marks
- Insufficient heating of the head end
- Cold work rolls, insufficient thermal crown
- Un-uniform roll gap lubrication
- Improper stand calibration
- Wrong tilting in finishing mill
- Too large deviation between set-up and actual rolling force
- Too little crown on the strip
- Missed or too little head cut on the crop shear
- Ski on the head end
- Camber or hook on the head end
- Too much wear on the FM work rolls

Even though most steel producers have already low numbers of cobbles it remains a major driver to further reduce unplanned downtime and repair costs. To reduce the number of cobbles also means to better produce critical products, especially thin and wide strips.

Solution

It is hard for humans to evaluate if a strip is going to cobble or not, given the multitude of possible root causes. For this task algorithms powered by data analytics can be used. The algorithms can perform following tasks:

- Calculate a probability score that a strip will cobble
- Warn the operator that a strip will cobble
- Warn maintenance personnel that critical equipment needs to be checked
- Show the process engineers the root causes for cobbles
- Help the schedulers to reduce the cobble risk in the rolling schedule
- Extend campaign length without increasing the risk for cobbles



Value added

- Provide cobble probability for each strip early in the process. This outperforms non-analytics driven systems at least by a factor of 2
- Increase the uptime of the hot strip mill and avoid and improve reliability of the hot strip mill
- Avoid repair costs caused by cobbles
- Increase the ability of the mill to produce thin and wide products, or other products that are prone to cobbles



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Manfred has a decade's worth of experience in the Metals Industry. He engineered, commissioned and troubleshooted several plant types, such as plate mills, hot rolling mills, continuous casters, etc. Manfred also led the pilot implementation of a quality control system for an entire integrated steel plant in Asia. At SAS Manfred advises clients in Manufacturing Industry how to turn business challenges into solvable data science use cases.

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