Coordinating Optimisation of Complex Industrial Processes

COCOP Steel Pilot case

Steel making process

SCRAP
SCRAP
FERROALLOYS
DRI/HBI
STEEL MAKING
SIDENOR plant
EAF
SECONDARY METALLURGY
CASTING MACHINE
BILLETS
ROLLING MILL
FINISHING
REHEATING FURNACE
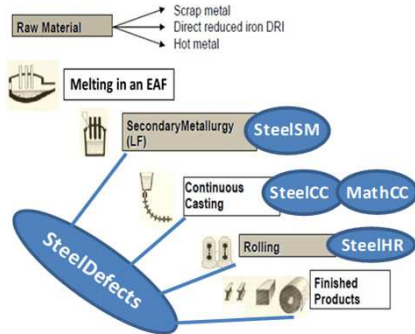ROLLING STANDS
BARS

Goal

The aim is to develop a steel manufacturing plant-wide monitoring and advisory tool to reduce the number of surface defects at the final product for micro-alloyed steels, ensuring a good performance of the related sub-processes (secondary metallurgy (SM), continuous casting (CC) and hot rolling (HR))
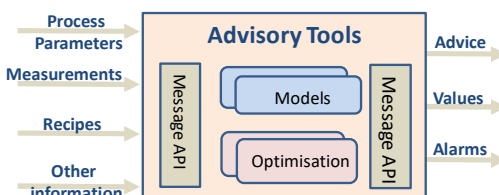
Architecture

Optimization and Model layer
Optimisation Algorithms
Process Models
python

Plant Wide Data Integration
RabbitMQ
SQL Server
AI Models & Optimization API
DB API
MQ (AMQP)
Process Data Source API
HMI API

Sidenor Facilities

Field Devices & Process Data Sources
Informix
OPC UA
iba

Operator HMI

Models

➢ Model *SteelSM*: data based model to **predict the castability index** of a heat after the SM process, a critical parameter regarding steel quality

➢ Model *SteelCC*: data based model to **predict the temperature of the billet before the straightener** during the CC process

➢ Model *MathCC*: mathematical model to **predict the thermal and shell thickness evolution** during the solidification process in the CC

➢ Model *SteelHR*: data based model to **predict the minimum and average temperature of the billet** before the continuous rolling mill

➢ Model *SteelDefects*: data based model to **predict the surface defects generation** in final product. It is defined by the parameters of the SM, CC and HR with the greatest influence on the occurrence of such defects
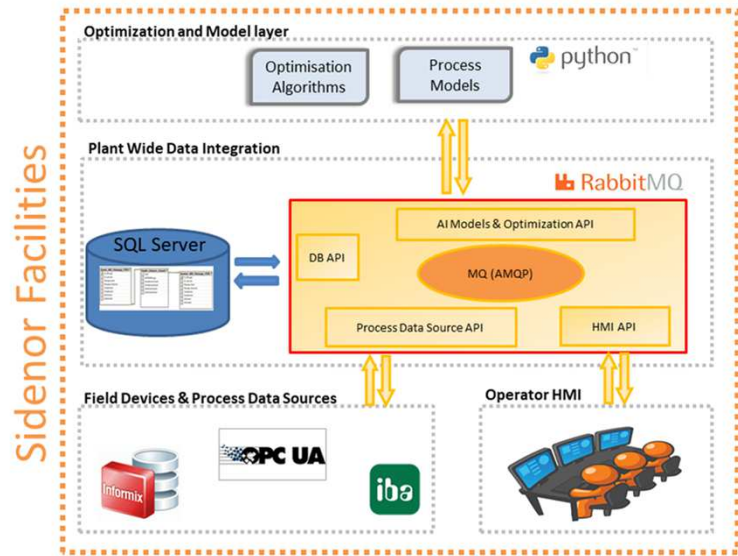

Raw Material → Scrap metal / Direct reduced iron DRI / Hot metal
Melting in an EAF
Secondary Metallurgy (LF) — SteelSM
Continuous Casting — SteelCC — MathCC
Rolling — SteelHR
SteelDefects
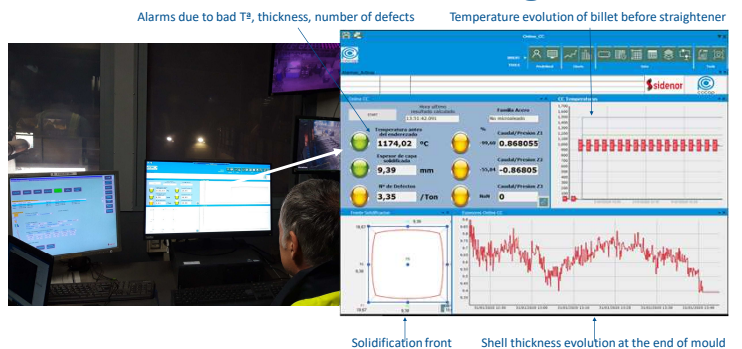Finished Products

Coordinating Optimisation

To find the best combination of values for the key defect-related parameters of the three sub-processes (SM, CC, HR) that minimise the generation of surface defects in the final product assuring a good performance of each sub-process

Coordination Layer to assure a good global performance

1. Use model *SteelDefect* to **get the optimal values of the key defect-related parameters** for each sub-process that **minimise the defects**

2. Optimize the parameters of each sub-process (using the models *SteelSM*, *SteelCC* and *SteelHR*) **to obtain a good performance**, considering as constraint the optimal values of the key defect-related parameters

Model *SteelSM* (data based model)	Model *SteelCC* (data based model)	Model *SteelHR* (data based model)
Optimisation: Maximise the **castability index**	**Optimisation**: Achieve the target **temperature of the billet before the straightener**	**Optimisation**: Achieve the target *temperature* before the *continuous rolling mill*

Model *SteelDefects* (data based model)
Optimisation: minimise the number of surface defects

Tools

➢ **Optimisation tools** ➔ to define the optimal parameters for the different processes

➢ **On-line monitoring and alarm tools** ➔ to provide values of relevant parameters of the process that are not measured and to warn in case of risks (alarms)

➢ **Off-line prediction tools** ➔ to analyse the influence of the different parameters of the process on its performance

➢ **Quality report tool** ➔ to generate a report of a heat with the analysis of the SM and CC process performance and the prediction of number of defects

Process Parameters
Measurements
Recipes
Other information
Message API
Advisory Tools
Models
Optimisation
Message API
Advice
Values
Alarms

On-line Testing

Alarms due to bad Tª, thickness, number of defects   Temperature evolution of billet before straightener

1174,02 °C
9,39 mm
3,35 /Ton

Solidification front   Shell thickness evolution at the end of mould

➢ It offers innovative data to support the production work and has a high potential the workers could benefit from. Additional functionalities are suggested

➢ It is user friendly, easy to use, not requiring additional workload