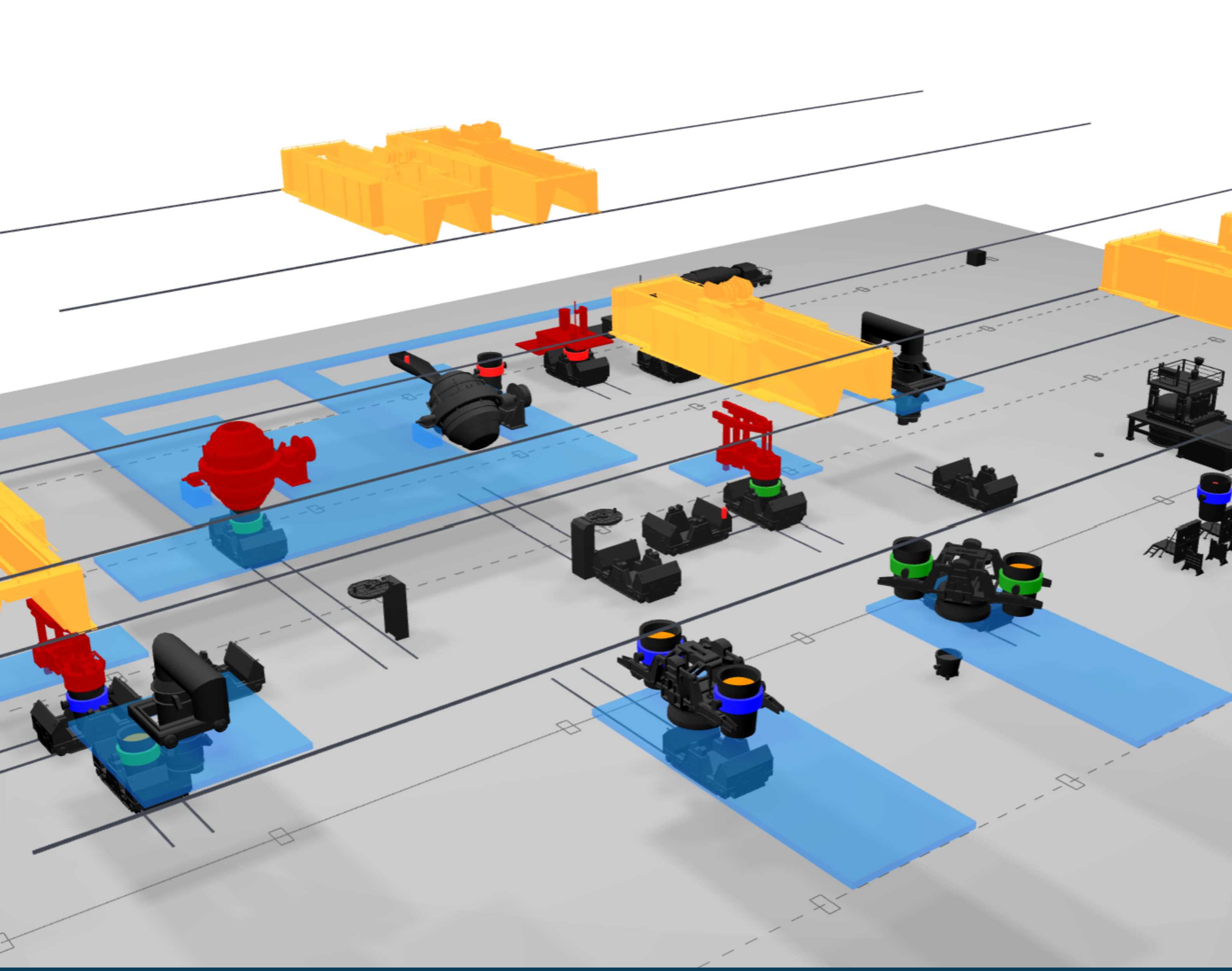


GREEN STEEL reDESIGN THROUGH SIMULATION

ENTER THE DIGITAL MELT SHOP

FESIOS

Whitepaper – September 2021

STEEL AND SIMULATION

THE MODELL OF THE FUTURE

Following the European Commission's plans to promote the production of green steel and expedite the circular economy, EU steel manufacturing is likely to see many changes and expansions in the coming years.[1]

The last decade's advances in computer sciences and technology have enabled a rapid development in the accuracy and effectiveness of simulation software tools for intralogistics modelling. There are **two primary use cases within the steel production** to be considered:

1. The **Simulation of new plants** prior to construction:
    - interactions and transports to determine whether target productivity can be reached.
    - By comparing layout alternatives and machine configuration concepts steel plant operators Simulating different production scenarios allows the steel plant operators to test out all can find the optimized solution for their steel plant before investing into building anything.

2. The **Simulation of new equipment** in an existing plant:
    - Simulating the changes in the layout allows steel plant operators to reduce the risk of creating new bottlenecks and limiting the plant performance.
    - Process simulation allows to stress test the new concept and identifies secondary and tertiary consequences before implementation.

However, in spite of the progress and capability of current technology, the potential of process simulation is not yet broadly used to model and optimize internal logistics within melt shops. Fesios has explored the current state of academic research and real use cases of applying material flow simulations in the steel industry. Subsequently, Fesios analyzed existing research for the factors that determine the successful application of simulation technology.

THE DEVIL IN THE DETAILS

ASSESSMENT OF SIMULATION OBJECTIVES AND PARAMETERS THROUGH MARKETSTUDY

The origin point of our market study were the following questions: **In what way are logistics simulations currently used** by steel plant operators? **What are the key objectives** that companies pursue while utilizing process simulations?

We reviewed the most recent academic publications on the use of simulation for melt shop logistics with the following two questions in mind:

1. What **objectives** are being pursued by companies using simulation?
2. What are the **differences** between production scenarios?

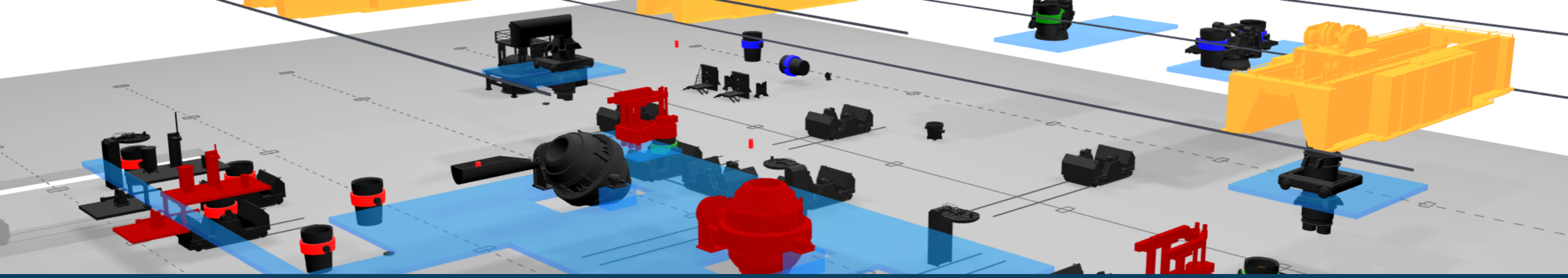
As a result we have come to the subsequent conclusions:

Objectives for analyzing results of simulation scenarios:

- Increase of productivity and throughput
- Increase of plant and crane utilization
- Detection and identification of performance bottlenecks
- Minimization of waiting times
- Determination of complex, best possible plant layouts
- Determination of total capacities
- Providing decision-making aids for long-term, cost-efficient action and investment recommendations

Differentiating parameters between production scenarios:

- Product mixes and production sequence
- Material flow changes (alternative or new routes, assigned crane operating areas)
- Process parameter changes (process or transport times, etc.)
- Machine configuration and positions (different plant layouts)



SEEING IS BELIEVING

A PRACTICAL INSIGHT ON THE BENEFITS OF PROCESS SIMULATION

In order to demonstrate the advantages of Process Simulation, Fesios has run simulations on a fictive melt shop that is based on an existing client case. A simplified two-converter Steel Plant with the following set-up was defined as the starting point: (cf. Figure 1)

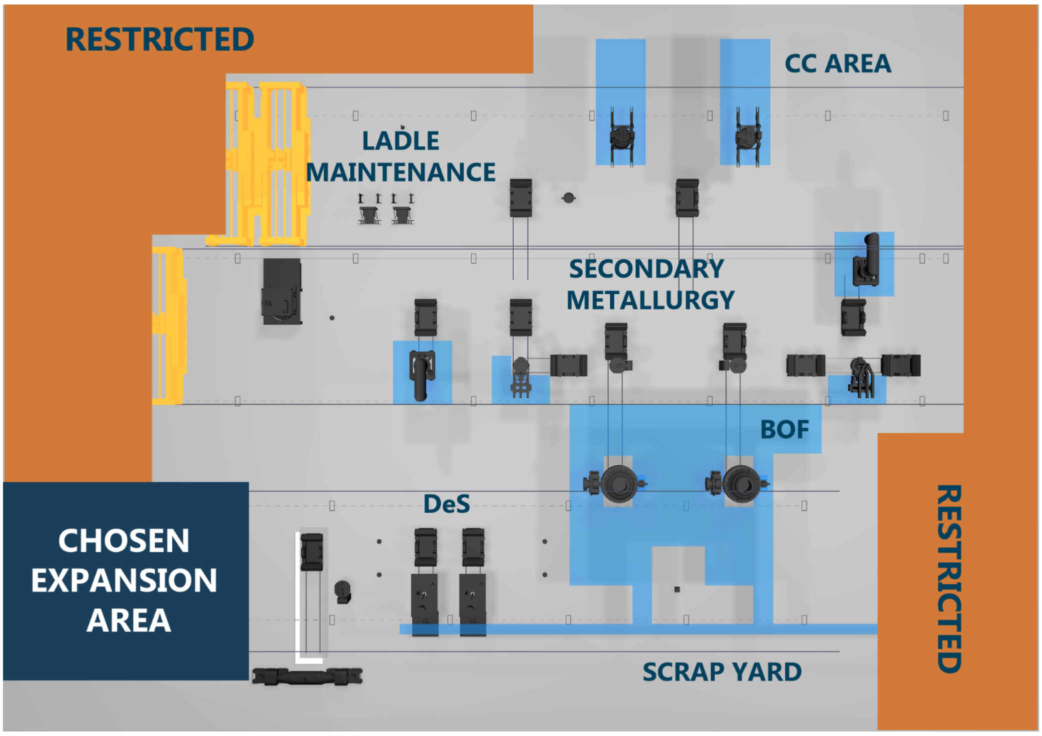


Figure 1 – *Layout of the initial BOF-based Melt Shop (Scenario A)*

The Steel Plant is supplied with hot metal from a Blast Furnace (BF) through torpedo ladles. It consists of two Desulphurization Stands (DeS) and two Basic Oxygen Furnaces (BOF). The secondary metallurgy is equipped with two Twin Ladle Furnaces (Twin LF), two Ruhrstahl Heräeus Degassing Stations (RH) and one Vacuum Degassing Stations (VD). Finally, the heat is transported into the casting area, where it is placed on one of two Continuous Casting Machines (CC).

In this scenario, there are **10 ladles permanently in circulation** throughout the melt shop. The melt shop reaches a productivity of **72 Heats per day**. The average tap to tap time of the BOFs is at 40.1 minutes. (Simulation Scenario A)

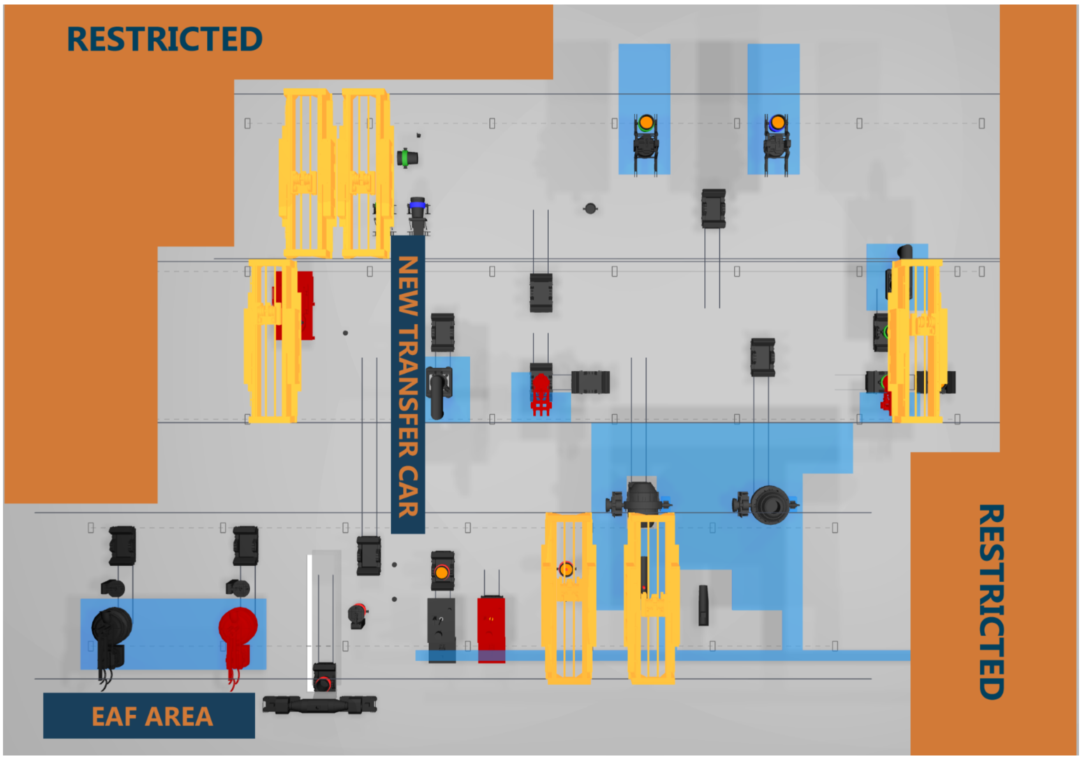


Figure 2 – *Melt Shop Layout for Simulation Studies (Scenario B & C)*

In order to increase the flexibility of production and raw material demand, and reduce CO_2 emissions, the steel plant wants to transform their plant from an iron ore-based production to a scrap-based production by exchanging their BOFs for **Electric Arc Furnaces** (EAF). Due to already existing equipment and facilities, the possible placement areas for new EAFs are limited.

The chosen area for the EAFs is at the west end of the melt shop and therefore less central to the follow-up processes than the BOF used to be. In order to integrate the EAFs, a **new transfer car** is needed to deliver empty ladles from the ladle maintenance and pick up the full ladles for further processing. The other production routes through the melt shop remain the same.

The production plan and produced steel grades are identical for all simulations. The target of the simulation is to calculate the differences between planned and current production processes, while keeping the melt shop's productivity at steady level of 72 heats per day. The primary objective of the simulation is to **provide a valid working design** for a melt shop layout that switched to using EAFs **by determining any needed changes in the operational parameters** (e.g. changes in crane utilization, the number of ladles needed, etc.).

The first run of the simulation of the new EAF based production has revealed that the productivity target of 72 heats per day cannot be reached. This is due to **waiting time of empty ladles at the EAFs,** due which **they cannot tap.** As a result, **the tap to tap time** on average **increases.** (Scenario B, cf. Figure 2)

In a first attempt to counter this development **two additional ladles are added** to circulation. This raises the average productivity and reduces the average waiting time by about 30%, but the target productivity cannot yet be reached (Scenario C). Furthermore, other KPIs are developing unfavorable – the KPIs “Time steel in ladle” and “Crane utilization in SecMet” increase. Adding further ladles into circulation shows no improvement to any of the melt shop’s KPIs.

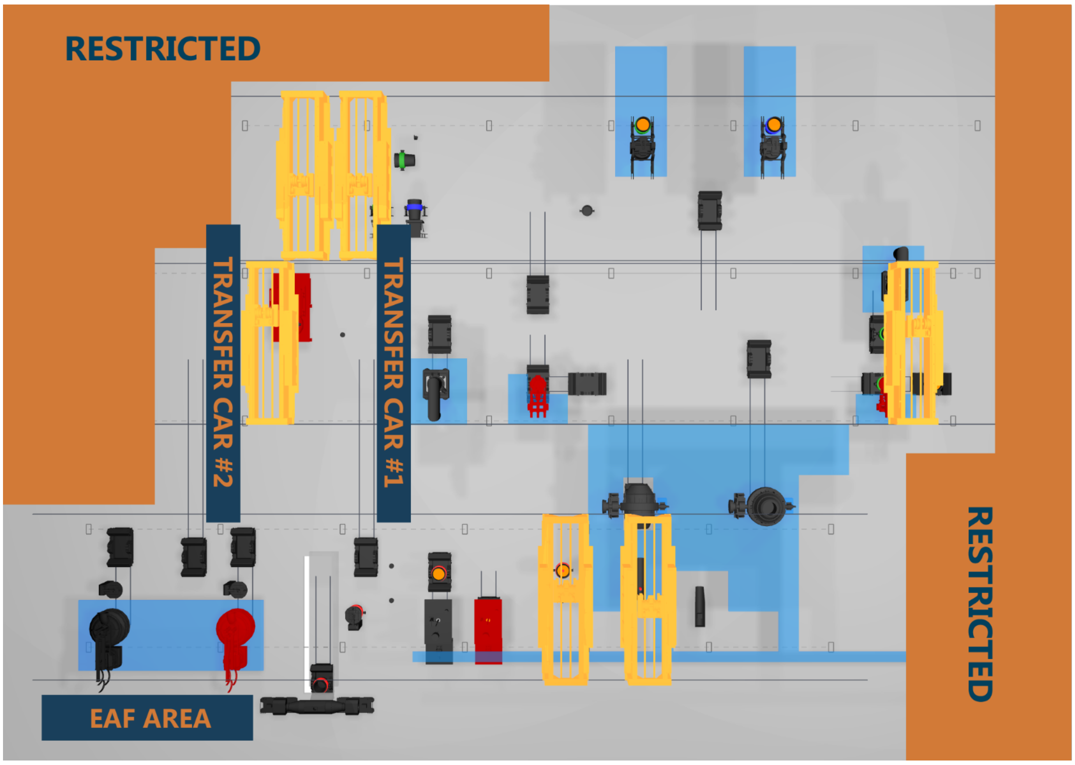


Figure 3 – *Melt Shop, after Transfer Car alignment (Scenario D)*

Extensive analysis of the logistics reveals that the differing location of EAFs and BOFs create a **bottleneck at the transfer point** between the EAF area and the SecMet Bay. The cause of the bottleneck is the singular transfer car, which has to take care of all full and empty ladles alike. It’s impossible to transfer empty and full ladles at the same time. More specifically, the full ladles arriving in the SecMet Bay are not immediately transported because the cranes are occupied with other tasks and therefore not ready to take them off the transfer car, resulting in even longer stretches of waiting time for the ladles. This delays any transport of an empty ladle to the EAFs, resulting in the waiting time at the EAF.

By adding a second transfer car, which exclusively transports the empty ladles from the ladle maintenance area to the EAFs, the first transfer car is freed up to smoothly transfer the full ladles for further processing. Consequently, in Scenario D the **target productivity can be reached**.

Table 1 (cf. page 6) summarizes the differences and KPIs of all four production scenarios. Notably, the increase of Time steel in ladle and Crane Utilization in SecMet from the base scenario A remains for all three following scenarios. This is due to the off-center position of the EAFs and the longer transport times that result from that.

SCENARIO		A	B	C	D
Characteristic		2 BOF	2 EAF	Scenario B + 2 Ladles	Scenario C + add. Trans. Car
Target Heats, total (arrived at CCs)	*heats*	72			
Productivity, avg. (based on CCs)	*heats/day*	72	66	68	72
Tap to tap time, avg. (incl. logistics waiting times)	*min*	40.1	43.5	42.2	40.2
Waiting time of empty ladle; avg.	*min*	0.2	3.4	2.4	0.3
Steel ladles in cycle, max	*number*	10	10	12	12
Time steel in ladle, avg.	*h*	2.25	2.49	2.52	2.42
Crane utilization in SecMet	*%*	68.7	74.1	75.5	72.2

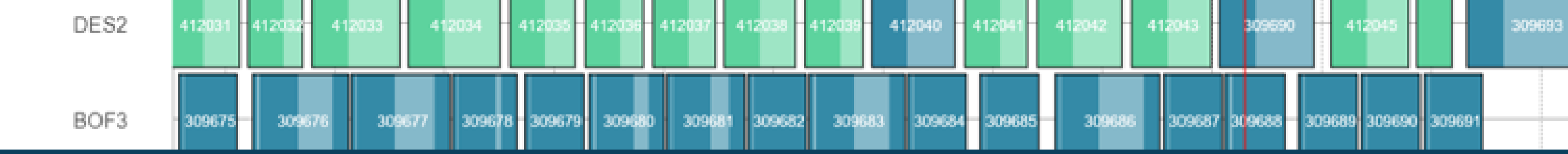
Table 1 – *Base Data and Logistics KPIs for all four Scenarios*

FESIOS CONCLUSION AS POTENTIAL STARTING POINT

In the coming decade, the pressure to **become** as **climate neutral** as possible will only continue to increase. Therefore, the switch to steelmaking methods that result in lower CO_2 emissions is unavoidable. While this case study was largely over-simplified, it gives a glimpse on the changes caused by the replacement of two LD converters with two EAFs.

Through meticulous analysis and adjustment throughout the simulation cycles, the **bottleneck point within the layout was found and resolved**. As a result, the target productivity – the original productivity from the base scenario – could be reached in the new layout.

However, while the same productivity can be reached through only a few changes, the new layout still requires two more ladles and causes higher durations of liquid steel in the ladles. Therefore, the resulting maintenance workload of the ladle refractory **may impact production costs** negatively.



SIMULATION SUCCESS TRIANGLE

CONSULT THE DIGITAL MELT SHOP

Often, the employment of logistics simulation in steel plants develops into prolonged and complex projects that demand far more customer involvement than anticipated.

Studies indicate that current project duration is approximately about 6-8 months. However, two thirds of that time is used for model creation and adaption of customer logic, while only one third or less is really used on creating business intelligence.

This development is rather contrary to highly common **customer expectations**:

- Speedy project execution
- Accurate translation of reality into the simulation
- Quality of the simulation
- Cost effectiveness of the project

Meeting those expectations requires a **high level of expert knowledge** about the logistical processes within the melt shop as well as a **high degree of modelling ability**.

This corresponds with our own experience from execution of several simulation projects for steel plants. Three factors have to come together to ensure a project's success:

- Domain specific **Know How**
- The right **Simulation Tool**
- **Data Visualization** customized to steel makers

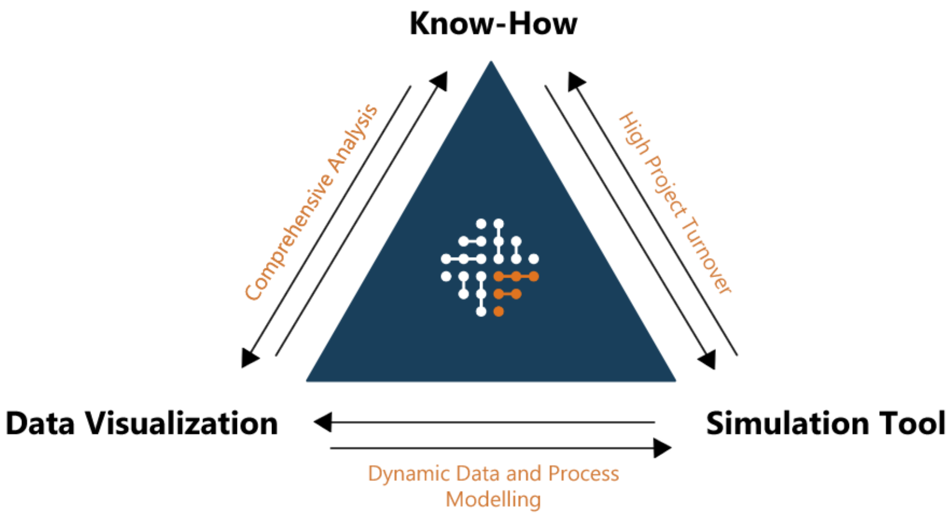


Figure 4 – *Fesios Success Triangle)*

Only when steel makers and-or consultants master all three domains, the application of simulation for production and logistic related studies will become the default method in this field.

To meet future demands, Fesios GmbH has developed the **Digital Melt Shop (DMS)**, a specialized Production and Logistics Simulation tool, which is dedicated to Steel Plants and is currently offered within the constricts of Fesios' highly specialized consultation service.

Know-How:

- The team of Fesios is headed by a group of metallurgical specialists, who already understand the inner workings of steel plants! Our focus is not on how a plant works, but on **what makes your steel plant unique**!
- Spend little time on modelling the simulation – instead, **focus on analyzing the results** in detail for most of the project!
- As a result, Fesios guarantees fairly **short project turnovers**!

Simulation Tool:

- The Digital Melt Shop is **designed and optimized** to be a tool to simulate steel plant logistics!
- The software library contains all common melt shop machines and equipment. No matter your layout, **Fesios already has the building blocks** to model it!
- **Your Data stays your data**! With our free Project Viewer, you can review the results of the simulation at any place and at all times, even after project conclusion!

Visualization:

- The Digital Melt Shop offers 3D Animation of your melt shop processes to create a **realistic understanding of the movement within the melt shop** and to minimize the risk of equipment collisions.
- Take advantage of the Digital Melt Shop's **dynamic Data Visualization**, which adjust immediately to any change within the simulation and allow fast and comprehensive insight into the simulation results.
- **Optimize your logistics processes** by adjusting the dynamic Gantt chart, which models the entire manufacturing process!

With the support of these three cornerstones, Fesios has successfully advised customers such as **voestalpine GmbH**, **sms-group GmbH** and **Metinvest** in problems similar to the earlier case study.

Fesios and the Digital Melt Shop cannot make your decisions for you – but the simulation results and our analysis of them can serve as baseline to find the right parameters for your successful steel plant production flow (re)design!

LET'S FIND YOUR BASELINE

Visit our website or email us for additional information or to answer your questions on our products and services! **We are here to help!**

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