FFG
Promoting Innovation.

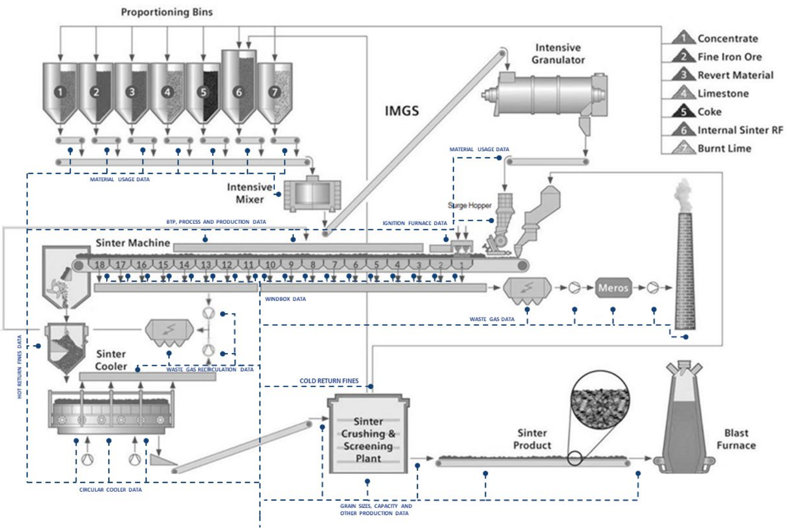
SUCCESS STORY

Pro²Future
Products and Production
Systems of the Future

Programme: COMET – Competence Centres for Excellent Technologies

Programme line: COMET-Centre K1

Type of project: SINPRO (Predictive Maintenance for Production Env.)
2,5 years, multi-firm



SINTER PRODUCTION IMPROVEMENT

A FORECASTING MODEL-BASED DISCOVERY OF CAUSAL LINKS OF KEY INFLUENCING PERFORMANCE QUALITY INDICATORS IN SINTER PRODUCTION

Sintering is a **complex** production process where the process stability and product quality depend on **various parameters**. Building a forecasting model improves this process. Artificial Intelligence (AI) approaches show **promising results** in comparison to current physical models, although often considered as black-box models because of their hidden layers. Due to their complexity and **limited traceability**, it is difficult to draw conclusions for real sinter processes and improve the physical models in a running plant. This challenge is addressed by focusing on **detecting causal links** from **AI-based forecasting models** in order to **improve** the **understanding** of **sintering** and **optimizing** existing **physical models**.

In the first step a **forecasting model** was developed to predict the **harmonic diameter** as a central **quality parameter** indicating the grain sizes distribution of the finished sinter. This forecasting model is a **ML** (machine learning) **regression model** based on the **Random Forest** ensemble method. Additionally, approaches such as **Support Vector Machine** regressor, **Multilayer perceptron** and **K Nearest Neighbours** regressor were evaluated. After an optimization step, the model showed a normalized root mean square error of 8.9% (equivalates to 0.2mm) on the prediction of the **target value** (grain size), which is **beyond** state of the art.

The model with the **best performance** was too complex to be interpreted and despite not being a black-box model per se, a control strategy or a new production insight was difficult to infer (see Figure 1). Hence, in the second step, a discovery interview was conducted with the **domain experts** to gather domain knowledge about the use case as well as materialize **implicit knowledge**. More specifically, the diagram of influences was developed as a rough approximation. Finally, the approach was verified through **Visual Analytics** and a **Forecasting Model Analysis** gave an additional insight into the model and its **decision basis** (see Figure 2).

Federal Ministry
Republic of Austria
Climate Action, Environment, Energy, Mobility, Innovation and Technology

Federal Ministry
Republic of Austria
Digital and Economic Affairs

SUCCESS STORY

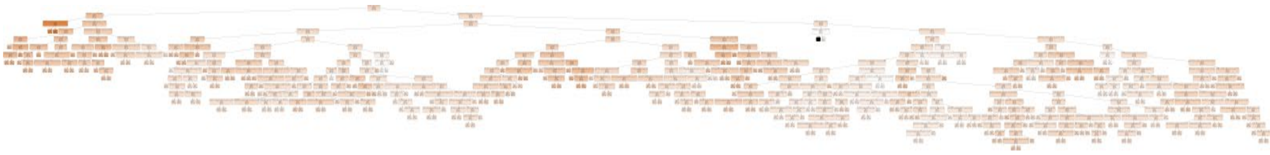


Figure 1: One out of 255 estimators (decision trees) of the Forecasting Model, showing the complexity of the inference model.

Modeling and understanding **interdependencies** in a production process was traditionally tackled through different **first-principle models**. Building these models required profound understanding of the nature of the processes and conducting **randomized controlled experiments**.

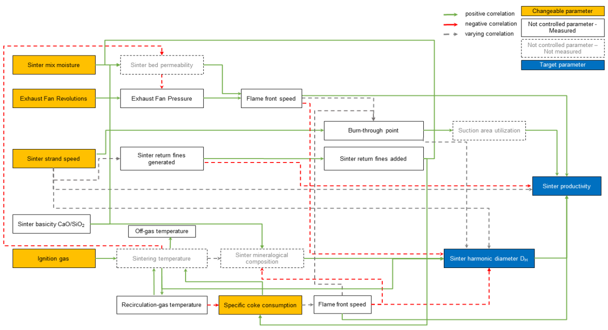


Figure 2: Diagram of influences in the sinter production process

In the sinter plant operation, the **process stability** is paramount which makes large scale experiments impossible to conduct (e.g., breaking the production, requirements for high process stability, supply chain dependencies etc.). Applying our approach **enabled gaining these crucial insights** in a non-obstructive way through analysis of observational data.

Impact and effects

The findings of the project take direct effect in the **production improvement** of **running sinter plants** and show **promising results** in the **prediction** of the **harmonic diameter**, therefore **increasing production** outcome while keeping **high quality** of the **sintered material**.

Applying the developed approach and building a **machine learning model** provided a **detailed insight** into main influences of the **sinter quality** and was used as a basis for a **holistic approach** in which additional models were built and utilized to further **maximize** the **output** and return fines for replacing the added coke in the process.

The results have been published in several conferences and in the renowned **AISTech Journal** of Iron & Steel Technology in March 2021 (details via http://digital.library.aist.org/iron-and-steel-tech.html).

Project coordination
DI Dr. Belgin Mutlu
Area Manager
Pro2Future GmbH

T +43 (0) 316 873 – 9163
belgin.mutlu@pro2future.at

Success Story by
DI Dr. Markus Jäger, MLBT
Center Communications Manager
markus.jaeger@pro2future.at
Matej Vukovic, M.Inf.
Researcher
matej.vukovic@pro2future.at

Pro2Future GmbH
Altenberger Straße 69
4040 Linz, Austria

T +43 (0) 732 2468 – 4783
office@pro2future.at
www.pro2future.at

Project Partner

- Primetals Technologies Austria GmbH
- Graz University of Technology, Austria
- Johannes Kepler University Linz, Austria

Pro²Future is a COMET Centre within the COMET – Competence Centres for Excellent Technologies Programme and funded by BMK, BMDW, Upper Austria and Styria. The COMET Programme is managed by FFG. Further information on COMET: www.ffg.at/comet