

Pro²Future :: Cognitive and Sustainable Products and Production Systems of the Future

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Image: magazine.primetals.com

HUMAN-CENTERED ANALYTICS FOR SMARTER METALLURGICAL PROCESSES

FAST AND INTUITIVE PATTERN SEARCH SUPPORTING KNOWLEDGE DISCOVERY IN INDUSTRIAL SENSOR DATA

Modern metallurgical production relies on **thousands of sensors** capturing every aspect of the process. Operators face a daily challenge: identifying the few decisive moments hidden in massive amounts of sensor data. When an unexpected event occurs - be it a velocity spike, a thickness oscillation, or a subtle instability - the key questions remain the same: **Has this happened before?** Under what conditions? And what corrective action proved effective? Traditionally, answering such questions has necessitated painstaking **manual inspection** of historical data.

In corporation with Primetals Technologies, this project is set out to **fundamentally simplify this task**. The core idea is not to create another opaque analytics tool, but to design a solution that directly **strengthens operator expertise**. The result is a human-centered subsequence search system that allows operators and process engineers to find similar events in historical data simply by marking an example pattern on the

screen. Instead of configuring complex parameters or deciphering model outputs, users interact with familiar process signals - visually, transparently, and intuitively.

The workflow aligns closely with the way experts already think. A user selects a section of data that represents the phenomenon of interest. The system then searches thousands of historical products and returns similar patterns, even when they occur at different speeds or under different temporal alignments. Results appear in a **ranked and explorable form**, allowing operators to compare multiple occurrences, validate hypotheses, and understand which interventions previously stabilized the process. This makes root cause analysis and knowledge reuse **significantly faster and more reliable**.

One of the central achievements of the project is ensuring that the system works under real industrial conditions. In cold rolling, many sensor signals remain intentionally stable for long stretches of production -

SUCCESS STORY



precisely the type of data where conventional search methods struggle, often mistaking minor sensor noise for meaningful events. By specifically addressing this “noise amplification” phenomenon and integrating robustness measures tailored to quasi-constant signals, the solution avoids false alarms and presents only physically relevant matches. This **reliability** is essential for **operator trust** and **day-to-day usability**.

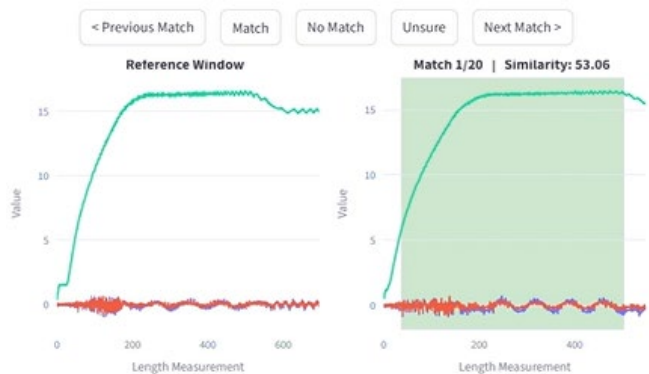
Performance is equally important. The system is designed to support interactive exploration, not offline analysis. Even large, high-resolution datasets can now be searched in seconds, which is critical for live troubleshooting and on-shift decision-making. The planned integration into TPQC ensures that these capabilities become available exactly where operators already work, **without additional tools or training overhead**.

The tool was evaluated in collaboration with domain experts and received **consistently positive feedback**. It was perceived as both **easy to learn** and trustworthy in practice. Operators highlighted that the visual and transparent presentation of results enables them to retain **full control over interpretation**, an aspect they often find lacking in highly automated or model-driven solutions. Rather than replacing expert judgment, the system reinforces existing expertise by bridging individual intuition with the plant’s accumulated operational knowledge.

Beyond its immediate benefits, the solution also contributes to **knowledge retention across teams** and

shifts. Recurring issues that might otherwise remain anecdotal become discoverable patterns. Troubleshooting no longer depends on individual memory but becomes a **structured, repeatable process**. This supports more consistent decision-making, particularly in complex cases such as hydroplaning events in steel production or process instabilities in aluminum thickness control.

The dashboard - shown in the image below - provides an intuitive interface through which users select query windows, inspect found matches, and evaluate based on the similarity scores. Its design ensures that even complex multivariate data remains easy to interpret, making the system suitable for both experienced specialists and less frequent TPQC users.



Pro2Future GmbH
Altenberger Straße 69
4040 Linz, Austria

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

Scientific Director
Univ.-Prof. Dr. Alois Ferscha
alois.ferscha@pro2future.at

Projektpartner

- Primetals Technologies GmbH, Österreich

Success Story by
DI Thomas A. Kristan
thomas.kristan@pro2future.at


DI Dr. Belgin Mutlu
Area Manager
belgin.mutlu@pro2future.at

Center Communications Manager
DI Dr. Markus Jäger, MLBT
markus.jaeger@pro2future.at



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 Federal Ministry
Innovation, Mobility
and Infrastructure
Republic of Austria

 Federal Ministry
Economy, Energy
and Tourism
Republic of Austria

Austrian Research Promotion Agency
Sensengasse 1, A-1090 Vienna
P +43 (0) 5 77 55 - 0
office@ffg.at
www.ffg.at