Improving Productivity Of Steel Cold Rolling With Time Series AI

How automated weld and strip break classification led to productivity improvement in ArcelorMittal's tandem steel cold rolling mill

Overview

Cold rolling of sheet steel is one of the most common steel manufacturing processes in the steelmaking value chain. To maximize profitability and keep up with ever-increasing demands, cold rolling needs to be a continuous 24/7 non-stop process. One of the major impediments that can cause rolling to come to a halt is the occurrence of strip breaks. These are physical tears that cause the steel sheet to break apart as it passes through the rollers of the cold rolling mill. The breaks are caused by a variety of reasons such as weak welds, surface defects, the tensile stress exceeding tolerance limits, among others. The challenge here is that when a strip break occurs, it is immensely difficult to diagnose the cause and address it in a timely manner. Root cause analysis and classification require manually extracting collected data on tension, current, torque, and other parameters leading up to the break, and then applying human interpretation to these signal traces from multiple systems. This has compelled steelmakers such as AM/NS Calvert (a joint venture between between ArcelorMittal and Nippon Steel Corp) to explore technologies that can automate this time and resource-intensive process.

Negative Impact of Strip Breaks

- Dozens of weld and strip break events each month cause 3-4% (10-15 days) of lost production each year, amounting to $3.5 M in losses
- Such events take up 20% of SME time weekly – spent in root cause analysis
- Classifying a strip break typically requires 8-man hours a week of a skilled data or process engineer at a cost of $100 K/year

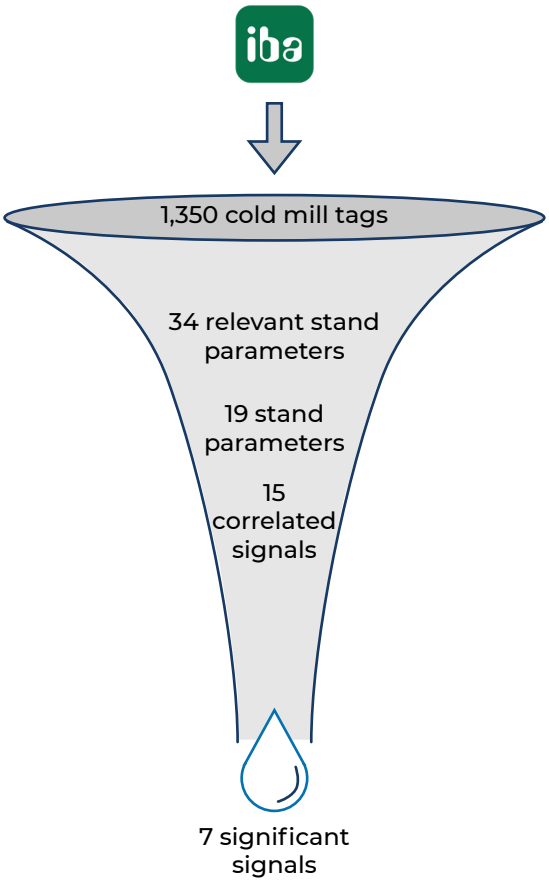
Falkonry Impact

- AI was leveraged to reduce the occurrence of strip breaks and the manual data analysis effort that goes into classifying them
- The automated classification workflow resulted in a 1% production improvement valued at $1,000,000 per year and a 20% reduction in SME man hours with a financial impact of $40,000 per year.

Falkonry Approach

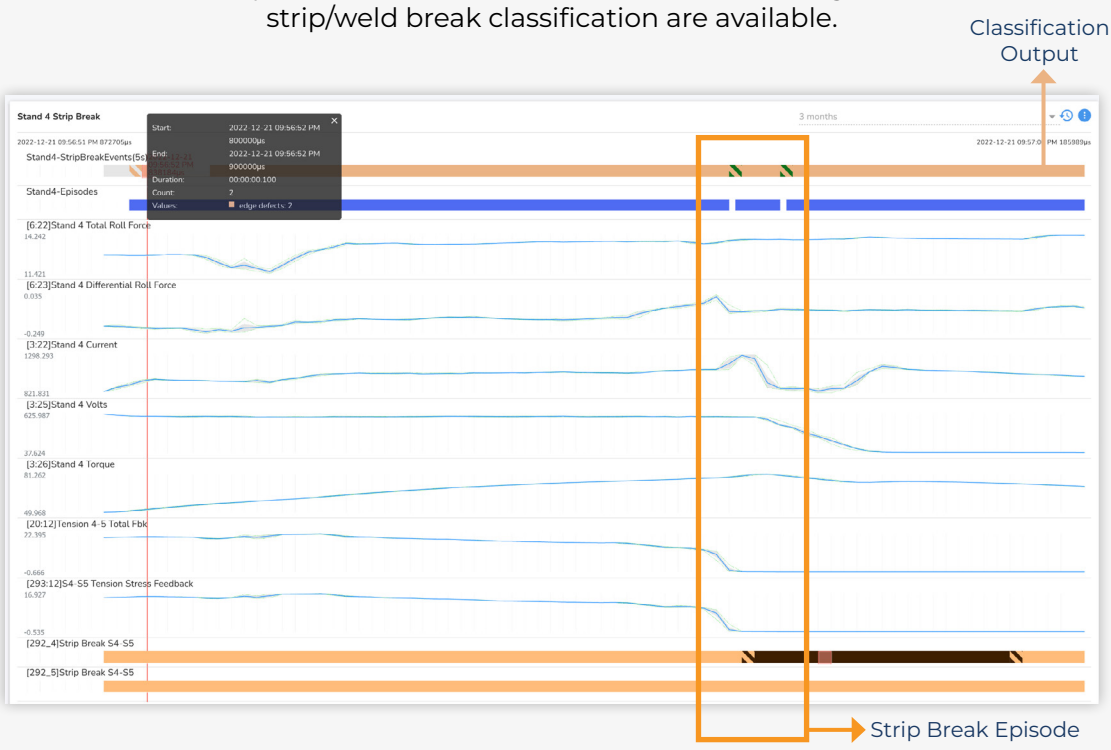
1. Data ingestion

- Sensors capture hundreds of process variables from the rolling mill stands every 10 milliseconds. This PLC data **seamlessly flows** into Falkonry through its integrated **connectivity** with the **iba system.**
- The data ingested contained both operational and non-operational parameters, detailing steel grade, width, and thickness. This dataset, encompassing historical strip breaks and ground truths, served as the foundation for **training and validating** the classification model.
- Two rolling stands (no. 3 and no. 4) were chosen based on the frequency and number of strip breaks available for model training. A classification model was trained for these stands and upon validation, the model was put into **live operation for real-time classification**.



Individual Classified Break On Stand 4

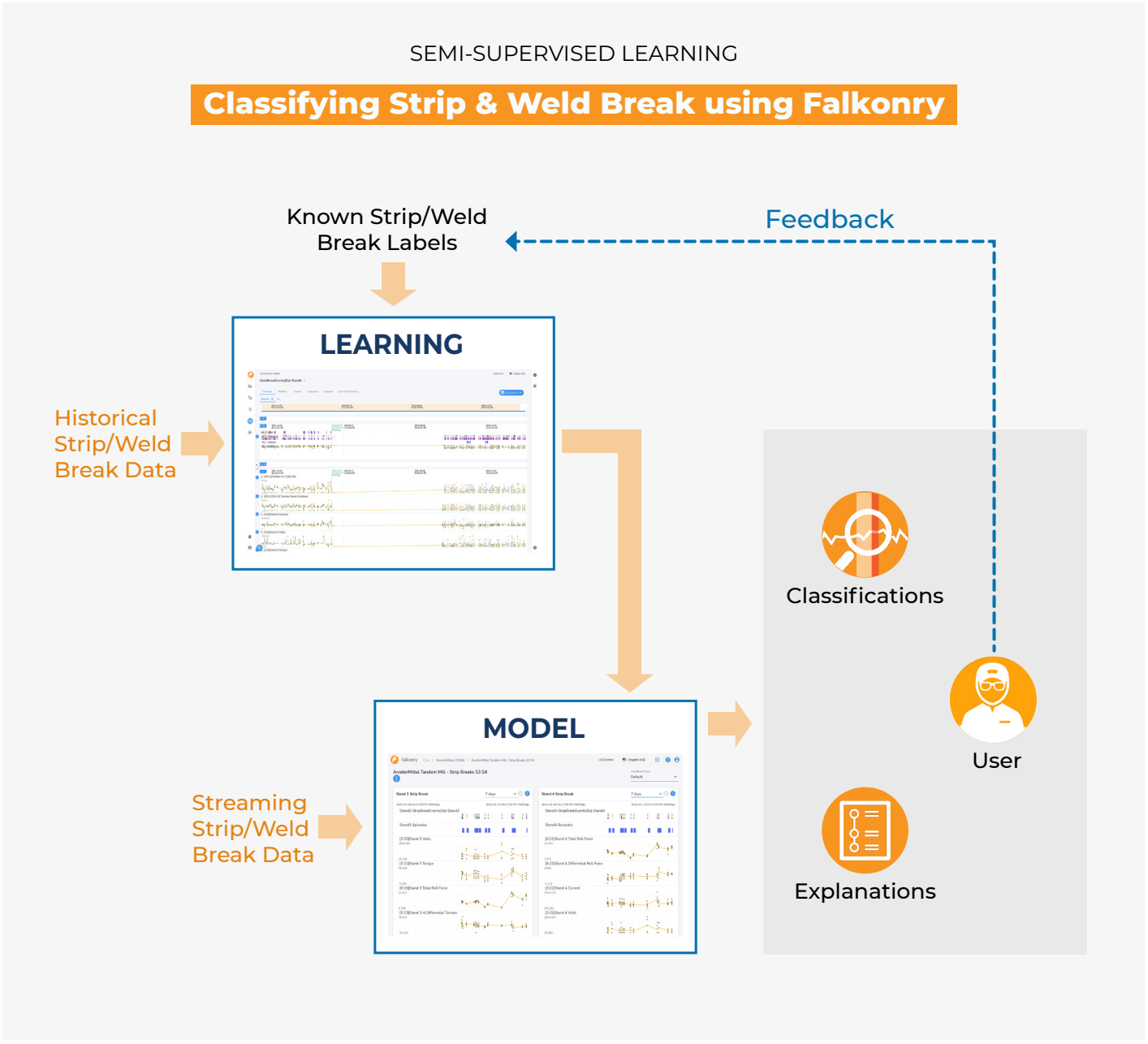
Episode view where more details about a single strip/weld break classification are available.



2. Learning & Model creation

When a live strip break occurs, data 10 seconds before and 5 seconds after the break for all signals of all mill stands, gets packaged as a parquet file and sent to Falkonry in near real-time. Soon after ingesting this parquet file, Falkonry's live models produce strip break classification output in the form of cards within a customized dashboard. Each card displays the signals used in the model as well as the indicator signals that denote whether it is a strip break or weld break.

For each strip break instance, Falkonry provides the analytical tools to compare the selected strip break's distributions to other existing classifications both in the value and frequency domain for comparative analysis. Falkonry also provides the ranked contribution scores of model signals for this strip break. These contribution scores help diagnose and pinpoint the cause and number of occurrences of a particular type of defect.



Results

- By having a near real-time window into the causes of strip breaks, process engineers reduced the occurrence of breaks by making upstream parameter changes. In turn this made a significant dent in the $3.5 million lost to this issue every year.
- The automated classification resulted in a 1% production improvement. This translates to a financial impact of $1 million per year.
- Automating strip break classification resulted in a 20% reduction in the workload of a full-time subject matter expert, leading to annual cost savings of $40,000.
- A Smart Manufacturing Profile (structured information model) for the tandem cold rolling mill was created with an accuracy of 85.6%. This SM Profile can be utilized to make deployment across other mills easier, improving the scalability of the solution using transfer learning.

Advantages

- ☑ Off-the-shelf nature makes for faster deployment
- ☑ Records tacit knowledge of subject matter experts
- ☑ Versatile solution, leads to competency development

Acknowledgements

This project was a collaboration between CESMII – The Smart Manufacturing Innovation Institute, Falkonry and ArcelorMittal Nippon Steel Calvert and ArcelorMittal Global R&D. The project was selected under the CESMII Roadmap Projects RFP3 initiative, supported by the Department of Energy, which aims to accelerate the adoption of sustainable and smart manufacturing practices in production operations.