Digital Transformative System for Pre-failure Alert Generation and Cobble Reduction based on Data and Video Analytics in BRM

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BSP Project

Under the Guidance of
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Problem Statement

Steel plants face sudden equipment issues that stop production and cause financial loss. One major issue is **"Cobble"** – when a hot metal piece gets misaligned and tangles inside the rolling mill.

This leads to:

- 🔧 Equipment damage
- 🕒 Production downtime
- 💸 Wasted material and loss

Why it happens:

- No real-time monitoring of key parts
- Operators only act *after* something goes wrong
- Delays in taking action increase the damage

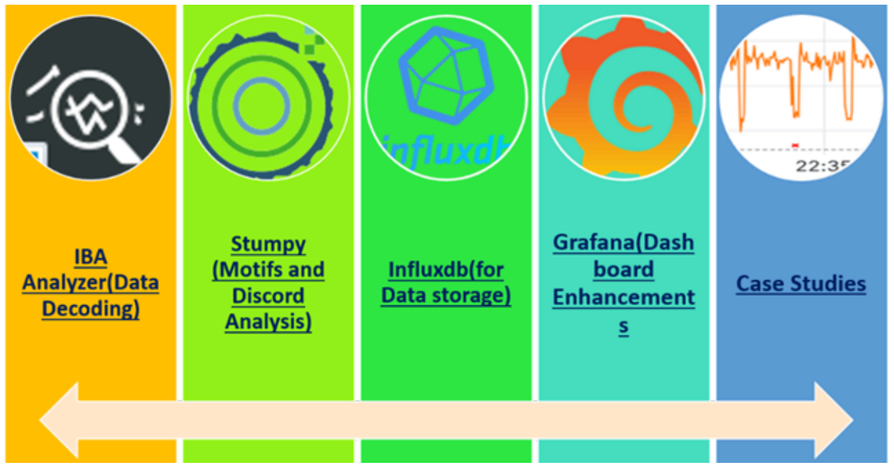
DATA DECODING

Here is a comprehensive summary of my Contribution to the Project.

we converted the mill data, originally in **.dat** format, into a more usable format for the models,
i.e. **.Parquet** format using Pandas
Finally Converting it into DataFrames. This was accomplished by decoding the data for the specified days using IBA Analyzer.

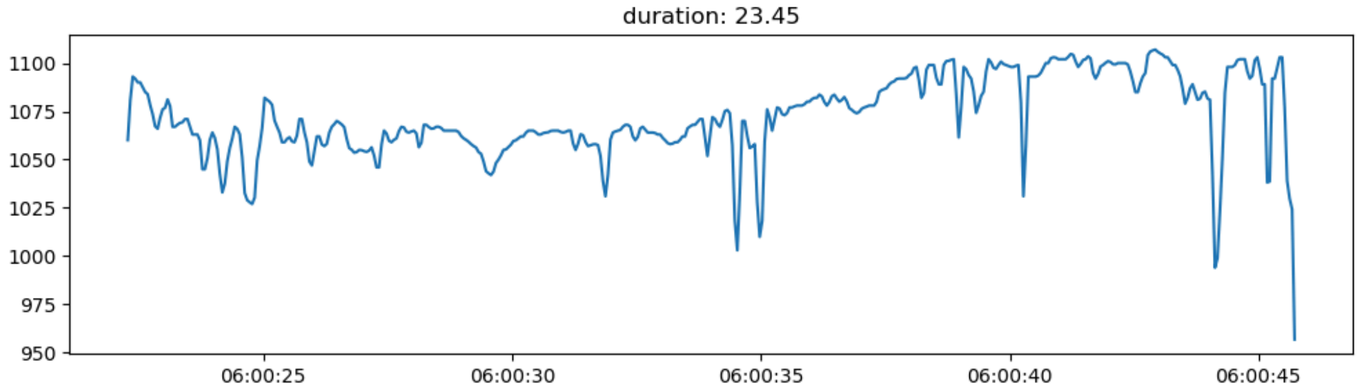
Records of Data Decoding

Month	Days
January	29 - 31
February	Feb 10, 2025
March	01 - 10, 23 - 31
April	Apr 8, 2025



PYROMETER BASED ALERTS

- **Data Acquisition and Exploration:**
  - Collect and examine historical pyrometer and billet data from the BSP rolling mill. Identify relevant signals (e.g. temperature at various stands, HMD triggers) and understand their semantics.
  - The BSP system records a wide range of signals from the reheating furnace and rolling mill. Key signals for this project included pyrometer temperatures and HMD triggers. For instance, a channel named [13:0]_STAND 1 ENTRY BILLET TEMPERATURE corresponds to the optical pyrometer reading at the entry of stand 1 (just after the furnace) – essentially the hot billet temperature entering the first rolling stand. Another channel, [9.10]_HMD on Fce exit R.Table Exit, likely denotes a digital Hot Metal Detector (HMD) sensor at the furnace exit, indicating when a billet passes that point.



DATA HANDLING AND METHODOLGY

- ## Exporting .dat to Text/Parquet

Using IBA Analyzer's data extraction add-on, each .dat file was batch-exported to ASCII text and Parquet format. This step automated the conversion of IBA's binary data into standard formats. In practice, IBA Analyzer File-Extract tool allows "easy creation of files in ASCII format" and even directly to Apache Parquet. Parquet was chosen for its columnar storage, which is highly efficient for large time-series (it offers faster query performance and better compression than CSV).

- ## Loading into Pandas DataFrames

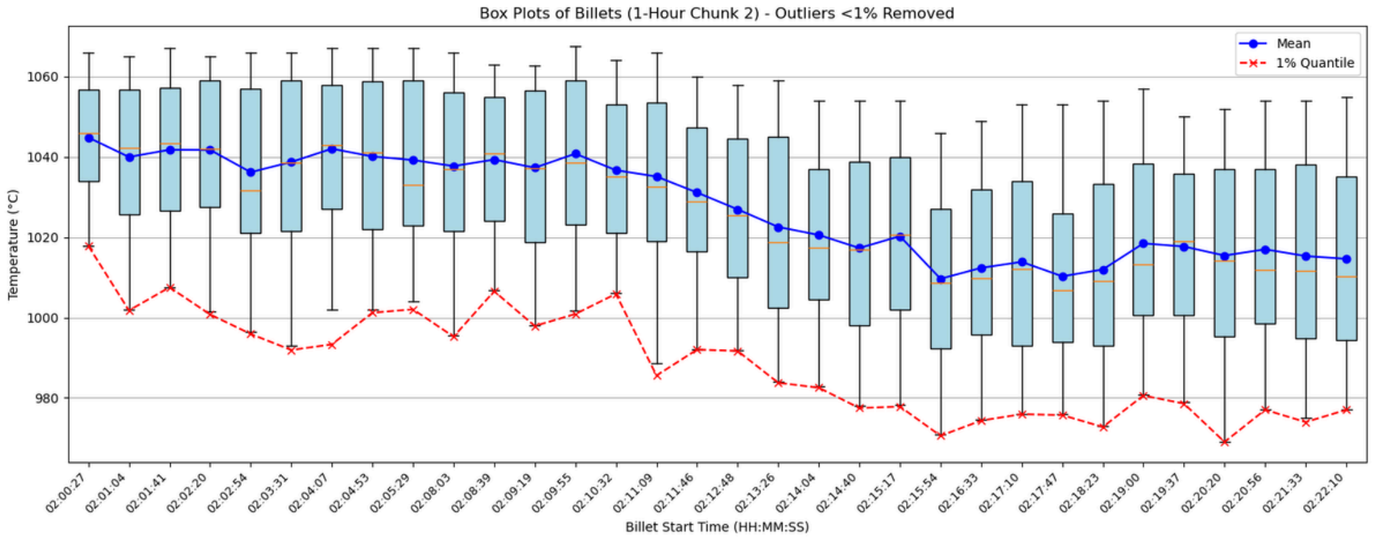
The text files were read into Pandas using pd.read_csv). For example, after exporting [13:0]_STAND 1, we used pd.read_csv('STAND1') to parse time and value columns into a DataFrame. Pandas can "read .dat files...and convert them into a structured form that is easy to analyze". Each signal (e.g. Stand1 entry temperature) became a column in the DataFrame, indexed by timestamp.

- # Data Cleaning and Alignment

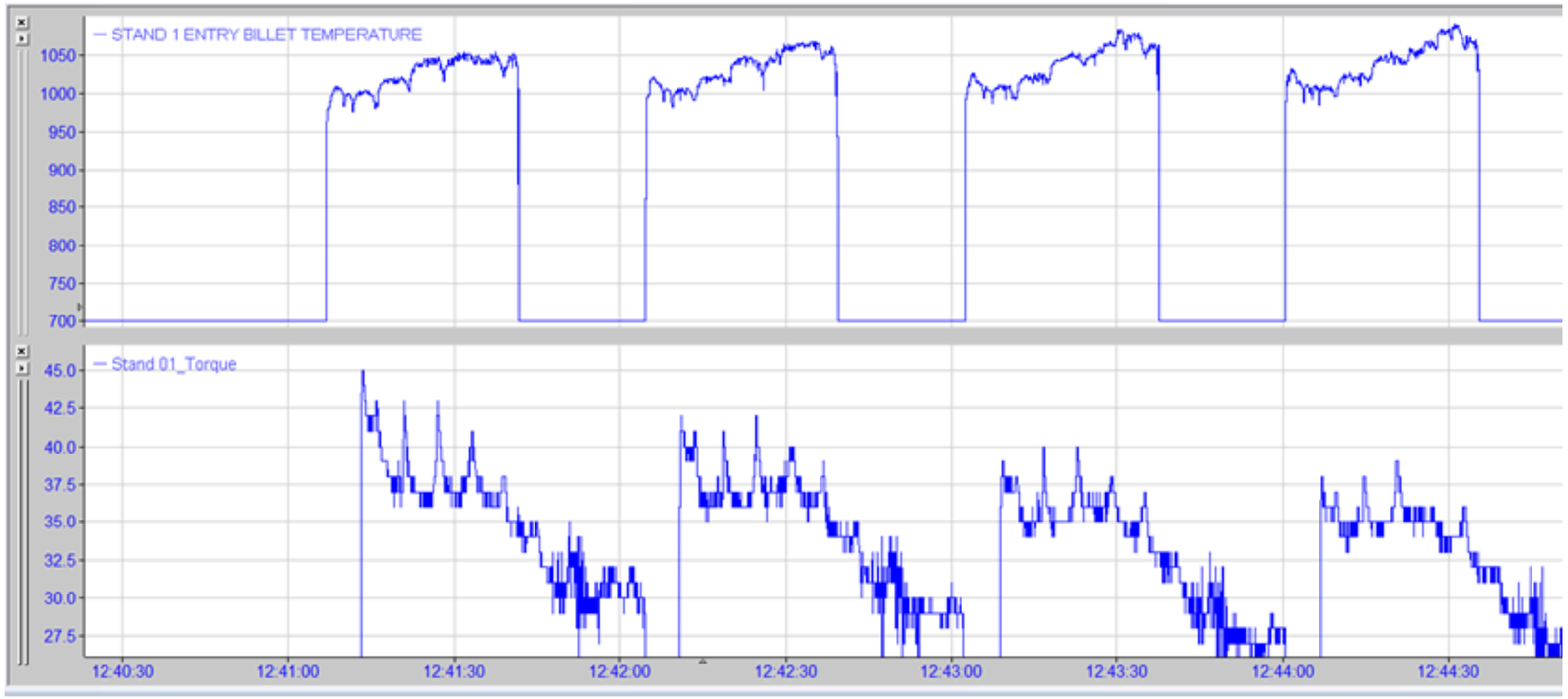
We inspected each DataFrame for missing or out-of-range values and applied basic cleaning (e.g. Truncation or interpolation for brief signal gaps, if needed). Signals from different sources (e.g. furnace pyrometer vs. HMD binary) were merged based on timestamps to create a master DataFrame per billet or heat.

- # Used BOX PLOT For Better Understanding

I used the Box Plot Visualization for Stand1 Entry Billet Temperature for Better Understanding of Statistical Values of Each Billet Over Specific TimeStamp.



Effect of Temperature Variations on Rolling Torque

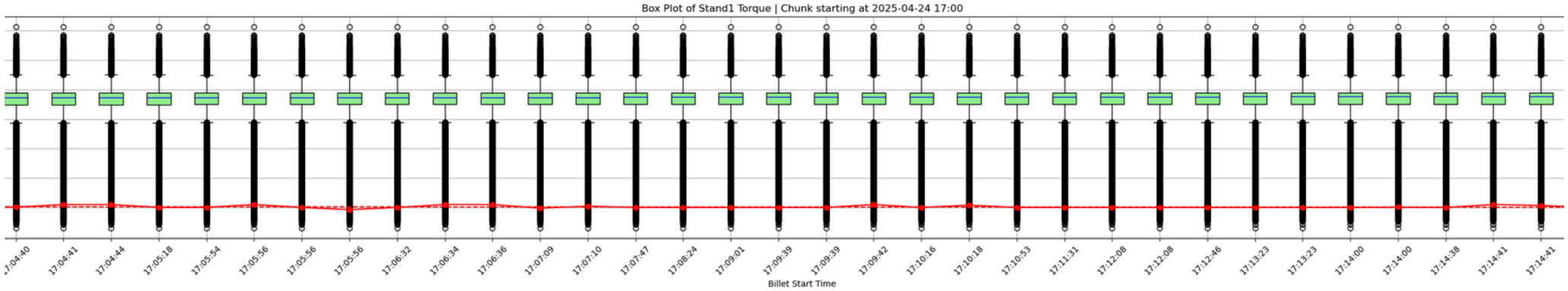


Progressive decrease in torque with higher billet temperatures – evidence of thermal optimization in rolling mill operations.

Solutions

we are trying to Correlate the Torque with the Temperature at Different Locations of the Mill in BSP.

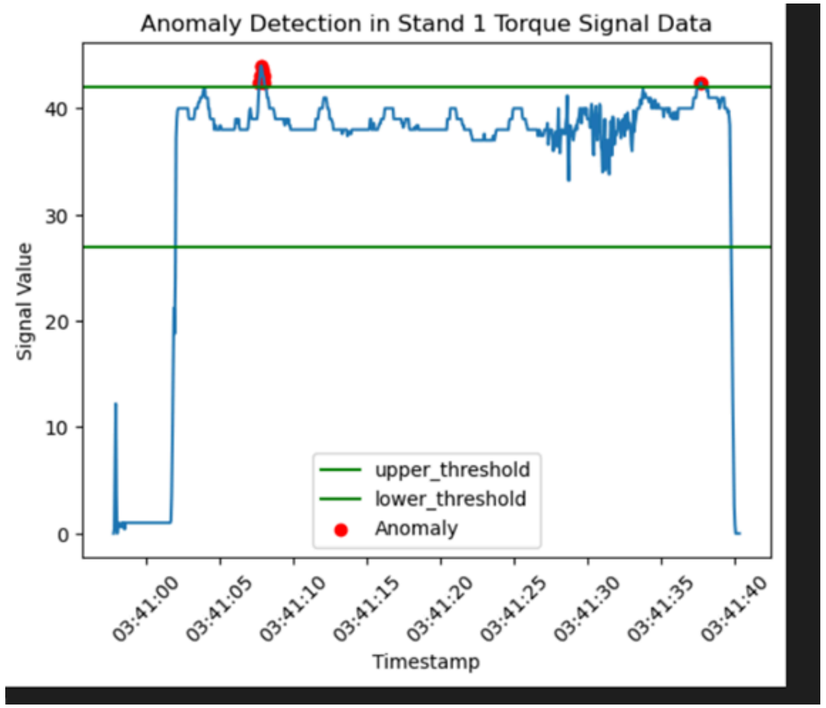
BOX PLOT Visualization of the TORQUE



Threshold Selection

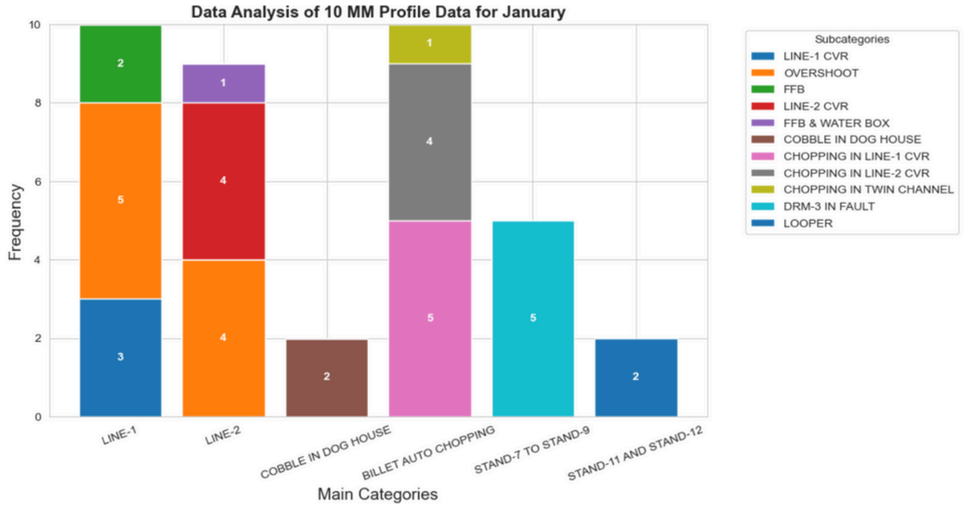
We Used Threshold Based Anomaly detection in Stand 1 Torque signal and Also The Stand1 Entry Billet Temp. using threshold logic derived from pyrometer-informed billet temperature analysis.

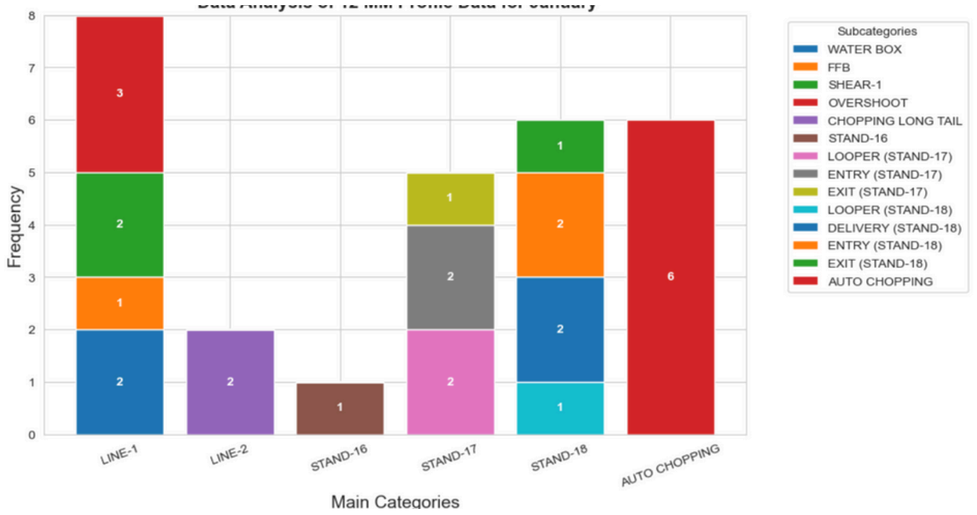
Also, Consulted with the Operator in the BSP For Specific Threshold Based Alerts.



Data Analysis of Failures on Monthly Basis

- ## Analysis of most Frequent Regions Failures





- **Tried to Analyze the Most Disturbed Regions and Equipment Failures Through Cobble Sheet Provided by BSP Operator**
- **Also Pre-Processing (Data Cleaning, Features Addition, Etc...) is Done Before the Analysis of the Cobble Sheet**
- **Required Actions are Taken Based on the Cobble Sheet Results as It also Includes Profile Changeover Dates**

Key Contributions and Learning in Other Projects

- **Action Recognition Based Industrial Safety CVA Dataset Model**

  An AI-driven system using YOLOv8 and DeepSORT on the CVA dataset to detect PPE compliance and unsafe actions in real time, enhancing worker safety in industrial environments via CCTV analytics.

  - **Research Paper Link:- https://arxiv.org/pdf/2412.05531** (Existing last Year Paper of Gagan Sir)

- **My Work:-**

1. Extracting the Raw Video of Steel Plant and Breaking the Video into Frames at 10fps or Sometimes at 30fps
2. Annotations of Each Frames Using LABELME Software and Saving Files in .Json Format for Further Usage
3. We Also make One Standard Action Dictionary for Annotation and Model Training
4. We used tools like CVAT for efficient bounding-box labeling.

- # PREDICTIVE QUALITY ANALYSIS OF BILLETS

A machine learning (Regression) model using pyrometer temperature and torque Statistical data to predict billet quality (UTS, YS) in real time, enabling early defect detection and improved control in steel rolling processes.

- **My Learning:-**

1. Learned about the Chemistry of the Billets and their Production Stats
2. Learned about Model Training and Evaluation
3. Industrial Data Handling and Correlation

My Overall Learning:-

- Data Science in Real Life
- Time Series Data Analysis
- Machine Learning Applications
- Gagan Sir DAV/DS250 Class (Activity Based Learning)

Thank You Everyone