Real-Time Data Integration and Predictive Modeling in BF-5 of ISP through Process Digital Twin

Presenter Details

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Academic Profile

- B.Tech (Computer Science & Engg.) NIT-Delhi

- Senior Manager (Computer & Automation)
- IISCO Steel Plant, Burnpur
- Steel Authority India Limited
- 10+ Years of Experience
- 20+ Papers
- 12 Copyrights (5 Granted + 7 Under Process)
- 2 Patents (Under Process)

RESEARCH INTERESTS

- Emerging Technologies in iron making
- Process Modeling
- Industry 4.0 & its role in steel manufacturing
- Carbon footprint reduction
- Green Steel

AREAS OF EXPERTISE

- Process Automation
- Blast Furnace Technologies
- Process Modeling
- Digital Transformation
- Industry 4.0
- Computer Programming

AWARDS & ACHIEVEMENTS

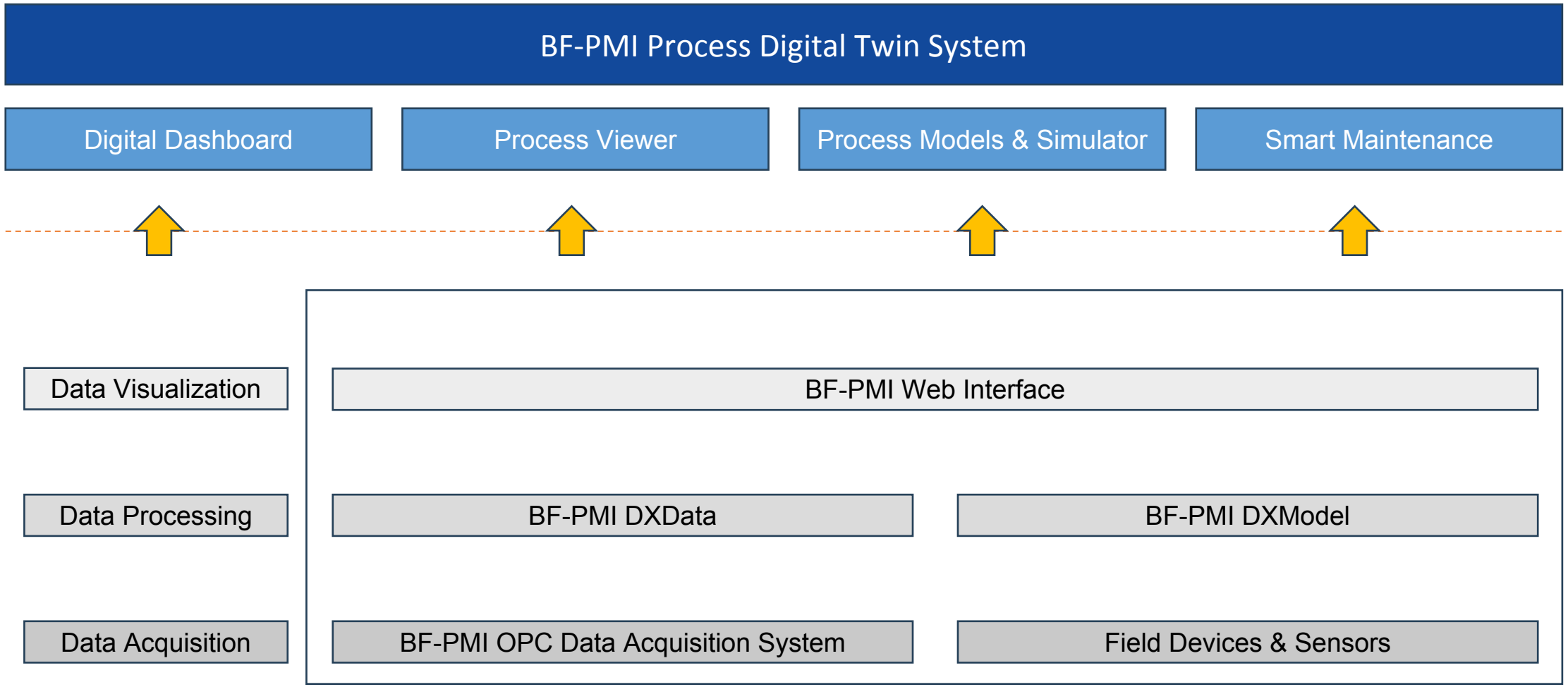
- SAIL-Corporate Excellence Awards 2021 under Innovation Architect for Digital Transformation Work in Iron making at SAIL-ISP
- Winner of Director's Cup for Young manager.
- CEO Excellence Award Winner
- Consecutive 7 years Jawahar Lal Nehru Team Award Winner.
- IIM ATM Best Oral Presentation Winner

Digital Twin: Introduction

- A digital twin is a virtual representation that serves as the real-time digital counterpart of a physical object or process.
- Type of Digital Twins:-
  - ✔ *Component Digital Twin*
  - ✔ *Asset Digital Twin*
  - ✔ *System Digital Twin*
  - ✔ *Process Digital Twin*

At **Kalyani Furnace (BF-5)** of ISP, our dedicated in-house team has developed and implemented a sophisticated Digital Twin system called as the "Blast Furnace Process Monitoring Interface" (BFPMI). This advanced system offers a comprehensive and integrated view of the entire blast furnace process. It features an enriched dashboard, an intuitive process viewer, and in-house implemented process models and simulators, all designed to improve operational efficiency and aid in decision-making.

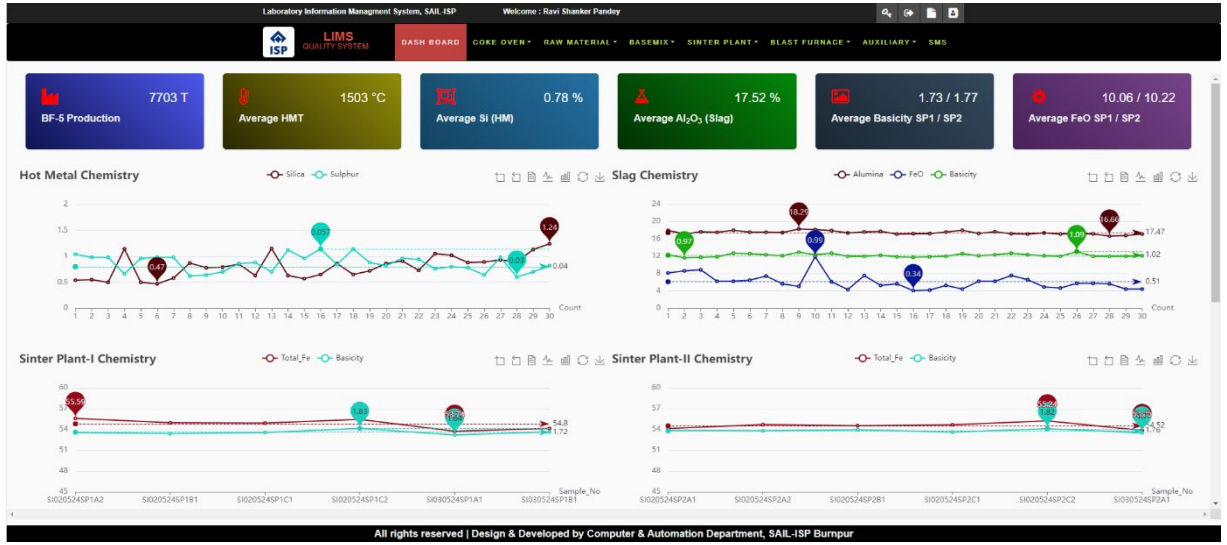
BF-PMI: Introduction



BF-PMI: Digital Dashboards

Digital Dashboards

- ✔ **Comprehensive Overview**: Provides a real-time snapshot of complete furnace operations through a single-page interface.
- ✔ **Data Consolidation**: Integrates data from multiple modules, presenting it in an intuitive and visually appealing format.
- ✔ **Key Parameters Highlighted**: Displays essential process, production, techno-economic, and quality metrics in one centralized location with enriching graphics.
- ✔ **Enhanced Monitoring:** With integrated dashboard for both Process & Quality it facilitates easy monitoring for concern personnel, enabling quick decision-making.



BF-PMI: Process Viewer

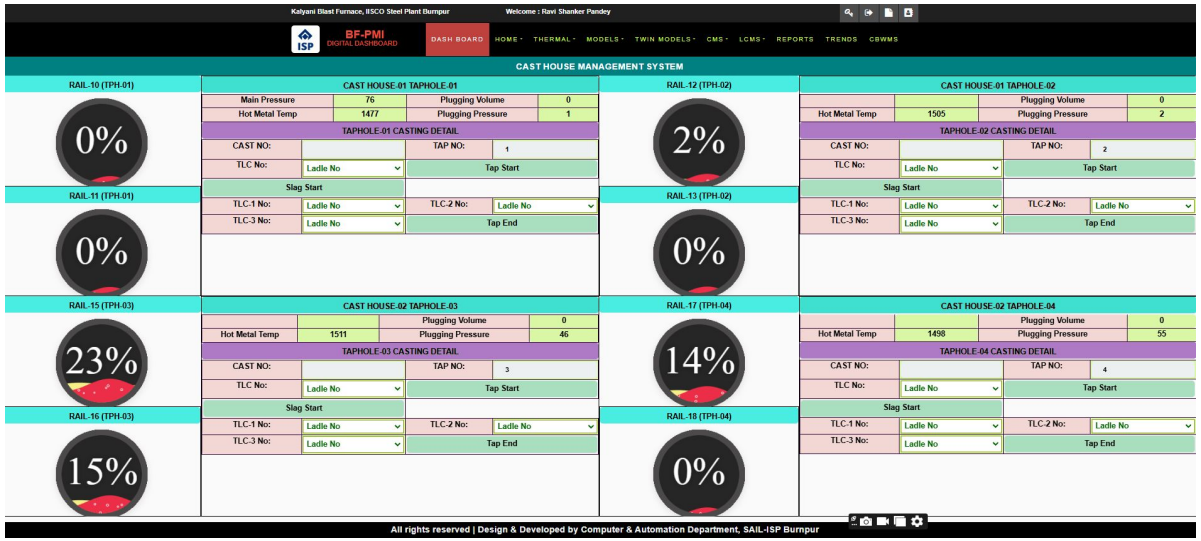
Process Viewers

- ✔ **Detailed Performance Tracking**: It provides detailed tracking of various Process through single point interface to monitor performance of various units within the blast furnace.
- ✔ **Comprehensive Coverage**: Incorporates detailed tracking of critical areas such as the furnace proper, stock house, cast house, stoves, SGP, GCP, CDI etc.
- ✔ **Real-Time Insights**: System provides real-time insight in different units of BF through BF-PMI-DXData module by taking feedback from various models and metallurgical calculations module.
- ✔ **Systematic Alerts**: Delivers timely notifications regarding various process events or anomalies, enhancing response efficiency.

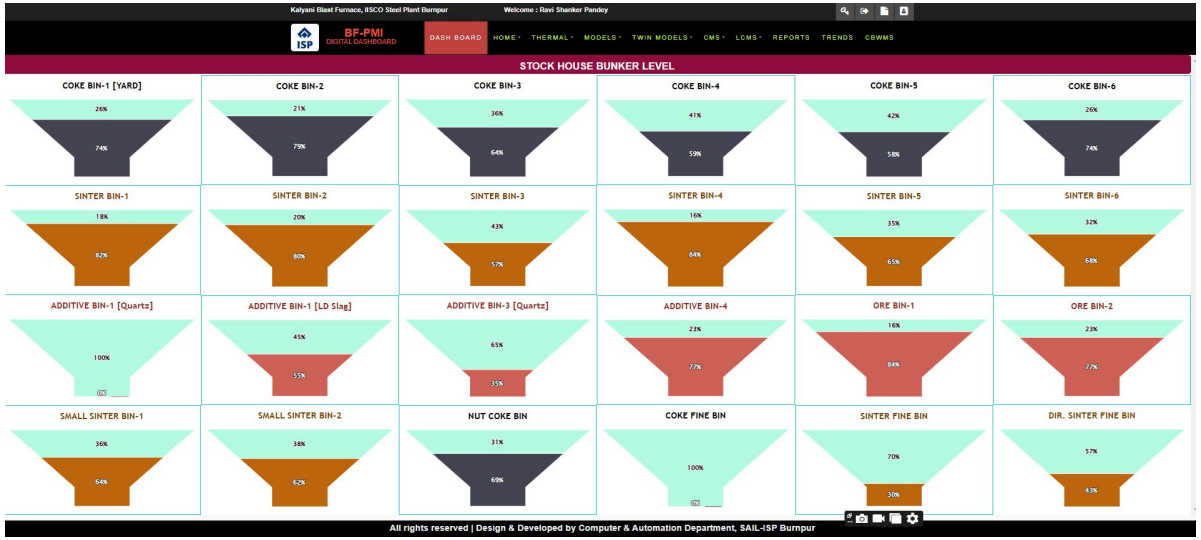
BF-PMI: Process Viewer

Process Viewers

- ✔ **Cast House Management**: The System connected with HM_Liquid Level Tracking Model helps in efficient casting practices by generating detailed casting reports and further connected with ladle management system to ensure cast-wise hot metal linking with SMS.



- ✔ **Raw Material Tracking**: The System track the movement of raw material in/outside the blast furnace. It tracks input material of Coke from COB, Iron Ore Additives from RMHS & Sinter from Sinter plant. As well as batch-wise charging material and fines generation in BF-5

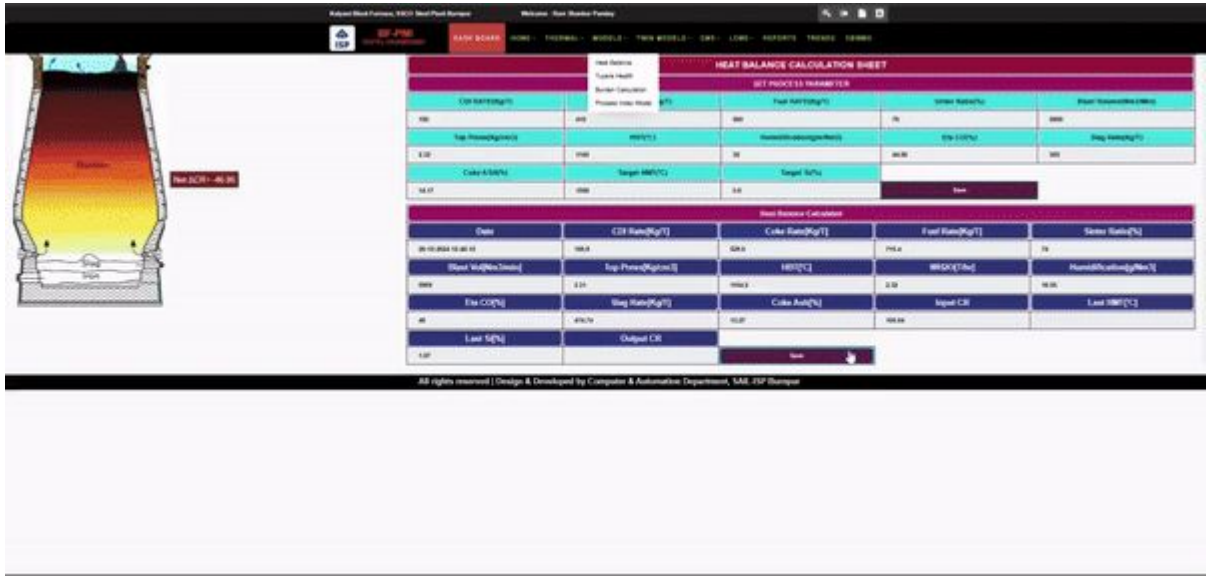


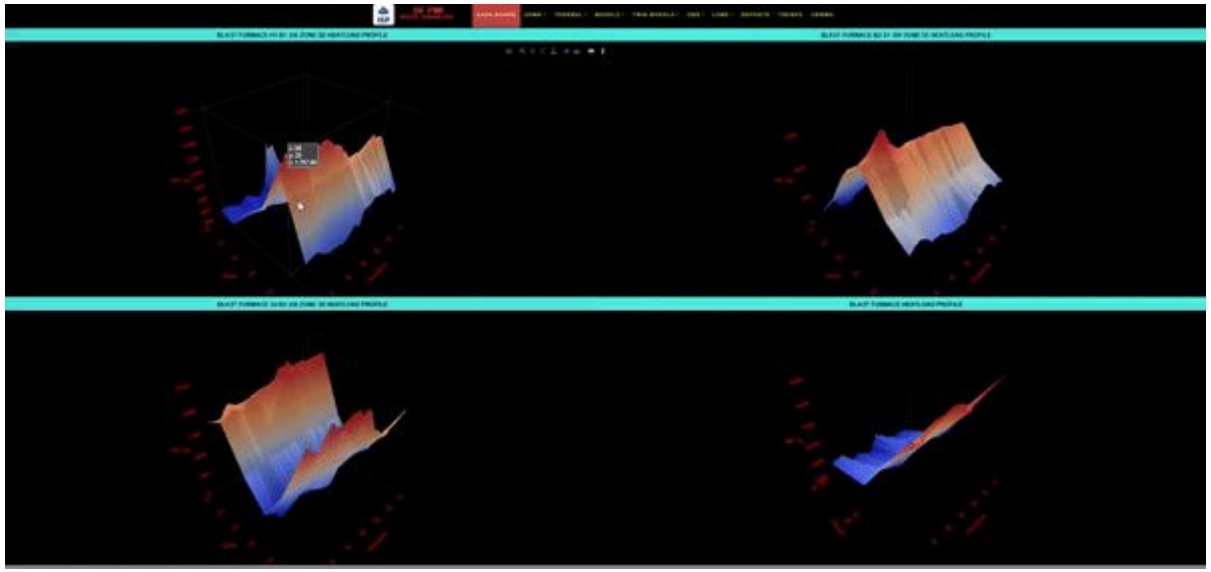
BF-PMI: Process Models

Process Models

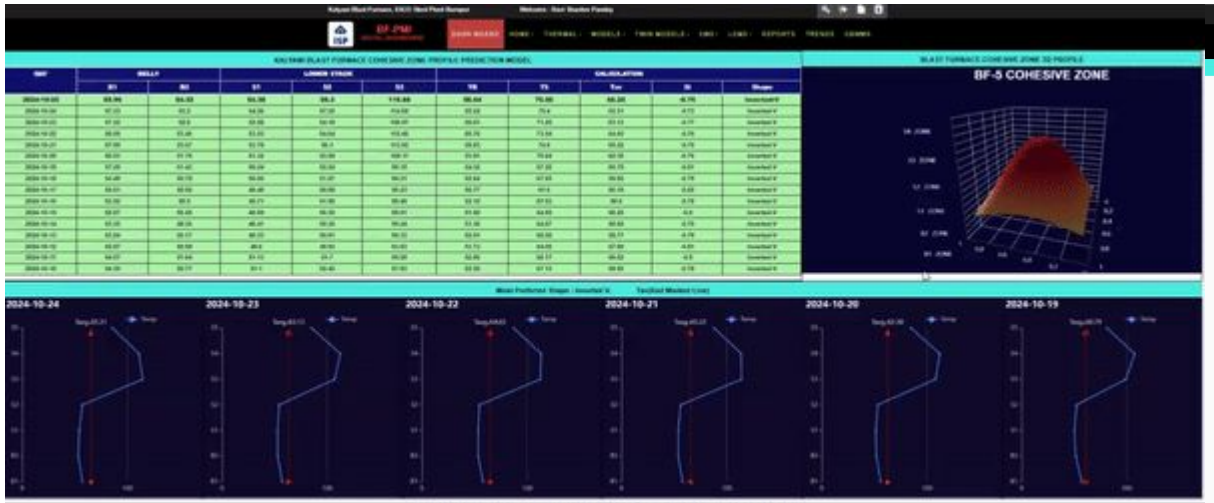
The BF-PMI System includes 11 In-house developed process models. The Models implemented in-house have been done based on the research and detailed study of the data and various process behaviours observed in operation of large blast furnace.

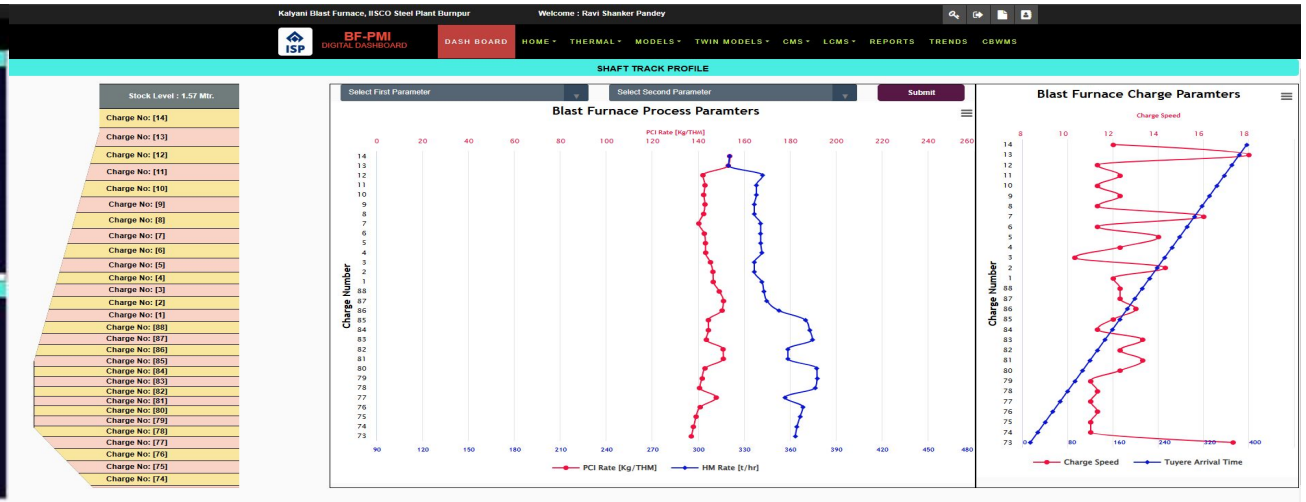
1. **Operational Index Model**
2. **Burden Calculation Model**
3. **Burden Distribution Model**
4. **Shaft Track Model**
5. **Heat (Energy) Balance Model**
6. **Stave Condition Monitoring Model**
7. **Heat Flux & Raceway Model**
8. **Tuyere Health Management Model**
9. **Cohesive Zone Prediction Model**
10. **Hearth Management Model (DCI)**
11. **Hearth Liquid Level Model.**

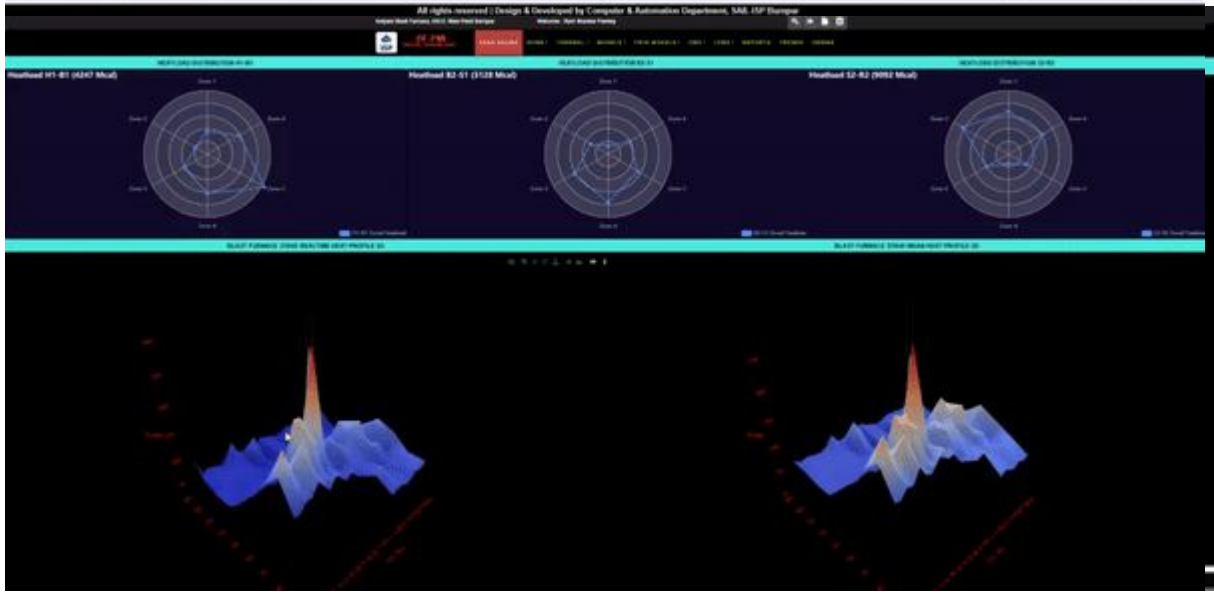


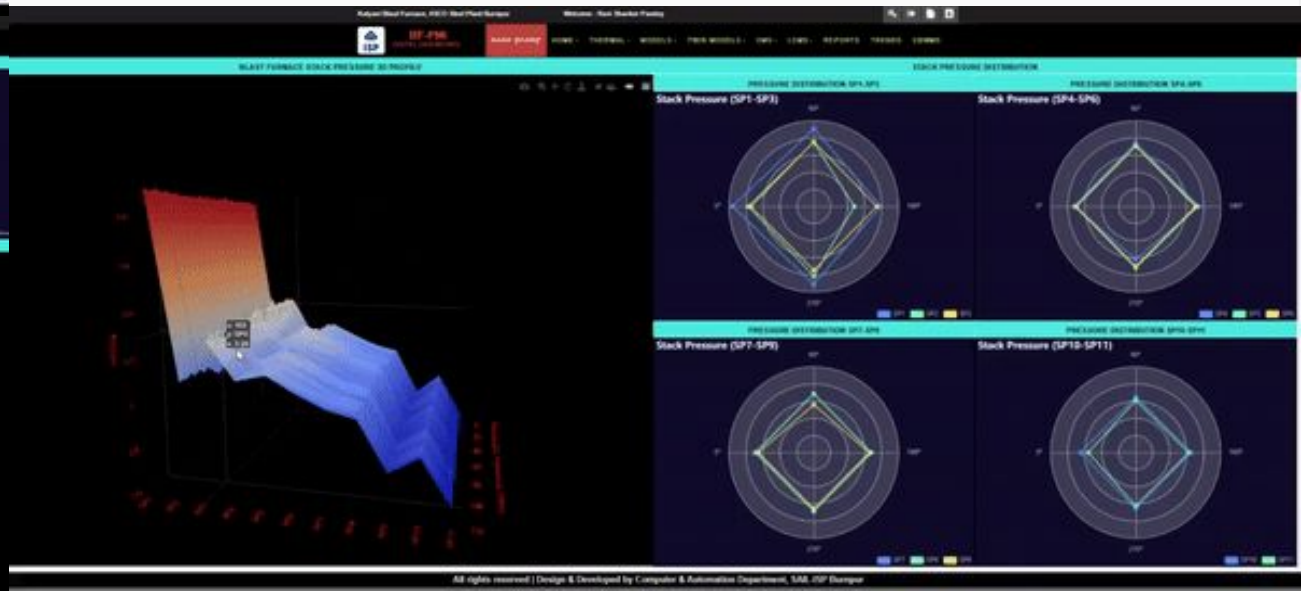


BF-PMI: Process Models (Snaps)









BF-PMI: Process Simulator

Process Simulator

- **Purpose**: To enable scenario testing and performance optimization without impacting production. The System Incorporates 14 controllable process parameters for comprehensive analysis.

- **Methodology:** By analyzing over three years of process and quality data, we utilized an AI-based Data Correlation Model to establish the relationships between the operator-controlled parameters and their direct impact on the overall process.

- **Benefits:**
  - ✔ **Techno-Economic Analysis**: Offers insights into techno-economic impacts of different scenarios.
  - ✔ **Productivity Metrics**: Measures productivity variations under different conditions.
  - ✔ **Mathematical Calculations**: Conducts various calculations to identify potential issues.
  - ✔ **Corrective Actions**: Facilitates timely interventions to optimize furnace performance.

BF-PMI: Smart Maintenance

Condition Monitoring & Life Cycle Management

Comprehensive Monitoring: Integrates all critical equipment onto a single platform for real-time asset health assessment.

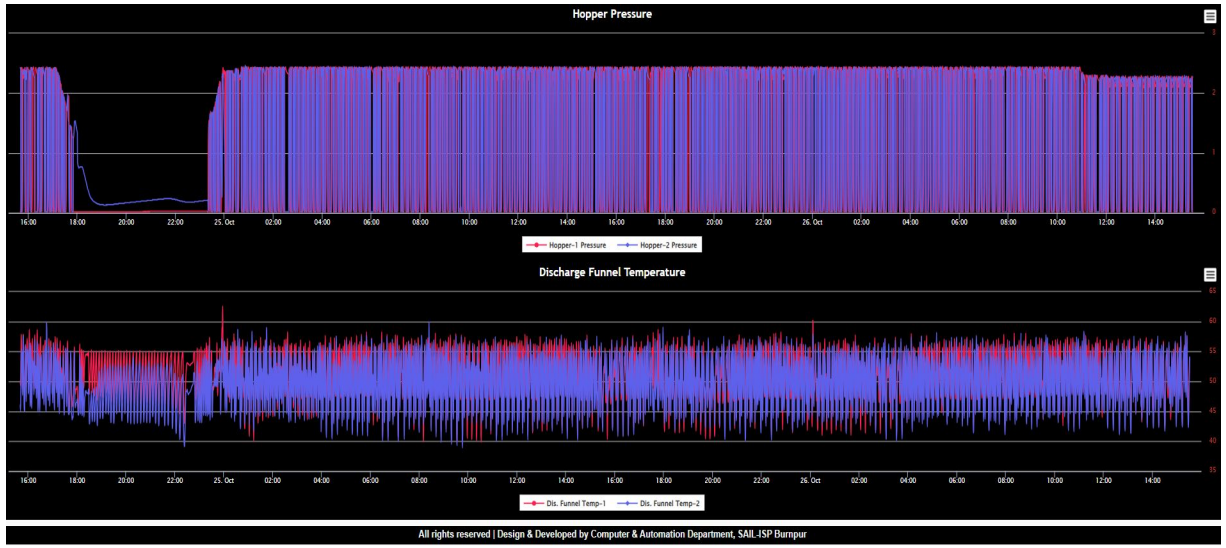
Alert Generation: Automatic alerts for each piece of equipment based on deviations in key performance parameters. Alerts are sent via Telegram for immediate notification of abnormalities.

Maintenance Logs: Digital documentation of maintenance, cleaning, and inspection records for all critical equipment.

Access to Documentation:Digital access to SOPs, SMPs, and key equipment drawings, including recent modifications and maintenance updates.

Data-Driven Insights:: Utilizes data to detect potential failures and conduct predictive analysis for proactive maintenance.

Alert System for Lifecycle Exceedance: Generates alerts when equipment lifecycle limits are approached or replacement is required.



BF-PMI: Reports & Graphical Trends

Reports & Graphical Trends

- **Reports**: Over 20+ reports available, including batch-wise, cast-wise, shift-wise, and day-wise, covering process, production, quality, maintenance, and consumption.

- **Graphical Trends**:

  ✔ **Parameter Monitoring**: Over **1,800 parameters** tracked, providing comprehensive insights.

  ✔ **Frequency of Data Collection**:Data collected at intervals ranging from **1 second to 2 minutes**, depending on criticality.

  ✔ **Access and Duration**:Accessible via the web / Mobile App for historical data spanning **6 months to 3 years**.

Charge No	Dump Time	Mat Type	Hopper No	Total Weight	Stockline_SV	Stockline_PV	Dist._Dir.	Ring Distribution										
								Event	1	2	3	4	5	6	7	8	9	10	11
44	26-10-2024 15:56:08	FERROUS	2	106.84	1.4	1.41	WTC	Weight	0	0	0	27.44	21	20.21	21.06	17.13	0	0	0
								Rotation	0	0	0	2	2	2	2	2	0	0	0
44	26-10-2024 15:49:07	C	1	21.53	1.4	1.54	WTC	Weight	6.27	3.12	3.29	3.63	5.22	0	0	0	0	0	0
								Rotation	3	2	2	2	3	0	0	0	0	0	0
43	26-10-2024 15:45:24	SS	2	10.14	1.4	1.42	WTC	Weight	0	6.02	4.6	0	0	0	0	0	0	0	0
								Rotation	0	2	3	0	0	0	0	0	0	0	0
43	26-10-2024 15:42:24	C3	1	4.44	1.4	1.41	WTC	Weight	0	0	0	0	0	0	0	0	0	0	4.44
								Rotation	0	0	0	0	0	0	0	0	0	0	4
43	26-10-2024 15:41:30	FERROUS	2	106.45	1.4	1.41	WTC	Weight	0	0	0	28.87	20.62	20.59	20.68	16.49	0	0	0
								Rotation	0	0	0	2	2	2	2	2	0	0	0
43	26-10-2024 15:35:31	C	1	21.42	1.4	1.5	WTC	Weight	6.18	2.83	3.5	3.47	5.45	0	0	0	0	0	0
								Rotation	3	2	2	2	3	0	0	0	0	0	0
42	26-10-2024 15:32:00	SS	2	10.12	1.4	1.48	WTC	Weight	0	6.8	3.78	0	0	0	0	0	0	0	0
								Rotation	0	2	3	0	0	0	0	0	0	0	0
42	26-10-2024 15:28:51	C3	1	4.43	1.4	1.41	WTC	Weight	0	0	0	0	0	0	0	0	0	0	4.43
								Rotation	0	0	0	0	0	0	0	0	0	0	4
42	26-10-2024 15:27:56	FERROUS	2	108.08	1.4	1.41	WTC	Weight	0	0	0	27.85	20.95	21.79	20.05	17.45	0	0	0
								Rotation	0	0	0	2	2	2	2	2	0	0	0
42	26-10-2024 15:20:26	C	1	21.59	1.4	1.67	WTC	Weight	5.81	3.33	3.38	3.72	5.36	0	0	0	0	0	0
								Rotation	3	2	2	2	3	0	0	0	0	0	0
41	26-10-2024 15:16:44	SS	2	10.17	1.4	1.41	WTC	Weight	0	5.94	4.89	0	0	0	0	0	0	0	0
								Rotation	0	2	3	0	0	0	0	0	0	0	0
41	26-10-2024 15:13:41	C3	1	4.44	1.4	1.42	WTC	Weight	0	0	0	0	0	0	0	0	0	0	4.44
								Rotation	0	0	0	0	0	0	0	0	0	0	4
41	26-10-2024 15:12:46	FERROUS	2	105.7	1.4	1.42	WTC	Weight	0	0	0	28.66	20.08	21.34	19.75	15.88	0	0	0
								Rotation	0	0	0	2	2	2	2	2	0	0	0
41	26-10-2024 15:05:42	C	1	21.22	1.4	1.51	WTC	Weight	6.26	2.59	3.77	3.55	5.06	0	0	0	0	0	0
								Rotation	3	2	2	2	3	0	0	0	0	0	0
40	26-10-2024 15:02:12	SS	2	10.18	1.4	1.42	WTC	Weight	0	9.7	1.14	0	0	0	0	0	0	0	0
								Rotation	0	2	3	0	0	0	0	0	0	0	0
40	26-10-2024 14:59:02	C3	1	4.44	1.4	1.41	WTC	Weight	0	0	0	0	0	0	0	0	0	0	4.44
								Rotation	0	0	0	0	0	0	0	0	0	0	4
40	26-10-2024 14:58:07	FERROUS	2	105.9	1.4	1.41	WTC	Weight	0	0	0	27.74	20.8	20.77	20.28	16.3	0	0	0
								Rotation	0	0	0	2	2	2	2	2	0	0	0

Transformation Impact

Pre- Transformation

Post Transformation

Maintenance Practices

Earlier the approach was to attend the breakdown when occurred.

Reactive → Proactive

Now the focus is on predictive and system scheduled maintenance to avoid the breakdown.

Participation

There was little or no participation from shops / other stakeholders in exploring or improving automation system

Little → Continuous

Continuous interaction between the development team and the stakeholders in shops to improve the system

Problem Analysis

Earlier there was no system of analysis so old age standard approach was followed for solutions.

Standard → Customized

Now Data is analyzed and customized solutions are explored based on the feedback from system.

Decision Making

Decision based on Previous personal experience.

Thumb Rule → Data Based

Decision based on the data and feedback from the supervisory systems.

THANK YOU

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