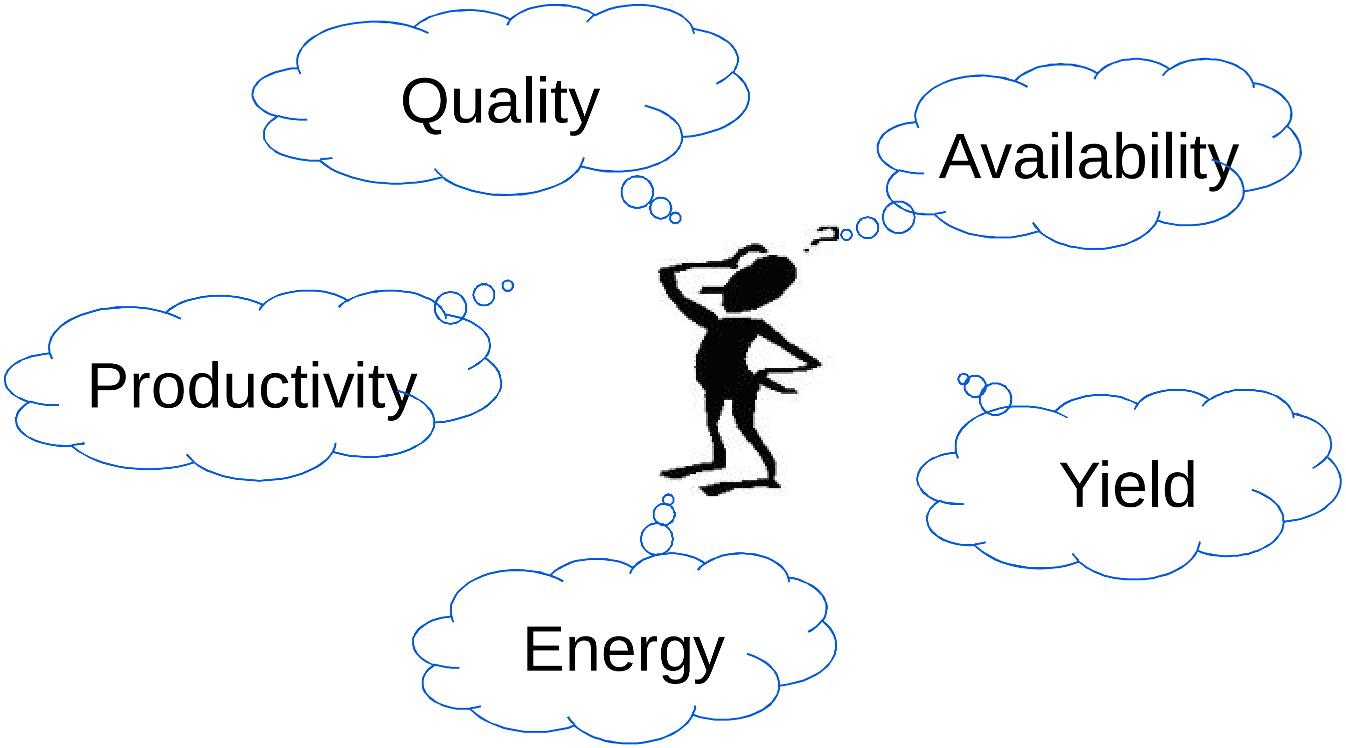
Nilabja Ash & Tarun Mathur/ 2013-08-19

Profile Mill Advanced Service Portfolio
Value Added Services

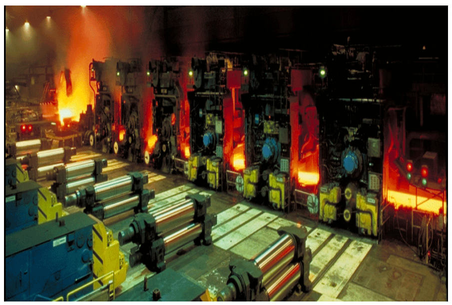
Motivation



How can I Ensure Availability ?
How can I Improve Productivity & Yield ?
How can I Optimize Energy ?
How can I Maintain Quality ?

What ABB can offer to address these

ProfileOpt



A physics based mathematical model to simulate and optimize rolling conditions

Profile Mill Fingerprint

life cycle index®

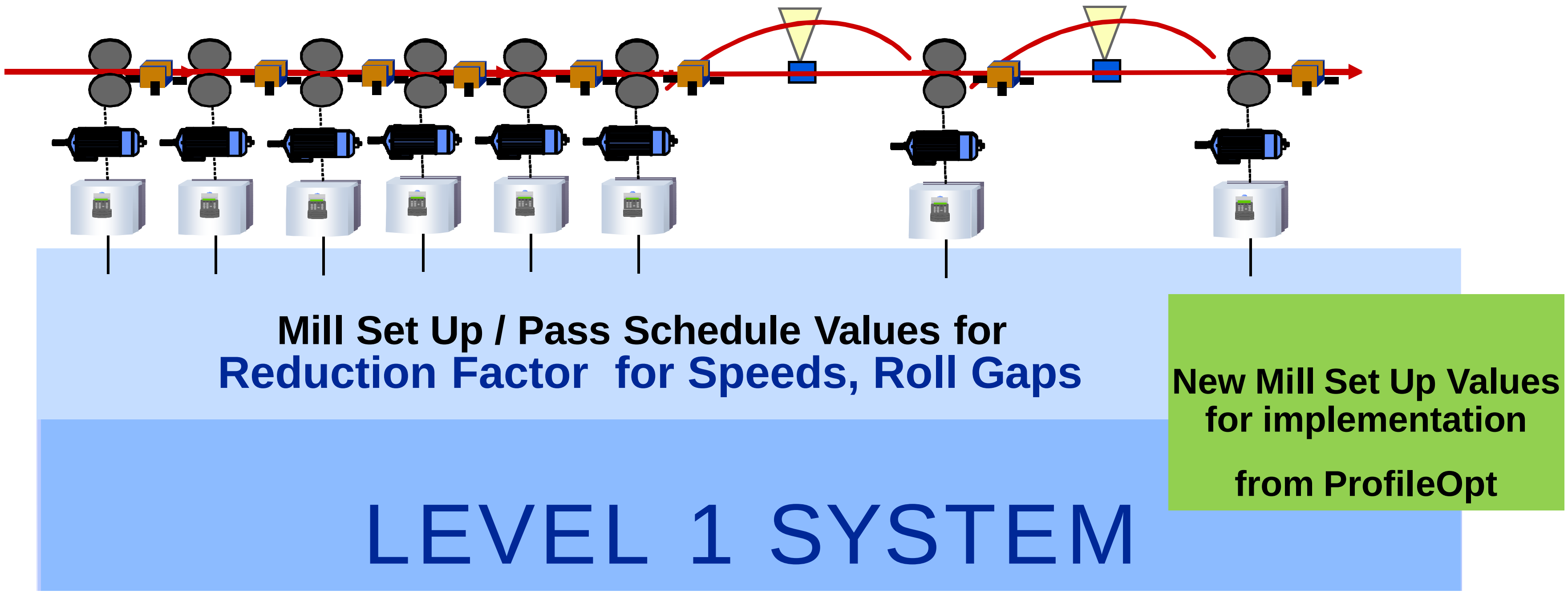
Questionnaire based, find out the life cycle status of the automation and drives equipment.

Technical Audit by intelligent and automated tool, to capture the long term trends

Advanced Service Offering for Profile Mills

What is ProfileOpt ?

- Model based optimization service for Profile Mills (Bar Mills, Wire Rod Mills), which is used to simulate and optimize rolling conditions.
- Solution combining physics based models with ABB's rich process know-how



ProfileOpt
Customer Benefits

Savings in rolling energy with same billet temperature

- A savings of 5 ~ 10 % of rolling energy consumption depending on process constraints

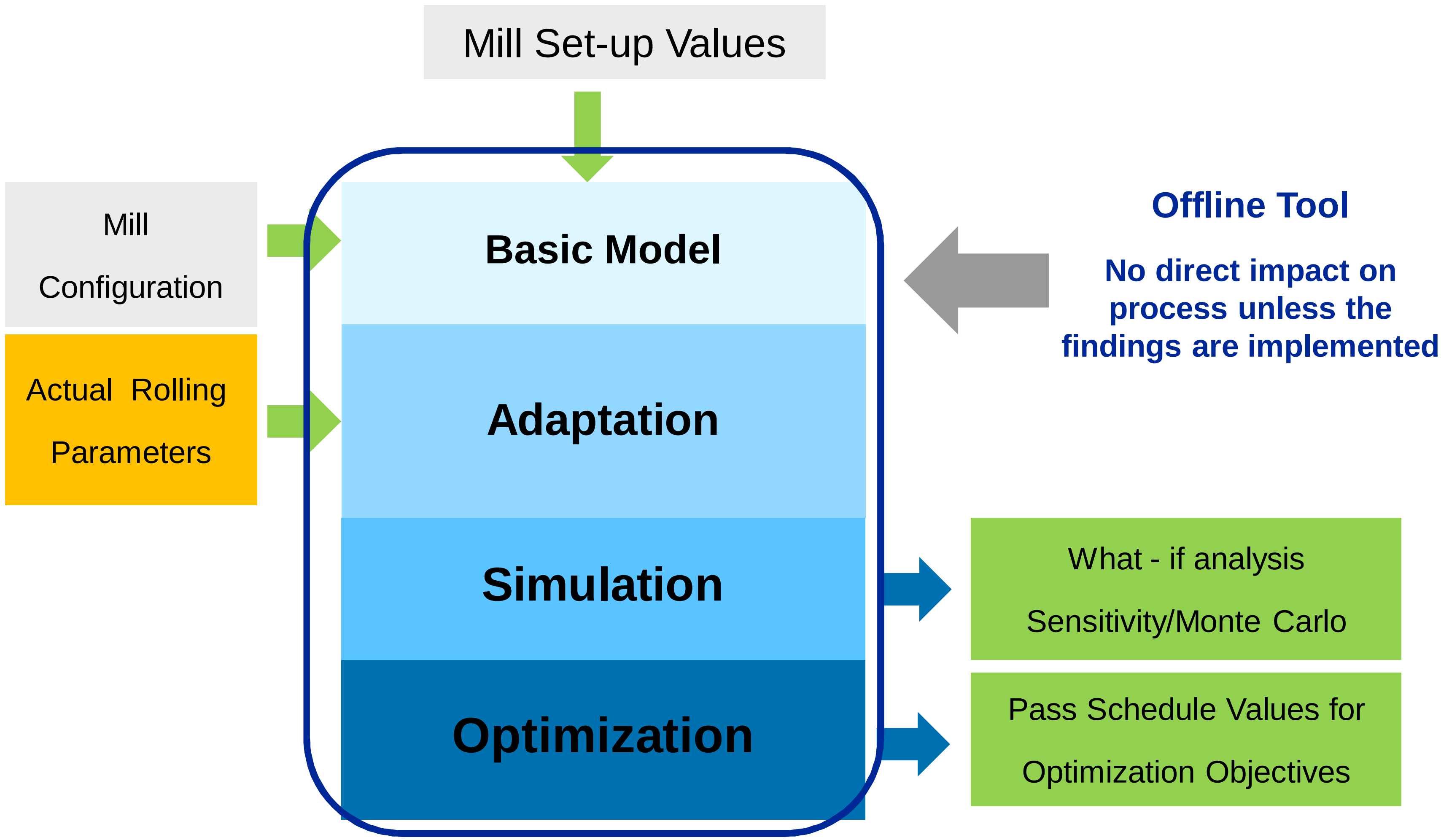
Improved productivity

- 10 ~ 15% increase in productivity depending on power constraints

Desired groove utilization, and load sharing at various stands

Simulate mill rolling condition to predict outcomes for changes in process inputs

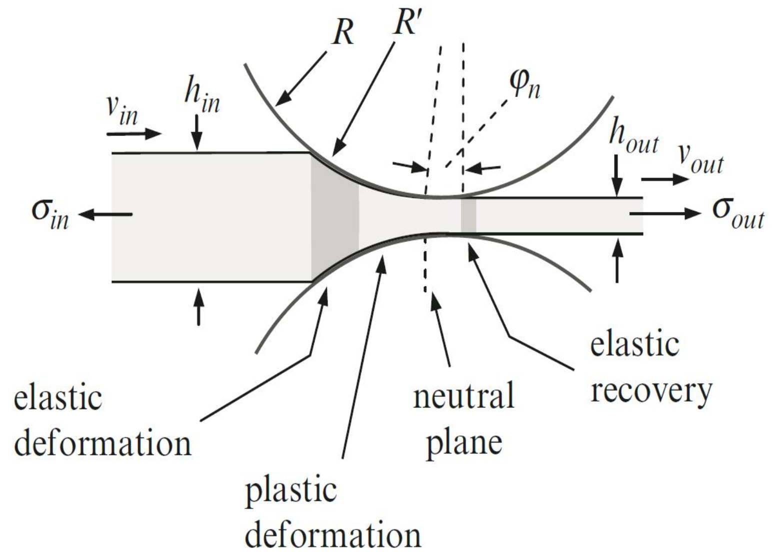
ProfileOpt
Technical Details and Features



ProfileOpt
Modeling Approach

A complete know-how of billet deformation during hot profile rolling, which includes

- Spread, torque and power – with interstand tensions
- Continuous mass flow and interstand dimension changes due to change in tensions
- Non-linear material model for thermo-elasto-viscoplasticity
- Thermodynamic for heat generation, conduction, transfer and radiation



Material deformation between rolls

ProfileOpt
Adaptation and Simulation

Model adaptation is done for four parameters for a particular material grade

1. Power
2. Neutral Angle (Speed)
3. Spread (Exit Width)
4. Temperature

Simulation

Once adaptation is done for all the above four parameters, it is possible simulate the actual roll condition for any set up values for the same material grade

ProfileOpt
Optimization

Objectives
(Either one can be selected)

- Minimize rolling power
- Maximize mill productivity
- Maximize productivity with minimal increase in rolling power
- Achieve target loading (power) at each stand (load sharing)
- Achieve target widths or area at each stand exit (groove utilization)
- Minimize billet entry temperature at given production speed

Mill constraints
(practical operation constraints)

- < Roll gap < , < Production speed <
- < Motor speed <, < Billet temperature <
- < Interpass tension<
- < Width < < Area <

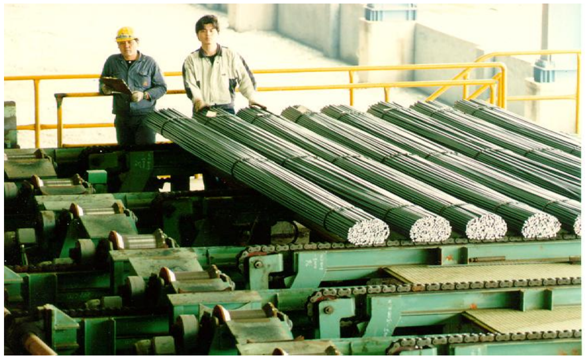
Optimization Outputs

- Optimal Mill setup (Roll gaps and Reduction factor setpoints for all stands)
- Billet entry temperature (Optional)

Case Study
Sample Results

Bar Mill (10 mm Rolling)

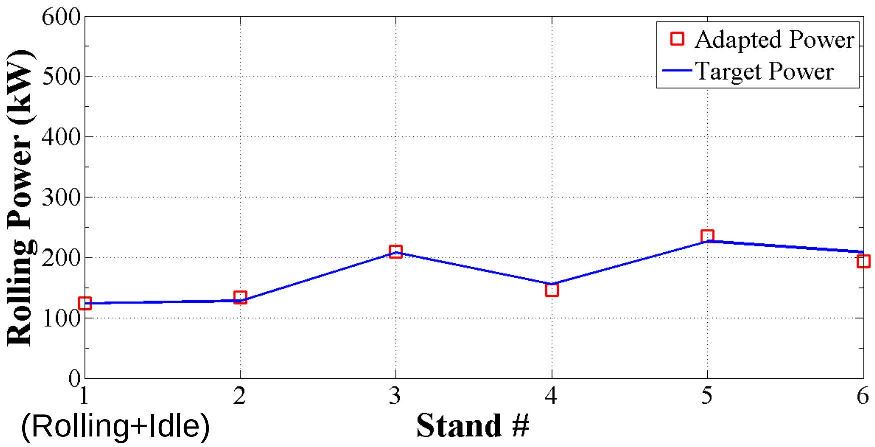
- Mill Set-Up
  - Sq. 150 mm x 150 mm Billet @1050ºC
  - Final Products: **10**, 12, 14 and 16 mm Bars
  - 16 Stand in Vertical and Horizontal Configurations in Roughing and Intermediate Sections
  - Finishing Block after Intermediate Section
  - Typical Final Production Speed of ~30 m/s



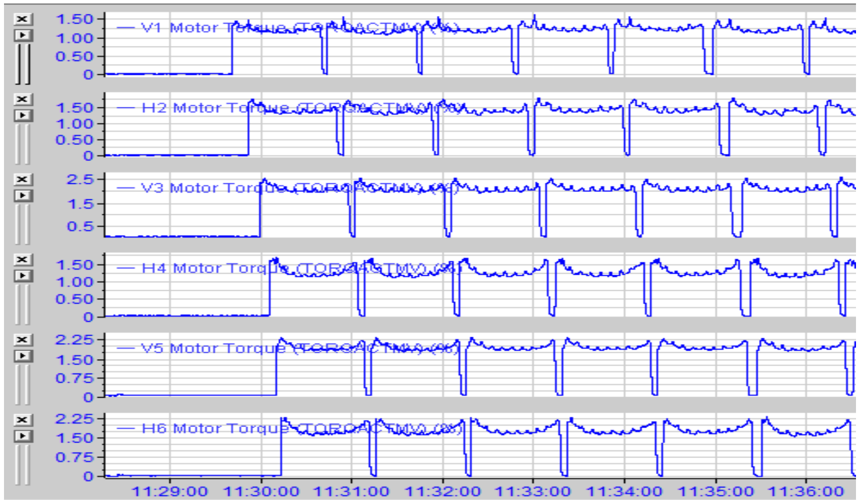
- Material: Plain Carbon Steel (C~0.2 %)

Model Adaptation
Rolling Power

Stand #	RPMs (iba)	Torque (T) (kNm) (iba)	Power (kW) P=2pi*RPM*T/60
1	1044.4	1.15	125
2	934.8	1.33	130
3	1049.5	2.0	219
4	1320.4	1.16	160
5	1209.2	1.9	240
6	1182	1.72	212



- Rolling power is calculated using stand RPMs and torques.
- Torque (in kNm, as shown below) for all stands from iba.

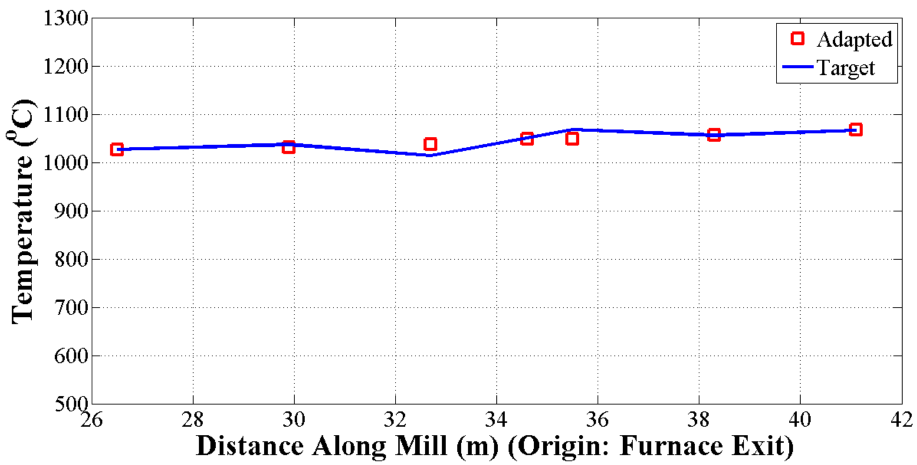


Power model of Avitzur adapted to rolling power within 3% mean absolute error.

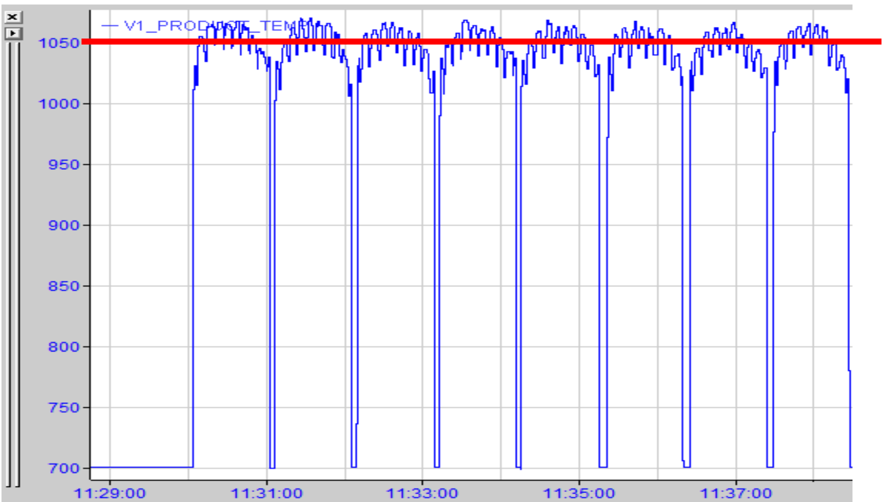
Model Adaptation

Temperature

Distance from Furnace Exit (m)	Temperature (°C) (Handheld and fixed Pyrometers)
26.5	1026
29.9	1036
32.7	1013
34.6	1051
35.5	1067
38.3	1055
41.1	1066

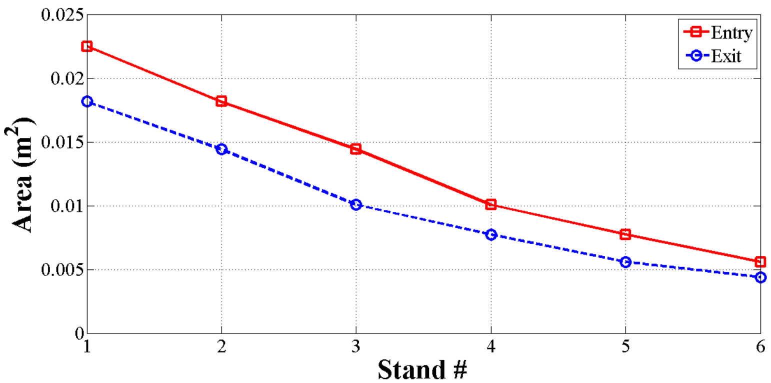


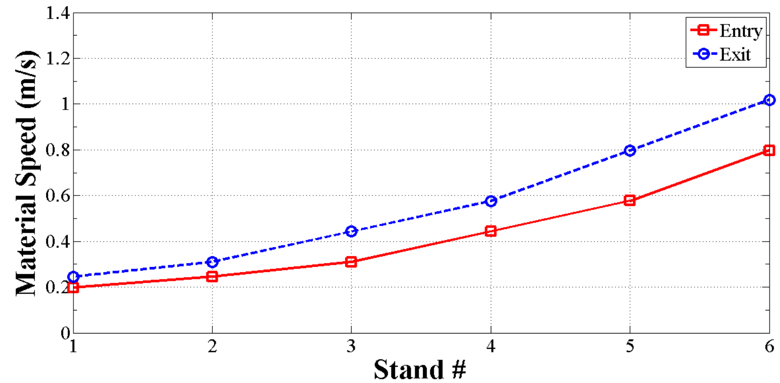
- Temperatures along the mill are measured
- To account for emissivity variations and other effects, temperatures measured using handheld pyrometers were scaled with measurements from installed pyrometers

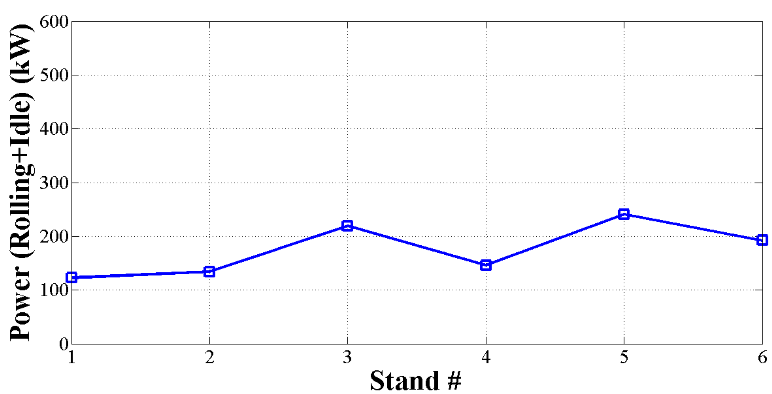


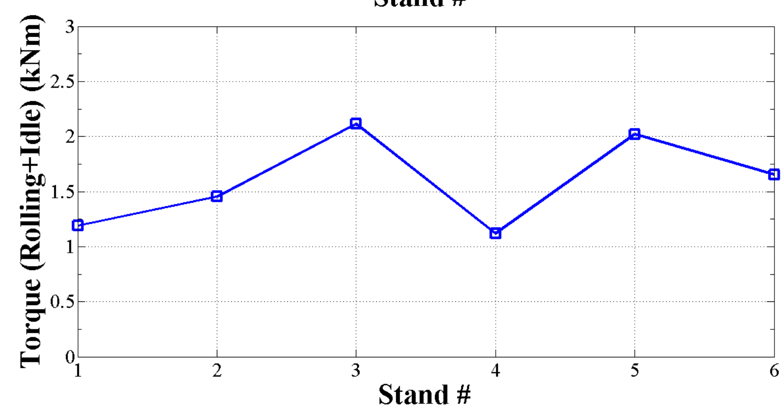
- Thermal model adapted to handheld and fixed pyrometer measurements within 1% absolute mean error.

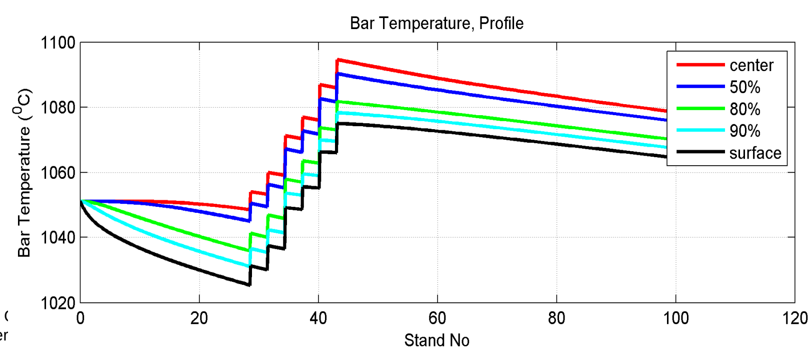
Initialization and Simulation
Simulating Actual Rolling







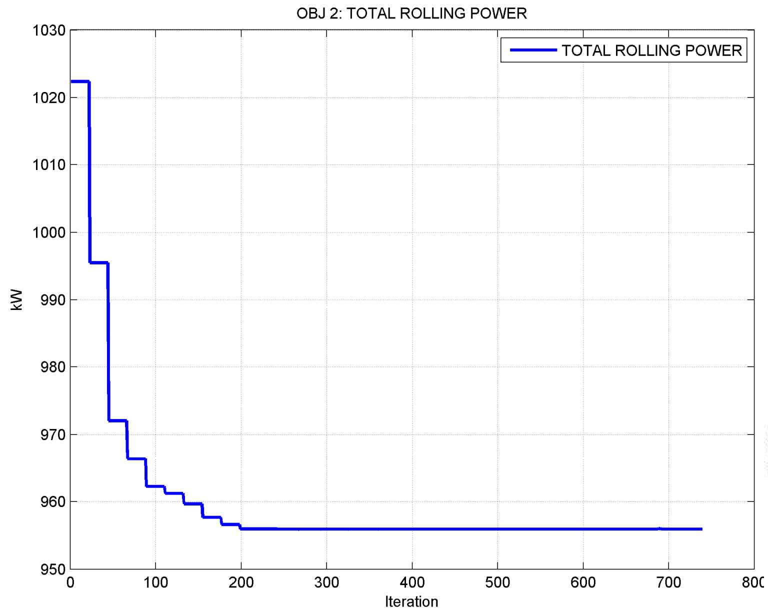


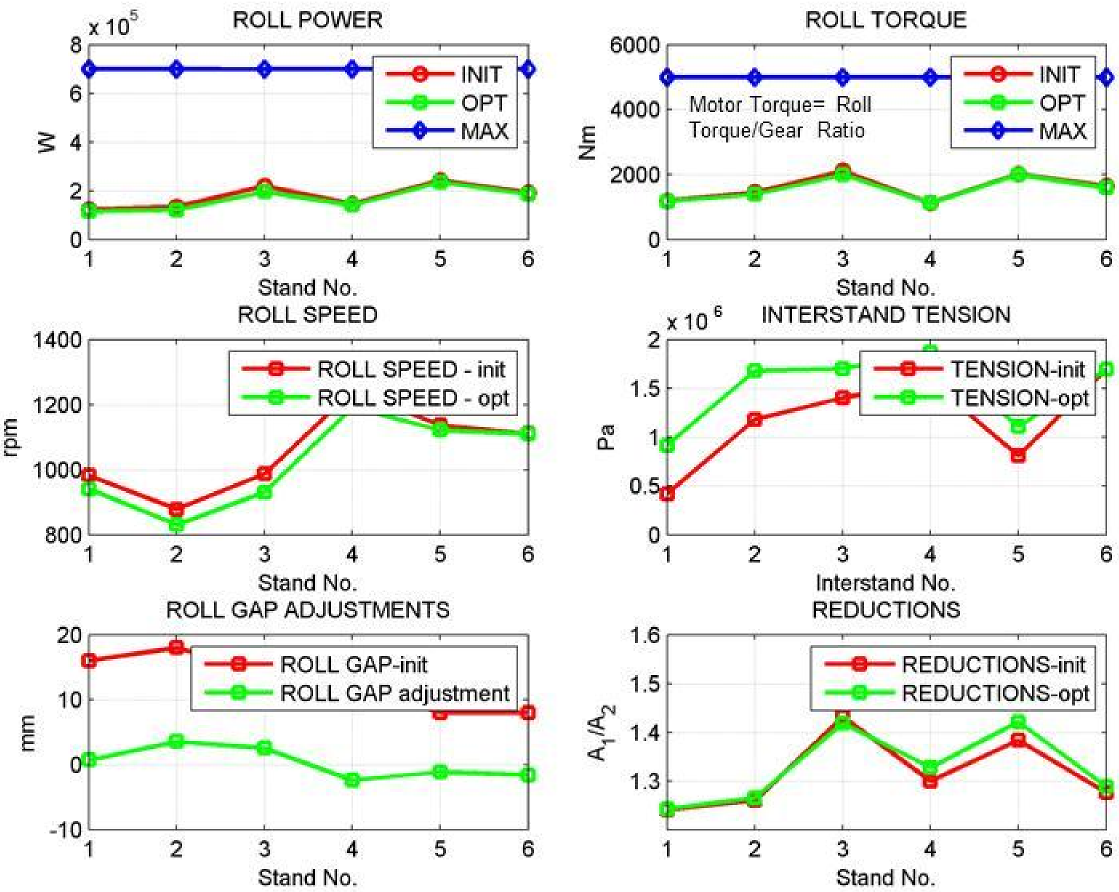


ProfileOpt simulates actual rolling conditions accurately.

Optimization: Minimizing Rolling Power

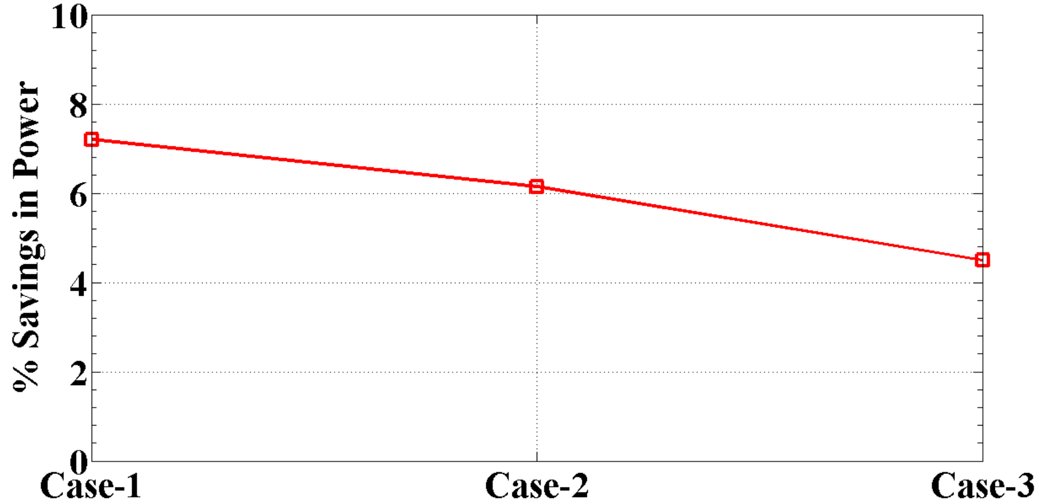
Minimizing Rolling Power (Keeping Production Speed and Exit Tension Same)





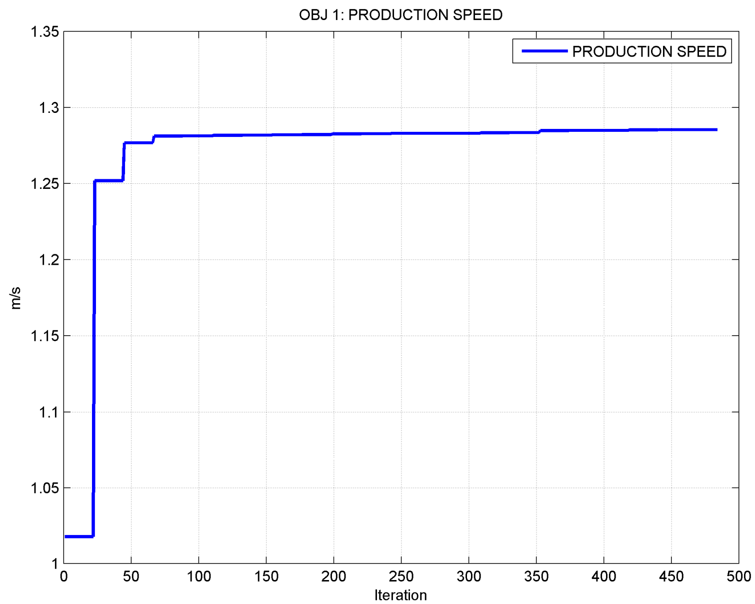
- Model predicted actual rolling power within 1-2 %.
- 6.2% savings in rolling power can be achieved by using optimum roll gaps and speeds.

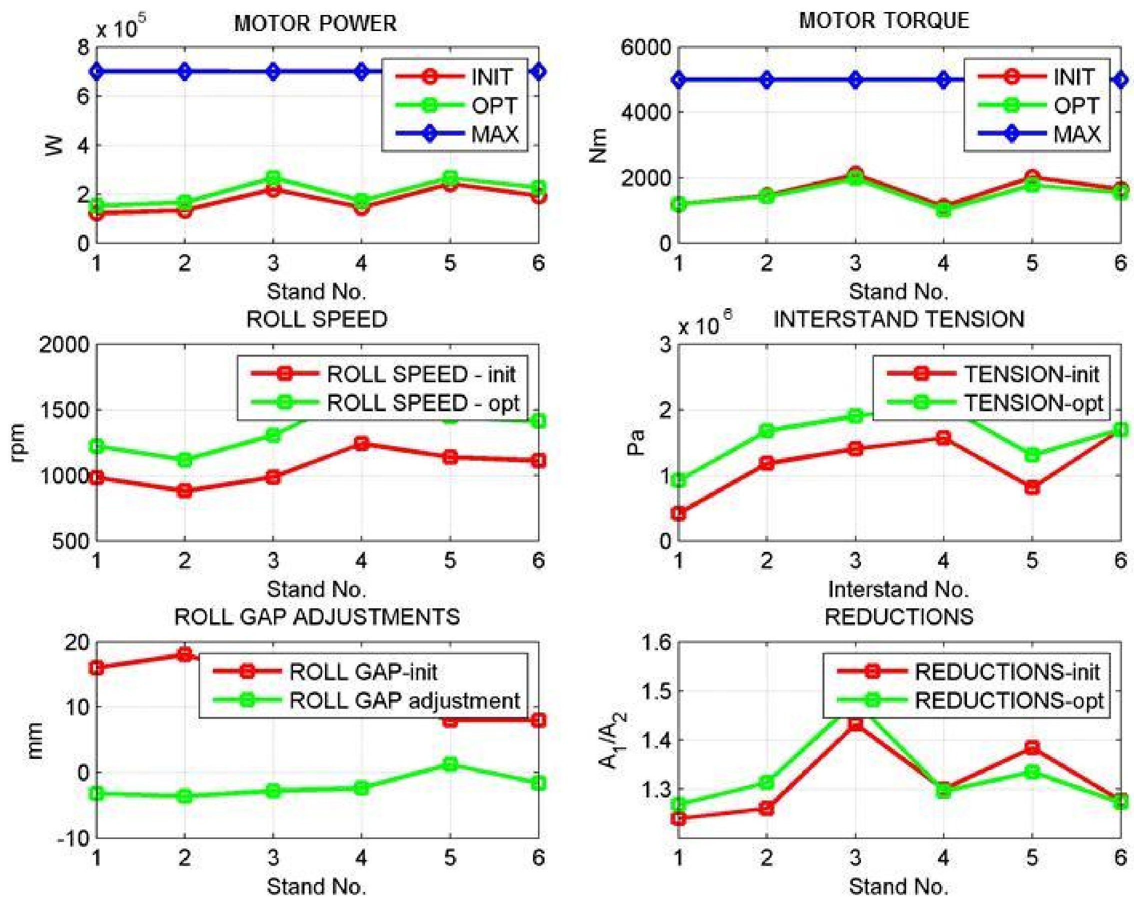
Optimization: Minimizing Rolling Power
Effect of Constraints



Power savings reduce as narrow constraints are applied.
From: 7.2 to 6.2 to 4.5 (%)

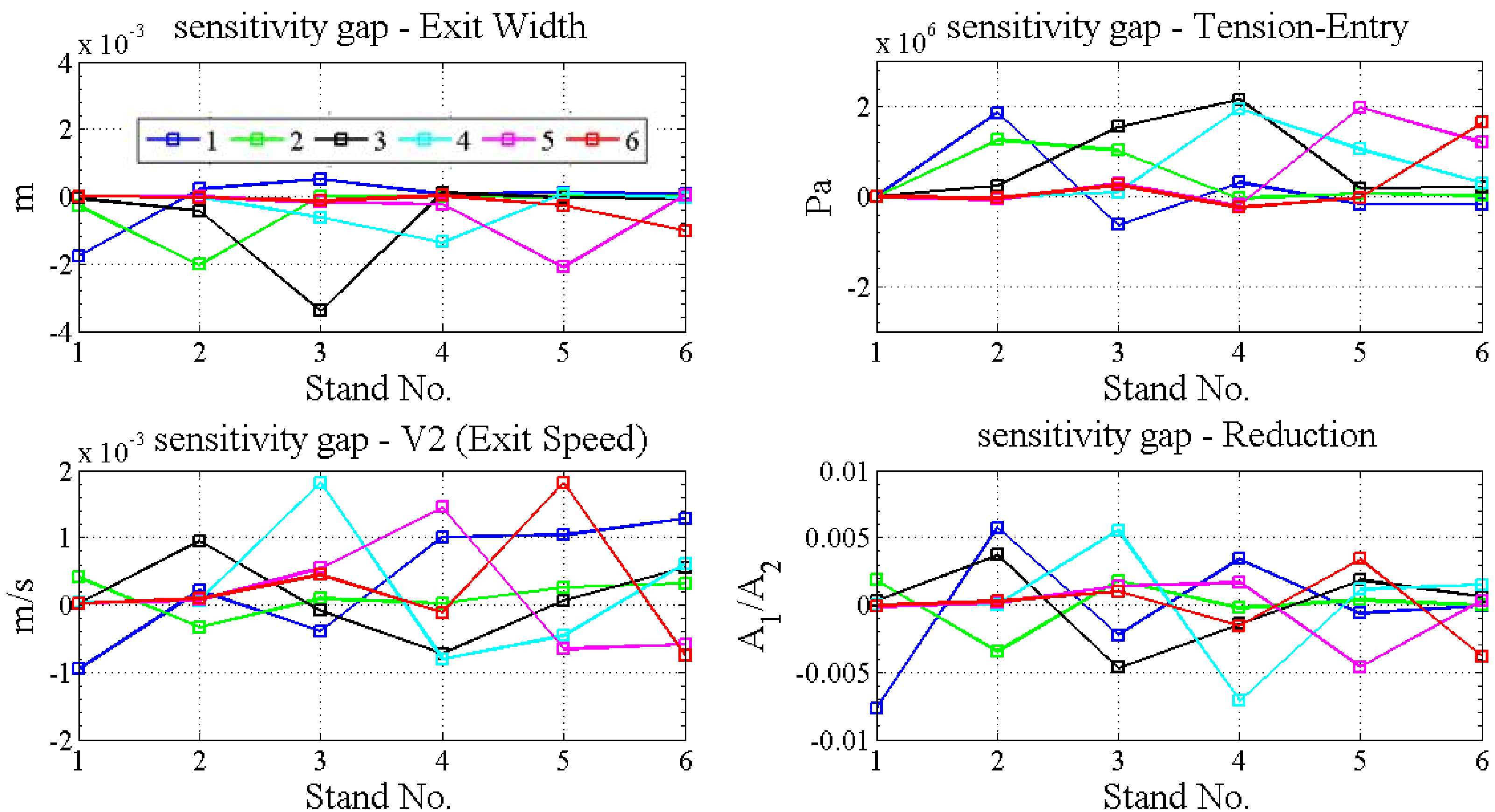
Optimization: Maximizing Productivity
Maximizing Production Speed at the cost of Rolling Power





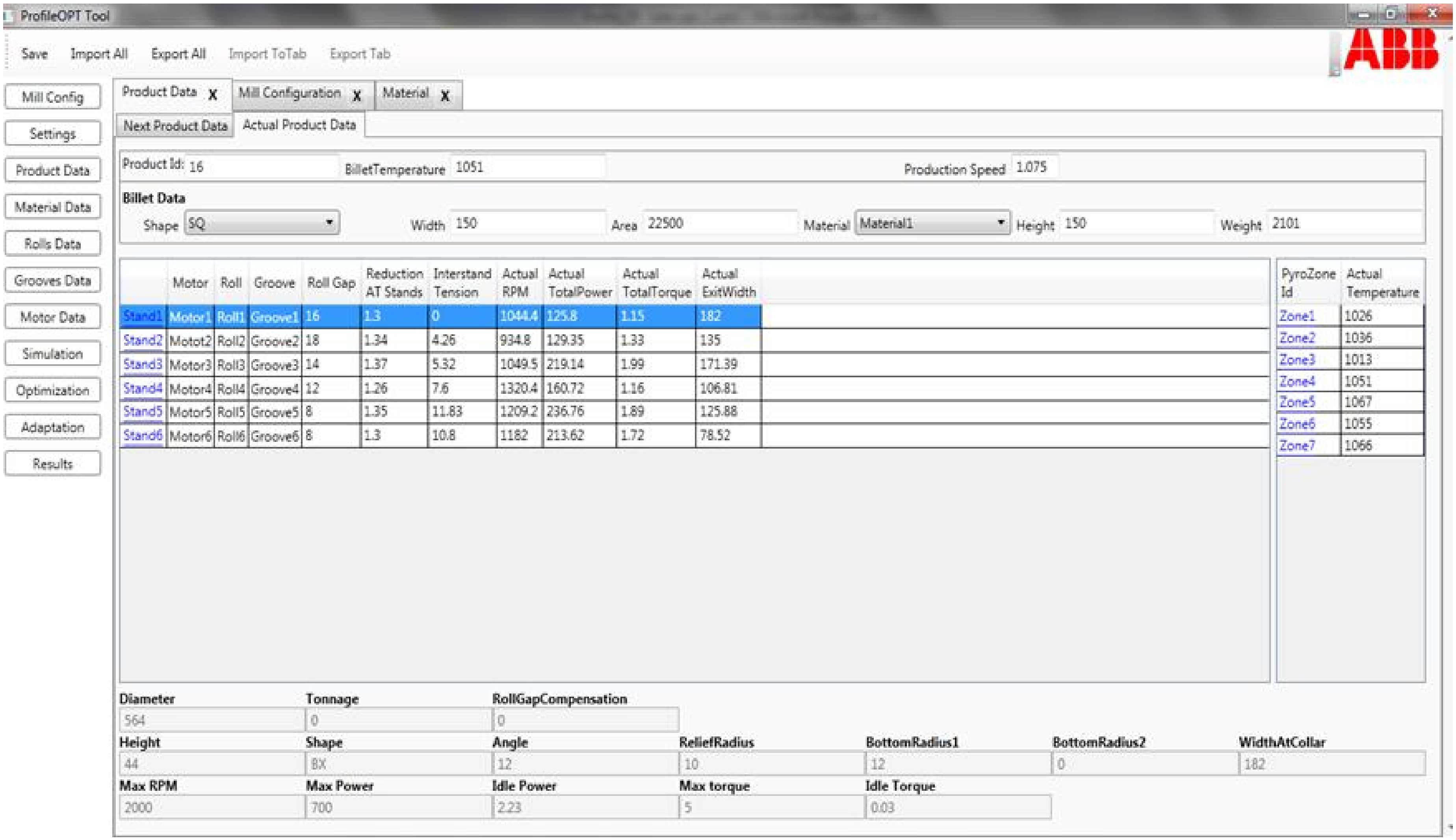
- Production speed predicted within 4% of actual.
- 18 % increase in productivity at the cost of 19% increased electrical rolling power.

Sensitivity Analysis
10% Increase in Roll Gap at Each Stand



- Tension, compression and their effects are seen propagating when roll gap is increased at stand #1.
- At later stands, its mainly tension which decreases exit width and correspondingly changes speed and reduction ratio.

ProfileOpt Tool



ProfileOpt
Service Features

Based on physics-based profile rolling mathematical models developed after years of research

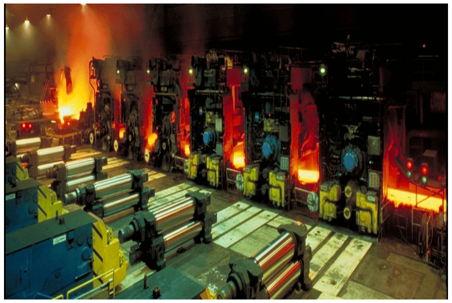
Possibility to choose among different optimization objectives – power, productivity, groove utilization, load sharing etc

What-if and sensitivity analysis to analyze the effect of change in operation parameters on mill performance

Practically implementable recommendations within mill operation and capacity constraints

Advanced Service Offering for Profile Mills

ProfileOpt



A physics based mathematical model to simulate and optimize rolling conditions

Profile Mill Fingerprint

life cycle index®

Questionnaire based, find out the life cycle status of the automation and drives equipment.

Technical Audit by intelligent and automated tool, to capture the long term trends

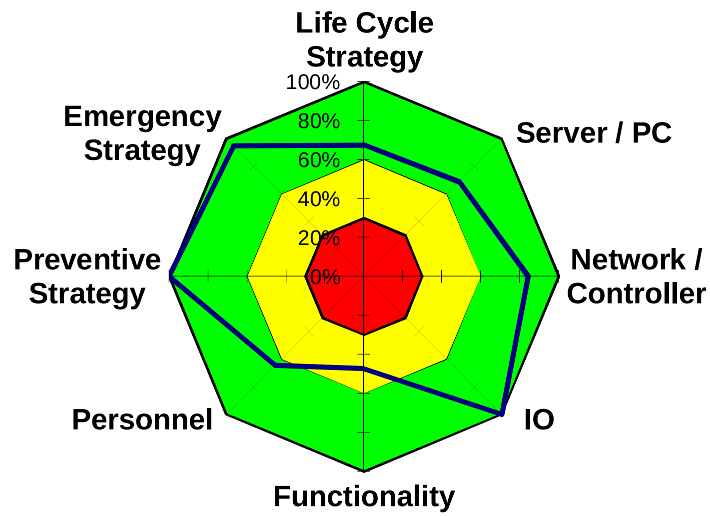
Profile Mill Fingerprint
Life Cycle Audit

Questionnaire based audit to address

- Prevention Strategy
- Maintenance Strategy
- Emergency Strategy &
- Life Cycle Strategy

For

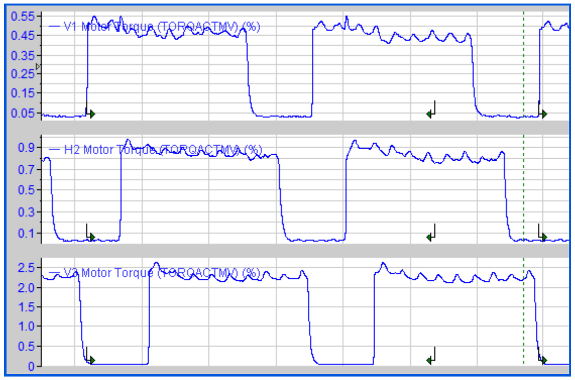
- Drives & Motors
- Automation & Sensors
- Level 2
- Process & Technology



Finds the issues and recommends to improve availability

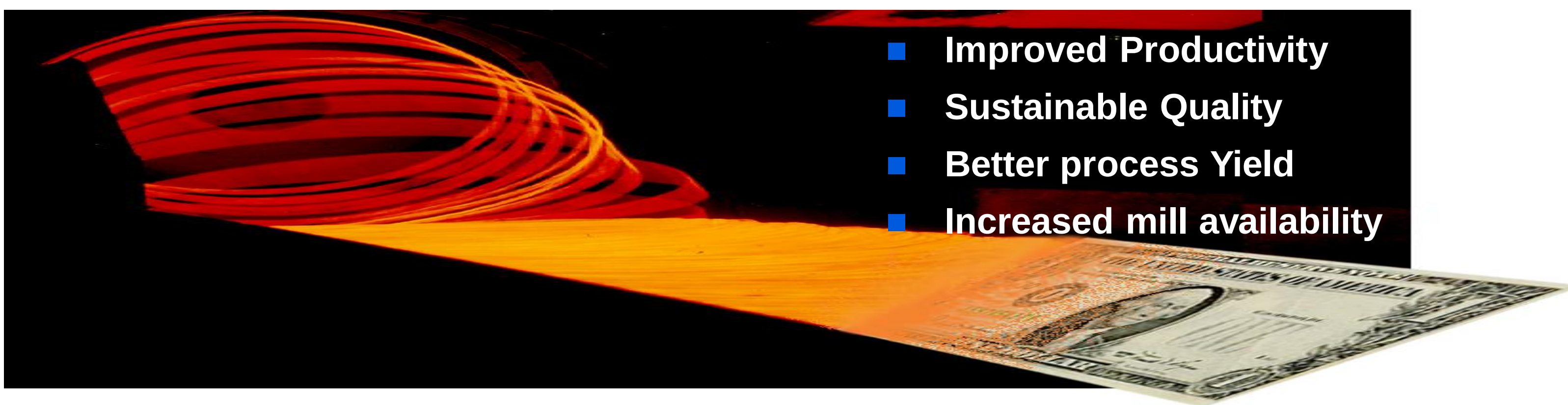
Profile Mill Fingerprint
Technical Audit

- Technical Audit is done by a tool, which takes a batch of historical data and analyzes various mill performance parameters
- Powered by Statistical Analysis and algorithms, it brings out the preliminary trends and inter-relations between various process parameters
- Finally with ABB's rich process know-how, a detailed summary report with recommendations are prepared and presented to customer.



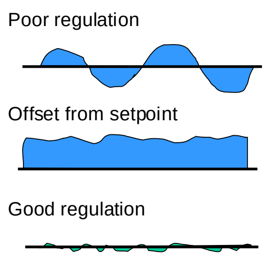
Profile Mill Fingerprint
Customer Benefits

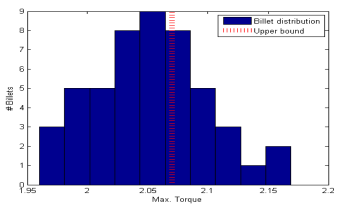
1. Assessment of current mill performance and performance gap
2. Recommendations for performance improvement
3. Solid foundation for Life Cycle Management
4. Facilitates management decision by highlighting high impact opportunities

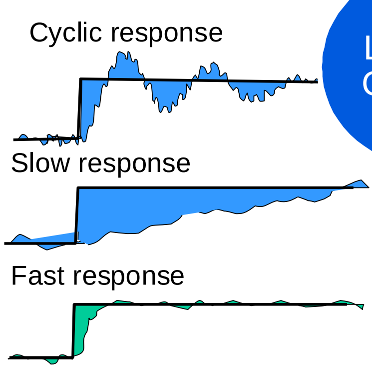


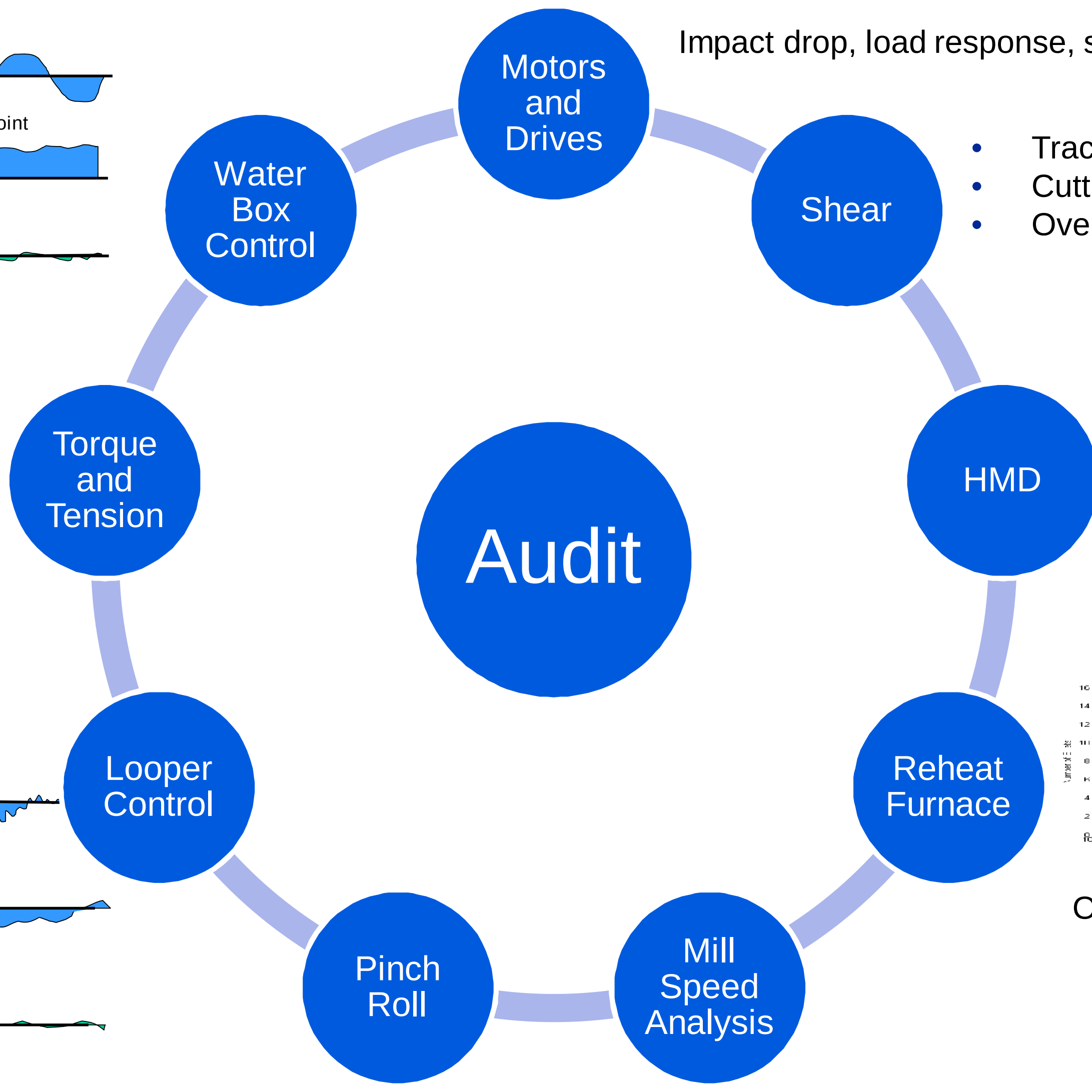
ABB

Technical Audit Scope
Modules





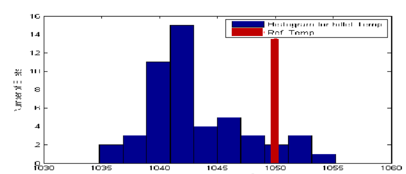




Impact drop, load response, setpoint tracking

- Tracking repeatability
- Cutting repeatability
- Overspeed calculation

HMD Accuracy

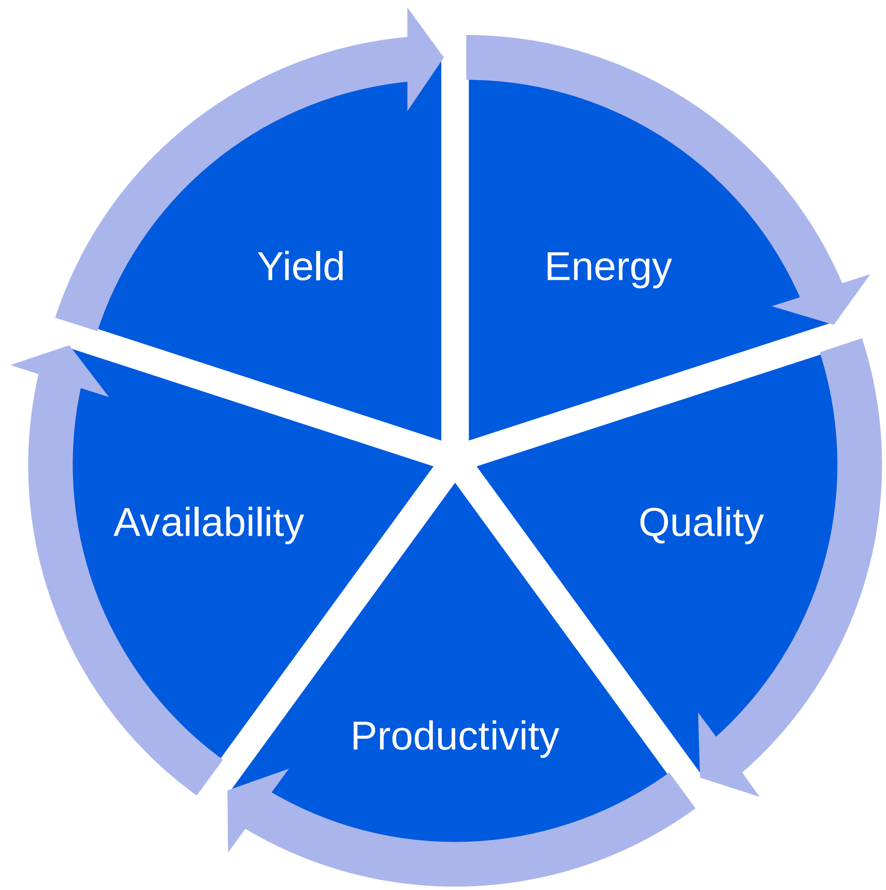


Optimal pace time calculation

Mill Performance Analysis

Sectional/Local

Performance Measures (KPIs)



Overall Mill KPIs

Profile Mill Fingerprint
Mill Data Requirement (From Iba or any other datalogger)

HMD Module Input Data

IBA Signals List	Units
HMD signals	Binary
Torque signals of the stand before HMD	%
Torque signals of the stand after the HMD	%
Motor speed of the stand before the HMD	% rpm

Shear Data

IBA Signals List	Units
HMD signal for the shear cut	Binary
Angular position of the shear blade	%
Speed of the motor for the shear	% rpm
Motor speed of the stand before the shear	% rpm

Looper Data

IBA Signals List	Units
Torque signals of the stands before looper	%
Torque signals of the stands after the looper	%
Looper height signal	mm
Looper arm initiation command data of that particular looper	binary

Profile Mill Fingerprint – Technical Audit
Modules and KPIs

Motor and Drives	• Torque - Average Torque, Torque Variance, Torque Peaks • Impact Drop • Impact Recovery Time • Load Speed Tracking • Travel Ratio
Interstand Control	• Looper Setting Time and Steady State Error • Looper Arm Initiation Consistency • R-factor Variation • Tension Control
Pinch Roll	• Overspeed • Speed drop • Torque Profile
Mill Speed Analysis	• Mill Speed increase potential, Bottleneck stands
Mill Pacing	• Average Pace time, Optimal Pace time, Downstream bottleneck
Shear	• Tracking and Cut Cycle Repeatability
Tracking	• Switching ON performance • Switching OFF performance
Furnace Temperature	• Mean Temperature • Temperature Profile
Water Box Control	• Settling time, Steady state error

Profile Mill Fingerprint
Sample Outputs and Recommendations

Motor and Drives

- Torque – Identify whether a batch of billets have abnormal toque behavior or a particular stand
- Impact Drop/Recovery time of a stand is higher than benchmark
- Load Speed Tracking – Actual speed is within 0.5% of setpoint
- Drive Tuning – Drive may be sluggishly tuned.

Interstand Control

- Yy% of billets in Looper 1 show oscillation before settling
- Zz% of billets have steady state error more than 10% of its reference
- R-factor Variation is loclized for stand 7, 9, 15. Need to check stand setting, loop scanner etc

Pinch Roll

- xx% of billets have average speed drop more than 2%
- xx% of billets reached torque limit

Mill Speed Analysis

- Maximum achievable production speed is 6.42 m/s. Stand 7 is limiting

Mill Pacing

- Productivity can be increased to ppp tph, pace time should be bb secs.

Shear

- aa% of billets have higher dev for head/tail cut cycle repeatibility

Tracking

- xx% of billets shows a time lag of more than 0.2 sec during head / tail
- xx% of billets show more than 2 disturbances in the HMD signals for HMD_1

Furnace Temperature

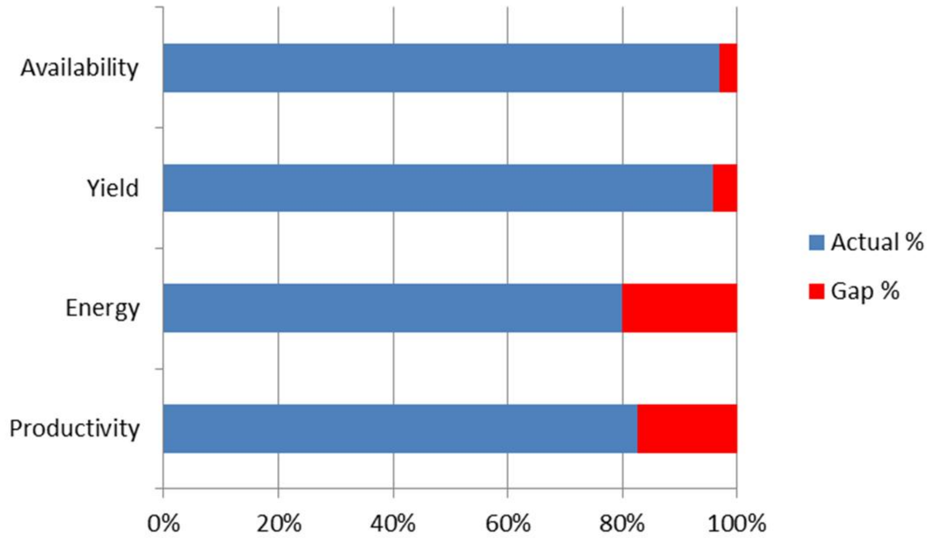
- a% of total billets are overheated by 50 ^{0}C, consumes excess thermal energy

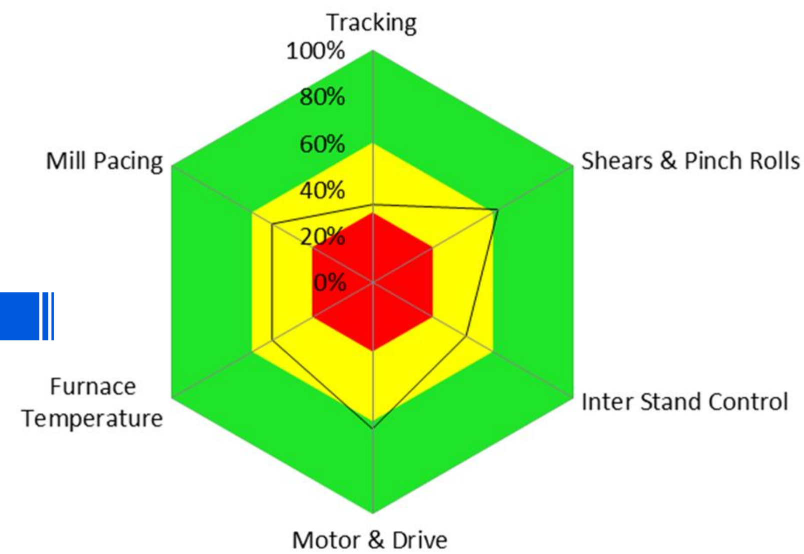
Water Box Control

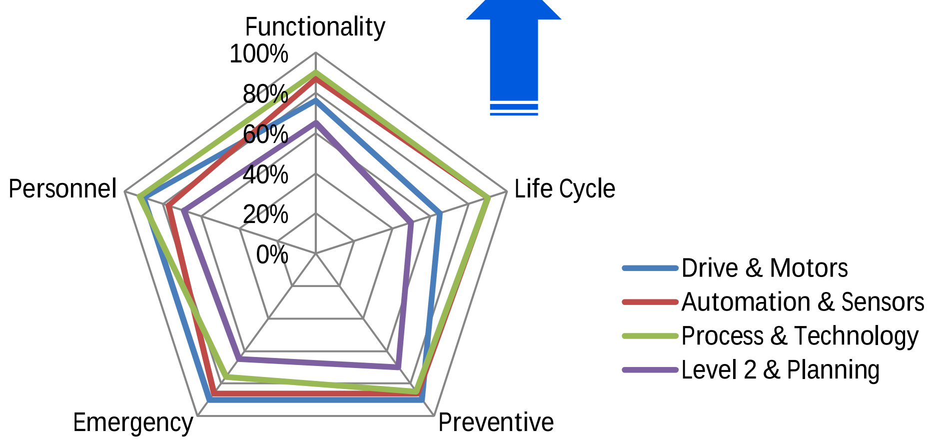
- x% of billets have temperature variation more than 50 ^{0}C from setpoint

Case Study
Sample Results

Profile Mill Fingerprint
Executive Summary – Sample Report







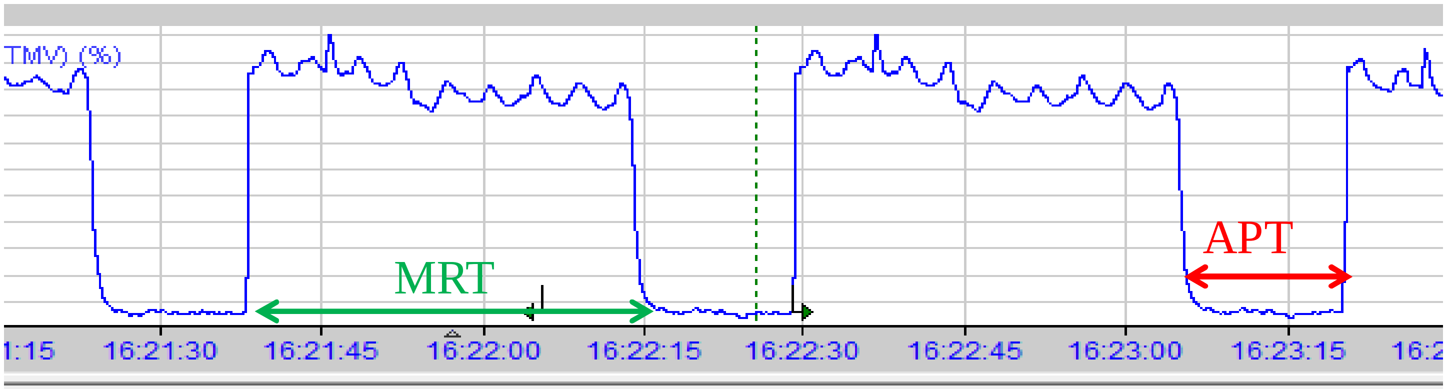
- Executive Summary indicates overall mill performance w.r.t. Availability, Yield, Energy and Productivity
- Separate executive summary for Life cycle Index and Technical Audit

Profile Mill Fingerprint Results
Mill Pacetime Analysis

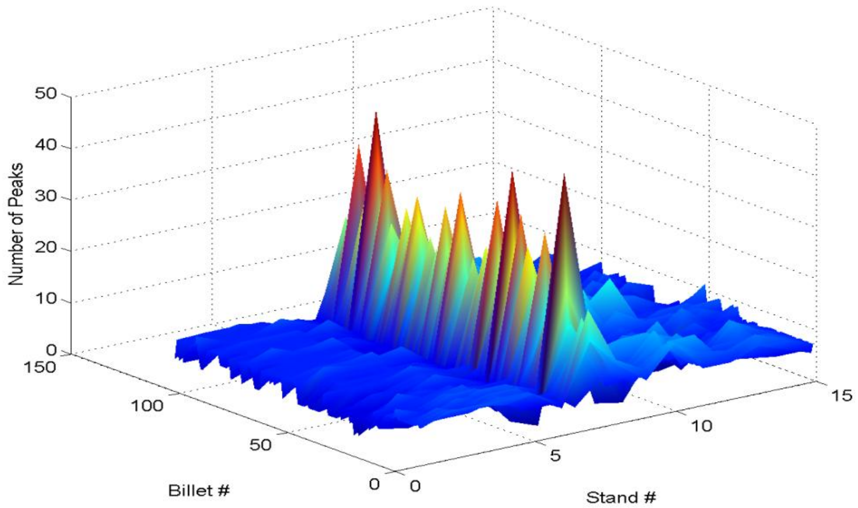
- Actual pace time (APT) calculation from data
- Optimal pace time recommendation based on Mill Rolling Time and Furnace Discharge Pace Time
- Evaluation of productivity bottleneck

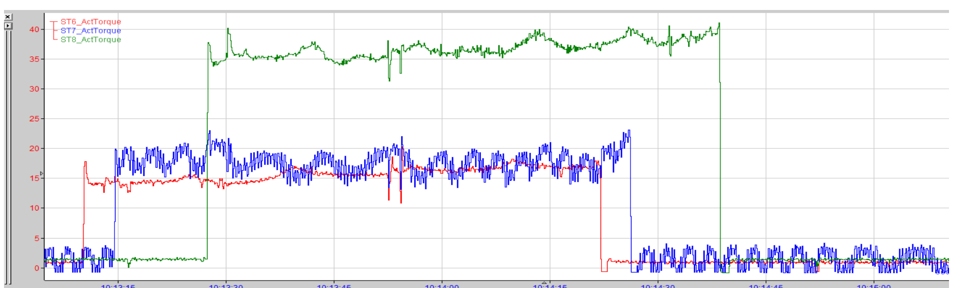
Results:

- Productivity improvement with current downstream limitation: 8.3%
- Productivity improvement without downstream limitation : 14.1 %



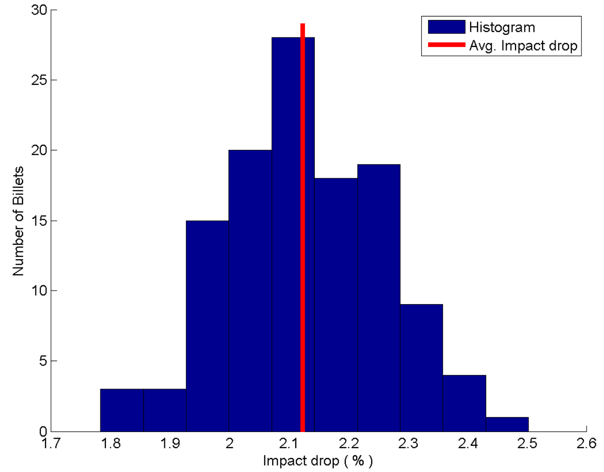
Profile Mill Fingerprint Results
Motor and Drives - Torque Analysis

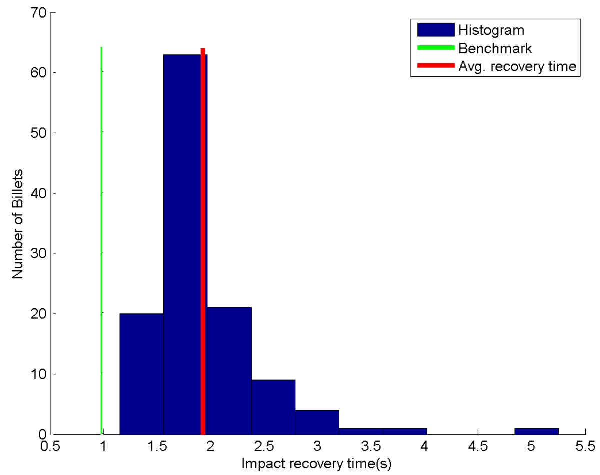




- Motor and Drive module of the tool captures large number of peaks in torque profile of rolling stand#7
- Same billets do not show peaks in other stands
- Validated by raw data from IBA
- Concluded that this abnormal behavior is due to stand#7 mechanicals

Profile Mill Fingerprint Results
Motor and Drives - Impact Drop and Impact Recovery Time





- Analysis:
  - Impact drop is higher than benchmark (0.5%)
  - Impact recovery time is higher than benchmark (1 sec)
  - Adverse impact on product quality
- Root cause:
  - Drive controller tuning is required

Profile Mill Fingerprint
Deliverables

Fingerprint report including

- Executive Summary indicating current mill status, performance gaps and key recommendations
- Current life cycle status of equipment and recommendations for life cycle management
- Process and control performance status
- Detailed improvement plan with potential impact on mill energy consumption, productivity, yield, and availability.

Profile Mill Fingerprint
Service Features

Uses large historical data to bring out statistical performance trends which is difficult to examine manually

Brings out inter-relations between various process parameters

Modular and Configurable Technical Audit tool

In-built intelligence in tool to provide first-level of analysis

Provides quantitative impact on Productivity, Energy, Yield

Benchmark the plant performance

Practically implementable recommendations

Service Products Overview

Profile Fingerprint

- Data based **audit** to assess process and control performance
- To identify poor performance and possible root causes in various sections of mill

ProfileOpt

- Model based optimization service for **mill-setup**
- Optimal mill setup (pass schedule) calculation

ProfileOpt and Profile Mill Fingerprint
Execution Methodology

- Agreement on which product (grade and dimension) the tool is to be applied.
- Collect data as per pre-defined template. Customer can also fill up the data sheet and send by email to ABB engineer.
- Run the tool in ABB premises.
- ABB will prepare the findings in form of report and present the same to customer.

Power and productivity
for a better world™