Advanced control solutions for rolling mill Reheating Furnaces - a case history -
1. AIC Automazioni Industriali Capitanio
2. Reheating furnace E&A
3. Case history
4. Results
5. APC
6. Conclusions
AIC Automazioni Industriali Capitanio srl
- Odolo (BS) Italy - 1975
- Torbole Casaglia (BS) Italy - 2007

AIC Capitanio Automation Systems India Pt.Ltd. - 2008

AIC North America Corp. - 2011

AIC South America Brazil - 2016
50+ employees
2500m² panel shop with 4 cranes 15/25ton
2017 turnover 15M$
950+ applications
160+ customers
40+ countries, 4 continents
System integrator for steel Industry specialized for LP
Our International Customers

- Feng Hsin Steel
- TSC
- Capitol Steel
- Outokumpu
- Nucor
- Sandvik
- Gerdau
- Acciaierie Venete SPA
- ArcelorMittal
- Ork Martin
AIC can suggest the most suitable solutions for all customer automation needs.
Today Electrical & automation are key factors for RHF:
- Efficiency (consumption & costs)
- Environmental issues
- Process control (temperature homogeneity)
- Yield
- Safety
- Data handling (Level 2, mathematical models, Industry 4.0)
Billets Reheating Furnace
- USA plant
- 5 zones pusher type
- Rated 110 Tph
- Structural mill

Issues:
- Old Automax PLC
- Obsolete HMI
- Material tracking issues
- External HW controllers
- Temperature homogeneity
- No data recording
Project scope of supply for the revamping E&A project:
- Combustion control upgrade
- Handling control upgrade
- Level 2 system
- CCTV system
Project targets

Targets:

- Replacing all obsolete automation components
- Landfill gas control
- All RHF control loops handled by PLC
- New HMI system integrated with Rolling mill HMI
- New Level 2 system that includes:
  - Reheating and delay strategies
  - Heating and cooling ramps
  - Material tracking
  - Feedback of billet exit temperature
- Improve efficiency of the system
- Improve safety of the area
Case history upgrade

- New PLC and RIO to control all the loops at the RHF:
  - Zone’s temperature PID control
  - Air/Gas DCL control
  - Flow control
  - Cutoff strategies
  - RHF internal pressure
  - Combustion air pressure
- Furnace light-up procedure by using new BCU
- Safety circuit implemented into PLC to control Main Gas
- Material tracking by reading EOH billet on loading table
- Interface with MES system
- Documentation to get approval from local agency
RHF Combustion control system

- Level 1 functions:
RHF Combustion control system
EOH Reading at RHF entry side
## RHF Table based Level 2

![RHF Table based Level 2](image)

### LEVEL 2: TRACKING

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Target for the system:

- Minimize necessary surface temperature of the billets, stabilizing final product quality and minimizing fuel specific consumption
- Optimize heating thermal profile
- Standardize furnace operations
- Guarantee coordination between RHF and rolling mill, with handling of scheduled and non-scheduled downtime
- Eliminate operators wrong behaviors in conducting the furnace
- Table based Level 2 system adjusts zones setpoints accordingly to billet tracking inside the furnace.
- It’s considering factors such as:
  - Rate pace
  - Loading billet temperature
  - Heat characteristics arriving from Recipe system
RHF Table based Level 2

RHF - LEVEL 2

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Descent Ramp (°F/H) | Delay Setpoint (°F) | Ascent Ramp (°F/H) | Turn Back Setpoint (°F) |
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Copy Heat Curve Number 1 in Heat Curve 1 COPY

Products Assignment Heat Curve List

Hot Charge Temperature

Temp [°F]
Rate [N]
North Soak
Center Soak
South Soak
Heat Zone
Preheat
RHF Table based Level 2
### RHF - LEVEL 2

**Tracking | QUAD | Heat Curve | Reports | Diagnostic**

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**BY HEAT**

**FROM** 10/21/2016 10:32:49 AM 
**TO** 10/22/2016 10:32:49 AM 
**Select Heat**

**Export table in .CSV**

**Weeks to Backup:** 3

**Weekly Backup Export**
Delay strategies

LEVEL II CALCULATIONS

<table>
<thead>
<tr>
<th>Setpoints</th>
<th>L2</th>
<th>DESC Ramp</th>
<th>Delay</th>
<th>ASC Ramp</th>
<th>Turnback</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREHEAT</td>
<td>1310 °F</td>
<td>999</td>
<td>1510 °F</td>
<td>500</td>
<td>1501 °F</td>
</tr>
<tr>
<td>HEAT ZONE</td>
<td>1450 °F</td>
<td>999</td>
<td>1630 °F</td>
<td>700</td>
<td>1729 °F</td>
</tr>
<tr>
<td>SOUTH SOAK</td>
<td>2190 °F</td>
<td>450</td>
<td>2131 °F</td>
<td>600</td>
<td>2230 °F</td>
</tr>
<tr>
<td>CENTER SOAK</td>
<td>2210 °F</td>
<td>450</td>
<td>2151 °F</td>
<td>600</td>
<td>2250 °F</td>
</tr>
<tr>
<td>NORTH SOAK</td>
<td>2230 °F</td>
<td>450</td>
<td>2170 °F</td>
<td>600</td>
<td>2269 °F</td>
</tr>
</tbody>
</table>

DELAY STRATEGIES

Manual Delay
START | FINISH

Automatic Delay
Trig. Time: 300 sec
DISABLE
START | FINISH

CANCEL DELAYS
Countdown Trigger
300 sec

Unscheduled Delay
Duration: 30 min
DISABLE
START | FINISH

Scheduled Delay
Duration: 60 min
DISABLE
START | FINISH

Downday Delay
23 49 10 23 2016
ENABLE | START
DISABLE | FINISH

Countdown Duration Delay
2214 min

Ready at Timing

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>HEAT ZONE</td>
<td>Sat Oct 22 11:02:43 2016</td>
</tr>
<tr>
<td>SOUTH SOAK</td>
<td>Sat Oct 22 11:26:34 2016</td>
</tr>
<tr>
<td>CENTER SOAK</td>
<td>Sat Oct 22 11:27:19 2016</td>
</tr>
</tbody>
</table>
Delay strategies

- **Manual delay:**
  - Started by operator, temperatures decrease according to decrease set rate
  - Stopped by operator, temperatures increase according to increase set rate

- **Automatic delay:**
  - Calling billet timer is later than scheduled trigger time, when activated temperatures decrease and the delay is deactivated when a billet is pushed again at furnace exit
**Delay strategies**

- **Unscheduled delay:**
  - Started by operator, temperatures decrease according to decrease set rate
  - Stopped when set day/time is reached

- **Scheduled delay:**
  - A flag on billet tracking detects the last billet to push out of the furnace and when stop production
  - As soon the flagged billet exits a single heating zone, the temperature of that single zone starts to decrease according to decrease set rate
  - Remains active until a new billet is pushed out of the furnace
Delay strategies

- **Downday delay:**
  - Start at set date/time and stops at day/time specified
Delay strategies

![Delay Logs]

- From: 10/21/2016 10:33:24 AM
- To: 10/22/2016 10:33:24 AM
- Refresh By Date and Time
- Finished Heat at: PM 10/21/2016 07:48:33 PM

Filters:
- Description

Delay Types Filter:
- Manual
- Auto
- Unscheduled
- Scheduled
- Down Day

Running/Finished:
- RUNNING AND FINISHED
Results

- **CONSUMPTIONS** – fuel consumptions was reduced by 5% on average
- **QUALITY** – Temperature variability was reduced by 40%
- **EFFICIENCY** – Operators errors are minimized due to reduced intervention on the combusting process (-70%)
- **ENVIRONMENT** – Better combustion control lead to less emissions in the atmosphere
- **YIELD** – Scale reduction (avg 1,2%)
Adaptive & Predictive model

- Predictive mathematical model

- Taking in considerations parameters like costs, technical constraints, targets and tuning parameters
Adaptive & Predictive model

- Predictive control algorithm is an Advanced Process Control technique that:
  - using an **explicit dynamic model** of the plant (model matrix for multiple input/multiple output systems)
  - **predicts** possible effects that **future changes on manipulated variables** could have on the outputs
  - taking account of specific cost functions, **it calculates** control signals that **minimize plant specific consumption**

- The controller aim is to lead the plant to the **most suitable working point**, respecting all the variables constraints.
Adaptive & Predictive model

- Move closer to process constraints = increase profit

**Predictive model**

**Optimum point**

- Optimum direction chosen according to economic variables

- Feasible working region

- Operators favorite region

- Iso-profit line
Adaptive & Predictive model

- Increase efficiency

Between 3% and 6% fuel savings on recent applications
State of the art Combustion control system can:

- Reduce fuel consumption
- Improve yield
- Improve quality of final product
- Educate operators to better run the plant
- Reduce emissions in atmosphere
- Give statistics data and analysis on final products
Thank you!

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