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Improving Energy Efficiency Using Advanced Process Controls

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Challenge

Develop a sustainable method of improving boiler efficiency by reducing excess air and/or maximizing black liquor throughput

Solution

Apply Aveva Consumed Air Optimization software on boilers operating with excess air and/or recovery boilers that are limiting chemical recovery cycle throughput

Benefits

Increased boiler efficiency, product throughput, reduce purchased fuel cost,

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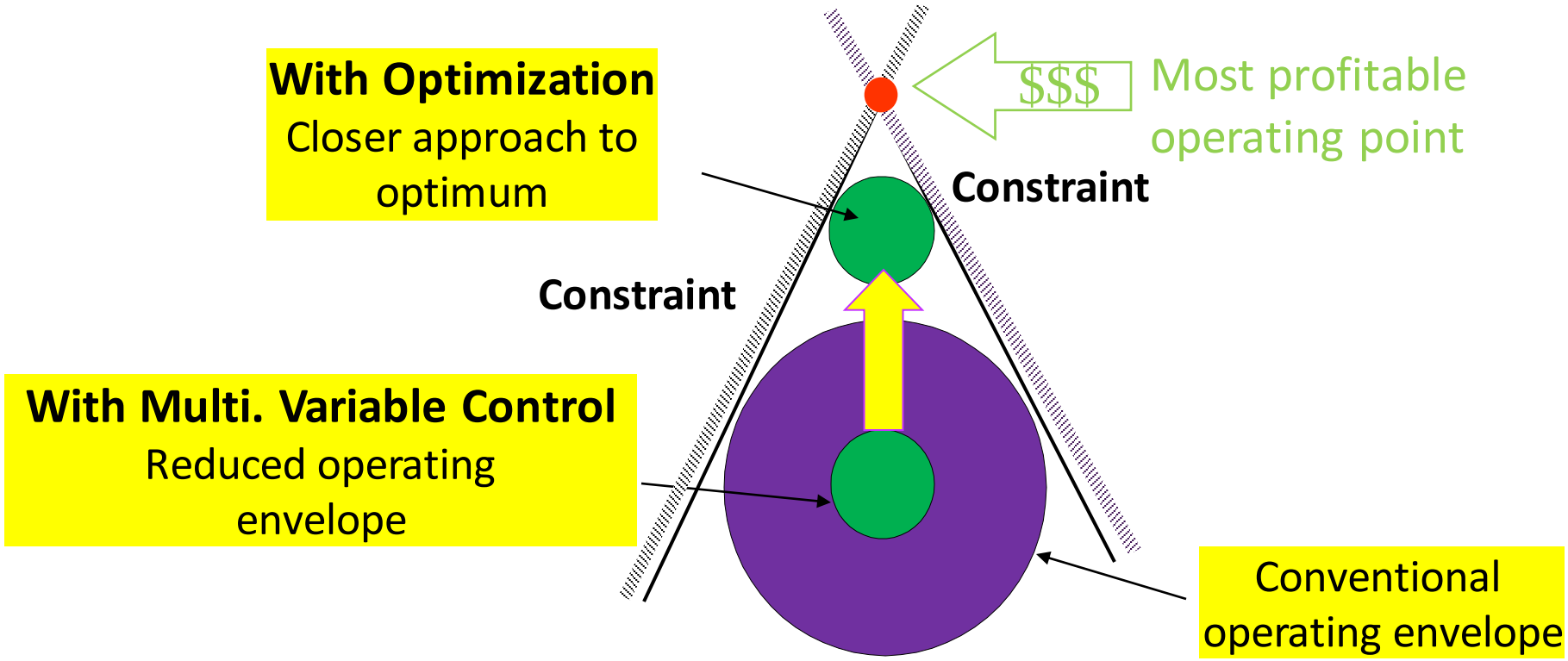
Topics for Discussion

- General methodology for determining energy efficiency improvements
- How to quantify opportunities
- Metrics for benchmarking
- Pre-project requirements
- Post project

Motivations for Optimization

- Improved control reduces operating variability



Optimization locates the best operating point

APC allows closer control to optimum point

General Methodology for Determining Energy Efficiency Improvements

- Is an additional steam gain or throughput available on the existing unit?
  - Analyze at least one year's worth of operating data
    - Typically use a process historian such as PI
  - Review the annual median steam flow and excess air results
  - Review the current utilization of the boiler – average annual steam flow (365 day basis)/Maximum Continuous Rating (MCR)
    - Underutilized - incremental steam gain is possible (Fully utilized RB will operate >90% Utilization)
    - Fully utilized - Steam flow control/throughput control will maximize production without exceeding maximum continuous rating (MCR)
  - Determine boiler efficiency based upon Mass Balance

General Methodology for Determining Energy Efficiency

Improvements

- Determine the components that may offer the largest impact – “Biggest Bang for the Buck”
  - Boiler Efficiency
  - Boiler Throughput
    - Paper Industry – maximize black liquor firing throughput/reduce purchased fuel consumption
    - Other industries – maximize lower cost fuels based upon $/MMBTU basis and boiler efficiency

Quantifying Opportunities

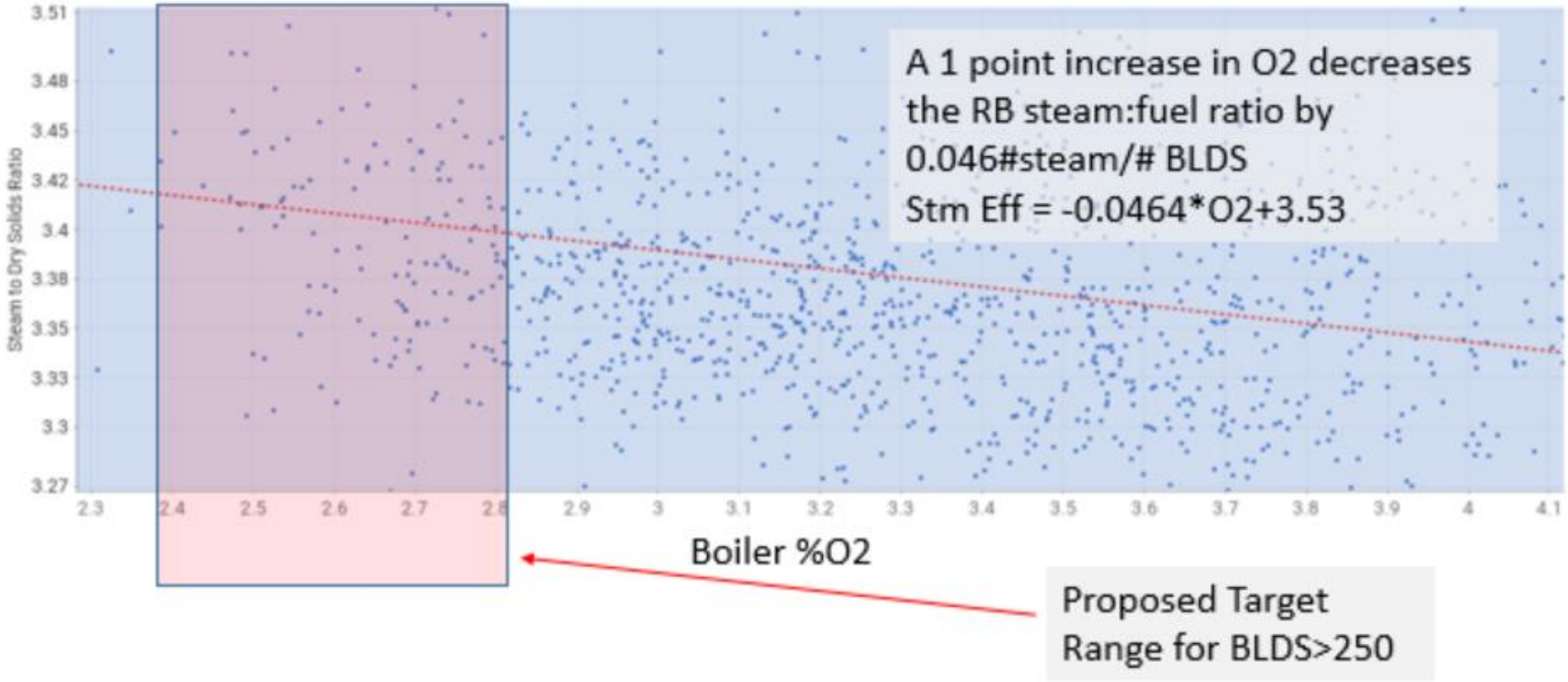
- Boiler Efficiency
  - Excess Air
    - 0.5% - 1% boiler efficiency gain for each 1% point reduction in O2 levels
    - Additional benefits
      - Reduces flue gas volume
        - Frees up ID fan capacity
        - Offloads highly utilized precipitators
      - Reduces flue gas outlet temperature
      - Reduces heat transfer surface fouling/carryover
- Boiler throughput
  - Recovery Boilers – maximize pulp production as part of the chemical recovery cycle
  - Power Boilers - dependent upon fuel mix

Quantifying Opportunities

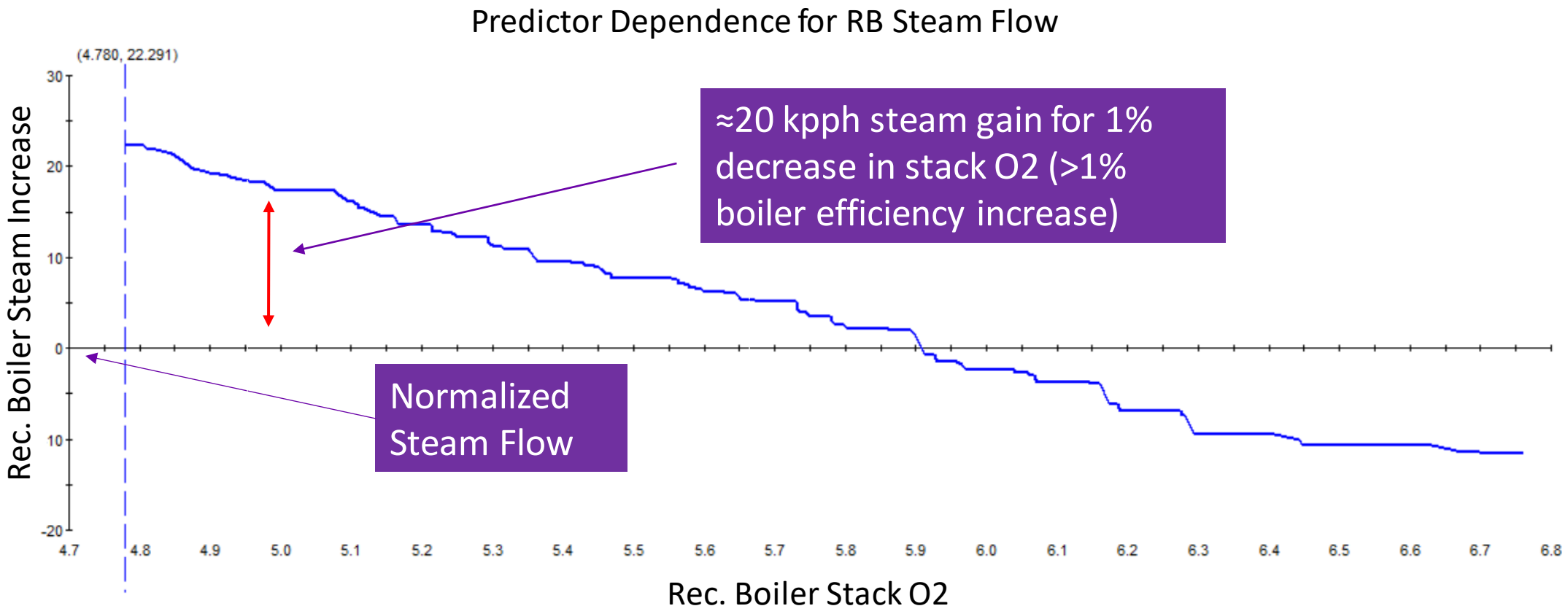
- Example - Boiler excess air reduction
  - Existing boiler efficiency – 65%
  - Existing %O2 (median annual value) – 3.2%
  - Annual median steam production – 492 kpph
  - Implementing Advanced Process Controls (APC) can reduce %O2 to 2%.
  - Efficiency increase – 0.75*(0.032-0.02) =0.009 (0.9%)
  - Steam Flow increase – .009/0.65*492 = 6.8 kpph
  - Given 94% availability, $7.50/kpph steam cost
  - Project savings - $420,000/yr
  - Typical project return 1-2 year(s)

Machine Learning – Filtered data based on specified load range

Alternative approach to determining efficiency gain – RB Specific



Machine Learning Gradient Boosted Trees – Key Variables Impacting Boiler Steam Flow



Quantifying Opportunities

- Example - Boiler throughput
  - Annual median steam production – 90% of MCR (Maximum sustained operation by manual control)
  - Maximum continuous rating – 523 kpph
  - Operate APC in steam control and maximize steam generation to within 93% MCR (based on 365 day basis)
    - Increase back pressure power for electrical generation - $/MWh
    - Off load higher cost fuel or less efficient boiler - $/kpph

Metrics for benchmarking

- What is industry best practice levels for utilization, throughput or excess air levels?

- What is the gap between your equipment and your industry's best practices?

Pre-project requirements

- Inspect all regulatory control systems
  - Air flow control loops must operate in automatic
  - Ensure O2, Combustible, or CO meters are working properly
  - Develop preventive maintenance routines for cleaning/inspecting probes and maintaining regulatory loops

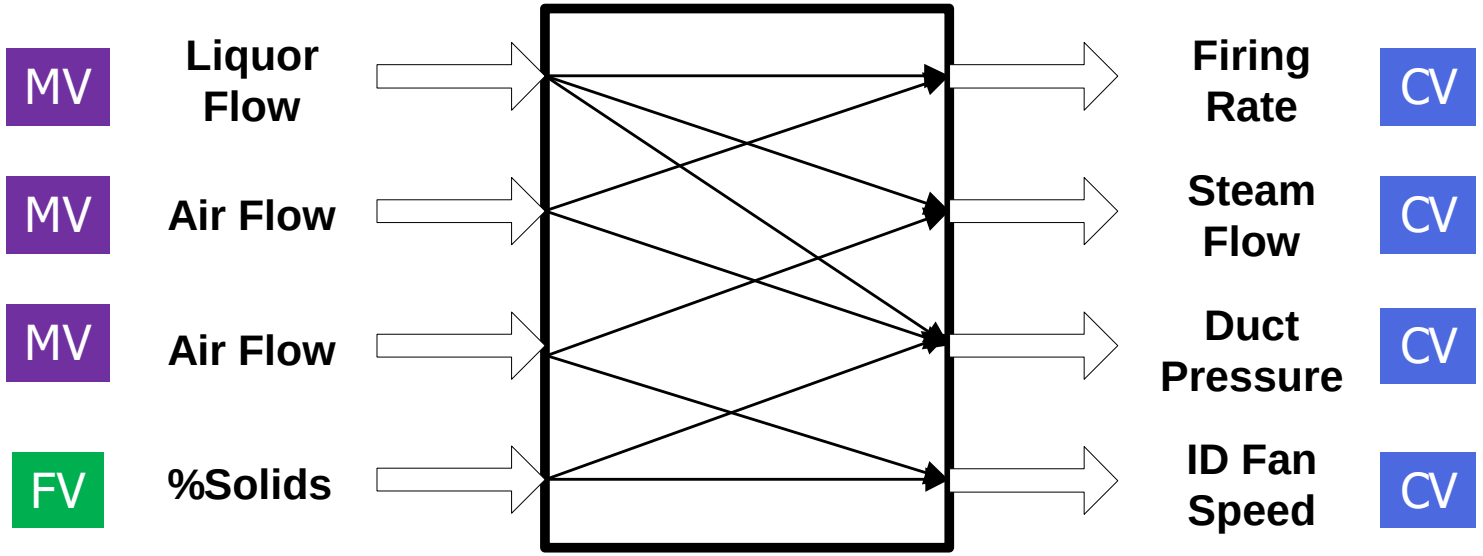
Pre-project requirements

- Data collection – know your current operating conditions
  - Boiler efficiency
  - Steaming rates
  - Headroom relative to MCR
  - Fuel Mix
  - Fuel Cost

Definitions

- Controlled Variables (CV) : Process variables that we want to keep within a range OR at a target
- Manipulated Variables (MV) : Process variables (valves) that can be manipulated and have an effect on one or more CVs
- Feedforward Variables (FV) : Process variables that have an effect on one or more CVs but cannot be controlled by the multivariable controller

Model Inputs and Outputs



Terminology:

CV – Controlled Variable
(Setpoint or range)

MV – Manipulated Variable
(Supervisory Setpoint to PID)

FV – Feedforward Variable

Post project

- Set expectations for operating in APC ≥ 95% availability
- Set expectations for operational parameters
  - %O2 levels
  - Boiler steam production - Maximum utilization
- Ensure operators understand the reason for operating with APC - Savings in $$
  - 1% reduction in excess O2
  - Every incremental kpph of steam generation on boiler X is worth $/MWh or reduction in higher cost fuel
- Audit the performance

Post project

- Consider an APC maintenance agreement for sustainability
  - Provide software maintenance support along with software updates
  - Provide performance assessments – often performed via remote monitoring
  - Supervisory control tuning/Model retuning as boiler operating conditions change
  - System troubleshooting
  - Supervisory control modifications based upon process changes
- Consider assigning a mill champion or performance champion in order to sustain the results

Conclusions

- Review operating data – data historians and/or logsheets to determine current operating performance
- Know where your equipment operates relative to industry benchmarks
- Determine the savings associated with “closing the gap” between your equipment and industry benchmarks
- Utilize tools such as APC as a means to help increase operating efficiency or product throughput
- Consider performance metrics and post-project support procedures to sustain benefits

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