SUOMEN SOODAKATTILAYHDISTYS
FINNISH RECOVERY BOILER COMMITTEE

CLYDE INDUSTRIES

Deposit Removal
Current Technology & Challenges

Danny S. Tandra

Clyde Industries

Deposit Removal

Three Objectives

Don't Plug & Damage	Don't plug and/or damage my boiler
Don't waste	Don't waste my steam
Safe & Reliable	Keep it Safe & Reliable

Technology Development

- Pulsating Jets
- Nozzle Separation Distance
  - Leading Edge Nozzle
- Fully Expanded Nozzle

- Targeted / Intelligent Sootblowing
- Zero Cooling Flow
- 9-14 bar Low Pressure Sootblowing

- Lance Design
- Carriage Fail Safe Design
- Fitness to Operate Sensors

Pulsating Jet & Nozzle Distance

- University of Toronto Research Consortium

6. Effect of Jet Characteristics on Removal of Cylindrical Brittle Deposits

Morteza Eslamian, Ameya Pophali, Donald Cormack, and Honghi Tran

breakup. When a single pulse jet (fast sootblowing) was used, only 20% of model deposits broke. In the case of a pulsating jet (fast and frequent sootblowing), all deposits broke and when a continuous jet was employed, 60% of deposits broke. Since the deposits made with $\eta = 1.5$ were breakable only at 5 cm, it was not possible to produce graphs similar to those for the soft deposits ($\eta = 2$).

- Single pulse jet : 20% deposits removed
- **Pulsating Jet : 100% removed**
- Continuous Jet : 60% removed

11. Effects of Nozzle Arrangement on Jet Propagation
Part II: Two Nozzle Tests

Andrei Kaliazine, Donald E. Cormack and Honghi Tran

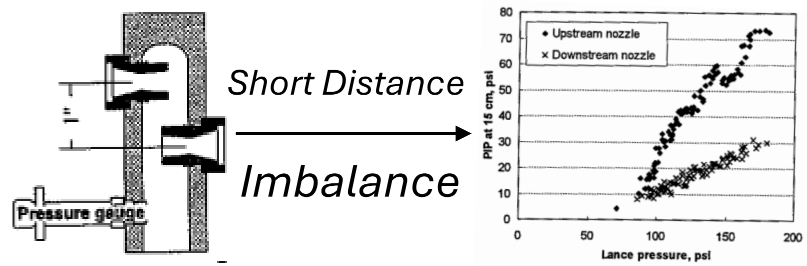


Figure 5. *Short block: PIP at 15 cm from the nozzles of type A.*

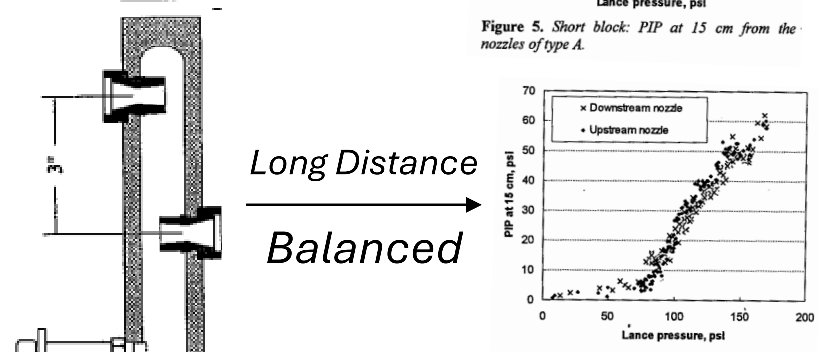
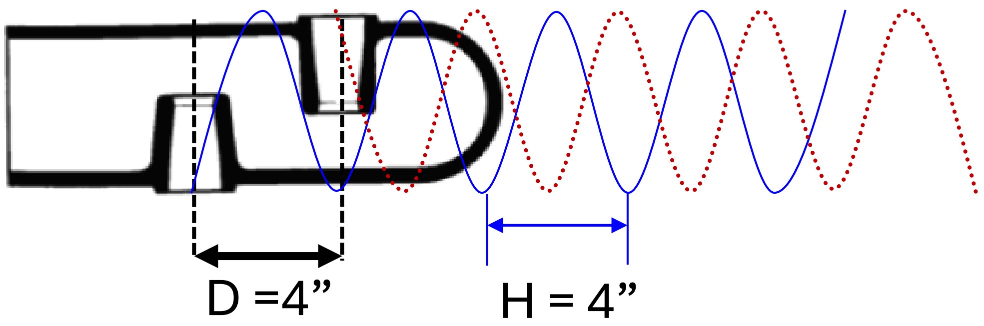


Figure 4. *Long block: PIP at 15 cm from the nozzles*

How Pulsating & Balanced Jet is created

Old Design

Single Pulse Jet



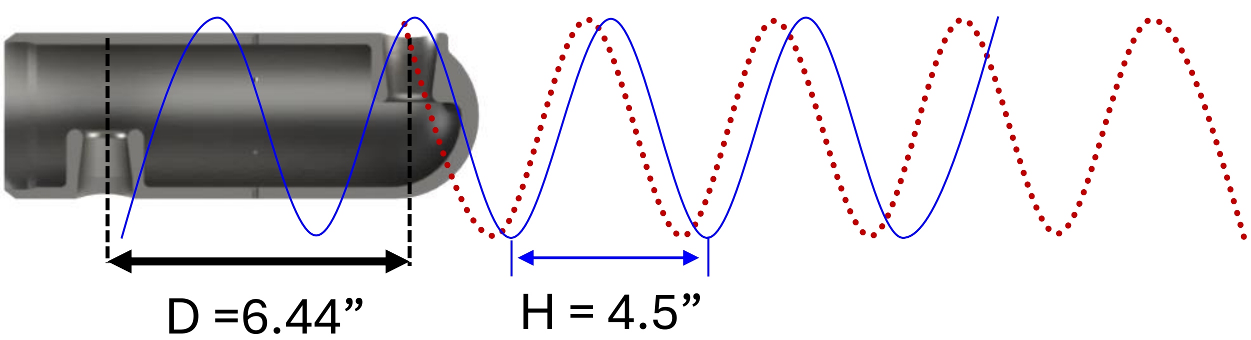
Insertion

Retraction

Same Patern

Current Design

Pulsating & Balanced Jets can be achieved by modifying Nozzle Distance (D) & Helix (H)



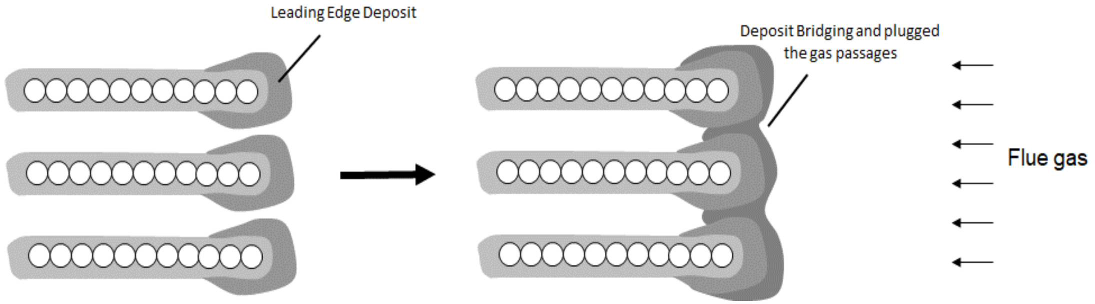
Insertion

Retraction

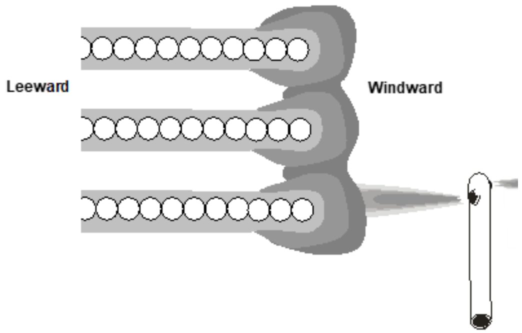
Different Patern

Leading Edge Nozzle

- Plugging in a recovery boiler superheater starts with the accumulation of leading-edge deposits



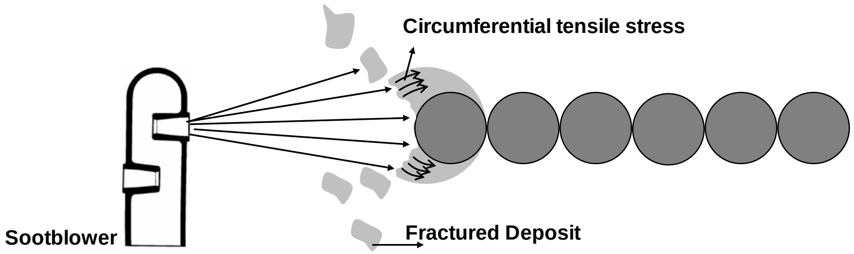
- Difficult to remove leading edge deposits with direct jet impingement



Leading Edge Nozzle

- In superheater where Tdeposit >350 ^{o}C
  - $S_{adhesion\ (\text{“glue”})} <<< S_{Deposit\ tensile}$
  - Easier to remove the leading edge deposit by debonding (*breaking the “glue” between the deposit/tube*) instead of brittle breakup (*breaking the actual hard-solid deposit itself*)

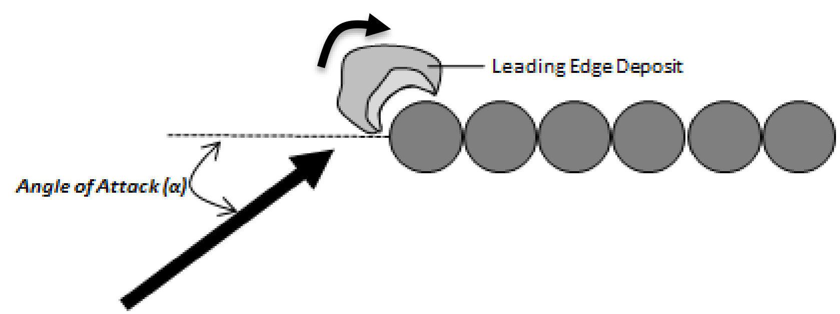
Brittle Break-up



Difficult to remove due to high $S_{tensile}$

Need high pressure and sharp jet to break the deposit (can also damage the boiler tubes)

Debonding



Easier to remove because $S_{adhesion} <<< S_{tensile}$

Leading Edge Nozzle

TAPPI PEERS 2020
Session 11

THE IMPACT OF UTILIZING THE LEADING EDGE SOOTBLOWER NOZZLE ON RECOVERY BOILER SUPERHEATER PLATENS

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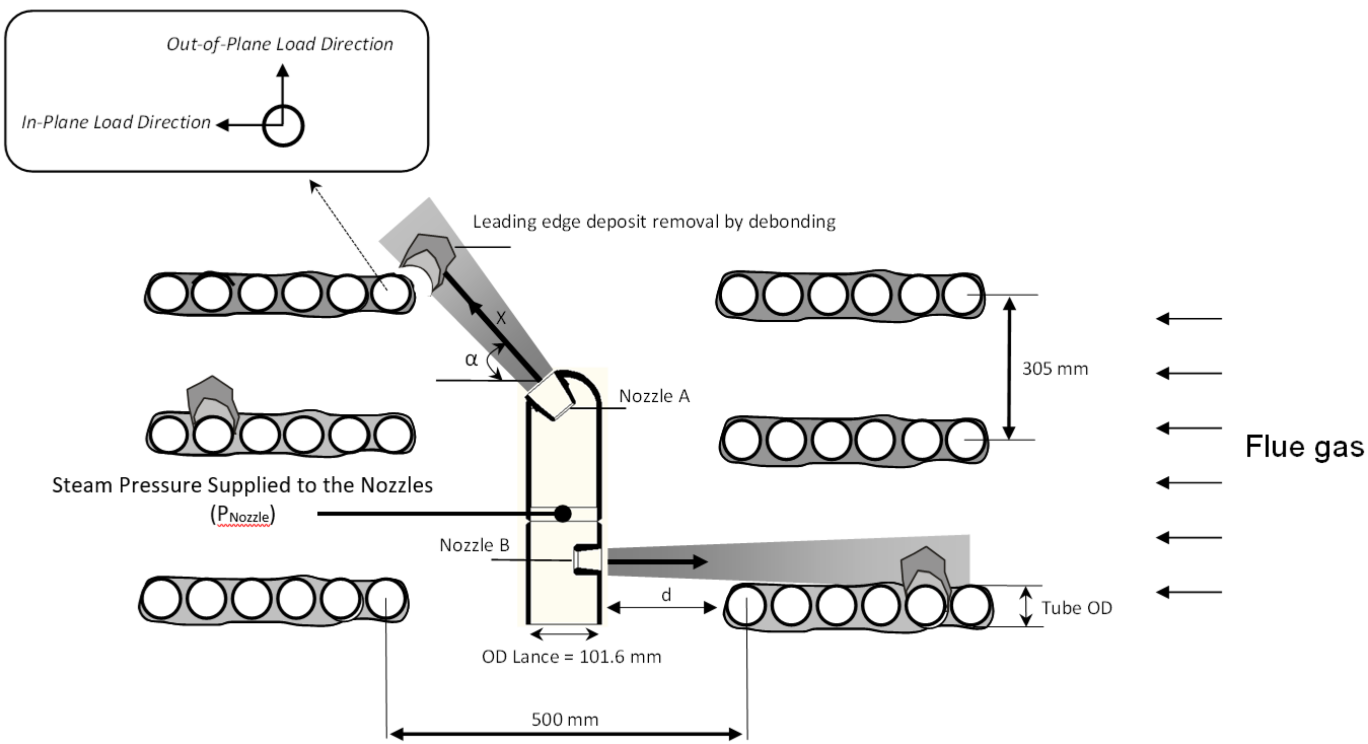
Andritz Inc.

Shenglong You, Markus Bussmann
University of Toronto



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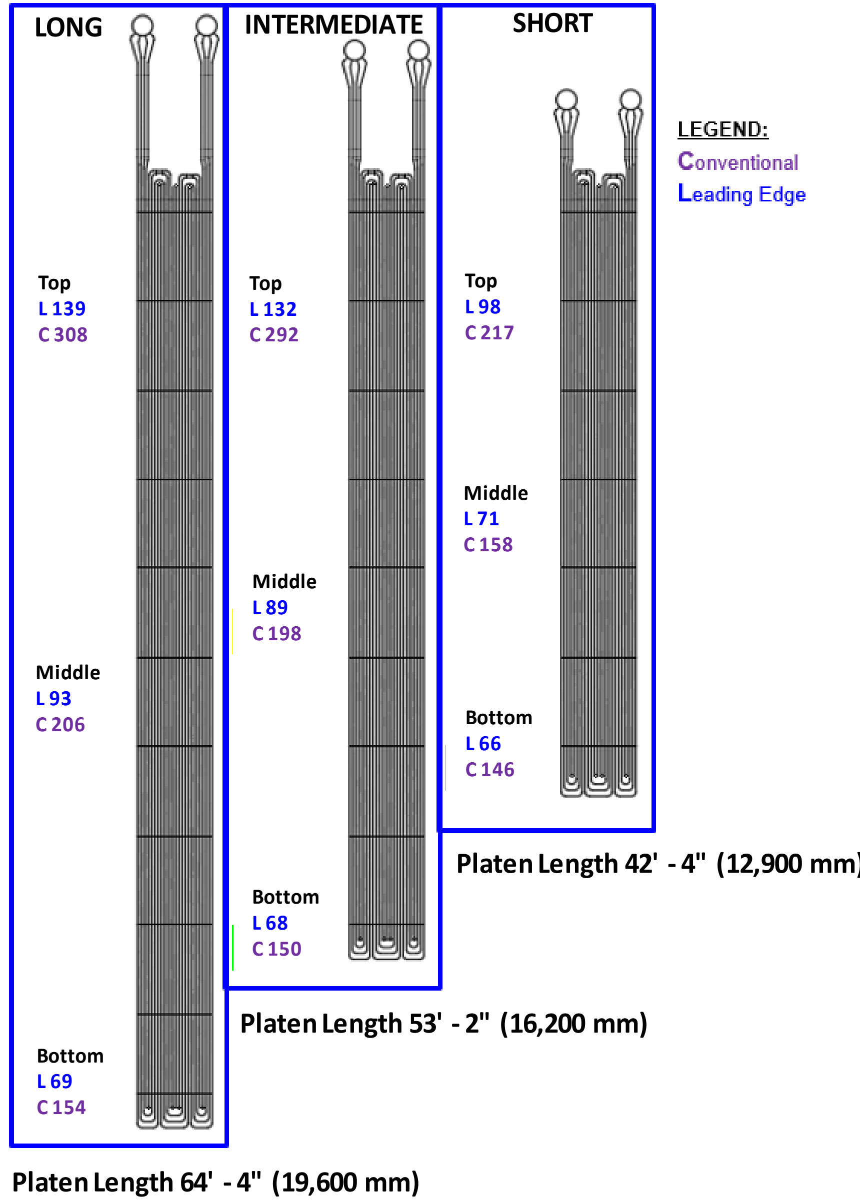
Guideline

TAPPI PEERS 2020

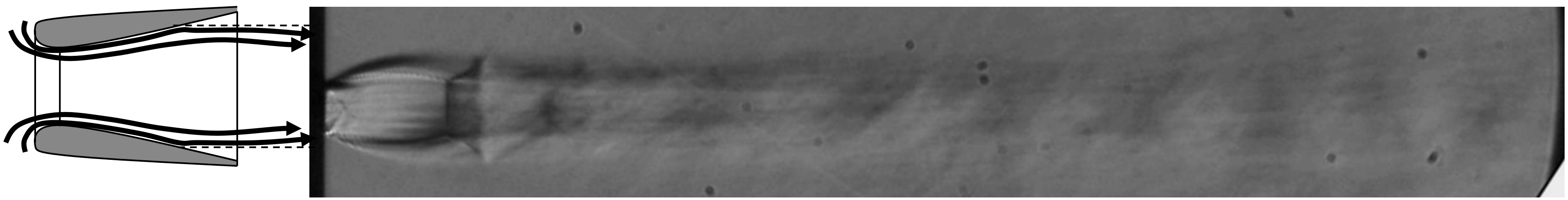
- Effective in dealing with heavy fouling & plugging
- May improve the boiler runtime
- However, there is a concern that it may damage the boiler tube if used inappropriately.
- Ongoing study with the University of Toronto.



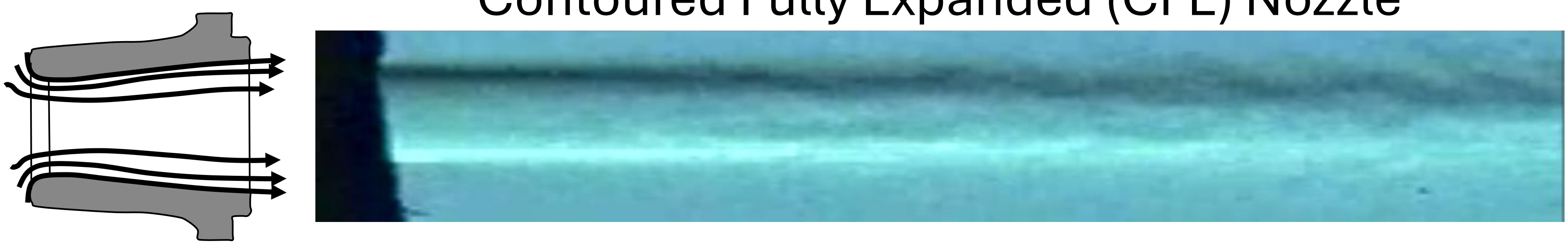
NOTE:
L 98 = The maximum P_{Nozzle} for leading edge nozzle is 98 psig
C 217 = The maximum P_{Nozzle} for conventional nozzle is 217 psig

Fully Expanded Nozzle

Conventional Underexpanded Nozzle



Contoured Fully Expanded (CFE) Nozzle

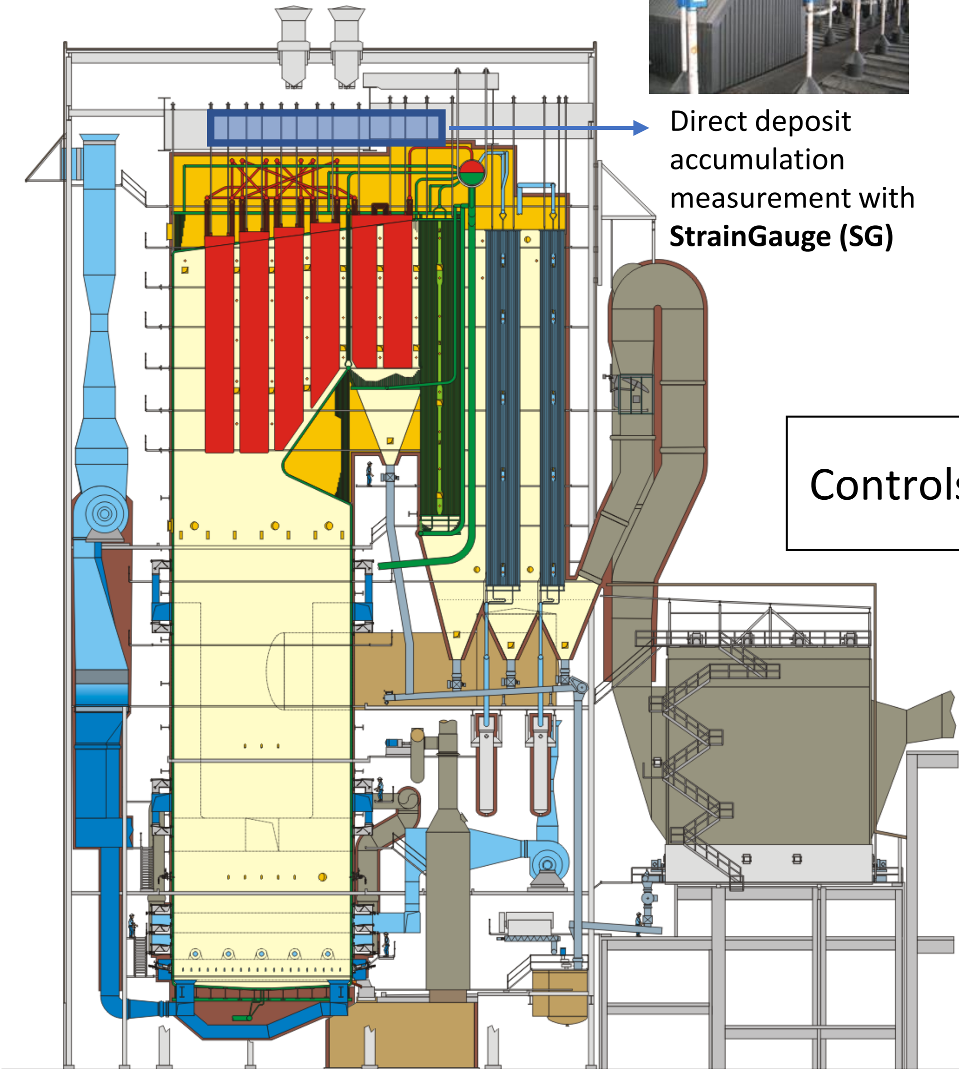


- Fully Expanded Nozzle is defined as a nozzle that can fully expand the P_{Nozzle} to the ambient pressure inside the boiler, thereby, converting the steam pressure completely into velocity, and prevent the formation of shock wave.

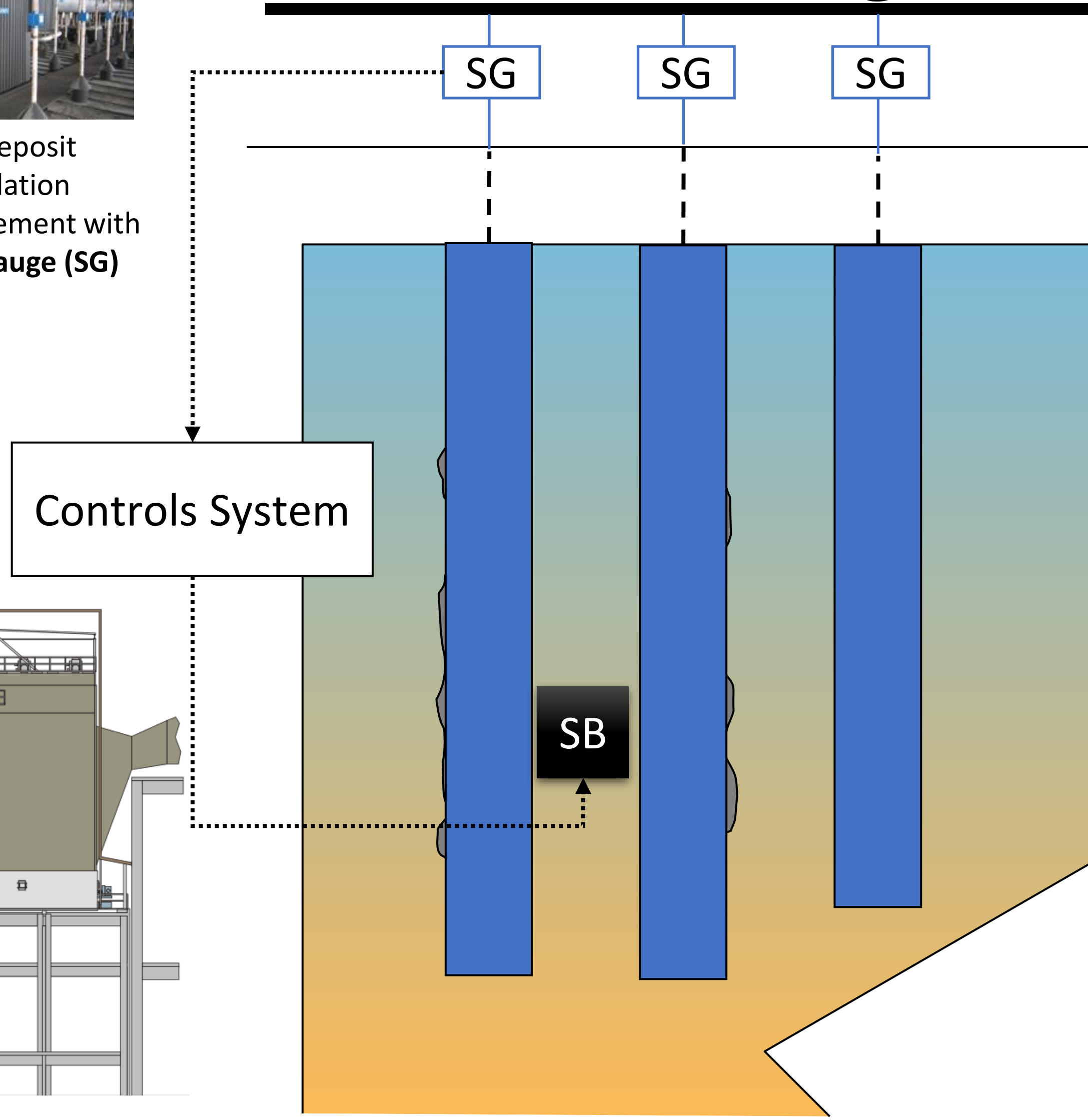
Deposit Removal

Three Objectives		Technology Development
Don't Plug & Damage	Don't plug and/or damage my boiler	● Pulsating Jets ● Nozzle Separation Distance ○ Leading Edge Nozzle ● Fully Expanded Nozzle
Don't waste	Don't waste my steam	● Targeted / Intelligent Sootblowing ● Zero Cooling Flow ● 9-14 bar Low Pressure Sootblowing
Safe & Reliable	Keep it Safe & Reliable	● Lance Design ● Carriage Fail Safe Design ● Fitness to Operate Sensors

Targeted / Intelligent Sootblowing



Direct deposit accumulation measurement with **StrainGauge (SG)**



Zero Cooling Flow

- The steam used for sootblowing also acts as a coolant to prevent the lance tube from overheating.
- If a sootblower is located in non-critical area and the lance material & design allow for one-way blowing operation, it is desirable to lower the cooling flow to save steam but not too low so as to cause lance tube overheating.

Active US Patent – International Paper
Andrew K. Jones

Zero Cooling Flow

Active US Patent – Andrew K. Jones

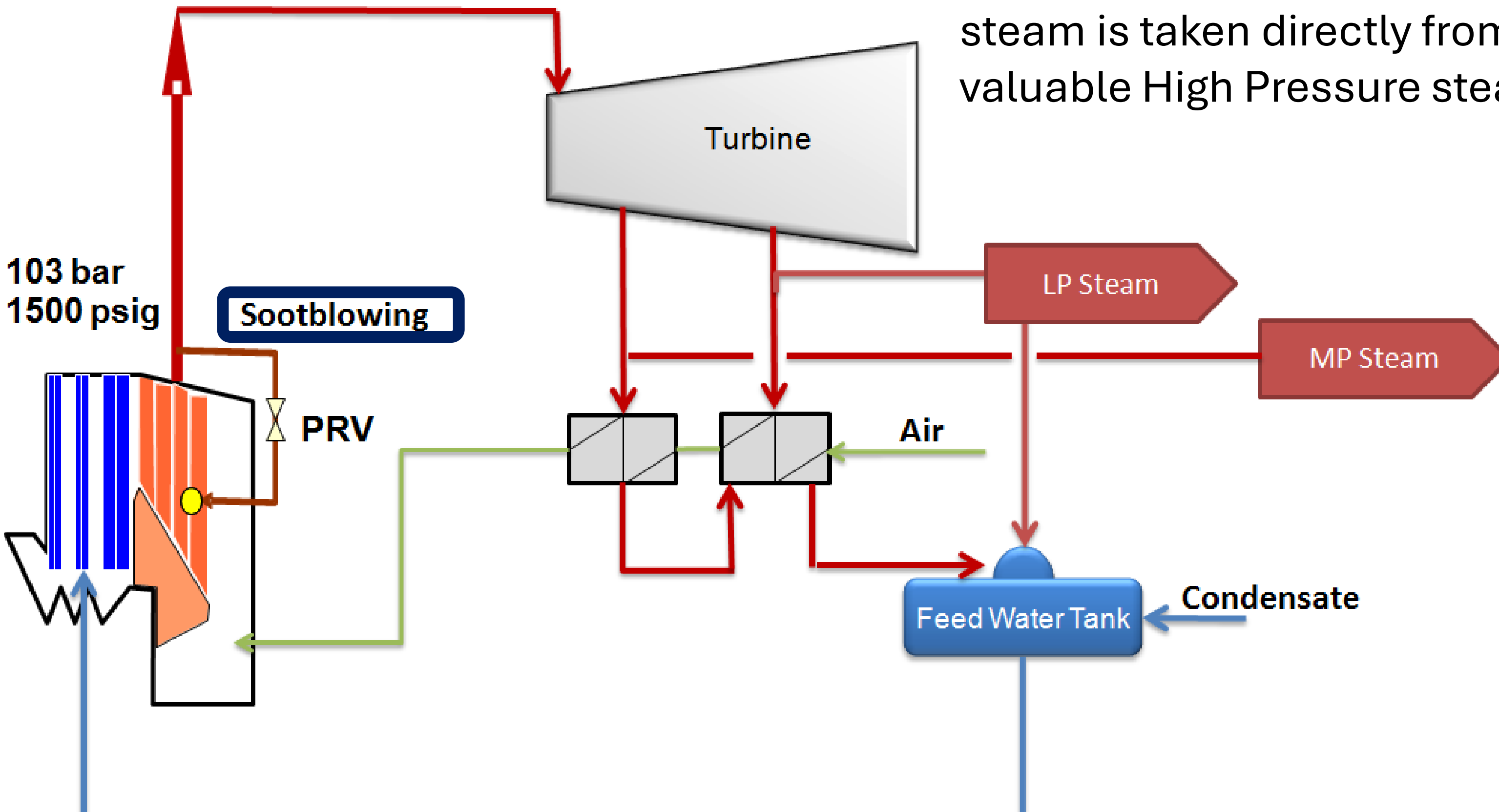
Stationary IR sensor can be used to monitor the skin temperature of the lance and adjust the cooling flow accordingly to prevent its lance tube and/or the neighboring lance tubes from overheating

9-14 bar low pressure sootblowing

- **Best Available Tech**:
  - Allow more MW Generation
  - For a new recovery boiler project, this technology most definitely provides the best ROI.

Old Tech: Sootblowing 20+ years ago

<u>VERY COSTLY</u> – sootblowing steam is taken directly from RB valuable High Pressure steam



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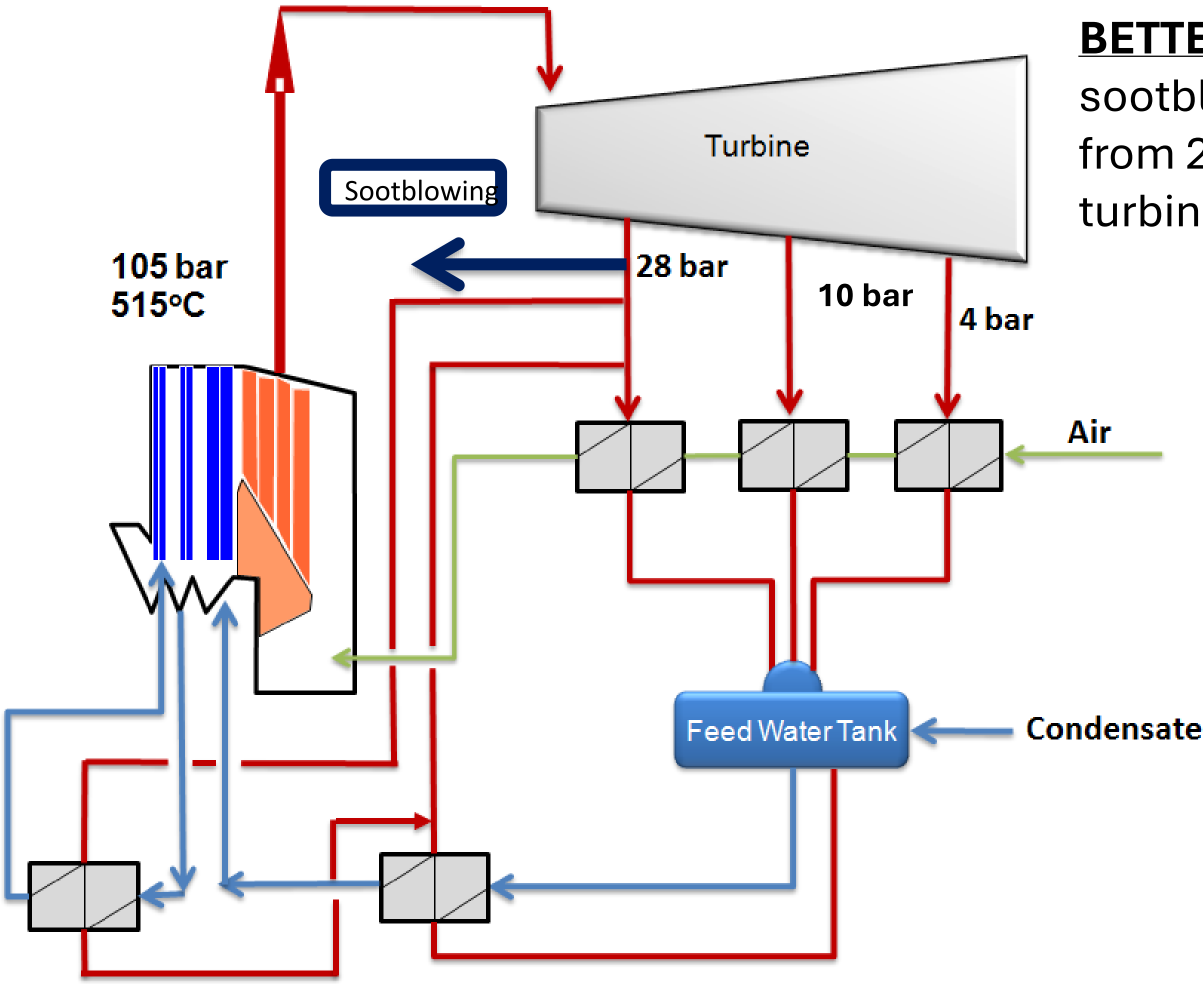
Conventional Sootblowing



BETTER BUT STILL COSTLY

sootblowing steam is taken from 28 bar g (400 psig) turbine extraction

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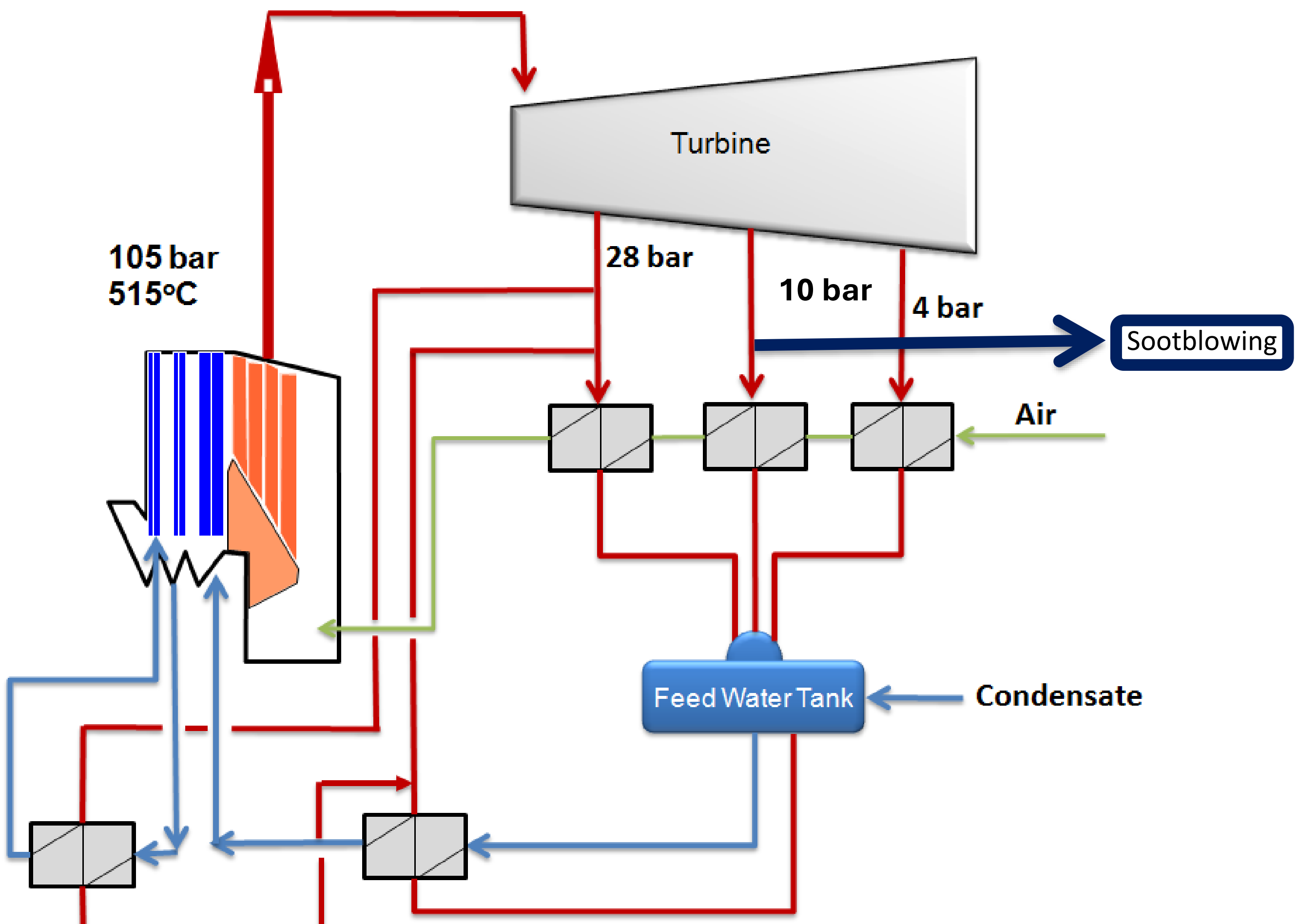
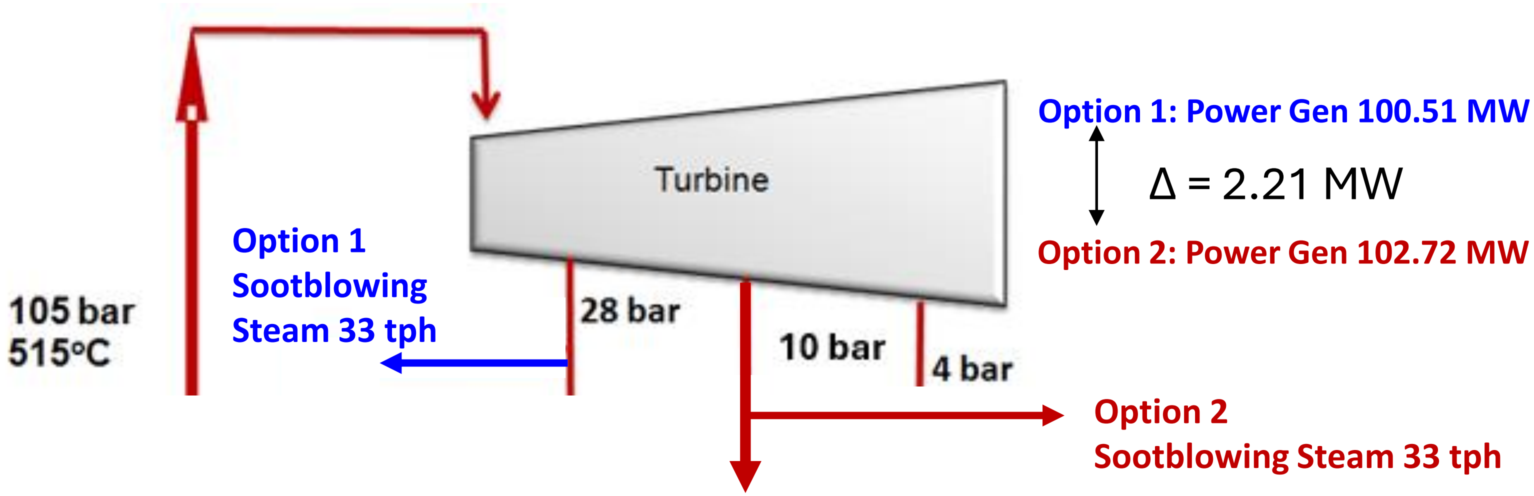
Best Technology: 9 – 14 bar sootblowing



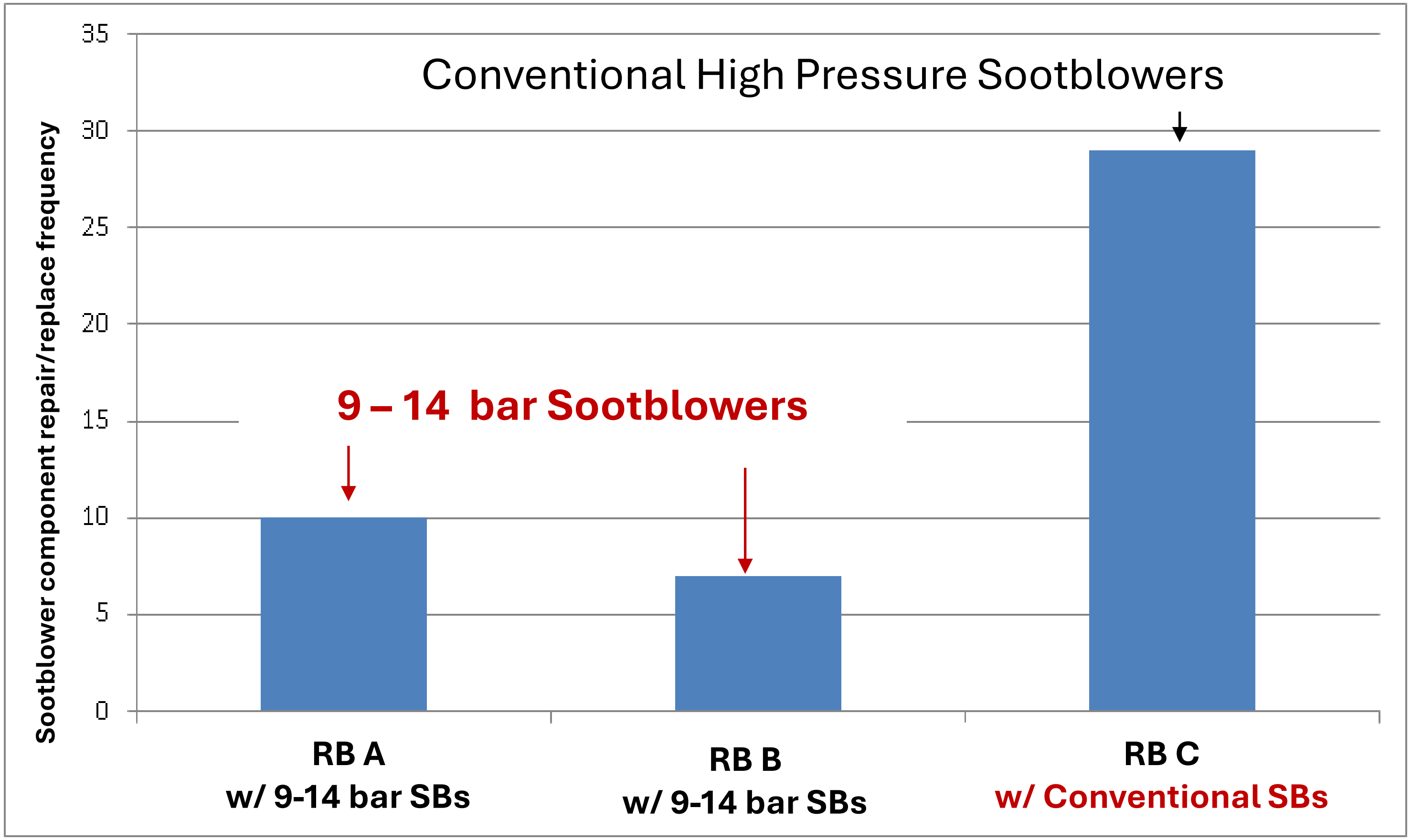
Comparison



- For 33 ton/hr steam consumption, the mill can generate additional 2.21 MW with Option 2
- If the cost of energy is assumed to be € 100 / MWh, the saving per year is estimated about €2M *(assuming 355 operation days per year)*

$$\boxed{2.21MW\,\frac{€100}{MWh}\,24hr\;355\;days = \mathbf{€1.9M/yr}}$$

Other benefit: Lower Maintenance Costs



- The wear and tear components, *such as packing and poppet valve, of the* 9-14 bar sootblower has longer service life than its High Pressure sootblower counterpart. This may be due to lower operating pressure experienced by the 9-14 bar sootblower.

Deposit Removal

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Summary

- Three objectives
  - Don’t plug & damage my boiler
  - Don’t waste my steam
  - Keep it safe & reliable
- Nozzle tech has reached its maturity, with the exception of the leading edge nozzle where ongoing research is underway to improve the advantages and minimize the downsides
- Targeting / Intelligent Sootblowing and 9-14 bar low pressure sootblowing provide the best available technology to save energy

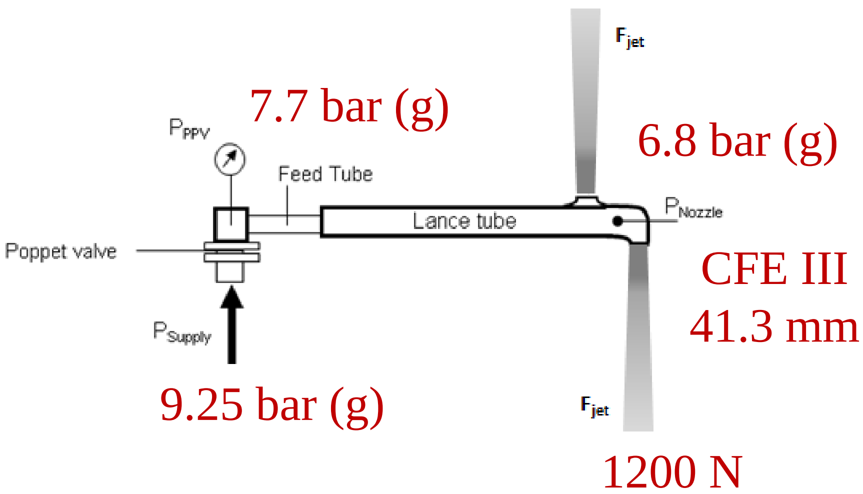
BACK UP SLIDES

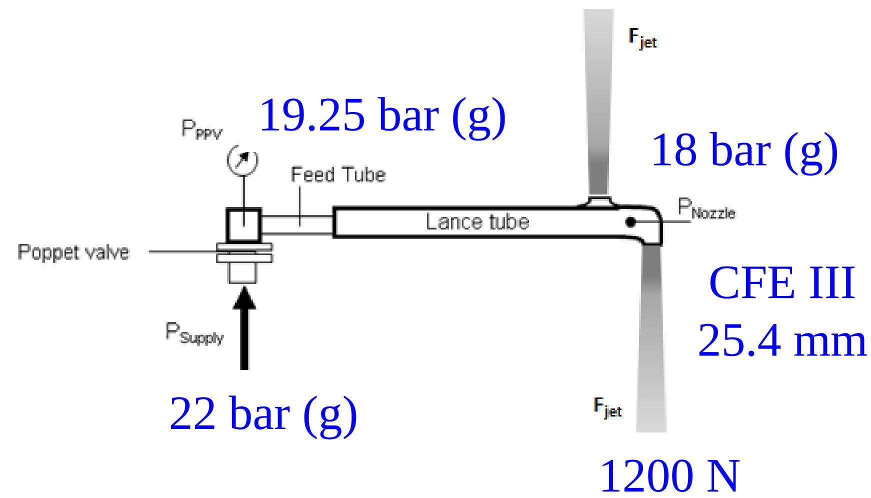
Sootblower Design: Basic Principles

Content	%Cl At BLDS	% K At BLDS	Required Cleaning Force
Very Low	< 0.1	< 0.7	800 N
Low	0.1 – 0.3	0.7 – 1	900 N
Typical	0.3 – 0.7	1 – 2	1050 N
High	0.7 – 2.5	2 – 4	1200 N

- Sootblower should be designed with the worst case scenario in mind, ready to combat heavy fouling if needed
- Clyde Industries recommends the sootblowers to be designed with the capability to increase the cleaning force to 1200 N ***to deal with possible boiler upset and heavy fouling***

Deposit Removal Criteria





F_{jet} (41.3mm) = F_{jet} (25.4mm)

P_{32mm} * Impact $Area_{41.3\ mm}$ = $P_{25.4mm}$ * Impact $Area_{25.4mm}$

$$0.68\left(\frac{N}{mm^2}\right)\ \frac{1}{4}\pi(41.3)^2\ mm^2 = 1.8\ \left(\frac{N}{mm^2}\right)\ \frac{1}{4}\pi(25.4)^2\ mm^2$$

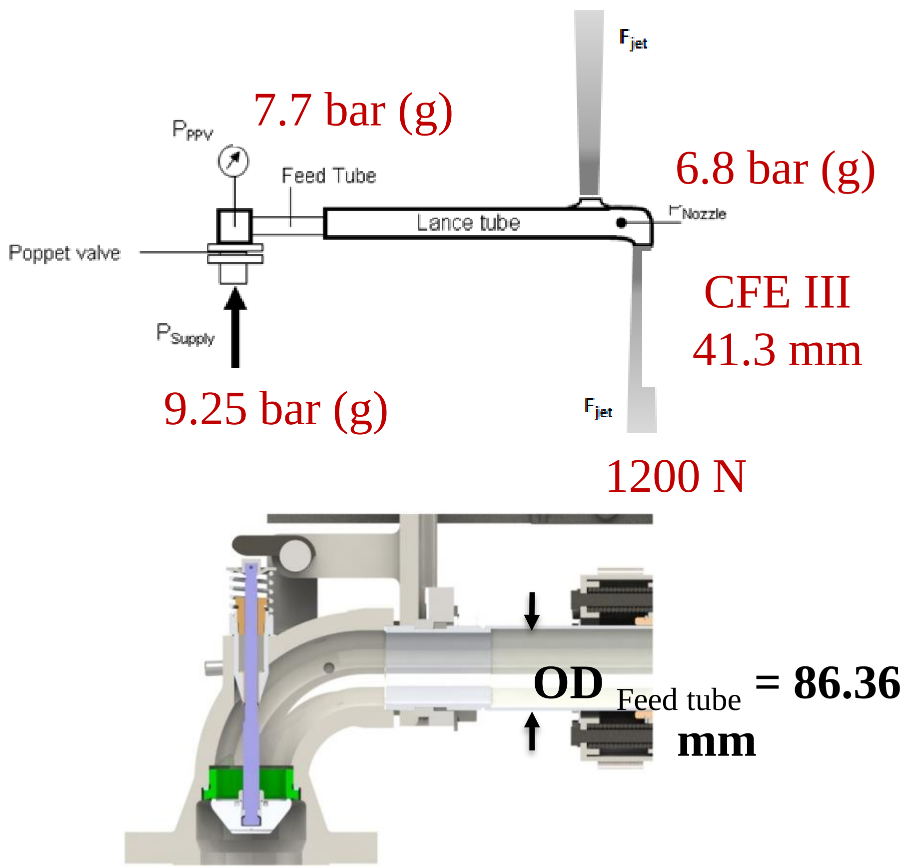
6.8 bar

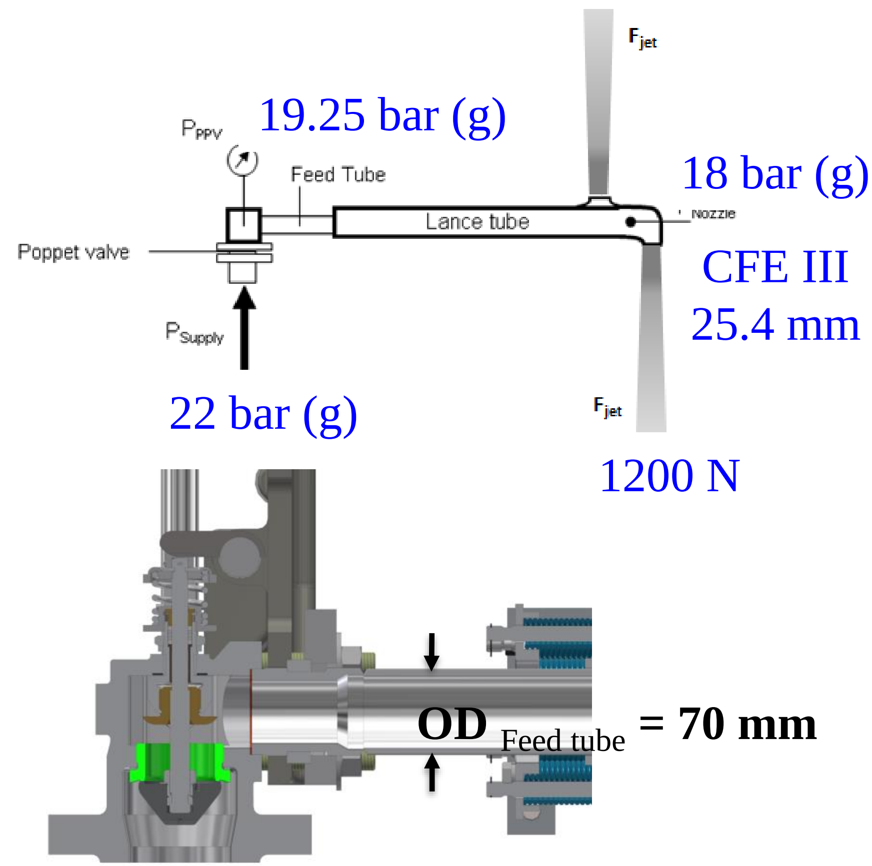
Note that the above equation is the simplified version of the physic of the jet dynamics

NOT TO BE USED TO DESIGN THE SOOTBLOWER

18 bar

Deposit Removal Criteria

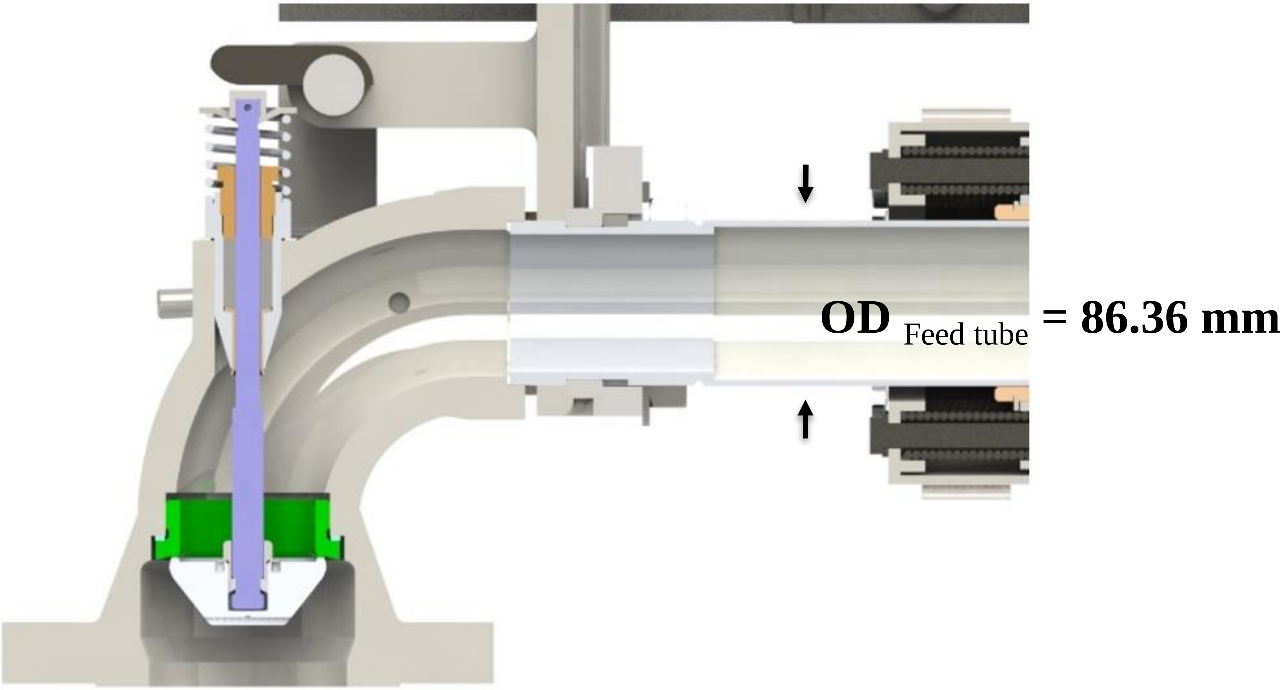




Lower P_{Supply} is possible with low pressure drop sootblower

9 – 14 bar Sootblower: Poppet Valve

- Elbow-like poppet valve to minimize costly pressure drop



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Introduction to Sootblower Nozzle

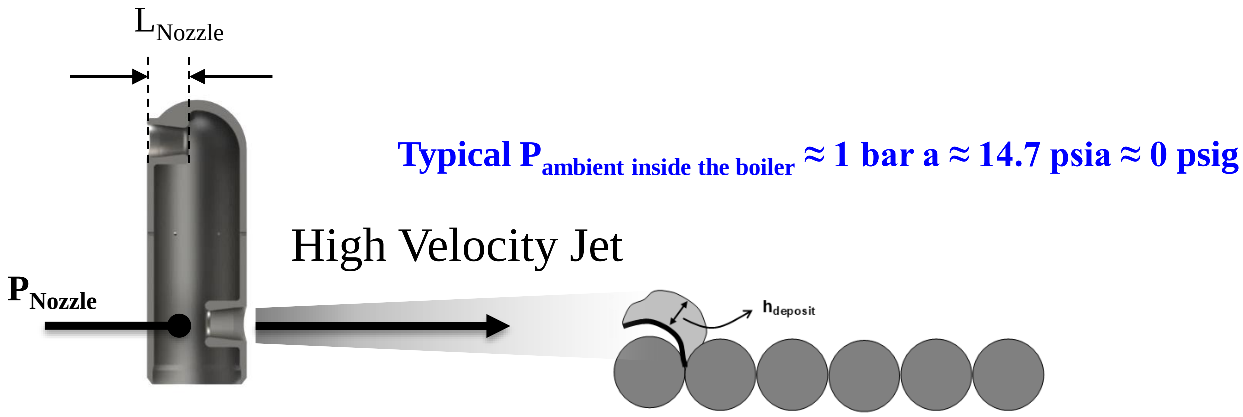
May 2023

How about the steam consumption?

Does **low pressure** consume more steam than **high pressure**?

No, it does NOT

Ideal Nozzle

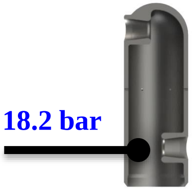


- The main function of a sootblower nozzle is to convert high pressure steam supplied to the nozzle (P_{Nozzle}) to high velocity jet.
- An ideal nozzle is defined as a nozzle that can fully expand the P_{Nozzle} to the ambient pressure inside the boiler, thereby, converting the steam pressure completely into velocity (i.e., 100% efficiency).
- A fully expanded nozzle is a nozzle with 100% nozzle efficiency

Comparison

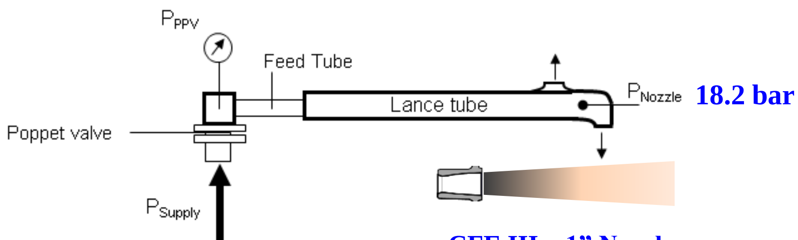
CFE III – 25.4 mm (1”) throat diameter

P_{Nozzle} = 18.2 bar



$P_{ambient\ inside\ the\ boiler}$ ≈ 1 bar a

Flow Rate through both nozzles = 2.43 kg/s



CFE III – 1” Nozzle
F = 1200 N (jet force)

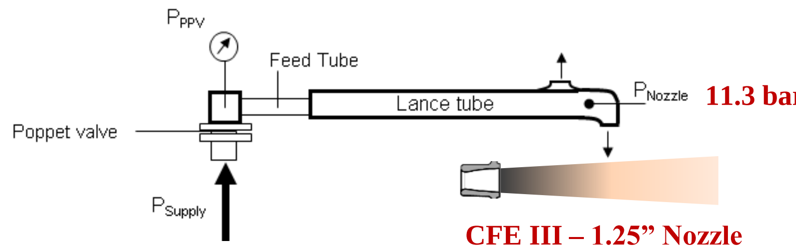
- Require 18.2 bar at the nozzle and steam flow rate of 2.43 kg/s to produce 1200 N

CFE III – 32 mm (1.25”) throat diameter

P_{Nozzle} = 11.3 bar

$P_{ambient\ inside\ the\ boiler}$ ≈ 1 bar a

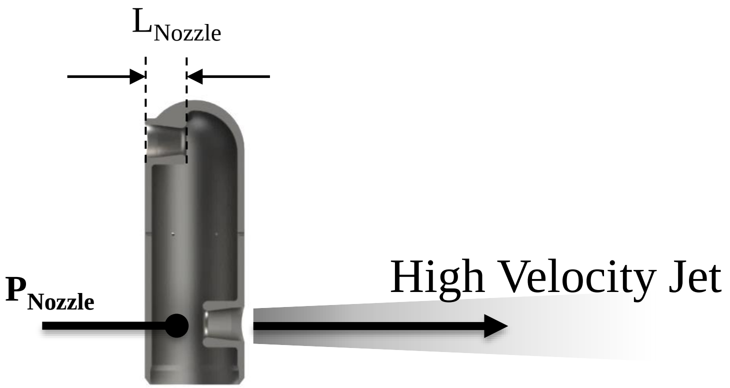
Flow Rate through both nozzles = 2.43 kg/s



CFE III – 1.25” Nozzle
F = 1250 N (jet force)

- CFE III – 1.25” nozzle is more efficient than its 1” counterpart. It produces higher cleaning force of 1250 N and requires only 11.3 bar at the nozzle and the same flow rate of 2.43 kg/s

Why CFE III – 1.25” is more efficient than 1”



- The higher the P_{Nozzle}, the longer L_{nozzle} (nozzle length) must be designed to fully expand the P_{Nozzle}.
- Unfortunately, the L_{nozzle} is restricted to the lance OD (which is typically 3.5” or 4”)
- CFE III – 1.25” is more efficient than its 1” counterpart because it only need to expand the steam pressure from 11.3 bar (compared to 18.2 bar for CFE III – 1”) to 1 bar ambient pressure.
- Hence the L_{nozzle} requirement to fully expand the P_{Nozzle} doesn’t have to be compromised by cutting it short (like the CFE III -1”) to fit the nozzle into the lance OD.
- Therefore, Clyde Industries has standardized its nozzle offering to a more efficient CFE III – 1.25”