Recovery boiler sootblowers: History and technological advances

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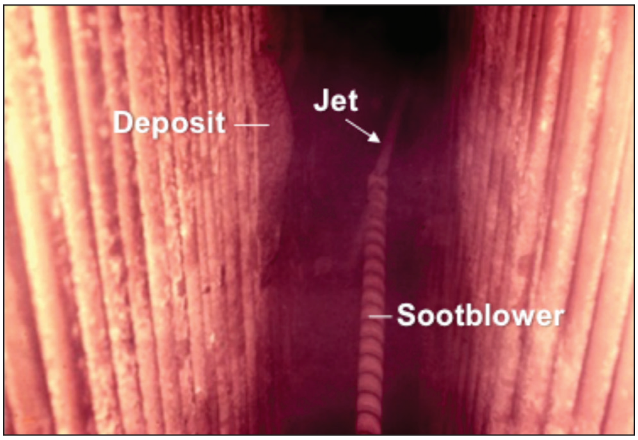
ABSTRACT: Sootblowing technology used in recovery boilers originated from that used in coal-fired boilers. It started with manual cleaning with hand lancing and hand blowing, and evolved slowly into online sootblowing using retractable sootblowers. Since 1991, intensive research and development has focused on sootblowing jet fundamentals and deposit removal in recovery boilers. The results have provided much insight into sootblower jet hydrodynamics, how a sootblower jet interacts with tubes and deposits, and factors influencing its deposit removal efficiency, and have led to two important innovations: fully-expanded sootblower nozzles that are used in virtually all recovery boilers today, and the low pressure sootblowing technology that has been implemented in several new recovery boilers. The availability of powerful computing systems, superfast microprocessors and data acquisition systems, and versatile computational fluid dynamics (CFD) modeling capability in the past two decades has also contributed greatly to the advancement of sootblowing technology. High quality infrared inspection cameras have enabled mills to inspect the deposit buildup conditions in the boiler during operation, and helped identify problems with sootblower lance swinging and superheater platens and boiler bank tube vibrations. As the recovery boiler firing capacity and steam parameters have increased markedly in recent years, sootblowers have become larger and longer, and this can present a challenge in terms of both sootblower design and operation.

Application: This article helps readers to understand the history of recovery boiler sootblowers and several important technological advances that have been made in the past three decades.

The accumulation of fireside deposits on heat transfer tube surfaces is a persistent problem in many kraft recovery boilers. The severity of the problem depends mainly on the amount and the melting behavior of fly ash particles (carryover and fume) entrained in the flue gas, and the efficacy of the deposit cleaning system that the individual boiler employs [1,2]. If left unattended, deposits may form a thick insulation coating on the tube surface, significantly reducing the boiler thermal performance and steam production capacity. In severe cases, deposits may completely plug the flue gas passes, leading to costly unscheduled boiler shutdowns for cleaning. They might also fall, and if large enough, damage screen tubes and floor tubes directly below [3].

Sootblowers are the principal means of cleaning deposits in recovery boilers. During boiler operation, sootblowers blast deposits off tube surfaces with high pressure steam (**Fig. 1**), while during boiler outages, they use hot water instead of steam to remove the deposits and clean the boiler tubes. Maintaining a high deposit removal efficiency and availability of sootblowers is of vital importance in recovery boiler operation [4,5].

Over the last three decades, much research and development has been done on deposit removal and sootblowing technology by researchers at the University of Toronto, and by researchers and engineers at recovery boiler and sootblower manufacturers. This includes jet hydrodynamics and nozzle design [6,7,8]; interactions between a jet and tubes and between a jet and deposits [9,10,11]; the mechanisms of deposit breakup and removal by a jet [12,13]; and the effect of composition, particularly chloride and potassium, on deposit removability [2,14,15]. The work was carried out through laboratory experiments, mathematical modeling, and computational fluid dynamic (CFD) modeling [16,17], as well as through mill trials [8,18,19]. The results provided significant insight into how a sootblower jet strikes and removes deposits from the tube surface, and factors influencing the removal efficiency. These research and development efforts resulted in two major innovations. One is the fully-expanded sootblower jet concept [6,7] that served as the basis for the



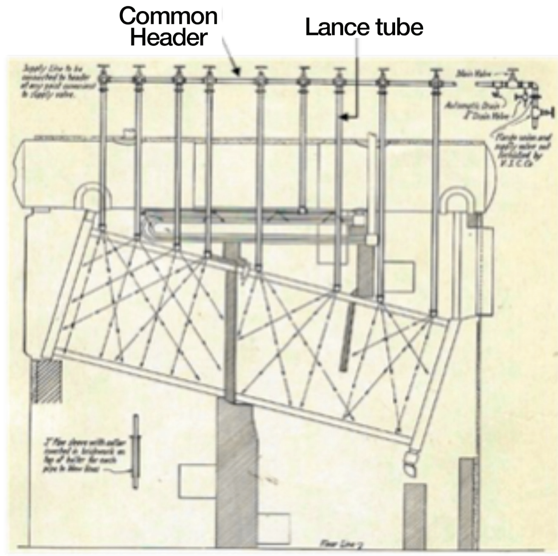
1. Sootblower in action in a recovery boiler.

development of the new generation of high intensity sootblower nozzles on the market today [20-23]. The other is low-pressure sootblowing technology [24,25] that has been tested [26,27] and implemented in several recovery boilers in the United States and Brazil [28].

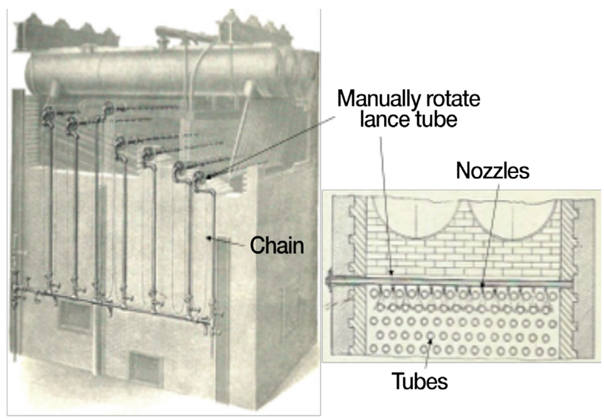
The availability of high-computing power computers, superfast microprocessors and data acquisition systems, sophisticated process control logics, and versatile CFD modeling capabilities in the past two decades has also contributed greatly to the advancement of sootblowing technology. Several deposit monitoring methods based on boiler and sootblower operating parameters were developed to estimate the state of fouling (or cleanliness) of the heat transfer surfaces in different regions of the boiler, and to incorporate the information to optimize the sootblowing operation [29-34].

There has been enormous change in recovery boiler technology since the first Tomlinson recovery boiler was built in 1929 [35]. The black liquor firing capacity of the boiler has increased substantially from under 200 TDS/day (tons of black liquor dry solids per day) in the 1930s to slightly over 2000 TDS/day in the 1980s, over 3000 TDS/day in the 1990s, and to 5000 TDS/day in the 2000s [36]. Several recently built recovery boilers are in the 6000-7000 TDS/day range [37], and presently the world's largest recovery boiler is being built at a new pulp mill in Oki, Indonesia, with a staggering designed firing capacity of 11600 TDS/day. The superheated steam parameters have also increased, from a maximum temperature/pressure of 350°C/30 bar in the 1930s, to 480°C/60 bar in the 1990s and 2000s [36], with a few recovery boilers in Scandinavia and Japan operating at 515°C/110 bar to maximize the electricity generating efficiency [37-39]. As the firing capacity and steam quality increase, the boiler size and heat transfer surface area also increase. This inevitably requires not only a larger number of sootblowers per boiler, but also longer and larger sootblowers that can deliver stronger and better controlled jets.

This paper reviews the history of recovery boiler sootblowers, as well as several important technological advances that have been made in the past three decades.



2. Stationary cleaning system [40].



3. Stationary rotary cleaning system [40].

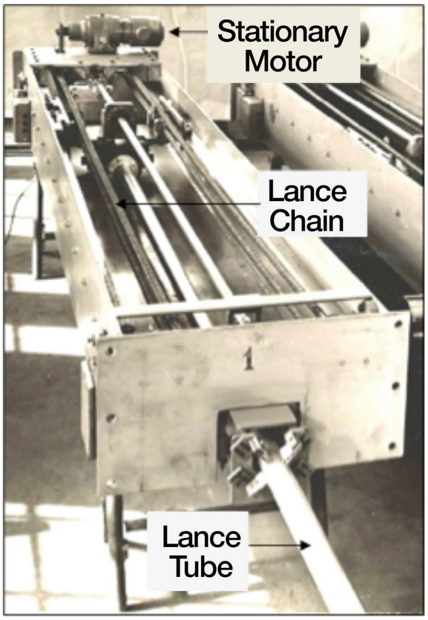
SOOTBLOWER HISTORY

The word "soot" refers to black, carbonaceous fine particles that are formed during the combustion of coal, wood, oil, etc. Soot forms deposits on the walls of the combustors, chimneys, and pipes that convey the flue gas. In the context of recovery boilers, soot is synonymous with carryover/fume deposits. A sootblower is simply a device that is used for blowing and removing deposits from tube surfaces.

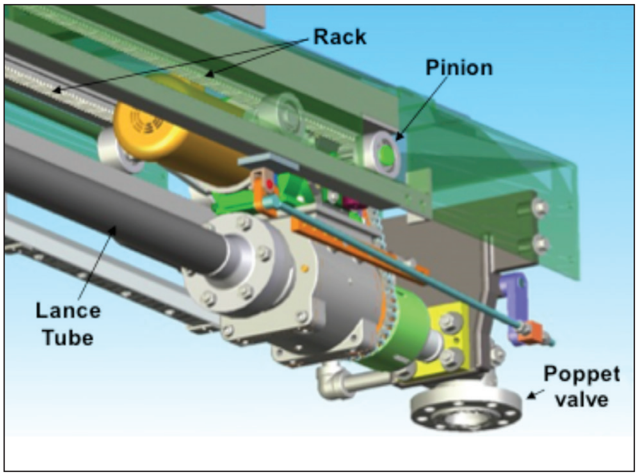
The first sootblower for online deposit cleaning was patented and first used in coal-fired boilers by Diamond Power in 1903 [5]. The technology evolved slowly but eventually found its way to other applications, including recovery boilers.

In the early days, recovery boilers were designed with close tube spacings that were difficult to keep open. Hand lancing was carried out frequently to remove deposits but was only able to keep the boiler in operation for a short period of time [4]. As the boiler became plugged, the operators stopped the liquor firing, opened the boiler mandoors to locate the deposits, and used a long steel rod (or lance) to manually knock them off the tubes. Hand lancing could only handle deposits that were close to the boiler wall. For deposits that were far from the boiler wall or were obscured by tubes/other deposits, hand lancing was difficult, as the steel rod needed to be extended deeper into the boiler. For deposits that were behind tubes, it was even more difficult since the steel rod needed to be bent in order to reach the deposits. Hand lancing was dangerous to carry out during boiler operation due to the constant puffing of hot flue gas from the boiler, particularly when the boiler became plugged.

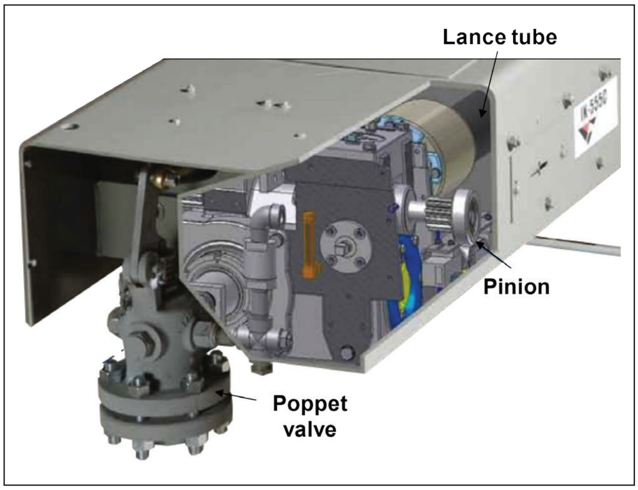
Hand blowing became a preferred means of deposit removal. A hand blower was basically a long steel pipe with a



4. *Early retractable sootblower[40].*



5. *Clyde Bergemann's sootblower [41].*



6. *Diamond Power's IK-555 sootblower [43].*

handle on one end and small nozzles on the other end. Compressed air was manually regulated through the pipe to produce an air jet of various strengths. Depending on the nozzle design and position, operators could direct the air jet straight into the boiler or at an angle to clean deposits. Since the passing air helped cool the pipe lance, hand blowing could be carried out during boiler operation.

Hand lancing and hand blowing were laborious and useful only for small boilers. As the boiler size increased, these manual cleaning devices became obsolete and were replaced by fixed-position (stationary) multi-nozzle cleaning systems, as shown in **Fig. 2**. In this system, several lance tubes were connected to a common steam header (steam is mostly used since it is readily available and less costly than compressed air). The nozzle at the end of each lance tube was designed so that the steam jet could be directed to a desired area. These stationary multi-nozzle cleaning systems were later replaced by stationary rotary cleaning systems to increase the coverage area. This was achieved by mounting multiple nozzles along the length of the lance tube, which was manually rotated by pulling the chain around the lance tube (**Fig. 3**).

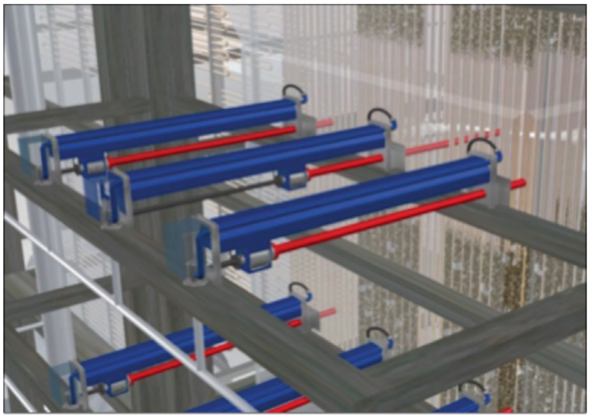
The large number of nozzles mounted on each lance tube reduces the steam flow rate per nozzle, and hence, reduces the cleaning power of the jet. Furthermore, the portion of the lance tube that stays inside the boiler has a short service life since the lance tube corrodes quickly if it is exposed uncooled to the corrosive environment, particularly in the superheater region of the boiler. Even in the cooler and less corrosive regions of the boiler, the lance tube temperature is still high, close to the flue gas temperature. When the cleaning is initiated, the cooler steam supplied to the lance tube causes the tube temperature to drop abruptly, resulting in thermal cyclic stresses that can shorten the lance tube life. As a result of these drawbacks, stationary rotary sootblowers were soon replaced by retractable sootblowers.

Retractable sootblowers

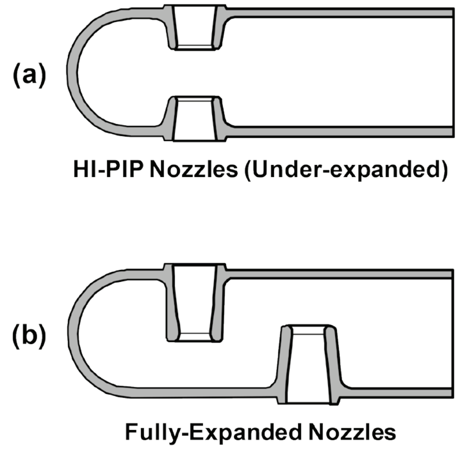
Retractable sootblowers were developed to address the shortcomings of stationary rotary sootblowers. When the sootblower is not in use, the lance tube is fully retracted and parked outside the boiler, and thus is not exposed to the hostile environment in the boiler. In order to maximize the jet cleaning power as well as to balance the lance tube, retractable sootblowers are equipped with only two opposing nozzles at the tip of the lance tube.

Retractable sootblowers were introduced to recovery boilers in the 1940s; this significant development made large recovery boiler design practical [35].

Early retractable sootblowers had a chain drive system that moved and rotated the lance tube in and out of the boiler. The chain was driven by a stationary motor mounted on top of the sootblower canopy (**Fig. 4**). Safety and reliability were the main concerns for this version of retractable sootblowers.



7. Schematic of retractable sootblower installation in a modern recovery boiler.



8. Nozzle design comparison (HI-PIP=high performance peak impact pressure).

The chain system required constant maintenance. If it failed and broke during sootblower operation, the high pressure steam in the lance tube would cause the tube to torpedo forward and strike the boiler wall on the opposite side at a high speed. This could cause severe damage to the wall tubes and injuries to mill personnel who happened to be nearby.

Modern retractable sootblowers replaced the stationary motor and chain system in the early version with a traveling motor that had dual-rack and pinion drives. With such an arrangement, the motor travels together with the carriage as the lance tube is pushed in and retracted from the boiler. The dual-rack and pinion drives have greatly improved the reliability of the lance tube movement. This retractable sootblower design is currently used by the two major sootblower manufacturers, Clyde Bergemann (**Fig. 5**) and Diamond Power (**Fig. 6**).

A schematic of multiple retractable sootblowers installed in a modern recovery boiler is shown in **Fig. 7**. The number of such sootblowers may range from 60 in a small unit to as many as 150 in a large unit.

Alternative cleaning systems

There are several alternative cleaning systems that have been commonly used in coal-fired boilers and many other applications, but not in recovery boilers. These include sonic sootblowers, falling steel shot, and wall blowers.

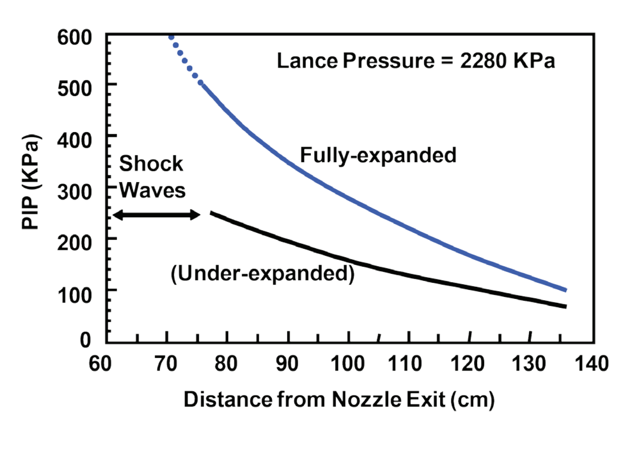
Sonic sootblowers pass compressed air into a wave generator to produce a series of sound-induced pressure fluctuations that emit loud low-frequency noise. These air horns cause loosely bonded ash particles to de-bond from the heat transfer surface. They work relatively well on fluffy, unsintered deposits in the ductwork and the back of economizers, but not at all on dense, hard, and sintered deposits in the superheater and generation bank regions of recovery boilers. Falling shot is a cleaning method that drops small steel balls from the upper section of the boiler down onto deposits in the lower section and removes them from the tube surfaces. The dropped balls are subsequently collected at the dust outlet and pneumatically returned to the upper section to be ready for the next shot. In recovery boiler operation, since the removed/collected dust are chemicals that need to be returned to the system for recovery, the possible inclusion of steel balls in the recycled dust and its impact on recovery equipment make the method impractical.

Wall blowers have also been widely used for removing deposits and slags from wall panels in the lower furnace of utility boilers. In recovery boilers, however, since deposits on furnace walls at locations before the superheater entrance are thin, wall blowers are usually not needed.

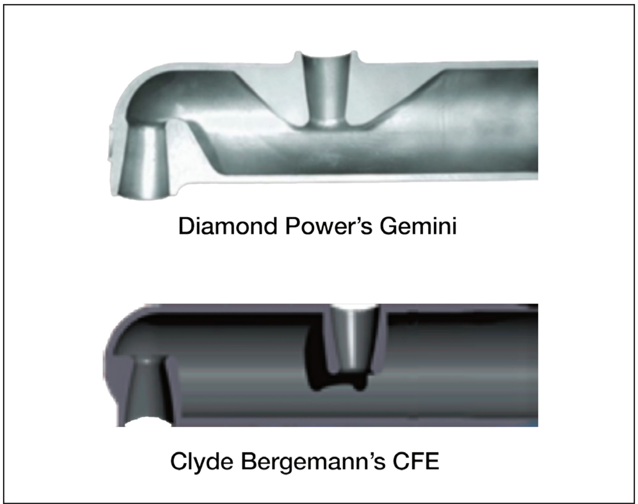
TECHNOLOGICAL ADVANCES

Up to the early 1990s, most improvements made on sootblowing technology were limited to the design and mechanical aspects of the equipment; little attention was given to optimizing the sootblower cleaning power, the steam usage, and deposit control strategies. The sootblowing technology used in recovery boilers was literally the same as that used in coal-fired boilers.

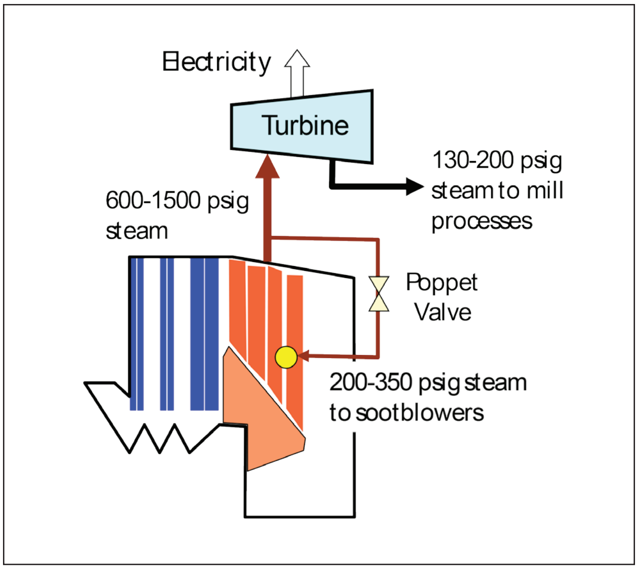
In 1991, with the support of 11 pulp and paper related companies and the Ontario University Research Incentive Fund, an industry-university collaborative research program on “Recovery Boiler Fireside Deposits” was initiated at the University of Toronto. The research program included, for the first time, projects on sootblower jet fundamentals and issues related to deposit removal in recovery boilers. The results of this research program, and of programs that followed over the subsequent two decades, and the work of recovery boiler and sootblower manufacturers, have significantly advanced the basic knowledge of sootblowing: how a sootblower jet behaves, how it interacts with tubes and deposits, and identification of the key parameters that influence the deposit removal efficiency. Two important innovations that resulted are fully-expanded nozzles and low pressure sootblowing technology.



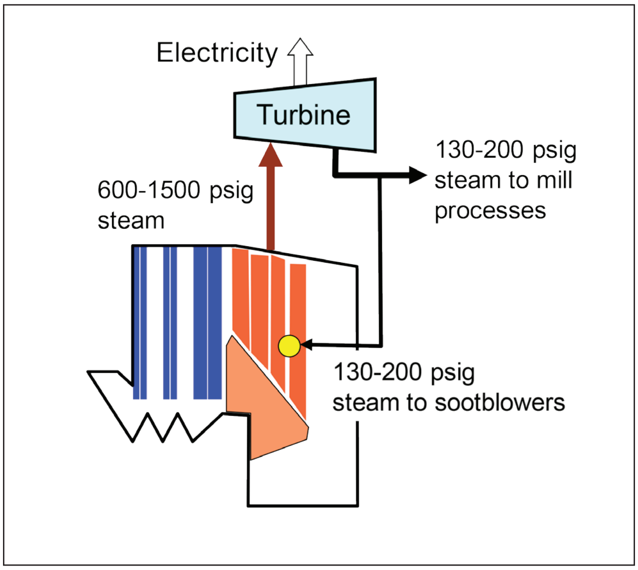
9. Peak impact pressure profile comparison [6].



10. New generation of sootblower nozzles [20,21].



11. Conventional high-pressure sootblowing operation [23].



12. Low-pressure sootblowing operation [23].

Fully-expanded nozzles

The design of sootblower nozzles used in industrial boilers until the mid-1990s ranged from two simple holes drilled into the lance tube to a more sophisticated venturi type, known conventionally as High Performance Peak Impact Pressure (Hi-PIP) nozzles (**Fig. 8a**). Hi-PIP nozzles were the most commonly used nozzles in recovery boilers from the mid-1980s to the mid-1990s.

The ability of a sootblower to remove deposits is directly proportional to the jet energy, which is closely related to the peak impact pressure (PIP) of the jet. PIP depends greatly on the steam pressure in the lance tube and the design of the nozzle through which the steam jet passes. By examining the hydrodynamics of a jet passing through a convergent-divergent section of a Hi-PIP nozzle, Jameel et al. [6,7] showed that the steam jet at the nozzle throat is supersonic. As the jet passes beyond the nozzle throat, it expands and accelerates to a velocity well above the speed of sound, while its pressure decreases in a manner controlled by the shape of the divergent section of the nozzle. Because of the short distance between the throat and the nozzle exit, the jet pressure cannot adjust to the ambient pressure; it is then "under-expanded," and must complete its expansion outside the nozzle through a series of shock waves. This means that a substantial fraction of the energy available in the steam jet is dissipated as the jet passes through the shock waves, and only a fraction of the initial jet energy is delivered to heat transfer surfaces for cleaning.

Jameel et al. [6,7] also showed that with under-expanded nozzles, increasing the upstream steam pressure above the nozzle design condition only results in a small increase in jet PIP, due to the formation of a larger shock wave. By extending the nozzle length and redesigning the nozzle contour (**Fig. 8b**) to allow the steam to expand fully before it leaves the nozzle, the shock waves can be substantially minimized, and this can greatly improve the sootblower performance. As shown in **Fig. 9**, for the same steam consumption, fully expanded nozzles provide much greater cleaning power than under-expanded nozzles [7,8,9].

This discovery led to the development of a new generation of sootblower nozzles that allow the jet to achieve full (or close-to-full) expansion before it exits the nozzle. With the help of CFD modeling and efforts made by sootblower manufacturers, the dimension, shape, and position of the nozzles around the tip of the lance were refined to make it easier for the stream to pass through the nozzles, thereby increasing the cleaning power of the steam jets even further. **Fig. 10** shows the most advanced nozzles presently offered by the two major sootblower manufacturers: the Diamond Power Gemini nozzles [20, 21] and the Clyde Bergemann CFE (Contoured Fully Expanded) nozzles [22,23].

Due to their superior performance compared to Hi-PIP nozzles, these fully expanded nozzles are now used in virtually all new recovery boilers and utility boilers today.

Low pressure sootblowing technology

Recovery boilers operate at a superheated steam pressure ranging from 600 psig on older units to as high as 1500 psig (41 to 103 bar) on modern units [36]. The high pressure steam from the final superheater outlet is passed through a steam turbine to generate electricity. The exhaust steam from the turbine, typically at 130 to 250 psi (9 to 17 bar), is subsequently used in various processes in the pulp mill (**Fig. 11**).

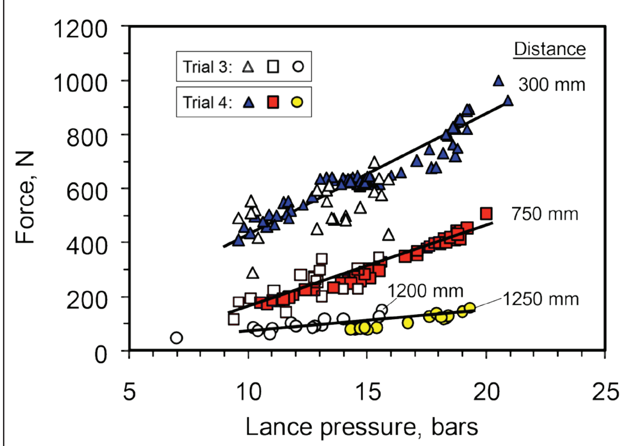
The concept of low pressure sootblowing was first introduced to us by a mill representative during our annual research review meeting at the University of Toronto in 2001. Instead of high-pressure steam, the exhaust steam from the steam turbine is used directly for sootblowing, as shown in **Figure 12**. Theoretical analysis, laboratory studies, and mill trials [22-26] were subsequently performed to evaluate the feasibility of the concept. The results clearly indicated that low pressure sootblowing is technically and practically feasible. However, in order for low pressure sootblowers to provide a deposit cleaning power that is comparable to that of high pressure sootblowers, they require a larger jet (a higher steam flow rate) to compensate for the adverse effect of reduced pressure. This can be accomplished by using larger fully-expanded nozzles with a modified design to achieve optimum performance at the lower pressure.

The economic benefits of implementing low-pressure sootblowing technology depend greatly on the amount of additional low pressure steam required to make up for the low pressure, in order to attain the same deposit cleaning power as high pressure sootblowers, and the differential cost between high pressure steam and low pressure steam [23]. Furthermore, the technology is difficult to implement on existing recovery boilers due to the need for re-piping the sootblowing steam lines to accommodate the higher steam flow rate. For new recovery boilers, this is not an issue, as sootblowing steam lines can be properly designed and installed from scratch. Presently there are three recovery boilers in the United States and two in Brazil using low pressure sootblowers. A few other new recovery boilers are expected to follow suit.

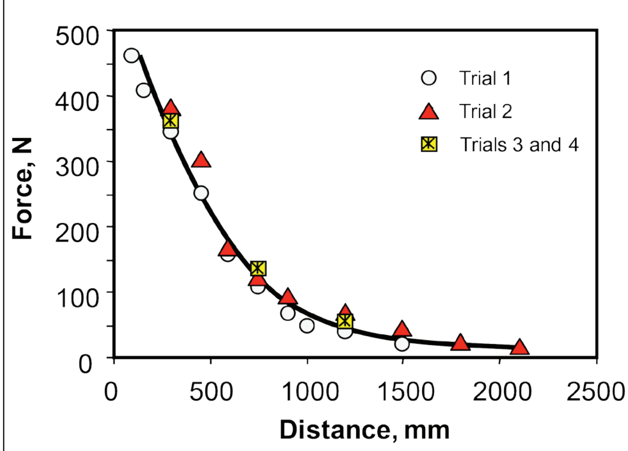
Sootblower jet strength

In 2007, a collaborative project was initiated by Andritz Inc., in collaboration with the University of Toronto, Diamond Power, and Clyde Bergemann, to systematically examine the strength of sootblower jets in-situ, using a jet force measurement system [18,19]. Four trials were conducted under various sootblowing conditions in recovery boilers at two different kraft pulp mills. The main conclusions were that the jet force increases linearly with an increase in lance pressure (**Fig. 13**).

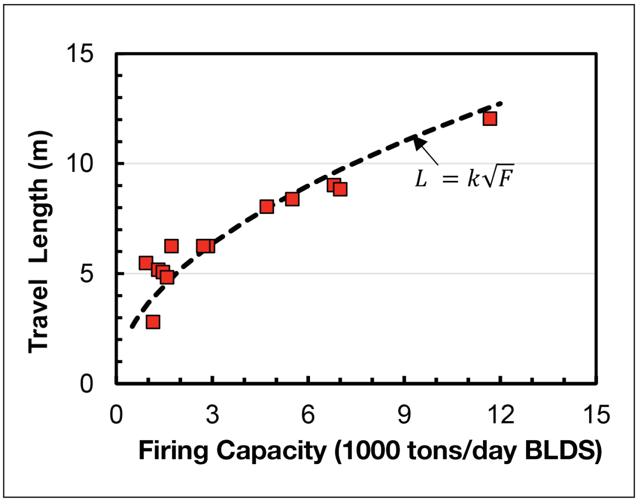
At a given lance pressure, the jet force diminishes markedly with an increase in distance from the nozzle. At a distance farther than 1 m (3 ft) from the nozzle, the jet exerts only 10% of its original force on the same target (**Fig. 14**). At greater



13. Jet force vs. lance pressure at different distances [19].



14. Average jet force vs. distance at lance pressure of 9-11 bars [18,19].



15. Sootblower travel lengths of selected recovery boilers.

distances, the jet strikes the target not only with a weaker force but also for a shorter period of time.

The angle at which the jet hits the target also has an impact on jet force [19]. For a given projected area of the target, the larger the impact angle (closer to the normal direction), the greater is the jet force, i.e., $F_\theta = F_{90} \times \theta/90$, where F_θ is the jet force exerted on the target at θ angle and F_{90} is the jet force at 90° (head-on).

Sootblower dimensions

Presently, there are only a few old and small recovery boilers in operation that have sootblowers mounted on one sidewall, with lance tubes that extend across the boiler width, 24 to 30 ft (8 to 10m), to the other side wall, in order to achieve full coverage. In most recovery boilers, sootblowers are mounted on both sidewalls so that they need to reach only half of the boiler width. Since the lance tube rests at about 6 in. (0.15 m) outside the boiler when it is fully retracted, the travel length (or distance) is slightly greater than 1/2 of the boiler width.

Prior to 1990, recovery boilers were relatively small, with a firing capacity under 2500 TDS/day. Sootblowers were equipped with a 3.5 in. (8.9 cm) outside diameter (OD) lance tube and had a travel distance of 15.7 ft (5 m). As boilers became larger and larger in recent years, larger 4 in. (10.2 cm) OD lance tubes have been used to support their longer length, >20 ft (6 m), as well as to better accommodate longer fully-expanded nozzles. They typically travel at a linear speed of 100 in./min (2.5 m/min) and take about 5 min to move in and out of the boiler. Longer sootblowers require a longer time to complete a blow cycle. In most modern installations, however, the sootblower system is equipped with variable frequency drive (VFD) that can operate at a travel speed as high as 150 in./min (3.8 m/min), significantly shortening the time requirement for each blow.

For sootblowers with a travel length greater than 25 ft (7.5m), a center support is needed to balance the lance tube while it is in the rest position and the feed tube while the lance tube is inserted deeply into the boiler. Without such support, the tubes may excessively deflect and bend.

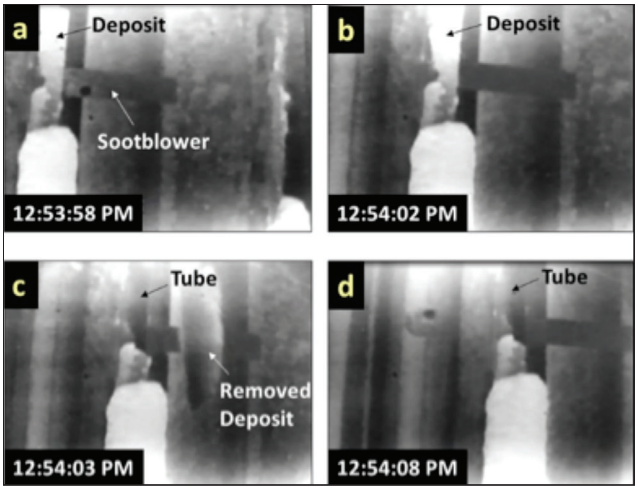
Figure 15 shows the sootblower travel length (*L*) versus boiler firing capacity (*F*) for a few selected recovery boilers (actual data points). Since most boilers are designed such that the total heat input to the boiler per unit furnace floor area is constant, slightly under 1 MM Btu/ft^2-h (or 3.3 MW/m^2), *L* is proportional to the square root of *F* (broken curve). The world's largest recovery boiler to be built at the pulp mill in Oki, Indonesia, will be equipped with 5 in. (12.7 cm) OD and 39.5 ft (11.6 m) long sootblowers. While they will be the largest and longest sootblowers ever installed in recovery boilers, sootblowers of this size are rather common in utility boilers.

Sootblowing efficiency

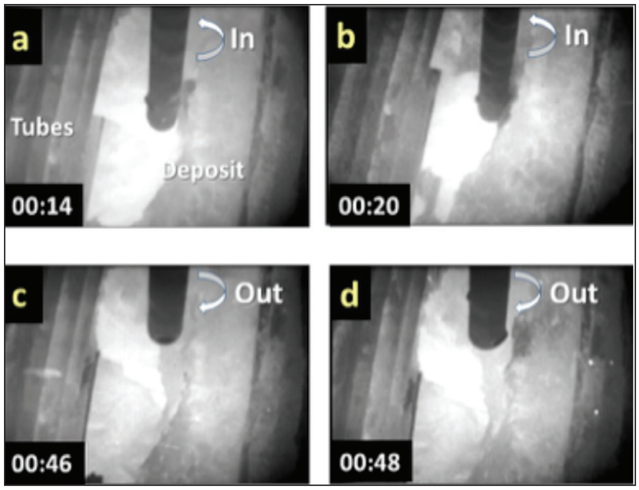
Flue gas pressure drop (draft loss) across individual heat transfer banks, steam production rate, attemperator valve opening, boiler bank exit gas temperature, economizer exit gas temperature, ID fan speed, etc., have traditionally been used to indicate the state of cleanliness (or fouling) of recovery boilers, and to decide when to operate the sootblowers more intensively in the heavy buildup area [1]. While these operating variables provide some indications of boiler fouling, they are not accurate, and are often influenced by other boiler operating variables. Furthermore, when a change in flue gas pressure drop is noticed, the boiler has already been plugged to a point where a waterwash is usually needed. The lack of reliable means for monitoring deposit buildup makes it difficult for pulp mills to automate their sootblowing operation.

In the early days, sootblowers were operated manually by pushing a button beside each sootblower or in the recovery boiler control room. Based on the experience and logic developed at the mill over the years, the blowing sequence and frequency were programmed into the mill programmable logic controller (PLC) and distributed control system (DCS), which automatically operate the sootblowers "blindly" without any feedback on the state of fouling or boiler cleanliness. In recent years, thanks to the availability of high speed microprocessors and data acquisition systems, several intelligent/smart sootblowing systems have been developed. These systems use more reliable fouling indicators to advise boiler operators when and where to activate the sootblowers, and to optimize sootblowing operation. These include:

- ***Heat balance:*** This involves the use of a fouling index based on the steam side heat balance performed on each individual superheater section (i.e., primary, secondary, and tertiary superheaters), boiler bank and economizer, and the gas side temperatures [29,30]. The fouling index is essentially a measure of the efficiency of a tube bank to transfer heat from the flue gas to the steam flowing inside the tubes. Thus, it can also serve as a key indicator of the sootblowing effectiveness.
- ***Strain gauge system:*** This system was patented by International Paper (IP) [32] and has been installed exclusively in recovery boilers at IP mills. It uses strange gaug-



16. Images recorded by an infrared inspection camera showing a deposit being removed by a sootblower from behind.



17. Images recorded by an infrared inspection camera showing the ineffectiveness of a sootblower in removing massive superheater deposits during a blowing cycle (time=mm:ss).

es installed on the hanger rods that support superheater platens to measure the elongation of the rods, which is directly proportional to the weight of the deposit buildup on the platen.

- ***Local deposition rate:*** This system analyzes the instantaneous fluctuations of flue gas temperatures at the boiler bank exit during single strokes of all sootblowers in the boiler, and converts them into a time series of raw data that indicates fouling of the tube surfaces [33]. This, in turn, can be used to indicate the short-term carryover deposition rate and the efficiency of deposit removal by the sootblowers. This approach yields a 3-D map of the local fouling rate in the vicinity of each sootblower that is useful in establishing the sootblowing sequence for minimum steam use or for plugging prevention.
- ***Principle component analysis (PCA):*** This system uses a multivariate statistical program to monitor the gradual and sudden shifts in boiler thermal efficiency for individual runs, allowing day-to-day analysis of changes in boiler fouling conditions [34].

Inspection Cameras

The availability of compact, high quality, and inexpensive infrared inspection cameras in recent years has enabled mills to inspect the state of deposit buildup at different locations in the boiler during operation, as well as to assess the deposit removal efficiency of sootblowers. **Fig. 16** shows images of a piece of deposit being knocked off by a sootblower blowing from behind the tube, while **Fig. 17** shows little evidence of deposit removal by a sootblower in a different recovery boiler as the sootblower moves in and out of the boiler.

Inspection cameras have also helped identify the following: 1) the swinging of sootblower lances caused by the imbalance of jet forces exiting the two opposing nozzles at the tip of the lance tube; 2) locations where massive deposits build up in the boiler; 3) the cleanliness of the tube surface after thermal shedding events; and 4) the swinging of superheater platens and the vibration of boiler bank tubes caused by sootblowing.

FUTURE OUTLOOK

Sootblowing is a fairly mature technology, particularly with respect to hardware. With the trend toward operating recovery boilers with fewer and fewer operators in years ahead, it will be a challenge for sootblower manufacturers to provide equipment that is easy to operate and to maintain, such as gear boxes and other moving parts that can be quickly greased; poppet valves and lance tubes that can be easily replaced; etc.

Sootblowing efficiency depends on two factors: 1) the force exerted by the jet on the deposit, and 2) the strength/tenacity of the deposit on the tube. The peak impact pressure of the sootblower jet and the resulting force can now be predicted accurately based on the nozzle design, stream conditions inside the lance tube, and the distance between the nozzle and the deposits. The deposit strength, however, is not as straightforward since it varies widely with location in the boiler, depending on gas temperature, deposit composition, and tube surface condition. These, in turn, are a strong function of black liquor composition and boiler operating conditions. Without the knowledge of deposit strength, it would be difficult to optimize the deposit removal process, unless reliable fouling indicators can be developed to advise boiler operators when and where to activate the sootblowers and to optimize sootblowing operation.

Fully-expanded nozzles will remain the preferred choice. Since the present nozzle designs have been optimized for best performance, these nozzles will be used for years to come. New recovery boilers will likely adopt the low pressure sootblowing technology due to its economic advantage.

We will probably see more research and development work on CFD modeling of jet-tube and jet-deposit interactions in the near future. Application of CFD results will help improve understanding of sootblowing jet behaviors. **TJ**

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ABOUT THE AUTHORS

We chose this topic to research because it was the keynote topic that the Finnish Recovery Boiler Committee requested us to address at its 50th Anniversary Celebration Event in conjunction with the 2014 International Chemical Recovery Conference. The work here is a historic review, and as such, it is complementary to all the previous work by our research group and others.

Tran

Tandra

The most difficult aspect of this work was to uncover the relevant historical information, which is not readily available. We addressed this by conducting an intensive library search of articles related to sootblowers, as well as making requests of people who might have had this information. The most surprising aspect of this research was to discover that our group at the University of Toronto is part of sootblower history as the only group in the world pursuing recovery boiler sootblowing research!

Mills may include this historical information in training programs for their new engineers.

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