Cost Analysis of Soot Blower Use for Boiler Maintenance at Sasol Secunda

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Abstract

This paper presents cost analysis for maintenance in the steam plant department of Sasol in Secunda, South Africa, based on weekly boiler outage and general boiler breakdowns. All maintenance and contributing factors during a General Overhaul (GO) for a period of 48 months maintenance plan are carefully analyzed in this paper. The current cleaning technology which uses soot blowers was found to be the main contributor to the high costs due to its failure when the boiler is running, causing leaks and erosion on boiler tubes. As a result, there is a significantly high cost on superheater tubes with a variance of R29 704 191.18 from a budget of R50 919 502.53 in 14 days of a 90 days GO. The cost of soot blower repairs also exceeds the budgeted amount of R1 000000 by R428 884,73 in variance in 14 days of the GO. The results of metallographic examination of the tube used is presented in this paper. Based on this analysis a new maintenance method using an acoustics approach is proposed in this paper. This approach can either work hand in hand with the soot blowing technology currently being used for the existing design of boilers to minimize the exposure of the tubes to pressure hot air or be used independently for a whole new design of boilers.

Keywords
Erosion, General overhaul, Metallographic examination, Maintenance plan, Soot blowers, Acoustics maintenance.

1. Introduction

1.1 Determining RBI, Probability, Consequence and Risk Ratings for Boiler Tube

A rating scale of 1 (high) to 5 (low) is used for the probability ratings. Where appropriate likelihood of failure ratings is related to the remaining life of the item. These include internal wall thinning mechanisms, external wall thinning, fatigue and creep. For all other damage mechanisms, the likelihood of failure rating is derived according to the susceptibility of the item to in-service deterioration based on the process conditions and the equipment metallurgy. The consequence ratings are categorized into safety, environment and business consequences. The consequence ratings are linear relationships between the highest consequence value, above which the highest consequence rating of 1 is assigned, and the lowest consequence value, below which the lowest consequence rating of 5 is assigned, see Table 1. Once the probability and consequence ratings have been assigned, the risk rating for the pipelines of the boiler which are grouped in corrosion loops can be determined [1].

Table 1: Probability and Consequence Rating [1]

Probability		Consequence 5 (Low)	4	3	2	1 (High)
High	1	4	3	2	1	1
	2	4	4	3	2	1
	3	5	4	3	2	1
	4	5	4	4	3	2
Low	5	5	5	4	3	2

1.2 Risk Ranking

To determine the risk rating, the overall probability and consequence value for the corrosion loop is used as inputs to the risk matrix and the corresponding risk value is automatically calculated from the matrix and determined in Table 2. This risk value is captured on the inspection report or other document such as request for delay of inspection, etc. [2, 3].

Table 2: Risk Matrix Table [1]

Risk \ Confidence Factor (Lines)	0	1	2	3
1	36	48	72	N/A
2	36	48	96	N/A
3	48	72	96	144
4	48	72	96	144
5	48	72	96	144

1.3 Analysis

In 2014 a risk-based inspection was conducted and failures of boilers which went on unplanned outages because of breakdowns was tracked from December 2013 to February 2018. This showed numerous unplanned outages before the end of a 48 months period which was the frequency pre-determined by risk-based inspections done back in 2013. The second track that was conducted on the same period was Mean Time Between Failure/Incident (MTBF/I). This proves that although very good risk assessments can be conducted still several undesirable failures exists which is the reason why more research needs to be conducted to improve maintenance and availability of the boilers shown in Figure 1. The GO in 48 months feeds to the risk-based inspection done and history is kept for reviewing the strategy. This is done through inspection reports and any findings found during a GO as well as any other breakdown experienced [2, 3]. This process happens in every boiler for a period of 48 months maintenance plan, then a boiler goes out for general overhaul. Over and above that there will be breakdowns which becomes emergencies from time to time which also is costly.

1. Boiler Maintenance at Sasol

2.1 Repairs on Breakdowns and Metallurgy Investigation Report

Apart from General Overhaul (GO), the company also experiences numerous breakdowns during operation which often means short-term outages, from time to time which in turn minimizes availability of the boiler and loss of production. Figures 2 and 3 shows the failure on soot blower elbow which ruptured during operation and was sent to the metallurgy department for analysis and finding were obtained in a form a report. The report stated that on the 21st of March 2018, a rupture of an elbow from the 043BO-501 ring feed header was noted. It was subsequently cut and replaced. It was reported that the location of the rupture on the elbow was at the 6 O'clock position. The

Metallurgical Engineering department was then requested to determine the root cause of the elbow through a failure investigation. The findings of the failure investigation are presented in this paper in the next subsection of this section [3, 4].

Figure 1: Overview of Process – Coal & Gas Cycle.

Figure 2: Thick-lip Rupture on the Neutral Axis of the Elbow of a Soot Blower [3].

Figure 3: One of the Failures on the Soot Blower Elbow on [3].

Based on the findings of the failure investigation, it is believed that the final rupture was due to a pressure excursion in the line. The rupture occurred at the area where corrosion fatigue cracks were believed to have already manifested. Evidence of that corrosion fatigue cracks had already manifested at the rupture area includes the pits and fissures. The presence of corrosion fatigue cracks and a pressure excursion made the propagation of the existing cracks into a large rupture very easy. Evidence of that the rupture was caused by a pressure excursion is that the propagation direction of the crack changed from the neutral axis to an angle 45° from the neutral axis [5].

2.2 Design and Operating Conditions

The design and operating conditions of the elbow section are given in Table 3.

Table 3: Design and operating conditions of the elbow section of the ring feed header

Design Pressure [kPa]	5650
Design temperature [°c]	440
Operating Pressure [kPa]	4250
Operating temperature	435
Medium	Superheated steam
Material of construction	Din 17175 15mo3
Thickness of the material	4.5 mm

2.3 Visual Examination

A visual examination of the submitted elbow was carried out in order to document the as-received condition of the sample. A summary of the findings of the visual examination are given. Figure 4 is a photograph of the elbow sample. It was noted that there was a rupture on one side of the elbow, the rupture occurred mainly along the neutral axis of the elbow. The external surface of the elbow appeared to have no other significant damage. After the visual examination of the external surface of the elbow sample, it was longitudinally sectioned for the internal surface to be examination. A photograph of the sectioned sample is given in Figure 5 [3].

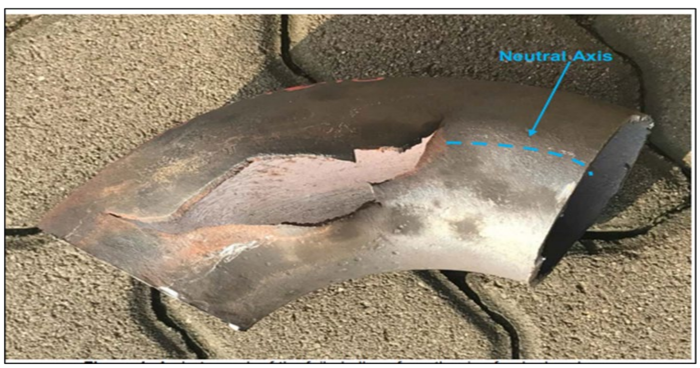

Figure 4: A failed elbow from the ring feeder header [3].

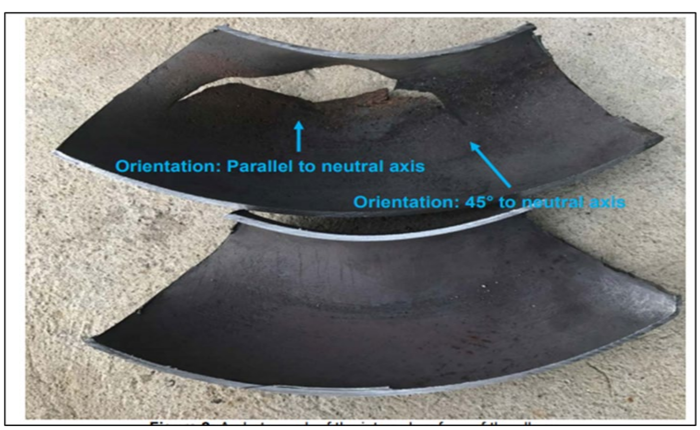

Figure 5: A photograph of the sectioned sample [3].

The internal surface had a black appearance which can be attributed to the formation of magnetite on the internal surface. It was noted that the significant damage was located mainly on one half of the sample - the bottom lying in the 6 o' clock position. It was noted that the orientation of the rupture was mainly longitudinal and along the neutral axis, however, the tips of the rupture are orientated 45° from the neutral axis. Given in Figure 6 is a photograph of the internal surface of the elbow section where most of the damage was located. Pitting and fissures along the neutral axis were noted as well.

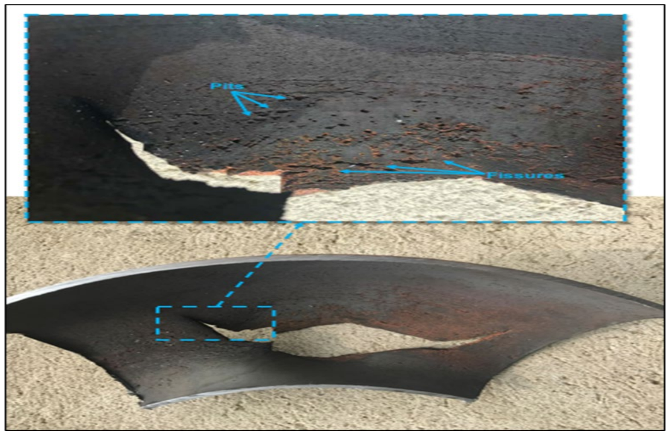

Figure 6: An internal surface of the elbow section with most damage [3].

2.4 Chemical Analysis

Chemical analysis was carried out in order to determine the chemical composition of the elbow sample. The chemical analysis was performed by using Spectrographic chemical analysis technique. The results are presented in Table 4. The chemical analysis revealed that the chemical composition of the elbow section was not comparable to the chemical composition requirements of DIN 17175 15Mo3. The elbow section was not alloyed and therefore is a carbon steel material in lieu of carbon-molybdenum steel. It is most likely that the elbow was fabricated from DIN 17175 St35.8 material [3].

Table 4: Spectrographic analysis results and the chemical composition requirements of DIN 17175 15Mo3

	Chemical analysis result	**Chemical composition requirements of DIN 17175 15Mo3**
Carbon	0.087	0.12-0.20
Silicon	0.22	0.10-0.35
Manganese	0.55	0.40-0.80
Phosphorous	0.031	0.035 max
Sulphur	0.026	0.0.35 max
Chromium	0.054	-
Molybdenum	0.023	0.25-0.35
Copper	0.13 -	-
Iron	98.7	Balance

2.5 Metallographic Examination

A sample for metallographic examination was sectioned from the damaged half of the elbow. The sectioned sample was prepared using standard metallographic techniques and was subsequently etched with Nital to reveal the microstructure. The etched sample was then examined under the light optical microscope. A photomicrograph of the pipe section where pits and fissure cracks were noted is given in Figure 7. It was noted that the cracks were almost parallel to each other and propagated perpendicularly to the inner surface. Evidence of superficial corrosion and pitting corrosion was noted on the internal surface. A higher magnification photomicrograph of the fissure crack is shown in Figure 8. It was noted that the crack was unbranched, oxide filled and had a blunt tip. A photomicrograph of the general microstructure of the elbow section is given Figure 9. The microstructure that was observed was that of a typical carbon steel. A microstructure of pearlite colonies in a ferrite matrix was noted. No evidence of thermal degradation of the microstructure was noted, despite installation of an incorrect material according to the drawing [3, 6].

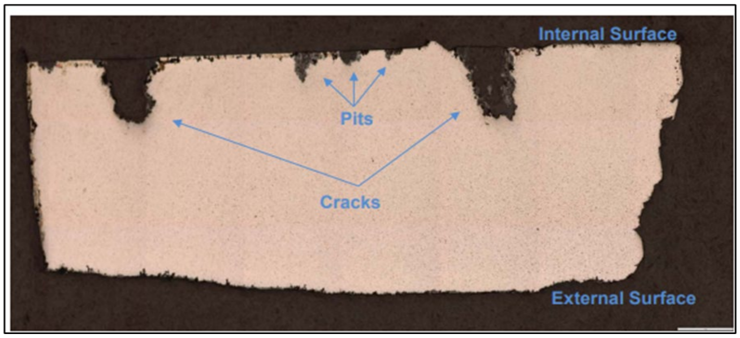

Figure 7: A photomicrograph of the cross-section through the pits and fissure cracks.

Figure 8: A higher magnification of one of the fissure cracks.

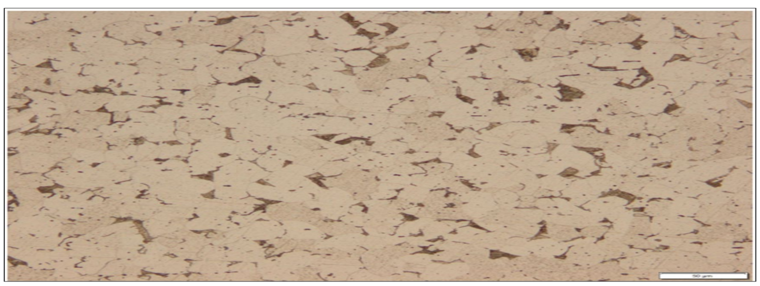

Figure 9: A photomicrograph of the general microstructure of the elbow.

2.6 Hardness Measurements

Hardness measurements were performed using a Vickers hardness (HV) tester with a 10 kg load. The average of the hardness measurements was approximated to a tensile strength value using the conversion of ASME section II, Part A, Specification SA-370. The hardness readings with the average alongside the approximated tensile strength are given in Table 5.

Table 5: Hardness test results and the tensile strength (UTS) approximation

	Measurements [HV10]
Reading 1	123
Reading 2	128
Reading 3	147
Reading 4	132
Reading 5	124
Average hardness and the approximated tensile strength	131 HV10 ~ 455 MPa

2. Boiler Maintenance Cost to Sasol

3.1 Direct Cost

This section illustrates what the company is spending in terms of maintenance per year per boiler on weekly basis of each boiler general overhaul (GO), excluding breakdowns. It covers all maintenance being done and contributing inputs that need to be taken into consideration during a GO. It involves a 4-weekly report of overspent cost on certain areas i.e. soot blowers as part of Non-Pressure Parts as well as superheaters as part of pressure parts. Table 6 among other things shows how much cost is allocated to soot blowers, the commitment as well as the actual that is spent, this was taken on weekly basis. Table 6 shows how much is spent on superheated tubes repairs. The table also continues to illustrate budget versus actual on superheater tubes and piping in general in the mud drums.

Table 6: Summary of cost for 2 weeks including soot blowers as part of non-pressure parts

Non-Pressure Parts			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Structures	R 2 550 000,00	R 457 298,41	R 2 092 701,59
De-Asher / Drag chain	R 6 000 000,00	R 1 987 303,37	R 4 012 696,63
Burners	R 5 433 092,00	R3 681 748,78	R 1 751 343,22
Soot blowers	R 1 000 000,00	R 1 428 884,73	R -428 884,73
Fan Runner/Silencers	R 2 500 000,00	R 1 160 210,58	R 1 339 789,42
Mechanical Precip/Hydrovacs	R 2 300 000,00	R1 349 392,51	R 950 607,49
Scoop plates/Air heater/Rearpass Roof	R 15 450 000,00	R11 756 790,18	R 3 693 209,82
Total	**R 35 233 092,00**	**R 21 821 628,56**	**R 13 411 463,44**

Table 6 illustrates the cost of soot blower repairs which exceeds the budgeted amount of R1 000 000 by an amount of R428 884,73 in variance, taken on the second week of the General Overhaul (GO). Soot blowers being the actual technology used for dislodging ash from boiler tubes, themselves contributes to high repair costs because of failures, sometimes rapture failures. Soot blower failure also has direct impact on boiler tube erosion depending on the type of failure, which mostly is being stuck in one position as a result giving excess pressure to the tube and weakens the strength of the materiel for tube walls [3].

Table 7: Summary of cost per week including superheater tubes as part of pressure parts

Pressure Parts			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Sidewalls	R 7 800 000,00	R 44 681,00	R 7 755 319,00
Vent Silencer	R 1 500 000,00	R 97 069,20	R 1 402 930,80
PSV's	R 1 000 000,00	R 116 210,31	R 883 789,69
Convections, mud drums & wings	R 17 800 000,00	R 914 500,43	R 16 885 499,57
Piping/Pipe Repairs	R 4 500 000,00	R 1 171 554,65	R 3 328 445,35
Flash tank	R 800 000,00	R 60 910,89	R 739 089,11
Superheaters	R 15 300 000,00	R 17 864 735,80	R -2 564 735,80
Attemperator	R 1 219 502,53	R 337 535,64	R 881 966,89
Mechanical Valves	R 1 000 000,00	R 608 113,43	R 391 886,57
Cooling Air Fans	R -	R -	R -
Total	**R 50 919 502,53**	**R 21 215 311,35**	**R 29 704 191,18**

Superheater tubes repair which is the second highest on the budget first one being convections and mud drum tubes with a budget of R17 800 000,00, Table 7. The superheater tubes are already exceeding the budget by two and half million South African Rands per week. This forms part of the tubes inside the boiler which needs to be repaired because of the exposure to soot blowers and burners in the period of 48 months. Already in a week for a budget of R50 919 502.53 the amount spent is getting very close to half of budgeted amount by a variance of R29 704 191.18 [3].

3.2 Indirect Contributors to Keep Soot Blowers Running

Table 8 is the cost of electrical repairs by the service provider who does welding on tubes, sectional replacement, and so on which also shows an overdraft of more than R1 091 18058 from a budget of R3 000 000.

Table 8: Electrical costs on repairs

Electrical			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Electrical Precips	R 5 000 000.00	R 4 928 096.92	R 71 903.08
Electrical Motors	R 5 000 000.00	R 700 582.74	R 4 299 417.26
Electrical Switchgear	R 3 000 000.00	R 454 503.95	R 2 545 496.05
Service Provider Electrical Service	R 3 000 000.00	R 4 091 180.58	R -1 091 180.58
Total	**R 16 000 000.00**	**R 10 174 364.19**	**R 5 825 635.81**

Table 9 is the cost for Instrument services, testing repairs and renewal of technologies and programmes. Instrument controls the operation of the soot blower system in certain interval because they are timed to avoid continuous exposure on the boiler tubes as a result which causes erosion. The instrument service also shows an overdraft from a budget of R2 500 000.00, where a R5 654 848.89 was spent or committed with the variance of R3 154 848.89 overdraft a week [3].

Table 9: Instrument services

Instrumental			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Instruments	R 13 650 000.00	R 4 959 057.99	R 8 690 942.01
Instrument Services	R 2 500 000.00	R 5 654 848.89	R -3 154 848.89
Instrument Mills	R -	R -	R -
Total	**R 16 150 000.00**	**R 10 613 906.88**	**R 5 536 093.12**

Table 10 is an illustration of the technical costs which includes drawings for any modification work, change of materiel on the tubes as well as boiler hangers which is not so bad in terms of what was budgeted versus what was committed. No overdraft for the week everything was still within budget.

Table 10: Technical costs

Technical			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Drawing Charges	R 1 000 000.00	R 583 690.16	R 416 309.84
Boiler Hangers	R 500 000.00	R -	R 500 000.00
Total	**R 1 500 000.00**	**R 583 690.16**	**R 916 309.84**

3.3 Other Contributors on Cost for General Overhaul

There are more contributors when it comes to cost regarding the overhaul but all of them go to the main purpose of repairs on the boiler tubes in different areas as well as supporting structures. Tables 11-13 are some examples of those. Table 11 shows cost on scaffold, a boiler structure, as one of the support services which is a very high and big structure. Before any maintenance happens there is always a need to design scaffold and platforms for excess. It also exceeds budget with a variance of R1 111 963.88. Table 12 shows labour services which exceed almost on everything on the budget. Table 13 shows Tarpaulins as part of PPE to work inside the boiler which also exceed the budget [3].

Table 11: Supporting Services Costs per week Scaffold

Supporting service			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
HP Cleaning	R 1 000 000.00	R 1 811 019.56	R -811 019.56
Refractory	R 6 000 000.00	R 4 543 387.04	R 1 456 612.96
Scaffolding / Lagging/ Sandblasting	R 16 500 000.00	R 17 611 963.88	R -1 111 963.88
Rigging	R 5 500 000.00	R 4 566 115.19	R 933 884.81
Total	**R 29 000 000.00**	**R 28 532 485.67**	**R 467 514.33**

Table 12: Labour costs outsourced services

Service Provider Labour			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Mechanical labour HA	R 5 025 000.00	R 5 475 339.30	R-450 339.30
Management Fee	R 15 141 000.00	R 16 497 933.00	R -1 356 933.00
Mech Labour - Prommac	R 9 000 000.00	R 8 566 753.97	R 433 246.03
Standby's	R 2 000 000.00	R 2 207 536.50	R -207 536.50
NDE Testing (Inspections)	R 4 000 000.00	R 7 197 677.49	R -3 197 677.49
Total	**R 35 166 000.00**	**R 39 945 240.26**	**R -4 779 240.26**

Table 13: Sundries with Tarpaulins

Sundries			
Activity	***Budget Cost***	***Current Act & Comm***	***Variance***
Buildings	R 2 600 000.00	R 645 810.35	R 1 954 189.65
Off-sites, meetings	R 50 000.00	R -	R 50 000.00
P & G's	R500 000.00	R 340 074.60	R 159 925.40
Tarpaulins	R 800 000.00	R 2 374 735.35	R -1 574 735.35
Lights	R 700 000.00	R 670 381.90	R 29 618.10
Fuel systems	R -	R -	R -
Total	**R 4 650 000.00**	**R 4 031 002.20**	**R 618 997.80**

3.4 Summary of Cost Per Week

Tables 11-13 are cost summaries that illustrates how much it cost to maintain the boilers. Each contributes towards repairs of boiler tubes due to erosion, and fatigues on tubes. The cost summaries also illustrates that it is not only the tubes that need repairs, but also the technology used for cleaning must be repaired and it is mostly the cause of its malfunction that leads the tubes to need such repairs in the first place. In addition, for the technology of cleaning to work properly there has be supporting instruments and electricity which also need maintenance, technical drawings with the right bill of materials and correct implementation. There must be personnel to perform those duties who specialize in the area of boiler repairs and those personnel had to have the right PPE as well as platforms to have excess in terms of heights which is why a scaffold is designed. All these cost contributors are in addition to the cost of breakdowns which are unplanned that also happen throughout the year on different boilers. Another consideration are feeders that needs budget for repairs which is included on Table 14 for totals.

Table 14: Summary of Cost Week per week including feeders

Summary - Mill GO - Including the Mill Feeders	
Budget	R 194 018 594
Actual & forecast	R 142 317 629
Difference (over) / under spend	R 51 700 965
Summary - Mill Feeders - Only	
Budget	R 4 060 033
Actual & forecast	R 78 124
Difference (over) / under spend	R 3 981 909
Summary - Total	
Budget	R 198 078 627
Actual & forecast	R 142 395 754
Difference (over) / under spend	R 55 682 874

3. Acoustic Technology

Some of the challenges the plant encounters with the soot blowing system are the fact that they get stuck due to extension and retraction, and a more than necessary amount of compressed air at high temperatures damages the tubes which are exposed when all ash is removed. The control system of soot blowers cannot tell the air to stop blowing when it senses that the soot blower is stuck although it does report that there is a problem, but the blowing continues hence making tubes weaker and weaker. Another challenge the plant encounters is the fact that mostly they experience cracks and damages on the bends of the tubes, even tubes for soot blowers themselves. These were the challenges the plant considered most regarding maintenance of the boiler except for one boiler which is the biggest. A study was done to investigate another device which is different from soot blowing that uses acoustics to dislodge soot and can be used in conjunction to with soot blowers. This can be done by minimising the use of soot blower while gradually introducing the acoustic cleaner to minimise the challenges faced when only soot blowers are used and that can save cost as well as increase availability of the boiler plant [5-7].

4.1 Acoustic Cleaning VS Steam Soot Blowers

Table 15 shows a comparison between acoustic cleaning and steam soot blowers; it shows some of the limitations that soot blowers have and their need of water and steam but at the same time which also in return brings about erosion and corrosion. In previous publications we detailed the development of an acoustic device to be used for the cleaning of these boilers [8]. With the use of sound energy, which is converted to vibrations along the boiler tubes, an acoustic horn along with its beam was designed to dislodge soot form the walls. Using AutoCAD Invertor 2016, parts of the acoustic horn are modelled and simulated against predicted forces and pressures and then compared with calculated results. The consideration taken for the design was frequency for deflection of the diaphragm, pressure that was to be experienced by horn chamber, stresses that will be experienced by the diaphragm as to not bleed out air and to work with acceptable pressure limits. Table 15 shows a comparison between acoustic cleaning and soot blower cleaning.

Table 15: Acoustic Cleaning VS Steam Soot blowers

	Acoustic cleaning	**Steam Soot blowers**
1. Fast and easy installation even when boiler is running	✓	✓
2. Can be used in all temperature areas of a boiler	✓	✓
3. Can be used also with molten or partly molten ash	✓	✓
4. Can be used with no steam available or a shortage of steam	✓	×
5. Continuous cleaning of the process	✓	×
6. Also cleans shadow areas and around the corners	✓	×
7. Can be used together with other cleaning methods	✓	✓
8. No water needed	✓	×
9. Doesn't cause erosion	✓	×
10. No corrosion	✓	×
11. No mechanical wear	✓	✓

4. Discussion

Based on the findings of the soot blower failure investigation, it is believed that the final rupture was due to a pressure excursion in the line. The rupture occurred at the area where corrosion fatigue cracks were believed to have already manifested. Evidence of that corrosion fatigue cracks had already manifested at the rupture area includes the pits and fissures that were noted in figures 6 and 7. The presence of corrosion fatigue cracks and a pressure excursion made the propagation of the existing cracks into a large rupture very easy. Evidence to suggest that the rupture was caused by a pressure excursion is that the propagation direction of the crack changed from the neutral axis to an angle of 45° from the neutral axis [3, 7].

Corrosion fatigue cracking resulted from the application of cyclic tensile stresses. The cracking proceeded as follows: when the protective magnetite layer fractured due to cyclic stresses, a bare metal surface is exposed, which will spontaneously oxidise. As the oxidation occurs, surface discontinuities or notches (which now act as stress raisers) are produced. During the next stress cycle, the magnetite layer fractures preferentially at the newly produced notch. The continuous process of magnetite fracture and re-formation is what causes cracks to propagate into the metal surface in directions that are usually perpendicular to the applied stress and wedge-shaped cracks often result as seen in Figures 2-8. While corrosion is a necessary factor to cause corrosion fatigue cracks, usually it is the stress that is the most important factor in crack growth. Corrosion will always be present in a boiler simply due to normal thermal oxidation. Every cyclically loaded steel boiler component exposed to a corrosive environment will develop corrosion fatigue cracks if stresses are routinely high and frequent and if enough time elapses.

The drawing for the ring feed header specified that a 15Mo3 elbow be installed, however, it was confirmed by spectrographic analysis that the chemical composition of the elbow section was not comparable to the chemical composition requirements of DIN 17175 15Mo3. The elbow was not alloyed – it was a carbon steel material in lieu of carbon-molybdenum steel material. It is most likely that the elbow was fabricated from DIN 17175 St35.8 material. Although the microstructure of the incorrect material did not thermally degrade whilst it was in service, the correct material (15Mo3) would have had better corrosion fatigue resistance because of its alloying elements and higher strength at the operating temperature. The room temperature tensile approximation of the elbow was found to be within the requirements of DIN 17175 grade 15Mo3 and St 35.8.

5. Conclusion

The vibrations and sound waves from the use of an acoustic device may cause other different types of risks to the whole structure itself. Using AutoCAD Invertor 2016, parts of the acoustic horn were modelled and simulated against predicted forces and pressures. A frequency range of 60-70 Hz was used which fell currently into real life limitations and powerful enough for cleaning large vessels such as boilers and is more practical with a less amount of vibrations to be used for acoustic purpose. It is advised that improvements be done on the current design or combination of the soot blowing and acoustic may be used. As improvement of the current cleaning process (soot blowing) for the aim of more availability and minimizing breakdowns on the boiler plant and ultimately reducing maintenance cost [3, 7].

6. ACKNOWLEDGEMENT

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Biographies

Purity Mimi Shandu is an Energy and Demand Management Engineer at Airports Company South Africa (ACSA), and a PhD candidate at the University of Johannesburg, Gauteng, SA. She earned MTech and BTech in Mechanical Engineering from University of Johannesburg, Gauteng and a National Diploma in Mechanical Engineering from Mangosuthu University of Technology, KwaZulu Natal, SA. She holds a higher certificate in Production, Operations and Proactivity Management form the University of South Africa (UNISA). She has published an article for conference proceeding, at the 11th South African Conference of Computational and Applied Mechanics. Her research interests include power generation, simulation, optimization, reliability, scheduling, manufacturing, and energy management systems. She is registered as a candidate with the department of labor towards obtaining her Government Certificate of Competency (GCC) ticket and has a candidacy membership with Engineering Council of South Africa (ECSA). She is a nominee for International Executive Development Programme (IEDP) 2020/2021, an initiative by Transport Education Training Authority (TETA) in partnership with Gordon Institute of Business Science, to train highly skilled, competitive and competent people in the various facets of the transport sector (Rail, Aerospace, Maritime, Road Freight, Road Passenger, Taxi, FreighHandling and Forwarding & Clearing.

Dr Daramy Vandi Von Kallon is a Sierra Leonean holder of a PhD degree obtained from the University of Cape Town (UCT) in 2013. He holds a year-long experience as a Postdoctoral researcher at UCT. At the start of 2014 Dr Kallon was formally employed by the Centre for Minerals Research (CMR) at UCT as a Scientific Officer. In May 2014 Dr Kallon transferred to the University of Johannesburg as a full-time Lecturer and later a Senior Lecturer in the Department of Mechanical and Industrial Engineering Technology (DMIET). Dr Kallon has more than twelve (12) years of experience in research and six (6) years of teaching at University level, with industry-based collaborations. He is widely published, has supervised from Masters to Postdoctoral and has graduated seven (7) Masters Candidates. Dr. Kallon's primary research areas are Acoustics Technologies, Mathematical Analysis and Optimization, Vibration Analysis, Water Research and Engineering Education.