Effects of Air heater Leakage on Thermal performance

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1. ABSTRACT

Air heaters improve the efficiency of the boiler by recovering waste heat from the flue gas and pre-heating the combustion air. Eskom uses two types of regenerative air heaters namely, Rothemuhle and Ljungstrom air heaters. Air leakage to the gas side reduces the thermal performance(X-Ratio) of the air heater, and increases auxiliary power consumption by increasing the load on the Induced Draught (ID) fans. The simulator calculates oxygen leakage from the air side to the gas side of the air heater under normal boiler operating conditions.

2. APPROACH

The causal loop diagram (CLD) can be seen in Figure 1, this shows the variables that have an impact in the thermal performance of the air heater. Loop R1 shows the impact of pack maintenance on air heater leakage and in turn affecting the thermal performance. Whilst loop R2 show that an improved air heater performance increases the boiler efficiency and that is the purpose of the air heater. A system architecture map can be seen in Figure 2 it describes how the simulator would be constructed and it illustrates the flow of information/physical quantities through the system itself.

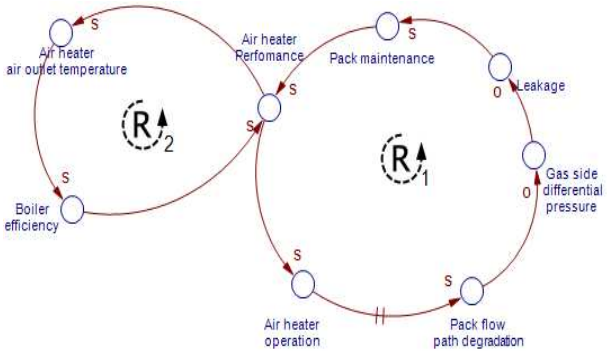

Figure 1: Causal loop diagram

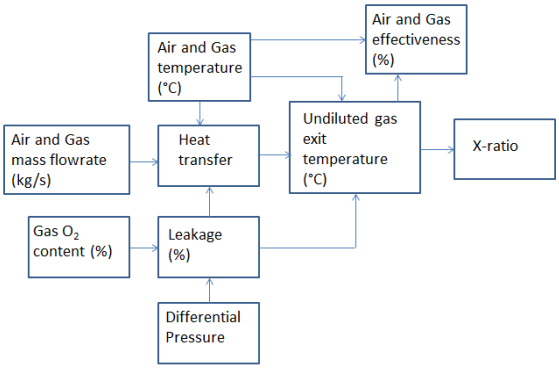

Figure 2: System architecture map

3. MODEL STRUCTURE

The simulator was constructed in iSee Stella (iSee System, Stella 10.0.6) at an hourly resolution for a time frame of 1 week (06 December 2017 to 13 December 2017). Figure 3 shows that the user can either use historical average boiler load or specify a user defined boiler load target. The flue gas inlet temperature (Tg1) is related to the boiler load, the air heater leakage is calculated using the air and flue gas temperatures. The model structure in Figure 4 illustrates how the X-Ratio and the Log Mean Temperature Differential (LMTD) is calculated using the air and flue gas temperatures.

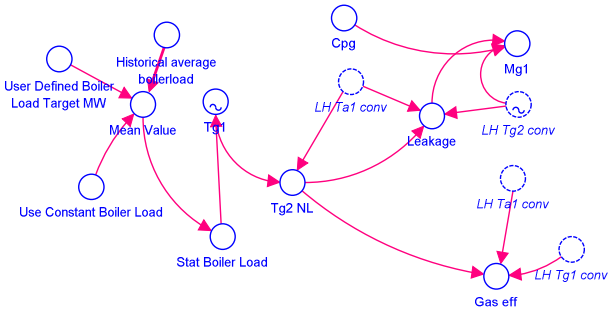

Figure 3: Leakage model structure

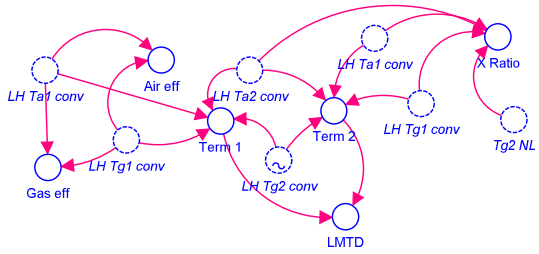

Figure 4: Thermal performance model structure

4. RESULTS DISCUSSION

Figure 5 below shows the impact of gas side effectiveness on air heater leakage, a slight increase of 2% in gas side effectiveness reduces the leakage by an average of 4.8%. The X-Ratio in Figure 6 increases with an increase in gas side effectiveness and it is inversely proportional to air heater leakage. Gas side effectiveness (GSE) is directly proportional to the heat transfer between the gas and air side. Figure 7 shows how air heater leakage changes with changing boiler load, at a lower load the leakage is higher compared to higher boiler loads because at high boiler load there is less excess air. Figure 8 shows the impact of boiler load on X-Ratio it increases by an average of 9% at a higher boiler load, and it shows the improvement in the air heater thermal performance.

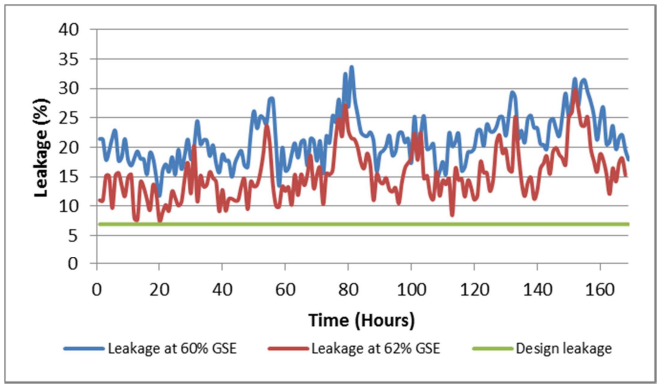

Figure 5: Scenario 1 Leakage

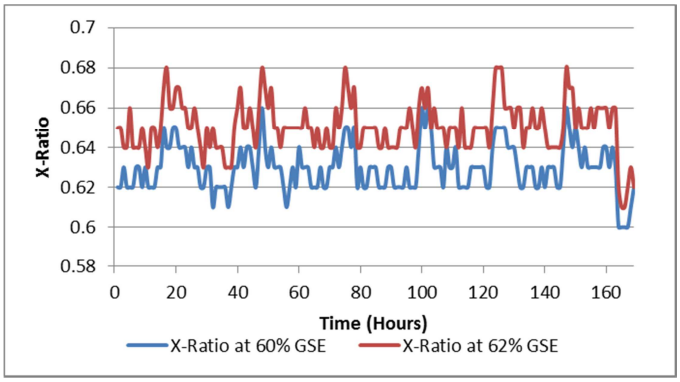

Figure 6: Scenario 1 X-Ratio

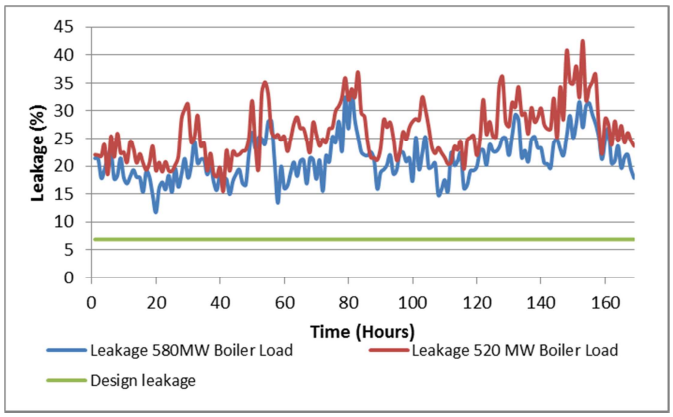

Figure 7: Scenario 2 Leakage

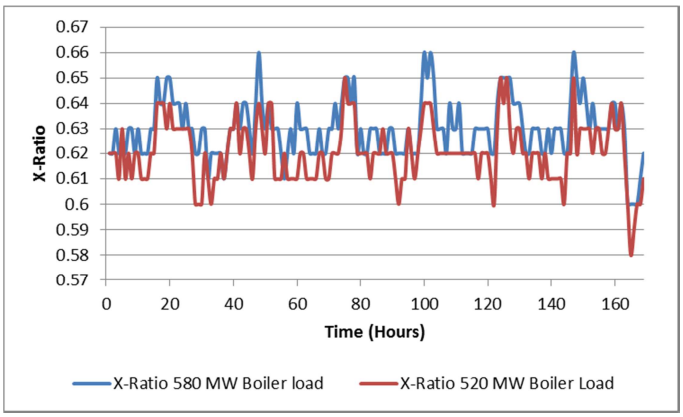

Figure 8: Scenario 2 X-Ratio

5. CONCLUSION AND FUTURE WORK

The development of the simulator showed the ability to calculate air heater leakage without having to conduct a full leakage test, instead using real time operating data already at the power station. The results demonstrate the impact of leakage on air heater thermal performance. A challenge with the current calculation method is that it is not accurate, value. A new methodology of calculating air heater leakage using air flow and flue gas flowrate that is calculated using coal analysis and products of combustion, is being investigated.

6. ACKNOWLEDGEMENTS

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