W1 Kiln Caustic Soda Trial – 18/10/16

Introduction

The HCl gas concentration in the exhaust gas of W1 kiln exceeds current permitted limits. This trial is to investigate ways to reduce the HCl levels. It is a repeat of a similar trial carried out on T3 kiln at Thrislington. One significant difference was that a higher concentration of caustic soda was used for the Whitwell trial (32% instead of 25%). The kiln was producing dolofrit at the time (34T/hr feedrate) and burning solvent at around 20% (coal 80%). Background HCl levels were lower than ideal.

Equipment set-up

A diaphragm pump (OBL MD201A) was used to deliver the caustic soda to the spray bars (Diagram 1).

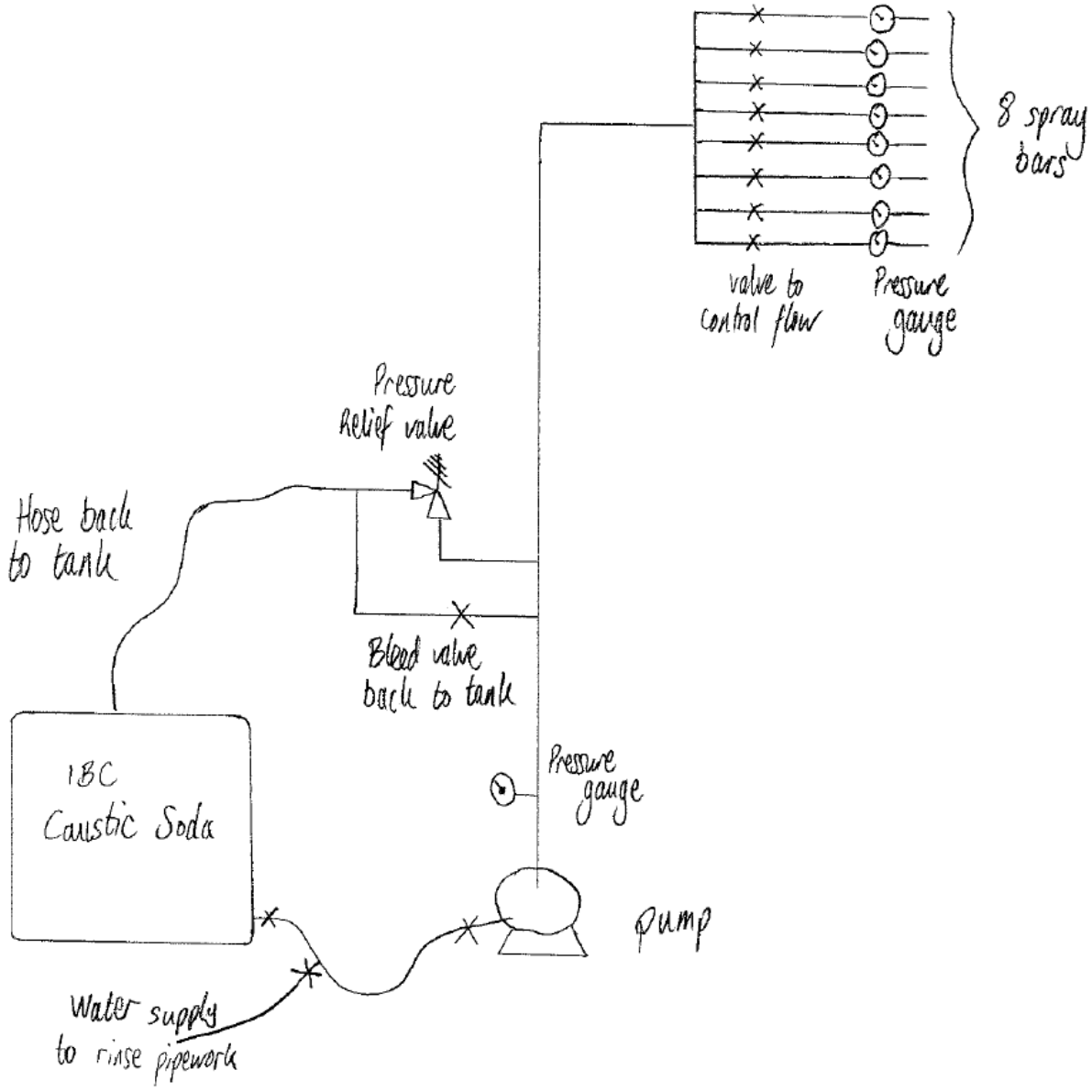


Diagram 1 – Pump configuration

The eight spray bars were configured as shown in Diagram 2. Nozzle positioning and type were dictated partly by the equipment available (as transferred from Thrislington) and partly by EESAC's recommendation.

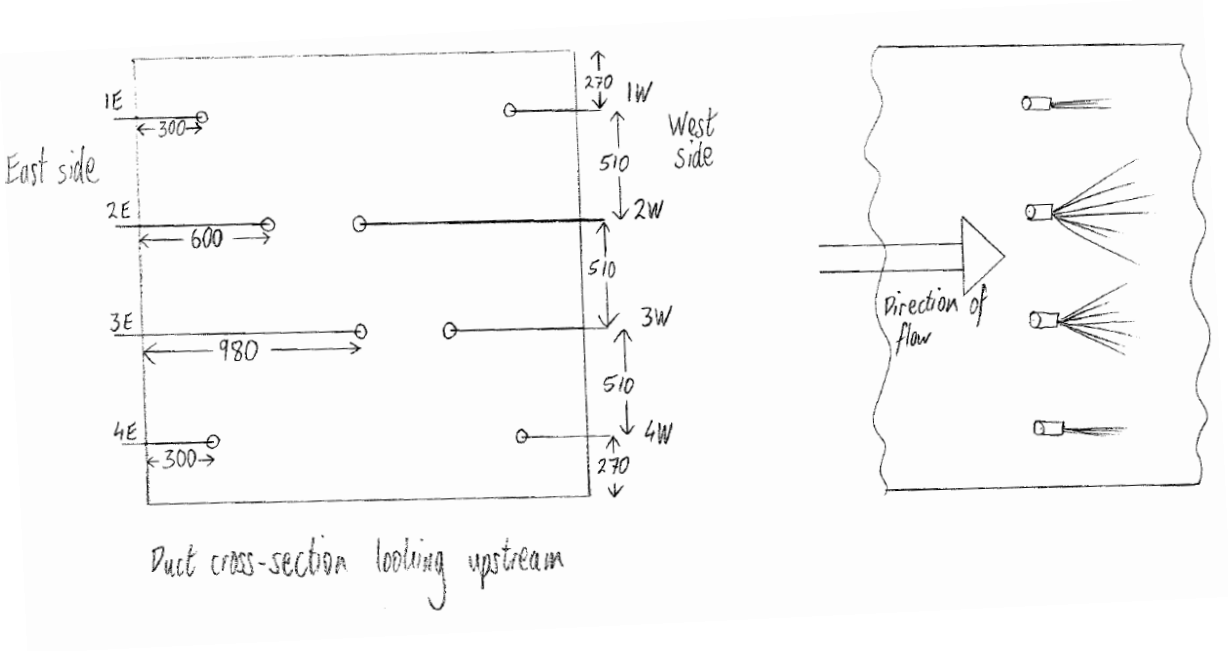


Diagram 2 – Nozzle positions in the duct

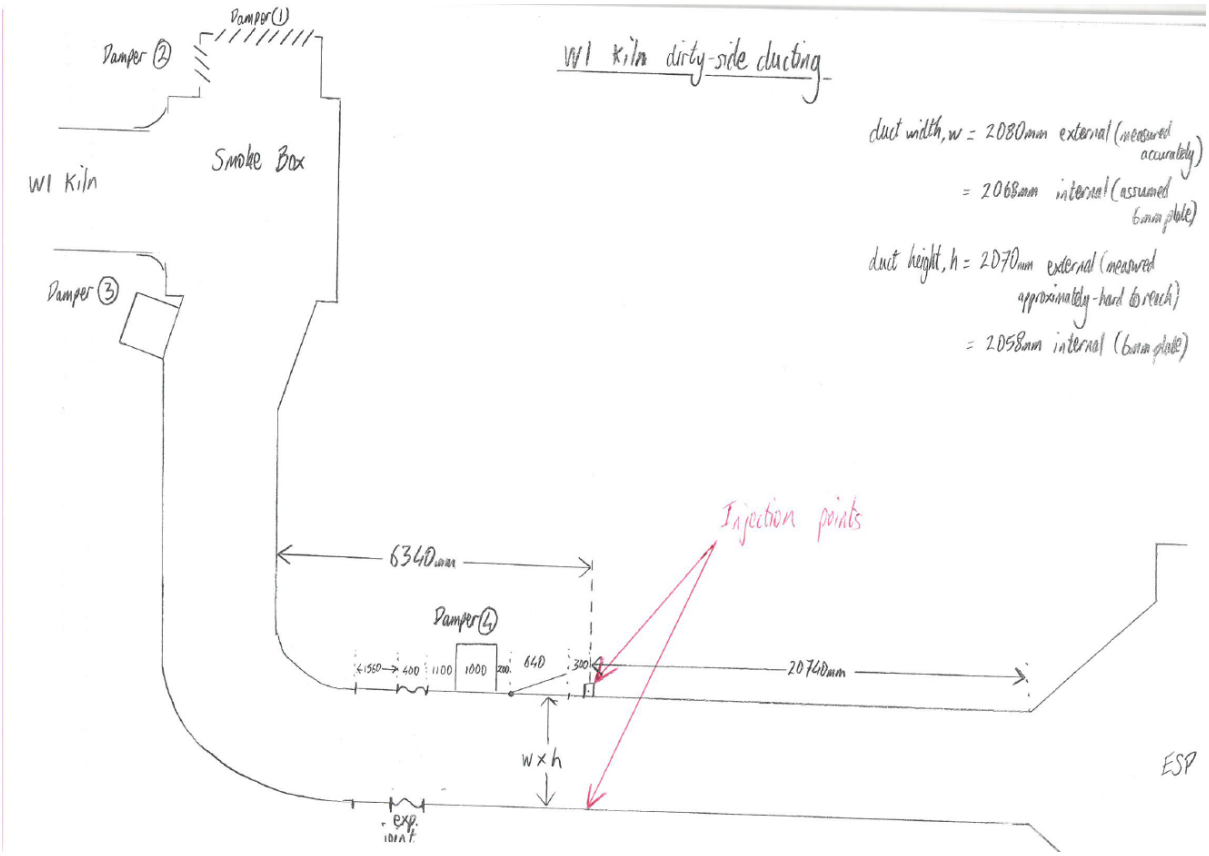


Diagram 3 – Injection position relative to kiln and ESP (not to scale)

The nozzle details were as follows:-

Position	Description	spray pattern	Min litres/hour	Max litres/hour
1E	SUN13 2850	flat fan	4.3 @5.7bar air	16.1 @4.5bar air
2E	Lechler 1AW.251.17.00.00.0	cone	15.6 @6bar air	69 @1bar air
3E	Lechler 1AW.251.17.00.00.0	cone	15.6 @6bar air	69 @1bar air
4E	SUN13 2850	flat fan	4.3 @5.7bar air	16.1 @4.5bar air
1W	SUN13 2850	flat fan	4.3 @5.7bar air	16.1 @4.5bar air
2W	Lechler 1AW.251.17.00.00.0	cone	15.6 @6bar air	69 @1bar air
3W	Lechler 1AW.251.17.00.00.0	cone	15.6 @6bar air	69 @1bar air
4W	SUN13 2850	flat fan	4.3 @5.7bar air	16.1 @4.5bar air

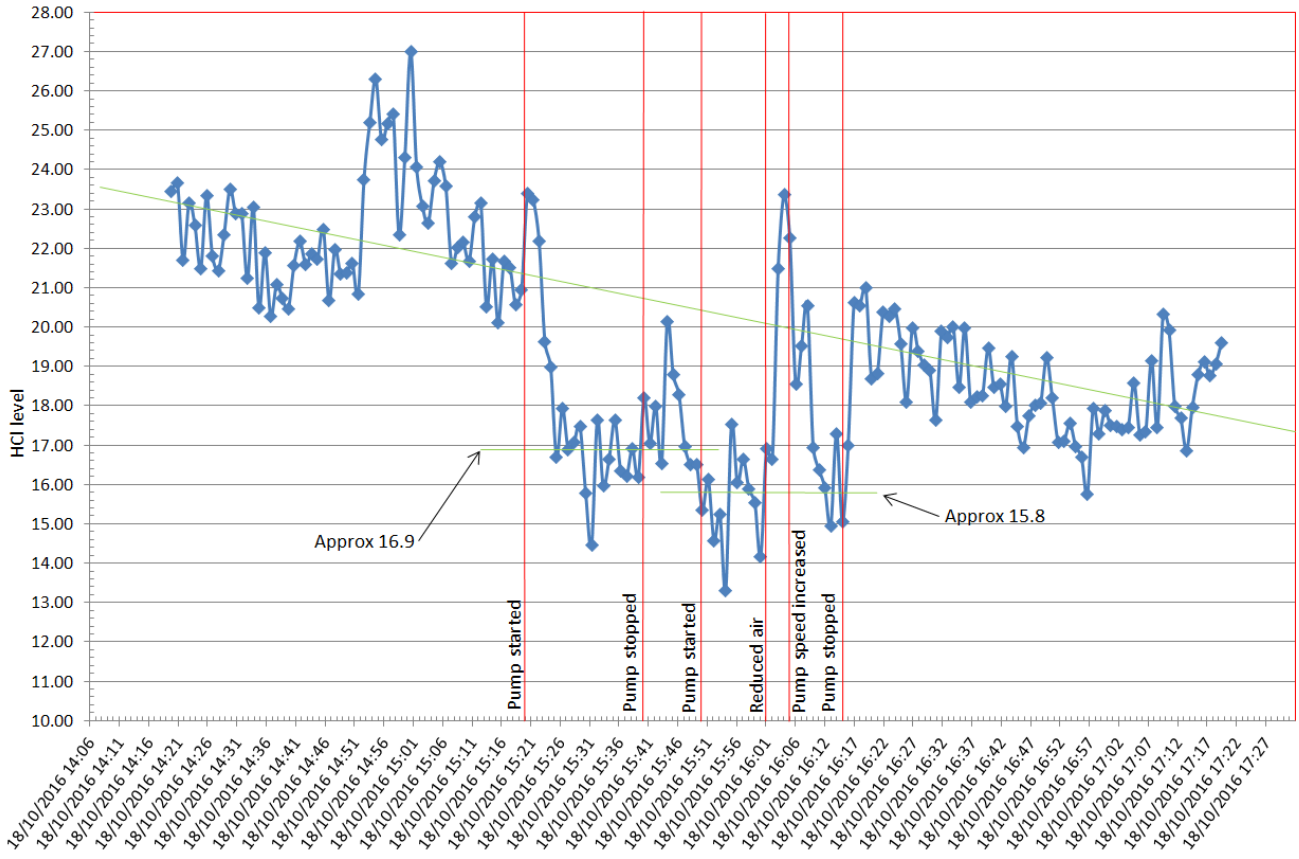
Flow-rate of caustic soda was calculated by recording the tank level against time.

Timeline of events

Time	Tank level in mm	Pump rate in litres/hr	Comment
15:20	900	46	start pump.
15:30	882	46	Turned pump speed down to avoid pressure relieving
15:40		0	stopped pump
15:50		191	started pump
15:54	840	121	
16:01			Turned air pressure down from 5.2 bar to 1 bar
16:04	821	86	Increased pump speed to maximum
16:15	784	0	Stopped pump

Average flow rate of caustic while the pump was running was 164 litres/hour.

Results



Practical problems with the trial

There were a number of problems setting the equipment up and operating the actual trial:-

1. Pump destroyed a diaphragm (due to failure to install a pressure relief valve)
2. Pump destroyed it's gearbox (damage probably occurred when operating without a pressure relief valve)
3. All four SUN nozzles broke off during the trial (or after the trial). This was perhaps down to the high temperature of the gas duct. A second trial was conducted on the 19th October with these broken nozzles. No reduction in HCl was observed, presumably because the full liquid volume was sent to the broken nozzles that had no pressure restriction. With no atomisation possible, the liquid would make very poor contact with the gas.
4. All the nozzles blocked. It is not clear whether this occurred during the first trial or afterwards. An attempt was made to protect the nozzles after the caustic soda was turned off by running water through. Unblocking the nozzles is a difficult and time-consuming process, and almost impossible to do when wearing the full PPE (chemical overalls, visor, rubber gloves, boots, apron). The danger is that behind the blocked nozzle is caustic soda
5. Limited opportunities to carry out the trial due to the kiln programme, Dioxin testing and personnel availability.

Analysis

Observations:-

1. The initial effect appears to be a reduction in HCl from around 21.4 to 16.9. This represents a 21% reduction.
2. When the trial was stopped, the HCl appeared to increase from 15.8 to around 19.7. This suggests the caustic soda injection was causing a 20% reduction.
3. The HCl trend was somewhat declining irrespective of the trial (see the green line on the Chart)
4. There appears to be an approx. 2 minute delay from stopping/starting the caustic soda pump to seeing an effect on the HCl level.
5. High atomising air pressure created a high liquid back-pressure which restricted the flow-rate of caustic soda. This was evident by the pressure relief valve leaking back to tank. When the atomising air was reduced, it was possible to speed up the pump and no liquid was returning back to tank. A reduction in atomising air pressure will have resulted in larger droplet sizes. This will theoretically allow the droplets to travel further before evaporating which could help with coverage. Conversely, larger droplets are less able to make contact with the gas stream.
6. Flow rate measurements do not seem reliable, probably due to the limited time between changes.
7. The central four nozzles seem too close together (2E,3E, 2W, 3W)
8. The corner nozzles need to be perpendicular to the gas stream as they only give a two dimensional fan
9. Observations from the Thrislington trial had identified that the pump was creating a pulsating flow of caustic soda. This effect was minimised by using a larger pipe diameter at Whitwell.

Further Trials

Ideas to further improve the effectiveness of the caustic dosing:-

1. Change the angle of nozzles 1E, 4E, 1W, 4W to cross duct
2. Repeat the trial when the kiln is producing much higher HCl levels
3. Further trials with lower atomisation air pressure to see if better dispersion can be achieved with larger droplets
4. Increase the gas concentration by eliminating the air dilution (calculated to be around 50% of total gas volume) by using water injection in the Smoke Chamber or injecting caustic soda before the air dilution damper

Conclusion

Although the trial was short in duration, it clearly showed an almost immediate effect. An addition of around 165 litres/hour of 32% NaOH provided a reduction of around 21% from 21.4 to 16.9mg/m3.