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BP Australia Installs & Commissions Pall GSS 3rd Stage Blowback Filter System to Reduce RCCU Flue Gas Emissions

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Fig 1: external cyclones BP Kwinana RCCU R2 regenerator

Fig 2: R1 & R2 common stack

Around the world, for environmental reasons, oil refineries equipped with a FCCU or RCCU have to face the challenge of particulate emission reduction.

In Europe many countries have now legislated for or are moving towards legislating for 50 mg/Nm³ emissions in the FCCU/RCCU flue gas. Furthermore, some countries have already decided to reduce those emission targets further to less than 40 mg/Nm³. Another environmental regulation which will be even more stringent is the proposed microparticulate specification relating to particles below 10 microns and 2.5 microns (so called PM 10 and PM 2.5 respectively). This is currently under discussion and is likely to become legislated for in some countries around the end of this decade if not before.

Outside Europe, refiners are often required to meet similar requirements. For instance, BP Refinery (Kwinana) Pty Ltd, a refinery in Western Australia, equipped with a 2 stage RCCU regenerator was requested by the Western Australian Government's Department of Environmental Protection (DEP) to implement new air pollution control requirements coming into effect from 2005. BP Kwinana was also advised that some form of microparticulate emission limits would be likely to be imposed around 2010 also.

In 2003, BP Kwinana Refinery RCCU flue gas emissions ranged from 150 to 400 mg/Nm³ particulate matter in the RCCU flue gas. This met the 2003 particulate emission limits however the refinery would not be able to meet the tighter 2005 limits with its existing RCCU regenerator flue gas cleanup equipment. The particulate emission licence limits for BP Kwinana for 2005 and beyond are: ▶

Year	RCCU Particulate Emission Limits
2003	<400 mg/Nm^3 100% of time <250 mg/Nm^3 95% of time
Proposed 2005	<250 mg/Nm^3 100% of time <150 mg/Nm^3 the majority of time
2010	<50 mg/Nm^3 & likely micro particulates emission specifications, lower limits on PM10 and PM2.5 are expected.

As a significant amount of BP Kwinana's RCCU flue gas particulate emissions is derived from the 2nd stage RCCU catalyst regenerator (R2), and the R2 flue gas flow rate is smaller than R1, BP Kwinana decided to concentrate on that stream to meet 2005 and beyond emission requirements.

Several technologies were considered by BP Kwinana including:

- Wet Scrubber
- New Secondary cyclones (external or internal)
- TSS with/without filter on underflow
- Electrostatic Precipitator (ESP)
- High temperature 3rd stage blowback filter

The wet scrubber was rapidly eliminated, as this option was extremely high in capital and operating costs, and would also require a new wastewater treatment plant to be installed to treat the effluent produced. Acid gas reduction in flue gas was also not required.

Secondary cyclones would drop emissions down to 150 mg/Nm^3 only, and had an extremely high installed cost. Future emission requirements would certainly not be met. This option was also not favoured.

Third Stage Separator (TSS) combined with an underflow filter was studied in some detail. However, a review of the particle size distribution of the catalyst fines from the 2nd stage regenerator indicated that the catalyst particle size distribution was too fine to allow the TSS to deliver the required particulate emission requirements all of the time. This left an ESP and a Third Stage Blowback filter for parallel investigation in a detailed study against numerous criteria that were of importance to BP Kwinana Refinery.

The result of that study is summarised as follows:

Criteria of selection	ESP	3rd stage blowback filter
Proven technology	Many references	Some references
Meet 2005 emission requirement	Yes	Yes
Ability to meet future 2010 requirements (<50 mg/Nm^3) on the second regenerator	Yes for total particulates Maybe for particle size	Yes for both total particulate and future microparticlulate size limits
Work required to meet 2010 limits	Large	Probably zero for R2 regenerator
Size of the equipment (the plot space being limited)	Very large	Small-Medium
Capital cost	Medium	Medium to high
Installation costs	Medium to high	Low to Medium
Availability during start-up	No	Yes
Additional Safety Risks	Yes	No
Sensitivity to process upset	High	Low
Required maintenance	Medium	Low
Required operating costs	Medium	Low

Another advantage of a 3rd stage blowback filter over ESP or other conventional FCC flue gas cleaning equipment was identified. This additional advantage is the improved protection of the turbo expander against erosion and therefore improvement of its reliability. In BP Kwinana's case, this is not a factor as BP Kwinana does not have a turboexpander installed. However other refineries equipped with turboexpanders would likely benefit from the installation of a 3rd stage flue gas filter, especially where FCC blowers and turboexpander cannot be easily decoupled.

BP endeavors to invest ahead of legislation. The 3rd stage blowback filter option would enable BP Kwinana to meet current particulate emission requirements and also get close to if not already meet particulate emission limits a number of years in advance of 2010 requirements. Therefore at the end of the study, BP awarded an order to PALL CORPORATION for the design, fabrication, testing, and commissioning of a Pall Gas Solid Separation System (GSS) for installation as a 3rd stage RCCU flue gas filter.

The main design parameters are:

Flow	2100 tons per day
Temperature	250 up to 400°C
Solid loading	250 to 400 mg/Nm^3 and up to 20,000 mg/Nm^3 on major upset
Dust Emissions	<10 mg/Nm^3
Run Time	4 years continuous operation

To cope with the process conditions, the Pall GSS 3rd stage blowback filter has been designed as follows:

Vessel diameter	3.5 meters
Vessel height	12 meters
Weight	52.5 tons
Filtration candles	corrosion resistant stainless steel
Control System	PLC based control system
Blowback Gas	Plant Air (Heated)

The filter system was also designed with the capacity for expansion for possible future RCCU debottlenecking. The filter system was delivered after a fast-track 10 month design and fabrication period.

Fig 3: Tubesheet assembly ready for shipment

Fig 4: Filter vessels arrive on site at BP Kwinana, Perth, Western Australia

Fig 5: Filter vessel lifted into position

Fig 6: Filter tubesheet assembly installation

Filter Start Up & Operation

The Pall GSS 3rd stage blowback filter system vessel, gas accumulator, and associated blowback piping was installed late 2003/early 2004.

Installation of piping tie-ins was conducted during BP Kwinana's major RCCU turnaround in May-June 2004. Pre-Commissioning services were conducted over a 2 week period in early-mid June. The filter was bought on-line on June 16th 2004.

Since start up, the filter system has operated virtually without incident. The filter system achieved a steady state recovery pressure differential after approximately 100 blowback cycles which was in line with expectations. (Refer fig 7).

The filter has had a low operating pressure drop and since incorporating this 3rd stage blowback filter into BP Kwinana's RCCU operation, there has been no adverse impacts on the RCCU operation in any way.

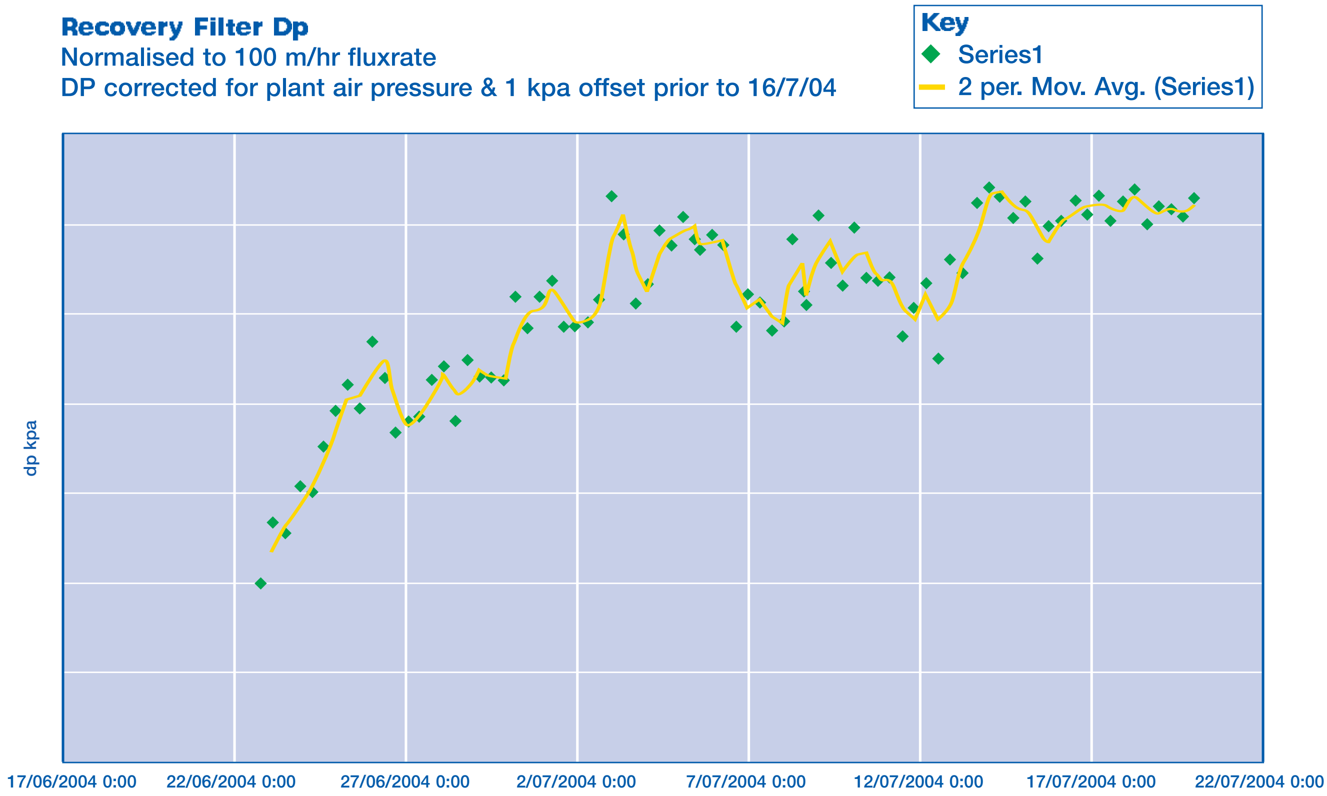

Fig 7: Filter Recovery dP (Normalised)

Besides the filter pressure drop, other variables such as valve opening and closing times, flue gas temperature, blowback accumulator pressure and blowback gas temperature are monitored also. The catalyst levels in the filter hopper are monitored and periodically the catalyst fines are removed from the filter hopper and pneumatic conveyed to the spent catalyst hopper. The filter operation is monitored locally by BP Kwinana and remotely by Pall commissioning engineers.

Filtration Efficiency

Following start up of the filter an opacity analyser was commissioned on the R2 stack. This analyser has read consistently less than 1%, with an average around 0.5%. This is believed to be equivalent to less than 5 mg/Nm^3.

However, although isokinetic stack tests have been done it has been difficult to get an accurate result due to the low levels of particulates leaving the stack.

Fig 8: BP RCCU common stack before and after blowback filter start up. (Note: 2 plumes on left hand photo, and 1 plume on right hand side photo).

Upset Conditions

Besides normal operation during which the Pall 3rd stage blowback filter operation was stable, the filter was subject to 2 upset conditions.

Upset 1

During late August BP Kwinana experienced a leak in the slurry oil system which required the RCCU feed to be taken out so repairs could be made. Torch oil was burnt in R2 regenerator to maintain R2 temperature with the plan to re-introduce feed again quickly once the leak was repaired. During torch oil firing, the blowback filter was maintained on line throughout.

During this period of torch oil firing, the filter pressure drop increased by approximately 15% however the filter differential pressure recovered back to previous levels after RCCU feed was reintroduced. This was a significant event as the filters ability to cope with torch oil firing meant that BP Kwinana did not have to be concerned about particulate emissions during a unit start up. This also proved that the filter can be used on-line from a cold RCCU start up, which up until now was always difficult to control due to particulate emissions. It is anticipated in future more and more scrutiny will be placed on emissions during the start up of the RCCU at Kwinana.

Upset 2

During late August/early September, BP Kwinana experienced a catalyst attrition problem which caused the solids loading to the blowback filter increase substantially from approximately 250 kg/day to 1000-2000 kg/day.

The emissions from the R2 regenerator remained constant throughout and allowed BP Kwinana to continue RCCU operation until the catalyst attrition issue was resolved without exceeding any licence limits.

Refer to Fig. 9 below to see the increase in loading without change in opacity at the stack.

At one stage BP operated the R2 regenerator in such a way that encouraged the catalyst fines to go to R2 rather than R1 and be captured by the blowback filter rather than go up the R1 stack and to atmosphere.

During this upset, the filter blowback cleaning frequency increased automatically to cope with the increased solids loading.

The Pall GSS 3rd stage blowback filter system recovery pressure drop remained unchanged throughout.

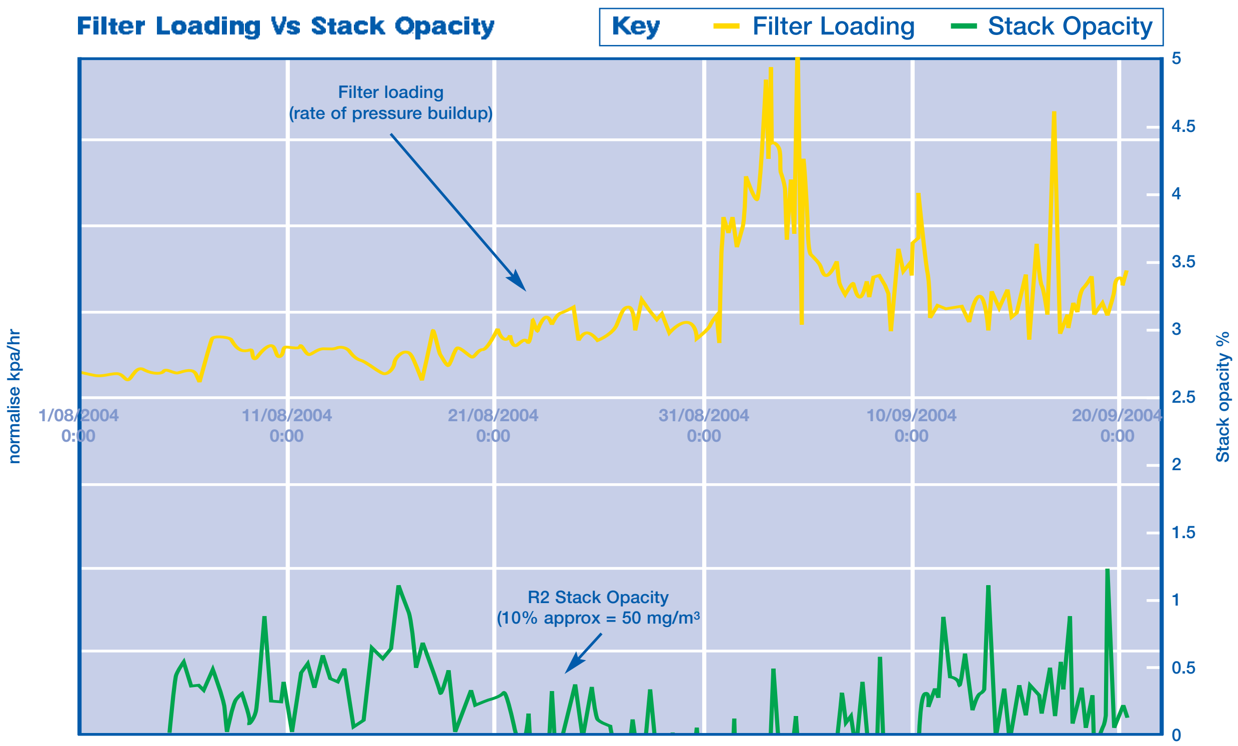

Fig 9: Increase in dust loading versus R2 stack opacity measurement

Conclusion

Since commissioning, the GSS Third Stage Blowback Filter has so far met BP Kwinana's expectations during normal operation and has also proven to be reliable and robust during two upset conditions experienced. The GSS filter pressure drop is low and stable.

The operation of the Pall GSS 3rd stage blowback filter has not adversely effected RCCU plant operations in any way. This is in part due extensive HAZOP analysis and potential failure mode analysis which was conducted in the early stages of the project between BP & Pall specialists to ensure that the 3rd stage blowback filter was integrated as seamlessly as possible into BP Kwinana's RCCU operation.

The installation of this Pall GSS 3rd stage blowback filter system allows BP Kwinana refinery to meet or exceed existing RCCU particulate emission requirements and is also expected to meet future 2010 emission requirements (including microparticulate emissions) for R2 regenerator flue gas.

This has reduced the risk of BP Kwinana investing in 'stranded capital' should conventional hot gas clean up technology have been installed in 2004 which might not meet future 2010 requirements as well. The introduction of this Pall GSS blowback filter technology into BP Kwinana's RCCU has also not introduced any new safety risks into the refinery.

The BP Kwinana experience demonstrates that Pall GSS 3rd Stage Blowback filter technology will likely have a significant role to play in future FCCU/RCCU flue gas emission reduction projects as tighter emission limits for total particulate and microparticulate emission levels gradually come into force around the world.

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