CFB scrubbers make a case for India

While wet flue gas desulphurisation (FGD) is the incumbent technology for cleaning up coal fired plants, circulating fluidised bed (CFB) scrubbers are poised to challenge the status quo, especially in markets such as India. Junior Isles

Pressure on power plant operators to cut emissions has never been greater. It is a global trend that has seen even the likes of China introduce tougher emission standards for sulphur and nitrogen oxides (SOx and NOx), particulate matter (PM) and CO2. Even developing countries such as Indonesia, the Philippines, Thailand and Vietnam are looking at ways to cut emissions from their coal fired fleet. And in India, which has revised its emissions legislation, the pressure is more acute.

Certainly emission-free renewables such as wind and solar are growing at a tremendous rate in many of these countries. India for example has set a goal of adding 175 GW of renewables by 2022. But although renewables are making rapid progress globally, coal plants still have a role to play in providing base load generation and technology therefore needs to be adapted to drastically cut emissions from the coal fired fleet.

Nowhere is this truer than in India, where the country is now assessing technology options to cut SOx and NOx from its installed base and any new plants on the horizon.

Robert Giglio is Senior VP Strategic Business Development, Sumitomo SHI FW (SFW), which is currently targeting India as a key market for its circulating fluidised bed (CFB) dry scrubber technology. He commented: “Low emissions has become the new guiding principle for power plants – both old and new, coal and otherwise. Of course renewables are right there too, but they don’t always fit the role of these base load fossil plants. That means we have to deal with the fuel costs and operating costs, and that’s great. But renewables are not able to fill the role of these base load fossil plants. That means we have to deal with the fuel costs and operating costs, and that’s great. But renewables are not able to fill the role of these base load fossil plants.

“India is the key example in the world right now of a country that has moved from being one of the less conforming countries when it comes to regulatory environmental laws, to one that has actually become very progressive. India is setting the lead for what a big developing country has to do with its coal-based generation fleet.”

According to the Ministry of Power, in 2018 coal fired power plants represented just over 56 per cent of the country’s installed generating capacity. Many of these plants have no emissions controls, and determining the right technology to control coal plant emissions is a choice that India’s plant owners are now facing.

India issued new environmental legislation just over three years ago, setting new standards for NOx and SO2 but more recently made some modifications.

Market expert Ravi Krishnan, at Krishnan Associates, explained: “The standards introduced around December 2015 came about all of a sudden because of pressure from the international community at the time to get the country to move to greener energy and also clean up its coal fired power plants.

“But because the regulation came about so quickly, the government underestimated how long it would take to implement the air pollution control projects, and did not really factor in any delays due to custom design considerations for high ash Indian coals and how the costs would be passed on to the customer.”

This, he says, led power plant owners to push back on the legislation, forcing the government to extend the guideline for compliance from 2017 to 2022. The new legislation sets different limits for plants installed before 2004, those after 2004 but before December 31, 2016 and those after January 1, 2017.

In short, the legislation means that plants pre-2017 of less than 500 MW have to meet SO2 standards of less than 600 mg/Nm3, and less than 200 mg/Nm3 for plants larger than 500 MW. For NOx, the level is 600 mg/Nm3 for all sizes built before 2004. For plants built between 2004 and 2017, the SO2 limits are the same as pre-2004 plants but the NOx limit is 300 mg/Nm3. Notably, in some locations that are smaller than 500 MW but are close to populated areas, also have to comply with the 200 mg/Nm3 SO2 standard. For plants of any size built from January 2017, both SO2 and NOx must not exceed 100 mg/Nm3.

The choice of flue gas desulphurisation (FGD) system, which can either be a dry/semi-dry or wet system, depends on the level of SO2 removal needed and the plant specifics.

Dry/semi-dry FGD technologies include: simple injection of a sorbent into the boiler flue gas (direct sorbent injection or DSI); the more established spray dryer absorbent (SDA) system, which sprays a mist of lime slurry into the flue gas, and the relatively new concept of employing CFB scrubber technology, with boiler ash and lime circulated through an absorber reactor and typically a fabric filter.

With baseline SO2 emissions averaging around 1200 mg/Nm3, India’s 600 mg/Nm3 limit could be met using a DSI system for many plants but to meet the 200 mg/Nm3 standard would require the use of a wet FGD system, or one of the other dry/semi-dry processes.

For decades, the established technology for cleaning up coal plants has been wet FGD scrubbers, which use limestone as the reagent for capturing SO2. In India, the last year or so, around 15 wet FGD systems (representing 10-12 GW) have been ordered for power large plants but going forward, the choice of wet FGD for pollution control might not be so automatic.

“They have gained this dominant position because they were built at scale many decades ago, and proven themselves over a wide range of conditions and fuels and quality of flue gases,” said Giglio. “But they have some downsides: they use a lot of water, they’re expensive and they take up a lot of room. They don’t do a good job on non-water-soluble acid compounds like SO3 or some of the halogen compounds. And they don’t work well with heavy metals. They are really geared to removing SO2, and there’s a lot of maintenance that goes along with the extra equipment involved.”

One other potential drawback with wet FGD systems is that they also produce gypsum. Although this can be a valuable byproduct, in some countries such as India where it is projected that there will be an over-supply of gypsum, disposal costs can be a burden.

“The attractiveness of gypsum sale to wallboard manufacturers was initially a big selling point but it turned out there was not really a demand for it. So what was seen as a potential source of revenue offset has not been realised. Furthermore gypsum purity in many cases has not been high enough for commercial sale,” said Krishnan. “And with the Indian market being very cost-sensitive, the lower installed cost of the CFB scrubber and its other benefits mean the technology is beginning to emerge as a major alternative.”

Dry/semi-dry systems overcome several of the issues facing wet FGD technology. Notably, they have much lower capital cost and use less water than wet FGD technology.

According to Krishnan, in India, the price of wet FGD systems average at about $70-80/kW. According to SFW, this is typically about 40-50 per cent more than a CFB scrubber. This is due to the greater amount of equipment needed by the wet FGD process. A wet FGD system also consumes about 40 per cent more water. And although the limestone used in a wet FGD can be 40 per cent cheaper than the lime used in a CFB scrubber or SDA system, operating costs tend to be higher.
“In a CFB scrubber, you don’t have to maintain lime crushers, mills, slurry pumps, spray nozzles, or drying systems for the byproduct, etc.” noted Giglio.

Despite these advantages, however, in the past they have generally only been selected for projects where the boiler size was not too large and the fuel sulphur level was not too high. Traditionally, this has been true of both SDA and CFB scrubbers. Since their introduction 10-15 years ago, however, a steady increase in scale is seeing CFB scrubbers become an increasingly attractive alternative to wet FGD systems. During this time, they have also been proven over a much wider range of sulphur levels and fuel types.

Today, there are single unit designs up to 700 MW built by operating references on coal power plants of over 500 MWe and on fuels with sulphur levels above 4 per cent. In June 2011 for example, a CFB scrubber began operating at the 520 MW coal fired plant at Basin Electric’s Dry Fork station in Gillette, Wyoming, USA.

According to SFW, CFB scrubbers can operate on a wide range of coals. Low ash, high moisture fuels such as Indonesian sub-bituminous coals might require more reagent than the fuel’s ash level increases less reagent is needed since the ash plays a role in capturing the pollutants in the flue gas. Giglio noted: “It can take the widest range of fuels – from hardly any ash to an overwhelming amount of ash – and still function well. They can do what a wet FGD system can do in many cases, and they can do it for a lot less cost and a lot less water.”

For optimum operation, he says there is “a sweet spot” where ash levels are between 7 per cent up to around 30-40 per cent. This gives the maximum capture with the least amount of reagent injection. This agent could be anything from hydrated lime, sodium bicarbonate or even activated carbon, depending on the pollutant being targeted. “The scrubber is completely flexible to tailor the reagent recipe to most efficiently capture the target pollutants,” said Giglio. “Whereas a wet system has to be precisely controlled... it’s a tight control system – there can’t be too many chlorides, metals or ash in the system because they adversely impacting the capture efficiency. All these things move if it’s optimum operation.”

CFB scrubbers use dry absorption chemistry instead of water solubility chemistry to make the reactions work in the scrubber.”

He points out, however, that the choice of technology largely depends on the specifics of the project. “Wet FGD uses limestone, which is cheap; whereas the semi-dry processes use a more refined lime that is more expensive. It’s all part of a discussion around capital cost, operating cost, what to do with the byproduct, water usage, space requirement. It’s never a one size fits all solution.”

There are also differences between the dry/semi-dry processes to consider. Compared with SDAs, CFB scrubbers offer lower maintenance cost, compact footprint, and the flexibility to use low quality lime and water.

Another drawback of SDA technology is that it can’t accept as many solids. SDAs use atomising nozzles, some with motorised rotary heads to enable a very fine mist to be sprayed. Because the nozzles have very fine passages, passing boiler fly ash through them causes blockages and erosion. CFB scrubbers avoid this problem by using large diameter venturis to mix the ash with turbulent flue gas.

Giglio explained: “The CFB scrubber uses the boiler’s fly ash to help capture the target pollutants. This benefit can reduce reagent consumption and operating cost, which becomes most significant for fuels containing high levels of calcium in their ash. The technology uses the ash as receptor sites to absorb the vapour phase pollutants (SOx, HCl, H2S, etc.) on the surface of the solid particles. But the main process advantage of a CFB scrubber is that, unlike SDAs or wet FGD technology, the amount of lime injection is not limited by the gas temperature, allowing significantly improved acid gas scrubbing performance.”

“This is a key advantage; none of the other scrubbers do this. SDA and wet FGD technology use a slurry of lime and water to spray into the gas to clean it. But the problem with this is you’re now connecting gas temperature and moisture level to sulphur removal. The more slurry that’s sprayed into the gas, the lower the gas temperature becomes and the more humid it becomes. This means that whatever device is put behind the absorber vessel, you need to ensure that gas is safely above its water dew point so that it doesn’t cause operating problems or corrosion in the downstream device like a baghouse or ESP or stack,” said Giglio.

In both the baghouse and ESP need a gas that’s relatively dry – gas that at least has a 230°C approach temperature to the dew point of the flue gas. This limits how much sulphur you can capture. “This restriction is not there with a CFB scrubber, you can add as much lime as you want to the system because the chemistry is much less dependent on the amount of water injected into the flue gas; water is only used in the CFB scrubber to set the temperature and humidity of the gas. This gives the flexibility and freedom to go to very high levels of capture of all the acid gas and metals.”

SFW sees this ability to capture a wide range of pollutants, including SOx, PM, acid gases and organic compounds, as a big plus in today’s market.

Commenting on this flexibility, Giglio said: “You can install one today to get you to where you need to be on SOx but it also reduces SOx, HCl, HF, mercury, beryllium, cadmium – all of these metals that may not be regulated in many countries for a long time but it’s coming. So in the future, you don’t have to go out and buy another scrubber or add on activated carbon systems as regulations tighten.”

In a CFB scrubber, boiler flue gas enters at the bottom of an up-flow absorber vessel. The gas mix with hydrated lime and water injected into the absorber, as well as recirculated solids from the downstream fabric filter. The turbulent wall surface of the absorber causes high turbulent mixing of the flue gas, solids and water to achieve a high-capture efficiency of the vapour-phase acid gases and metals contained within the flue gas.

The scrubber design incorporates a number of built-in features to maximize reliability. The absorber vessel is a self-cleaning upflow reactor with a cloud of water droplets spreading over a large surface area of solids churning in a 23 m (75 ft) high section within the confines of the vessel walls.

Water injection nozzles, located on the perimeter of the absorber above the introduction points for the re-circulated and sorbant solids, provide an atomised spray cloud of water droplets. These nozzles must be removed periodically for replacement of components subject to wear. However, the entire perimeter of the CFB absorber vessel is used to locate the water nozzles thus additional nozzle locations are typically available to allow installation of a spare nozzle prior to removing an operating nozzle for inspection or maintenance.

One or more multi-compartment fabric filter baghouses are located downstream of the absorber vessel to allow recirculation of particulate solids. The multi-compartment baghouse lends itself to on-line replacement of filter bags with one compartment off-line.

Separate compartments are each lockable on the flue gas side for maintenance purposes thus it is possible to shut down one compartment...
A CFB scrubber has been operating at the 520 MW coal fired Basin Electric Dry Fork power station since 2011.
Photograph courtesy: Basin Electric Co-Op and Wyoming Municipal Power Agency

for maintenance while running the remaining compartments with 100 per cent boiler flue gas flow. The baghouse hoppers serve as temporary storage bins for the large portion of the material that is fed into the solids recycling system. This is accomplished by means of a control valve via maintenance-free air-slides back into the absorber.

But although the technology is proven and can in many cases be the best choice for pollution control, Giglio says that global deployment is short of where it could be.

There are around 80 SFW CFB scrubbers installed around the world, with half of these being behind waste-to-energy plants, mainly in Europe.

Notable recent references include the Soma Kolín project in Turkey, which has two 255 MW CFB boilers firing low quality lignite. CFB scrubbers have been installed behind the boilers to give future flexibility on what pollutants might need to be captured in the future. The Zabrze plant in Poland is another example, where the CFB scrubbers future-proof the plant against new potential emission legislation for years to come.

Giglio commented: “We have done well in our ‘home’ markets, i.e. where we supply CFB boilers proving that the scrubber brings additional value to the projects we do. These are mainly in Europe but now we are looking to expand into other key markets such as India, central Asia and southeast Asia.”

The opportunity in India is huge. According to Krishnan, the FGD market is roughly 120 GW in terms of size. Almost 100 GW – nearly 50 per cent of the coal fired installed base – is made up of units greater than 500 MW that will need an FGD solution. “The remainder will either have to go for a DSI type system, or retire their plant if it is old. Those [smaller units] that are close to populated areas will also have to put in an FGD system,” he said. “This means around 55-60 GW could potentially use CFB scrubbers.”

Giglio added: “I would argue it’s more about economics than size [of unit]. It also very much depends on geography, supply chains, byproduct options, etc.”

With the 2022 deadline fast approaching, power plant operators in India are in the midst of conducting evaluations to avoid stiff penalties for non-compliance. Giglio warned however: “Although the train is moving much faster now, there are still some lingering issues that are allowing the power producers to push back. They need clarification on things such as: will tariff reform allow plant owners to pass the compliance cost on to ratepayers? Will the limestone supply chain develop in time? What are my options for gypsum and byproduct sales or disposal? There are things that might delay the compliance deadline further.

While upcoming elections could heighten uncertainty, the clean up of coal plant is something that is supported by all parties.

In addition to India, SFW sees China and other high coal use countries as the main targets for CFB scrubbers. “China is the biggest market: they’ve already gone well down the road in adding a lot of systems – both wet and semi-dry CFB scrubber types. They’ve also done DSI-type systems for plants needing only limited reduction of select pollutants,” said Giglio.

“Australia is another key market, which is largely dependent on coal for its power generation with most plants having no control of SOx or NOx emissions. While they have been more focused on CO2, they have ignored the SOx, NOx, PM issues. Once they get through the CO2 debate, which seems to be coming out to a more balanced approach where they will allow upgrade of coal plants in combination with renewables, I think they will start looking at the coal they have and seeing what they can do to make it cleaner.

“Indonesia, Philippines and Vietnam are right now all in the midst of ratcheting down emissions when they look at new coal plants.”

He concludes: “The lower costs, lower water consumption, multi-pollutant capability, compact footprint and flexibility to handle a wide range of coals, now combined with the bigger unit sizes, make a compelling case for CFB scrubbers as a coal clean up technology.”
A flexible multipollutant technology

Our Circulating Fluid Bed (CFB) Scrubber efficiently captures all acid gases, metals and particulate matter down to the lowest levels. It is a versatile and flexible technology that can clean up flue gases from boilers and industrial processes using the least amount of water and project capital.

- Uses 30-40% less water than wet FGDs
- 50% lower capital cost than wet FGDs
- Best capture of acid gases and metals
- Excellent capture of oxides of sulfur
- Very low operating cost and need for lime reagent with calcium rich boiler ash (ideal for CFB boilers)
- Low maintenance since it doesn’t utilize lime slurry and rotary atomizers