In the majority of the developed world, legislation has been introduced to reduce sulphur emissions from coal combustion processes through flue gas desulphurization systems. On the downside, the installation of such technology is a costly business, even with governmental financial support. However, by combining the limestone gypsum FDG system with batch basket filtration centrifuges, a saleable product, i.e. high quality gypsum, can be produced, which makes the incorporation of FGD technology a much more economically viable option. Nigel Day explains.

Batch basket filtration centrifuges for FGD pay their way

Unless forced by legal legislation or other external rulings organizations will rarely select of their own accord to install large, high capital cost centrifuges (e.g. batch basket filtration type) and associated equipment to process a low, or even none profit making product. However, when the process generates a specific product with a profitable market value it is a very different situation. When selected in this way the payback on the capital investment can be anything from 1-5 years.

Flue gas desulphurisation or FGD is one such scenario. FGD is a process where the damaging sulphur laden gases from the burning of fossil fuels are removed from the plants exhaust gases before they are released into the atmosphere. FGD is often applied to processes where large amounts of coal are burnt, for example at coal fired power stations. Compared with other fuel sources, such as oil and gas, the sulphur content of coal is substantially higher, therefore FGD systems are being applied to coal combustion facilities where it is of greatest benefit.

During the combustion process the sulphur contained in the coal is converted into harmful sulphur dioxide (SO_2) gas, which if untreated is then released into the atmosphere.

In the 1950s sulphur emission controls were introduced because high-localized concentrations of SO_2 in the air of towns and cities were leading to numerous respiratory problems within the population, and even death in some cases. As a result measures were introduced outlawing the use of certain fuels in urban areas. Regulations were also introduced limiting the concentrations of SO_2 in the air. Such measures had a significant impact in reducing emissions and associated health issues.

Successful as this was, attention soon turned to the much larger picture of what effect SO_2 was having on the environment. Studies highlighted that emissions from tall flue stacks could travel vast distances through the atmosphere and produce acid rain when they came into contact with water . This resulted in the pollution of vast area, killing trees and acidifying lakes and rivers.

The reaction in countries such as Japan, USA, Germany and UK was to introduce legislation to collectively reduce sulphur emissions through the use of FGD technology. However, as the problem is international more recent legislation has been introduced to reduce emissions around the globe.

Within Europe the member countries have agreed levels of emissions reductions by individual countries in order to meet an overall target reduction level. The individual country targets vary depending upon their overall level of SO_2 emissions and the prosperity of the country. Some of the less wealthy countries have been given relaxed timescales, with some even allowed to increase emissions in the short term.

Available FGD systems

Currently there are around nine different FGD systems that have been adopted around the world, all of which differ greatly. The differences lie in the by-products produced, efficiency of SO_2 removal, sorbent used and the capital costs.

Normally, economics decide which process is chosen, however there are technical and commercial considerations that form part of the selection procedure too. The most viable FGD systems are listed below:

(i) Wet Systems
- Seawater
- Limestone gypsum
- Wellman Lord
- Ammonia scrubbing

(ii) Semi-dry Systems
- Fluidised bed
- Spray drying
- Duct spray drying

(iii) Dry Systems
- Furnace injection
- Sodium bicarbonate injection

The most popular system is the limestone gypsum process (Figure 1), which has been in existence in some form or other for almost 50 years.

Limestone gypsum system

The whole system is located between the outlet from the boiler(s) and the inlet to the main flue stack. SO_2 laden gas is sent to the FGD system after first being cooled.

The cooler gas is then pushed into an absorber tower, entering mid-way up its overall length. On entering the tower the gas immediately comes into contact with a limestone/water slurry. The limestone slurry is re-circulated through the absorber tower via a series of large pumps and spray nozzles.

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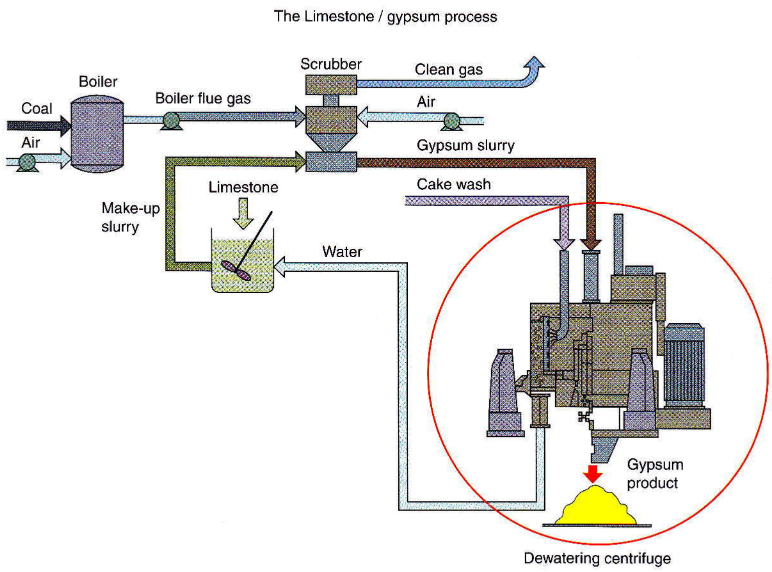

Figure 1: Schematic of the limestone gypsum system.

This counter-current flow of gas rising, slurry falling, promotes a chemical reaction to take place. The limestone is first converted into calcium sulphite. In order to complete the chemical reaction and turn the calcium sulphite into gypsum (i.e. calcium sulphate), extremely powerful pumps force oxygen into the absorber.

Gas that has percolated through the absorber tower, which is now almost free of any sulphur element, is first dried by a series of spray eliminators before being reheated and re-directed up the plants high flue stack.

Gypsum formed in the absorber tower precipitates to its base. From there it is withdrawn and is first sent to a bank of hydrocyclones, where it is pre-thickened to around 45% solids. It then flows freely into a slurry tank.

Finally the slurry is sent for dewatering, by the use of industrial centrifuges. Other separation equipment has been used in the past, but a large number of limestone gypsum FGD systems worldwide elect to employ industrial centrifuges because of their high degree of flexibility, containment and minimal operator intervention.

A suitable conveyor system transports the final product, i.e gypsum, to a large holding area, which is usually covered, prior to leaving the site.

Which centrifuge to choose?

Although by no means unique, a FGD gypsum slurry suspension lends itself to excellent separation by both filtration and sedimentation centrifugation techniques.

However, when looking closely at the overall requirements of the separation stage, one of the techniques clearly stands out as the perfect option. Factors affecting the decision are:

- Solid free filtrate/centrate
- Cake moisture contents <8% w/w
- Chloride free final solid
- High purity gypsum
- Saleable product

The major advantage a continuous sedimentation type decanter centrifuge has over the batch basket filtration type centrifuge is that it is continuous. Furthermore, because it is continuous the philosophy of operation is substantially simpler. It is also capable of processing a wider range of product variation without causing operating problems.

From a product throughput point of view a decanter centrifuge is capable of processing far higher material when compared to a filtration type centrifuge, which takes up a similar floor foot print size.

Maintenance-wise a decanter will also require far less operating cost. For example there are no real consumable items on a decanter centrifuge. This is in contrast to the filtration centrifuges, which periodically require the filter media and the solids discharge blade to be replaced.

Despite all the positives given above, it is the batch filtration centrifuge that is chosen for the majority of all FGD limestone gypsum process around the world. There are a number of key reasons underlying this.

Firstly the centrifuge must be capable of recovering 100% of all the suspended solids offered to it. A filtration centrifuge provides this facility, whereas a decanter centrifuge will have a small amount of gypsum slippage to the centrate liquor stream.

Final cake surface moisture is very important and the filtration centrifuge can produce dryer cakes than the decanter centrifuge, not by much, but enough to be important for downstream processes and transportation.

By far the most significant factor that favours the filtration centrifuge is the fact that the final solids must be chloride-free. And despite what some manufacturers claim this is not possible with this particular material using a continuous decanter centrifuge. Solids can receive a product wash within the filtration centrifuge. Washes can be incorporated in decanter centrifuges, but not on material with such a small particle size distribution.

Purity of the final gypsum solids is also a requirement. The feed material offered to the centrifuge(s) contains a small amount of very fine fly ash that cannot be removed by the upstream electrostatic precipitators. A decanter centrifuge is not equipped to remove this small fraction of impurity. FGD filtration type centrifuges, on the other hand, have such a facility.

The ultra-fine, very light fly ash is reluctant to settle even when subjected to a gravitational field. This allows the material to be decantered from the filtration centrifuge by way of spilling over the basket lip and captured in a special gutter arrangement located internally at the top of the outercasing.

The cost of an FGD system is very expensive even with assistance from various organizations and government bodies. High quality gypsum sold for wallboard, which is essentially a by-product, is assisting with the running costs. This however is dramatically influenced by the proximity of a convenient disposal area for the gypsum. For example, the FGD plant at Ratcliffe-on-Soar power

Figure 2: Typically several batch basket filtration centrifuges are installed at a FGD plant.

station (Nottinghamshire, UK) has a major user of the material located a short distance from the power station.

FGD centrifuge & its unique operation

Traditionally the FGD centrifuge comprises a vertically-oriented basket. To all intense and purpose it appears to be a large conventional filtration basket centrifuge. However, there is a very subtle, but vital addition to the centrifuge internally that ensures high quality gypsum production and trouble free operation.

The addition is the gutter arrangement mentioned above. Without this key feature it is virtually impossible to operate the centrifuge without it going seriously out of balance. This is explained further in the philosophy of operation below.

Gypsum suspension at approximately 45% w/w is introduced to the centrifuge via a pump fed ring main system. Invariably there are several centrifuges installed at a FGD plant (Figure 2). Here interlocks prevent the feeding of more than one centrifuge at a time. This ensures repeatable feeding of a homogenous nature. At the start of feeding each centrifuge basket is accelerated to the predetermined feed speed. On reaching this speed the slurry enters the machine via a tangential feed pipe(s). Feeding continues at a high flow rate filling the centrifuge in a matter of minutes. Initially the feeding stage follows that of conventional basket filtration centrifuges, but it is at this stage of the process that the philosophy breaks from convention. Feed continues to enter the basket, but is then deliberately allowed to flow over the basket lip for a few seconds. This gives the fly ash sufficient time to leave the basket, and more importantly the surface of the cake. After a short delay the process wash is introduced with the intention of flushing out the free chlorides held in the cake solids. This would not be possible if the ultra-fines were not allowed to flow over the basket lip because they create an impervious coating on the surface of the cake. In addition to the ultra-fines preventing acceptable washing, if they are not removed they will also promote a serious out of balance condition to develop becasue of excessive volumes of free liquor unable to escape from the basket. Upon completion of the overspill and washtime the centrifuge is then accelerated to spin speed for final dewatering. Final spin time is predetermined according to the final cake moisture requirement. Finally the basket is reduced to solids discharge or plough speed so as to remove all the solids from the basket before being accelerated back to feed speed for the whole process to start over again. This continuous cyclic operation is usually repeated approximately five times per hour.

Conclusion

The incorporation of a FGD system into a processing plant, such as a coal-fired power station, is very costly even with all the aid it may receive. Thankfully the limestone gypsum system, which is often chosen, generates a saleable product that look set to be in demand for many years to come. While this clearly does not cover the operating costs in full, the limestone gypsum and associated equipment, especially the FGD type centrifuges, are helping to pay their way.

It is anticipated that the demand for FGD systems will continue to grow for many more years, with a substantial number of companies opting to adopt the combination of limestone gypsum and batch basket filtration centrifuge operation. Technological and design developments mean that current systems are now capable of removing around 97% of the harmful sulphur. At the same time overall costs are steadily falling.

Most FGD systems are in operation in USA, Western Europe and Japan. However, FGD systems are now rapidly being introduced into East and Southeast Asia, with further market opportunities opening up in India and China. This is clearly good news for the suppliers of such technology and systems, as well as the manufacturers of FGD type centrifuges.

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