Fabric filter solutions with very long bags for power plants and industrial applications

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Developing more cost effective and compact high ratio fabric filters (HRFFs) requires increasing the total filter area fitted into a given casing volume, while not compromising the dust emission, pressure drop and bag life performance of the filter. Enhancing the bag length and the total bag area cleaned on-line per pulse valve is technically very challenging. GE (ex Alstom) has more than 35 years experience of supplying in-house designed HRFFs for power and industrial applications, and recently launched a HRFF design with 12 m long bags for power plants [1]. The new design necessitated an enhancement of the pulse system performance in order to meet benchmark design criteria, and a superior new nozzle pipe design was developed. This paper will provide further details on the radius nozzle pipe, which has an advanced engineering design. The nozzle has better fluid dynamic properties for the interface between nozzle pipe and bag and provides a more uniform cleaning pressure along the depth of the bags and along the length of the nozzle pipe. These properties enable implementation of 12 m long on-line cleaned bags and increased filtration area per pulse valve, with a potential for even longer on-line cleaned bags being available in the near future, based on ongoing R&D activities with regard to e.g. gas flow distribution design and bag cleaning performance improvements, which will be presented in the paper. A CFD computation is shown in Figure 1, comparing the standard nozzle (to the left) and the radius nozzle (to the right). The radius nozzle pipe may also be used for bag lengths < 12 m with expected benefits in compressed air consumption and bag life. The radius nozzles are produced in specially developed, GE proprietary stamping tools.

To cater to industrial applications, e.g. iron and steel, a tailor-made HRFF design with 12 m long bags has now been developed, and the paper will feature insights into the R&D efforts required for this design.

Special focus is laid on the application of HRFFs in the challenging sinter strand primary gas environment.

GE has developed a cost-effective and efficient HRFF system solution that complies to new tightened dust emission requirements for sinter primary gas applications, which are otherwise very challenging using conventional electrostatic precipitators. This paper presents the key aspects and requirements of the FF system design to address these challenges, and to achieve demanded performance and availability.

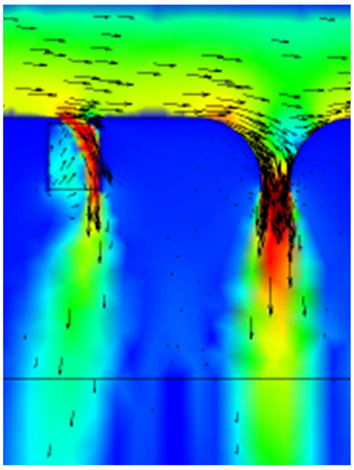

Figure 1. CFD comparison between standard nozzle (to the left) and radius nozzle (to the right)

Performance information from several reference plants with very long bags on power and industrial applications, including power plants up to 1000 MWe, will be covered in the paper.

1. Introduction

Developing more cost effective and compact high HRFFs requires increasing the total filter area fitted into a given casing volume, while not compromising the dust emission, pressure drop and bag life performance of the filter. Enhancing the bag length and the total bag area cleaned on-line per pulse valve is technically very demanding. GE (ex Alstom) has more than 35 years experience of supplying in-house designed HRFFs for power and industrial applications, and recently launched a HRFF design with 12 m long bags for power plants [1]. This improved product offers lower capital cost, a significantly increased total bag area per pulse valve and a reduced foot-print as compared to earlier designs, Figure 2.

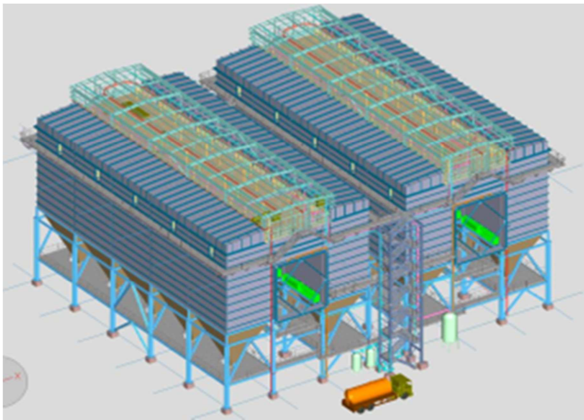

Figure 2. HRFF design with 12 m bags for power plants

2. Radius nozzle pipe

The new FF design required an enhancement of the pulse system performance to meet benchmark design criteria. This entails improvements with regard to minimum and maximum bag pulse pressure, as well as the pressure distribution along the nozzle pipe. The cleaning pulse must reach all the way to the bottom of the bags, without either excessive pulse pressure in the top of the bags – which causes mechanical rupture of the bags and short bag life – or insufficient pulse pressure in the bottom portion of the bags. Following a systematic development effort to address these challenges, a superior new radius nozzle pipe design was verified and launched, Figure 3.

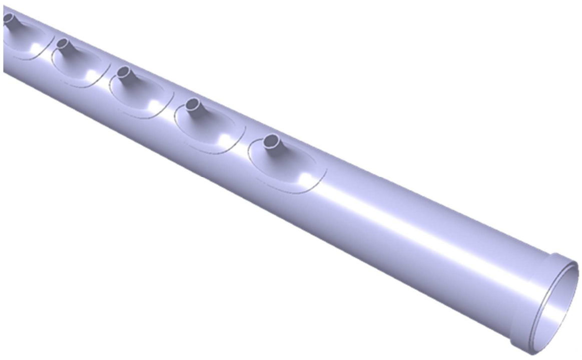

Figure 3. Radius nozzle pipe

A sample of the most important technology validation activities performed for the radius nozzle pipe includes:

- Validation of pulse pressure.
- Validation of tank volume requirements.
- Simulation of radius nozzle press tool with SimCom Stamping simulation software.
- Validation of radius nozzle production method.
- Validation of radius nozzle pipe welding procedure.
- Dynamic simulation of welded radius nozzle pipe lifetime with Abacus Finite Element Analysis (FEA) software.
- Validation of welded radius nozzle pipe lifetime in fatigue test rig.

The most important validation vehicles used were:

- Fatigue test rig (Figure 4).
- Abacus FEA: Dynamic fatigue life simulation (Figure 5).
- SimCom Stamping press tool simulation.
- CFD transient compressible flow analysis (Figure 6).
- Pulse pressure test rig.

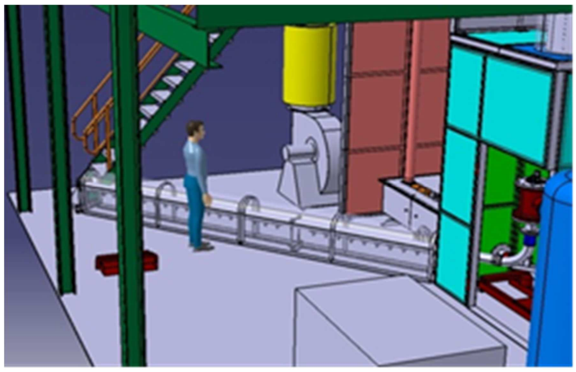

Figure 4. Fatigue test rig for validation of radius nozzle pipe lifetime

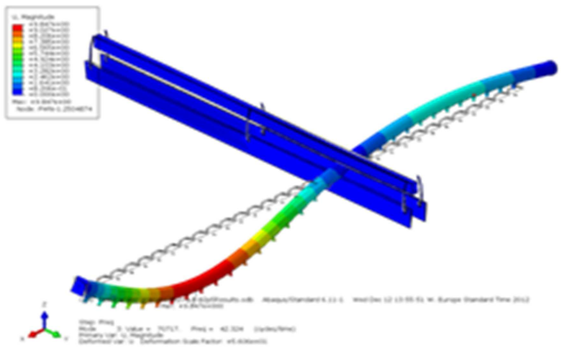

Figure 5. Dynamic fatigue life simulation with Abacus FEA

The radius nozzle has an advanced engineering design and utilizes the dynamic part of the pressure effectively, which reduces the energy loss between the valve and the bags. The nozzle has better fluid dynamic properties for the interface between nozzle pipe and bag, and provides a more uniform cleaning pressure along the depth of the bags and along the length of the nozzle pipe, see Figure 1, Figure 6 and [1]. These properties enable GE to commercially implement 12 m long on-line cleaned bags for the first time, with a potential for even longer bags being available in the near future providing additional capital cost reduction, based on ongoing R&D. The radius nozzle pipe may also be used for bag lengths
< 12 m with expected operating cost benefits in compressed air consumption and bag life.

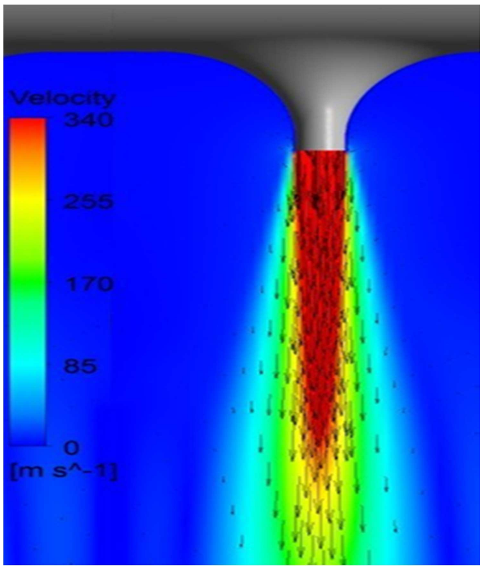

Figure 6. Transient compressible flow CFD computation of radius nozzle

The radius nozzles are produced in two specially developed, GE proprietary, stamping tools, with stamping in totally ten steps, Figure 7. Welding of nozzles to the pipe is then performed at qualified suppliers according to specific guidelines.

Figure 7. One of the stamping tools for production of radius nozzles

R&D activities with regard to e.g. gas flow distribution design and bag cleaning performance improvements with the aim to further enhance the online cleaned bag length beyond 12 m are ongoing.

This will provide additional capital cost and footprint reductions, as illustrated in Figure 8, showing a foot-print comparison for 10 m (blue), 12 m (red) and 14 m (yellow) long bags with the same total FF bag area and the same number of bags per pulse valve.

The gas flow distribution design is developed by means of CFD modelling using ANSYS CFX software. Figure 9 illustrates the flow distribution close to the bag nest of a 14 m FF design at a typical A/C (air-to-cloth)-ratio. Velocities are safely below the criteria for bag erosion.

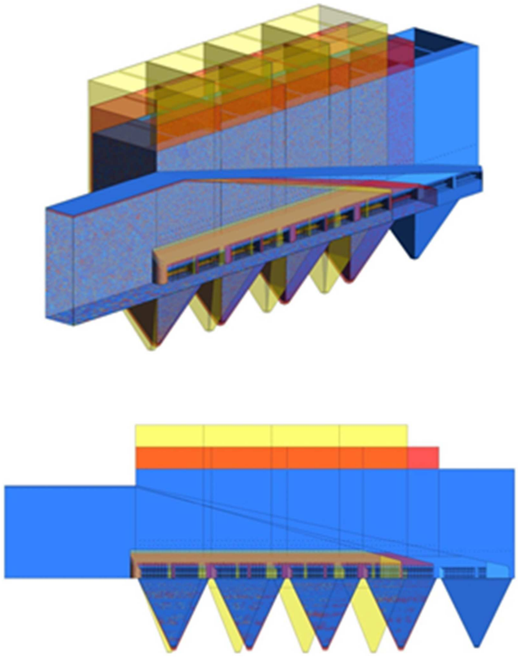

Figure 8. FF foot-print comparison for 10 m (blue), 12 m (red) and 14 m (yellow) long bags, same total FF bag area

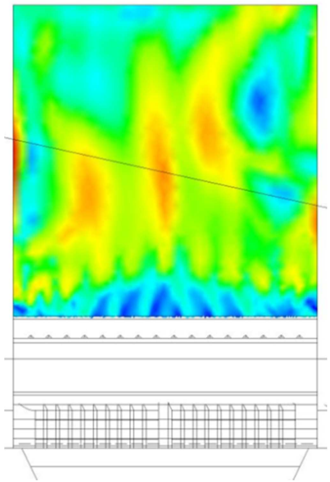

Figure 9. Velocities close to the bag nest from CFD modelling, FF design with 14 m long bags.

3. FF design – industrial applications

The use of FFs in industrial applications falls into two main categories. One is the collection of nuisance dusts, which may be injurious to health, or present a threat to the cleanliness of the general or a workshop environment. Frequently the gas is atmospheric air or at near ambient temperature. The second is filtration of process gas streams in industrial applications, where the filter is an important or even critical factor for the operation of the process. FFs are widely used in metallurgical applications, waste incineration applications and in the cement industry. Due to the wide spread in applications, it is difficult to generalize regarding process differences, as compared to power applications, impacting on the FF design. There will always be some exceptional cases and applications, such as e.g. the sinter strand primary gas environment described below. Some general statements can, however, be made:

- The total gas flow to be treated by the FF is generally smaller than for power applications.
- The inlet dust load to the FF is generally lower than for power applications.
- The inlet dust properties are generally more benign filtrationwise than for power applications.

To cater to industrial applications in general, a tailor-made HRFF design with 12 m long bags has been developed in a joint effort between GE R&D and GE´s Centre of Excellence (CoE) for FFs in Växjö, Sweden. The design is fully documented in Tekla Structures 3D parametric software.

The design is a development of a prior, well proven standard design with up to 10 m long bags, and aims to further reduce the capital cost and FF footprint, with no degradation in performance with regard to FF outlet emission, pressure drop and bag life. The major technical challenges include achieving low velocities close to the bags (avoiding bag erosion), the same or lower pressure losses, and to ensure that the pulse cleaning system has sufficient cleaning capability for the 12 m long bags and increased bag area per pulse valve, without maximum acceptable pulse pressure being exceeded.

As a result of the systematic R&D design development work, there are significant changes for the design with 12 m bag length as compared to the design for up to 10 m bag length, to enable handling of increased flows with respect to bag erosion and pressure drop, e.g.:

- Revised design of inlet duct. Inlet duct width increased significantly.
- Revised design of inlet dampers. Butterfly dampers used instead of “flap”-type dampers.
- Revised design of guide vanes in compartment baffle duct.
- The height of the baffle plate from the hopper level is increased.
- Increased size of outlet dampers.
- Radius nozzle pipe required.

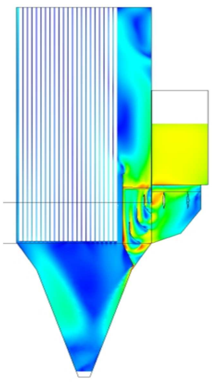

Figure 10. CFD results of final 12 m FF design for industrial applications

CFD modelling using ANSYS CFX software was utilized for optimization of the gas flow distribution design. Figure 10 illustrates the velocities of the final 12 m FF design at a typical A/C-ratio.

4. FF system for sinter primary gas

The HRFF design has proven its ability to achieve low dust emission in a wide variety of applications. Emission guarantees in a range of 1 to 2 mg/Nm^3 have been given and achieved, and actual emission levels of 0.1 to 0.2 mg/Nm^3 have been demonstrated [2, 3, 4]. Some additional reference plants with very low actual dust emission levels are detailed below.

Sinter plants are the major source of dust and toxic dioxin/furan (PCDD/F) emissions from integrated steel works. Electrostatic precipitators (ESPs) have historically been the dominating dust removal devices for sinter strand primary gas. This has generally been without major concerns until recently, when environmental standards have called for dust emissions lower than 50 mg/Nm^3. The dust from sinter strand primary process very often has a relatively high content of hydrocarbons and alkali chlorides. For these cases the resistivity is high, and emissions lower than 50 mg/Nm^3 are very difficult to consistently achieve and keep in the long-term

Limitations of present ESP technology for this application will become more pressing as environmental authorities in different countries are passing legislation to reduce particulate emissions to lower levels. For sinter primary gas applications, emission demands of less than 30 mg/Nm^3 are now regularly encountered, and more stringent demands of 5 – 10 mg/Nm^3 are seen on a regular basis. Such emission guarantees can be met in a cost effective manner with a well-designed, properly sized HRFF. A cost-effective and efficient HRFF system solution that complies with new tightened dust emission requirements for sinter primary gas applications has been developed. The application of FFs in the sinter strand primary gas environment is very arduous, due to several characteristics of the sintering process, as further detailed below. The key aspects and requirements of the FF system design to address these challenges, and to achieve demanded performance and availability, are presented below.

The sintering process, a key step in the integrated steel production cycle, is the most widely used method of agglomerating iron ore fines and other materials to give them suitable chemical and physical characteristics for use as feed in blast furnaces. The iron ore fines are laid out in large beds with fluxing additives, coke breeze, coal (anthracite), concentrates and iron rich by-products from the iron and steel process – dust and sludge from steel converters, blast furnaces, scales and cuttings from casting machines and rolling mills, etc. The mix is evenly fed onto a moving continuous grate – sinter strand, see Figure 11 – and ignited from the top by a burning coke oven gas flame. As the mix moves along the strand, air is drawn by an Induced Draft (ID) fan through the bed so that as the coke breeze and the coal burn, the mix is fused into a porous but strong sintered product.

Figure 11. Sinter strand

The waste gas resulting from drawing air through the sinter strand and burning the mix contains impurities such as iron rich dust and fumes, sulphur and nitrogen oxides, and other products of the combustion which include alkali chlorides, hydrocarbons (CxHy) and trace amounts of harmful contaminants such as heavy metals and PCDD/F. The dust emitted from the sinter strand contains a very fine fraction of mainly alkali chlorides and an iron rich coarser fraction of dust consisting mainly of iron oxides. The iron oxides make the dust abrasive. For wear protection of the ID fan a dust collector – normally an ESP or a cyclone - has to be installed upstream of the ID fan. Additional off-gas cleaning systems, when adopted, are installed downstream of the ID fan, not to be exposed to the high negative pressure generated by the ID fan. The fine dust consists of alkali and lead chlorides formed during the sintering process itself. The alkali chlorides will together with hydrocarbons give a high resistivity dust forming an insulating layer on the ESP electrodes, causing back corona and problems with dust removal. This will reduce the efficiency of the ESP. Figure 12 shows the mass size distribution, measured with Berner Low Pressure Impactor (BLPI), of dust emitted from multicyclones at the Rautaruukki Raahe sinter strand in Finland [5]. The total mass concentration was around 150 mg/Nm^3. The dust comprised a high content of K + Cl, which constituted 90% of the fine particle mode, and in average 45% of the total particle mass. CxHy emissions in the primary sinter flue gas mainly consist of products formed from pyrolysis and incomplete combustion of carbon-bearing raw materials fed to the sinter strand. Recycled oily materials, such as mill scale from rolling processes, and anthracite are the major sources of CxHy emissions from the sinter strand. These emissions include methane, aliphatic compounds, phenols, olefins and aromatics. Non-methanic volatile organic compounds (NMVOCs) in the flue gas contribute greatly to the risk of bag blinding and fires in the FF.

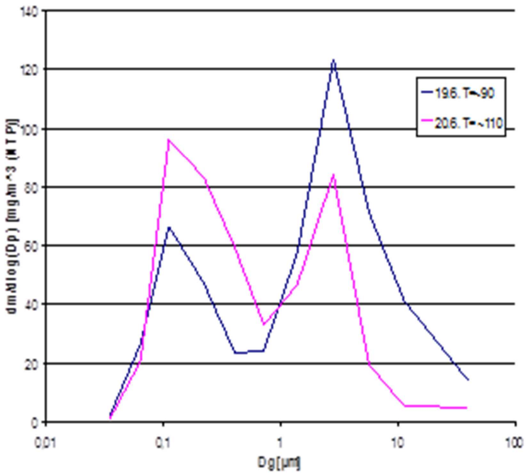

Figure 12. BLPI mass size distributions downstream multicyclone at Rautaruukki Raahe sinter strand [5]

The application of FFs in the sinter strand primary gas environment is very demanding, due to several characteristics of the sintering process:

- Bag blinding caused by penetration of fine alkali salts and sticky condensable CxHy.
- Bag damage by impact of glowing particles transported by the gas.
- FF hopper fires due to self-ignition (glow fires) caused by hopper dust build-up.
- Sudden inlet temperature increase due to unplanned sinter strand shutdown.
- High content (up to 10000 ppm) of carbon monoxide, CO – very poisonous and combustible gas – in the process gas ducts.
- High corrosion risk in the cold areas of ducts, hopper and filter casing due to the presence of chloride salts and SO_x in the gas combined with relatively high moisture content.

Above risks require a good understanding of the local operating practice, and a careful design of the FF system, for achieving specified performance and availability.

GE designed and installed a pilot plant at a sinter strand in Belgium for verifying the application of HRFFs in the sinter strand primary gas environment, optimizing the FF system design, and optimizing the bag material selection. see Figure 13.

The pilot plant, which was located downstream an existing sinter strand ESP, was operated for several years. The FF dust emission was measured gravimetrically throughout the test period, and was always < 5 mg/Nm$^3_{dg}$. The FF A/C-ratio varied within a range considered typical for this type of challenging FF application. FF pressure drop and cleaning cycle time remained approximately constant throughout the evaluation period. There were no tendencies for FF glow fires during the test period. The main purpose of the pilot plant operation was to evaluate the most suitable bag quality for the sinter primary gas environment, and to validate the long term bag reliability for achieving demanded bag life. Selection of bag quality candidates suitable for evaluation was made in cooperation with the bag supplier. Several bag samples were taken at beginning, middle and end of the test period. Samples were analysed at the GE laboratory as well as at the bag supplier laboratory. In addition, bag permeability and residual resistance was measured several times in-situ with a portable bag permeability tester. These results correlated qualitatively well with the results from laboratory permeability measurements at GE and the bag supplier. In general, the measured residual resistance values were lower than anticipated, and stable throughout the test period. No noticeable penetration of dust through the filter material could be detected with optical microscope, see Figure 14.

Figure 13. Sinter strand FF pilot plant in Belgium

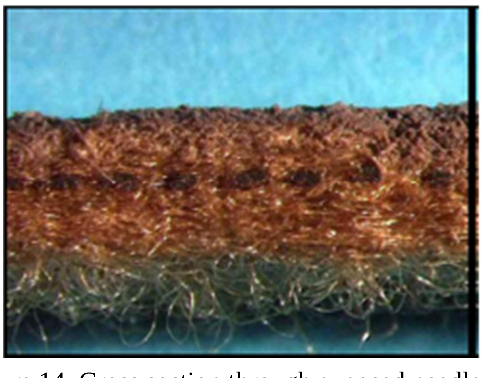

Figure 14. Cross section through exposed needle felt from FF pilot plant in Belgium

The bag quality that was evaluated as the most suitable, provided a solid performance with very limited fine dust penetration, a bag permeability that was maintained at a good level over the test period, and limited mechanical strength reduction. The demanded bag life was verified for the chosen bag quality.

GE also has full scale FF operating experience from the sinter strand at ArcelorMittal´s Fos-sur-Mer plant in France, which has been taken into account for the FF system design.

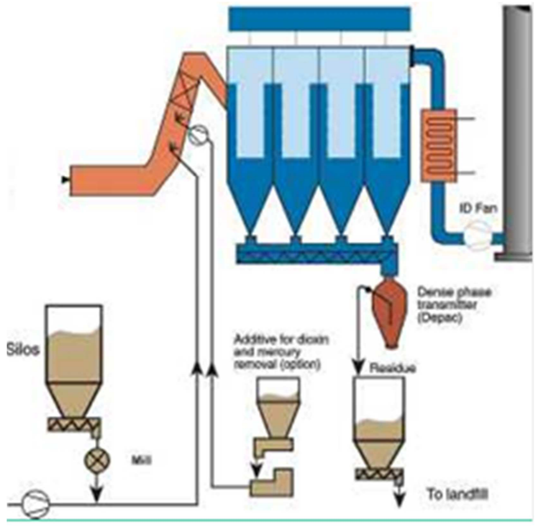

Figure 15. FF system layout design downstream precollector (not shown)

The FF system design comprises a HRFF for particulate control of primary gases from sinter strand, located downstream of a precollector, which can be either an ESP or a cyclone. Upstream the FF there is an additive material injection system designed for continuous hydrated lime, $Ca(OH)_2$-injection, Figure 15. The main purpose of injecting additive material to the FF is related to the clogging and sticking characteristics of residual dust and condensable CxHy content in the flue gas coming from the precollector. The main effect of the additive is to provide a thick porous cake on the bags, where fine dust and condensable CxHy will be collected, minimizing the risk of irreversible fine dust penetration into the fabric. It is mandatory for obtaining the required long term cleanability and efficiency of the bags, as well as for minimizing dust seepage. The dilution with inert $Ca(OH)_2$ will also reduce the risk of self-ignition (glow fires) of combustible materials in the FF. Reduction of PCDD/F can be achieved as additional value. A FF sized for particulate control of primary sinter gases can be retrofitted with a system for dosing activated carbon/lignite coal in the same injection line as used for the hydrated lime. The hydrated lime also reduces the emission of SO_2, HF and HCl. As an option, a portion of the dust removed in the FF can be recirculated and injected upstream the FF, in order to improve the utilization of reagents and decrease the costs for additives. The rest of the dust is discharged out of the system for landfill.

In some cases, part of the dust can be used as feed to the blast furnace. This is the practice e.g. at the ArcelorMittal Fos-sur-Mer plant.

The identified process risks can be mitigated by a careful design of the FF system, applying e.g. following design guidelines:

- Special design of FF hopper and dust transport system is required. Reliable dust transport from the FF is a must.
- Leakage-proof dampers at inlet/outlet of FF are required for allowing safe FF maintenance (high CO risk).
- There are specific demands on the bag quality.
- Include measures to protect bags from sudden temperature peaks due to unplanned sinter strand shutdowns.

5. Reference plants

Performance information from prominent reference plants with very long bags on power and industrial applications, including power plants up to 1000 MWe capacity, is detailed below.

5.1. Manjung Unit 4 power plant, Malaysia – 1 × 1000 MWe

Manjung Unit 4 is South East Asia's first 1000 MWe ultra-supercritical coal fired power plant. GE provided the core power parts – boiler, steam turbine, generator and auxiliary equipment including the air pollution control (APC) system. The plant is built for Tenaga Janamanjung Sdn Bhd, a subsidiary of Malaysia´s state-owned utility Tenaga Nasional Bhd (TNB). The unit produces electricity to power nearly 2 million households. The boiler is designed for efficient pulverized fuel combustion of a wide variety of coals, all imported, including Australian, Chinese, and South African coals. The APC system comprises HRFFs with 10 m long bags, followed by a Sea Water Flue Gas Desulphurisation (SWFGD) wet FGD system, Figure 16. The total number of bags is around 24 000 pcs. The bag material is PPS/PPS needlefelt with PTFE treatment, areal weight 580 g/m^2.

Figure 16. Manjung Unit 4 FFs and SWFGD

The stack emission guarantee tests were performed in February 2015. The SWFGD was in operation during these tests. All site tested emission guarantees were passed. The dust emission in the stack was measured at around 1.6 mg/Nm$^3_{dg}$ @ 6% O_2 at 100% boiler load with the SWFGD in operation, versus the guarantee of 50 mg/Nm$^3_{dg}$ @ 6% O_2. Manjung Unit 4 completed construction on schedule in March 2015, and reached full commercial operation in April 2015.

The overall plant performance has exceeded expectations, achieving 2% higher output and heat rate than specified. Manjung Unit 4 was selected as one of Power Magazine's coal top plant 2015 award winners [6].

5.2. Tanjung Bin Unit 4 power plant, Malaysia – 1 × 1000 MWe

The 1000 MWe Tanjung Bin Unit 4 power plant is GE's second turn-key contract for a ultra-supercritical pulverized coal fired unit in Malaysia, following the order to build the 1000 MWe Manjung power plant. The plant is built for Tanjung Bin Energy Issuer Bhd, a fully owned subsidiary of Malaysia´s largest independent power producer (IPP), Malakoff Corporation Berhad. Similar to Manjung, the APC system comprises HRFFs with 10 m long bags, followed by a SWFGD FGD system, Figure 17. The total number of bags is around 24 000 pcs. The bag material is PPS-PTFE/PTFE needlefelt, with PTFE treatment, areal weight 675 g/m^2, selected to fulfil a 4 year bag life warranty.

The stack emission guarantee tests were performed in March 2016. The SWFGD was in operation during these tests. All site tested emission guarantees were passed. The dust emission in the stack was measured at around 1 mg/Nm$^3_{dg}$ @ 6% O2 at 100% boiler load with the SWFGD in operation, versus the guarantee of 50 mg/Nm$^3_{dg}$ @ 6% O_2. Tanjung Bin Unit 4 reached commercial operation in March 2016.

Figure 17. Tanjung Bin Unit 4 FFs and SWFGD

5.3. Lomellina WtE plant, Italy

The Lomellina Energia S.r.I. plant in Parona, Italy, is a Waste to Energy (WtE) plant with a 22.7 t/h Foster-Wheeler fluidized bed incinerator, burning Municipal Solid Waste (MSW), industrial waste, and Refuse Derived Fuel (RDF). The plant was commissioned in 2007. The APC system was supplied by GE and consists of injection of milled $NaHCO_3$ and Powdered Activated Carbon (PAC) upstream a HRFF equipped with 9 m long bags, Figure 18. The bag material is PI-

PTFE/PTFE needlefelt with intrinsic PTFE coating, areal weight 630 g/m^2. The total number of bags is around 1600 pcs. The stack dust emission guarantee is stringent; 5 mg/Nm$^3_{dg}$, to be met continuously via monitoring by a calibrated Continuous Emission Monitoring (CEM) dust meter in stack. Also the guaranteed SO_2, HCl and PCDD/F removal efficiencies are stringent, 99%.

The plant performance since start-up has been excellent [7]. The dust emission has been kept at < 1 mg/Nm$^3_{dg}$, and very few bags have been replaced. The good plant performance is credited to a combination of correct selection of bag material, good engineering design of the FF and the flue gas treatment system in general, and solid plant operation and maintenance procedures.

Figure 18. Lomellina FF with $NaHCO_3$ and PAC silos

5.4. Rautaruukki Raahe steel plant, Finland

Rautaruukki Raahe stainless steel works in Raahe, Finland, is the largest steel works in Scandinavia, Figure 19. Steel production is based on the use of iron ore concentrates. The finished products are hot rolled plates and strips. Stringent new environmental permits in 2008 called for major investments in the steel mill in order to control emissions to air, including renovation of the two blast furnaces – which reduces the iron in the sinter and pellets feed to liquid iron, for further processing in the steel converter – and replacement of the APC equipment for the casthouse and stockhouse of the blast furnaces. Former ESPs and cartridge filters were replaced by new GE HRFFs with 9 m long bags with separate casthouse and stockhouse FFs for each blast furnace. The FFs on blast furnace 1 were commissioned in 2009, and FFs on blast furnace 2 were commissioned in 2011.

The stockhouse is the facility where the handling of coke, sinter and iron pellets is performed prior to their injection into the blast furnace. A number of ventilation hoods are installed in the stockhouse and this gas is drawn into the FF. The casthouse is the building surrounding the blast furnace. From this building secondary ventilation air is drawn to the FF from several hoods. The blast furnaces have a cyclical pattern with an average cycle taking about 2 hours. Blast furnace capacity is 3700 tons/day per furnace.

The total number of filter bags is around 7600 pcs. PES/PES needlefelt bags with ePTFE membrane, areal weight 550 g/m^2, were selected for stockhouse as well as casthouse FFs in order to meet the stringent dust emission guarantee of 5 mg/Nm$^3_{dg}$. The FF availability guarantee is 99%.

The stack emission guarantee test for blast furnace 1 was done in January 2010, resulting in a dust emission of 0.3 mg/Nm$^3_{dg}$. The casthouse and stockhouse FF performance has been very good at Raahe, meeting all performance guarantees on dust emission, bag life, availability and FF pressure drop. The modernisation of the dust removal devices for the blast furnaces reduced their particulate emissions by 68% compared to previous years [8].

Figure 19. Raahe steel works. To the right blast furnaces, in the middle power plant and to the left steel plant

6. Conclusions

The application of FFs in the sinter plant primary gas environment is very challenging, due to several characteristics of the sintering process. A careful design of the FF system is required to achieve demanded performance and availability. GE has developed a cost effective and efficient FF system solution that complies with new tightened dust emission regulations for sinter primary gas applications. Reduction of PCDD/F and SO_2 can be achieved as additional value.

GE has developed compact HRFFs with very long bags for power plants and industrial applications, to cater to the increasing market demands for more reliable equipment to achieve consistently low emissions, with focus on optimum capital expenses and minimized foot-print. The major technical challenges with these compact and cost effective designs are to achieve low velocities close to the filter bags – to avoid bag erosion – the same or lower mechanical pressure losses, very low emissions, and to ensure that the pulse cleaning system has sufficient cleaning capability for the longer bags and increased bag area per pulse valve, without maximum acceptable pulse pressure being exceeded. The newly developed radius nozzle pipe enables implementation of 12 m long online cleaned bags and increased filtration area per pulse valve, with a potential for even longer on-line cleaned bags being available in the near future.

Performance feedback from prominent reference plants with very long bags on power and industrial applications confirms that very low actual dust emission levels can be reliably achieved for the long-term.

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