

Energy Optimization and Emissions Improvement in Fume Treatment in EGA Jebel Ali Smelter

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1. Abstract

The Hydrogen fluoride (HF) gas emissions from potlines of aluminium smelters are treated in Fume Treatment Plants (FTPs) or Gas Treatment Centers (GTCs). In EGA, these installations are called FTPs in Jebel Ali and GTCs in Al Taweelah. Most smelters strive to creep aluminium production, which eventually increases the load on FTP scrubbing efficiency and increases emissions. Many improvements to increase the pot gas flow and improvement on emissions have been implemented in the past by increasing the total number of filter bags in the compartment, adding more compartments, or using filter bags constructed with high permeability fabric. However, the outcome was very limited and had many drawbacks including high cost. The aim of this paper is to share the experience of installing Extended Surface Bags (ESB) in EGA Jebel Ali FTP. There are many papers, explaining the fundamentals of using the ESB [1 – 3], but in this paper, the focus is on the challenges encountered during implementation and how each challenge was solved. In addition, this paper will explain the realised benefits of ESB.

Keywords: Fume Treatment Plant (FTP), Gas Treatment Center (GTC), hydrogen fluoride (HF), Extended Surface Bag (ESB), Emirates Global Aluminium (EGA).

2. Introduction

FTP-6A was built using EGA's CD20 technology at the DUBAL smelter complex (now EGA Jebel Ali) in 1999. This dry scrubber system was built with a total of 10 filter compartments containing 540 standard polyester needle felt filter bags of diameter 127 mm and 6066 mm length per compartment. It was designed to achieve a total gas volume of 720 000 Nm³/h at a gas temperature of 125 °C, treating flue gas from 120 reduction cells at an average draft rate of 6000 Nm³/h per cell. The plant was designed for nominal temperature of 125 °C and maximum of 140 °C at the FTP inlet to treat flue gas containing total fluoride of 160 mg/Nm³ and total particulate of 500 mg/ Nm³.

The gradual increase in potline amperage to increase aluminium production eventually caught up with the limitation in the FTP design. This led to the upgrading of the FTP in 2002. An additional 60 filter bags per compartment were added by installing new bags holding tube sheets. This modification helped to increase the filtration area but increased the CAN velocity (velocity between the bags) in the compartment. This has resulted in only a negligible increase in gas flow.

Further enhancement of cell technology and continued amperage increase of the reduction line took place in the following years. This put additional load on FTP and the performance was not adequate even after the completion of the upgrade. Total fluoride at FTP inlet increased to 250 - 300 mg/Nm³ and inlet gas temperature at FTP increased to an average of 130 - 140 °C (and even above 145 °C during the summer months). This impacted the filter bag life and treatment performance, resulting in higher emissions. High pressure drop across filter compartments

eventually reduced gas draft in the reduction cells; this affected the thermal balance and contributed to loss of productivity.

In 2017, EGA Jebel Ali, with close co-ordination with filter bag suppliers, introduced standard bags made of high permeability fabric. These bags enabled a 10 % increase in gas flow with particulate emissions within the target. Increased gas flow and low pressure drop helped to reduce the temperature of inlet gas at FTP. This initiative was implemented with very little cost and allowed EGA Jebel Ali to overcome this very critical operational issue in the plant.

At the same time EGA also looked for other options available technically to improve the existing plant operating condition such as upgrading the plant, ambient air duct systems, impulse duct systems and cooling the inlet gas with water spray, etc. High cost ruled out upgrading the plant and installation of impulse duct and a trial of water spray system were not found to be sufficiently effective. Even though a previous trial of extended filter bags was a failure, EGA was still convinced that extended surface bags are the future of FTP operation with minimum investments. In addition, EGA is committed to reduce fluoride emissions and ESB technology is one of the tools, which enabled EGA to achieve the continuous improvement in emissions.

3. Constraints

Replacing the standard filter bags with extended surface bags and cages was not a direct one-to-one bag replacement in the plant due to some of the constraints highlighted below:

- 3.1 Additional weight of ESB bag and cage,
- 3.2 Less gap between existing bags in each row,
- 3.3 Maintaining velocity in the hopper and between the bags,
- 3.4 Developing a procedure to handle new bags and cages.

- 3.1 The concern was whether the old tube sheet would be able to sustain the total additional load on the existing tube sheet after installing the extended surface bag and cage and for a longer period without deforming or buckling. Table 1 gives the comparison which shows that the load would increase by almost 50 % with ESB. Therefore, it was necessary to replace the tube sheet along with additional stiffener plates to keep the new plate from buckling before installing ESB. The task was more complicated since it was done in an operational plant without affecting the normal operation, and it required specialised scaffolding structures to access the bottom part of the tube sheet for welding stiffener plates. Furthermore, the task was planned during the peak summer with ambient temperature reaching as high as 45 to 50 °C with humidity between 60 and 90 %. Employee safety was the main concern.

Table 1. Comparison of weights (kg) between standard and ESB bags.

| | Standard | ESB |
|-------------------------|----------|------|
| Bag | 2 | 4 |
| Cage | 8 | 12 |
| Dust in the bags | 1.5 | 3.5 |
| Total | 11.5 | 17.5 |

- 3.2 In the previous modification in 2002, where 120 bags were added in each compartment, four rows were added within existing tube sheet plate. By doing so it narrowed the gap between the bags. During the trial installation of extended surface bags on one of these tube sheets, adjacent bags were found touching each other and this was expected to cause

damage during the operation. The narrowed gap between bags also reduced the CAN velocity. So further modification of tube sheet was required, removing the two rows totaling 60 filter bags to increase the distance between bags. Modification of tube sheet resulted in further requirement of procuring new bag cleaning pulsing pipes. Since any additional cost was the main constraint throughout the whole project execution, a decision was made to modify the existing pulsing by plugging in the existing nozzles and making new nozzles on the opposite side of the pipe to suit the new tube sheet.

- 3.3 The main purpose of installing the extended surface bag was to increase the effective surface area for filtration and reduce energy consumption. Since design of the FTP compartments were made for using standard filter bags of 127 mm x 6066 mm long, further evaluation was required to select the suitable ESBs. This is to ensure balanced gas velocity within the compartment without effecting the scrubbing process and efficiency. It required more data and trials to ensure the correct bags were procured to perform as per project scope. The final selection of 127 mm x 5500 mm bags was done after long trials and analysis of all available data. This reduction in size has eliminated potential damage due to high velocity at bottom of the bag after the increase of the gas flow. Moreover, this created additional space for the gas in the compartment.
- 3.4 Extended surface bags and cages required correct handling during transport, lifting and installing. On-site training was provided by the supplier during the initial installation to understand the basics of ESB and cage handling. Since bags are folded during transport, the pleats tend to get crumpled and the shape of the bags changes with misalignment of pleats. The bag was then stretched manually by pulling from either end before insertion into the tube sheet hole. Once inserted, the bag pleats were carefully aligned using the aluminium rod, provided by the original equipment manufacturer (OEM), before inserting the cage in to the bag. The cage was aligned with the pleats at the top end of the bag and slowly inserted along the pleats to ensure all the pleats were correctly aligned so that bags could have optimum performance. Extra care was taken not to damage the new bags while inserting the OEM rod provided for alignment. In the same way, cages needed careful handling during transport, lifting and insertion into ESB. Unlike standard cages, extended surface cages were heavier and required proper balancing during lifting to avoid bending or damaging. Strict inspection of cages was made to ensure there were no sharp edges or burrs to avoid damaging the bags. The cages were coated with high temperature paint to provide smooth surface finishes to protect bags from any sharp edges.

4. Installation

In most scenarios, the tube sheets were not changed and the replacement of filter bags was one-to-one. Each old filter bag and cage was removed and replaced with an extended surface filter bag and cage. However, in the case of EGA Jebel Ali, the old tube sheet was found to be deformed and there was a concern of further deterioration if heavier bags and cages were installed. So, the old tube sheet was replaced with new tube sheet of 5 mm thickness with the holding capacity of 600 bags per compartment. The proper sequence of removal of old bags and installation of new extended surface bags was also followed strictly to minimise the isolation time of each compartment. The bag supplier demonstrated the sequence of bag and cage installation to ensure the correct alignment. A purpose-made aluminium rod was used for stretching the bags to align the pleats. It was very important to ensure the pleats were centrally aligned with cage in order to ensure the effective functioning of filter bag surface. The time to install the ESB and cage is slightly longer than for the standard bag and cage.

During the conversion from the standard bag to ESB, each compartment flow needed to be adjusted, as the ESB tended to draw more gas than the standard bag, which eventually has the

potential to blind or damage the bag fabric. In our project, the flow was adjusted through the compartment inlet guide damper.

5. Results.

After overcoming most of the challenges and constraints, the filtration area was increased by almost 90 %. However, a 120 % increase on filtration could have been achieved if the replacement took place without reducing the number of bags and their lengths. The evaluation of ESB was undertaken through two different approaches. The first approach was to evaluate the differences in energy, emissions and plant parameters over two months. The second approach was to evaluate the efficiency of gas flow increase with ESB over six months.

The first approach was done immediately after completing the installation of ESB in all compartments. The outcome is shown in Figure 1. It can be summarized as follows:

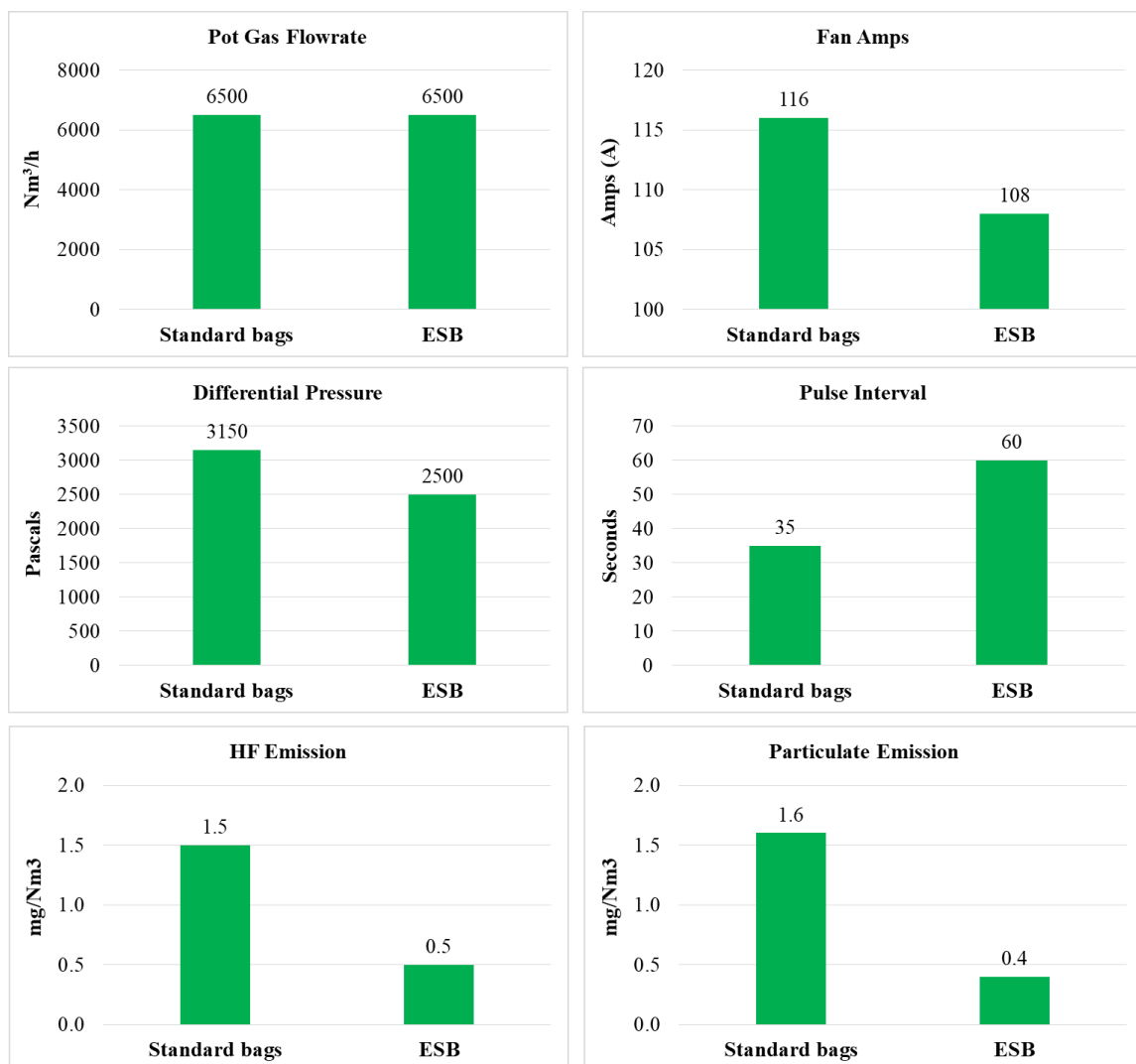


Figure 1. Comparison of parameters for approach No. 1 – evaluation over 2 months.

- Fan amperage reduced by 7 %,
- Differential pressure reduced by 21 %,
- Pulse frequency reduced by almost 71 %,

- HF emission dropped by 67 % as a result of increasing the recirculation rate,
- Particulate emission dropped by 75 %.

The second approach, done two months after completing first approach, continued for 6 months. The result is illustrated in Figure 2. The gas flow increased by almost 10 % compared to standard bags. Moreover, some of the benefits gained in first approach vanished. After 6 months the gas flow was reduced again to normal flow as there was no noticeable reduction in roof emissions or pot operation after increasing the gas flow by 10 %.

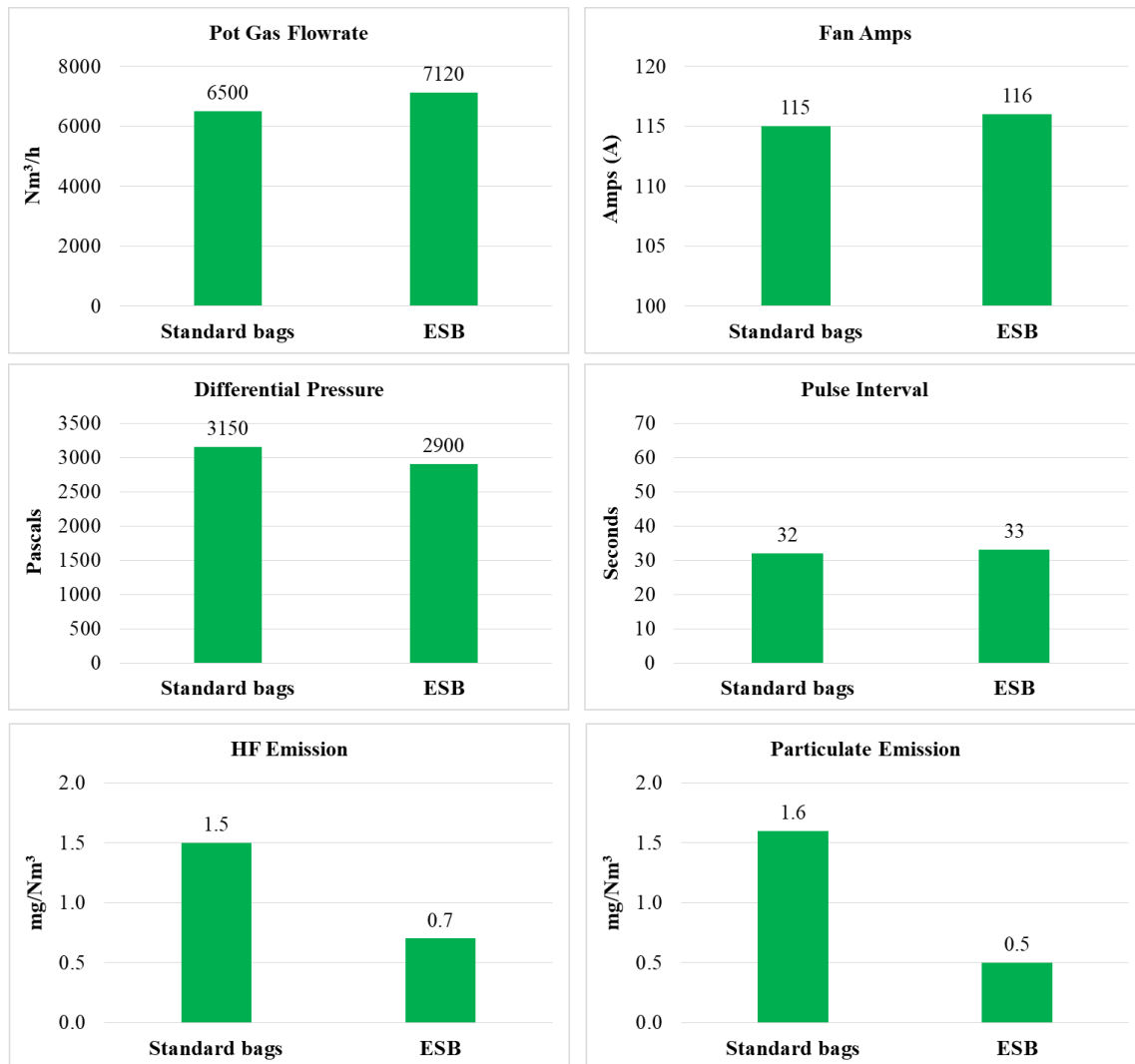


Figure 2. Comparison of parameters for approach No. 2 – evaluation over 6 months.

6. Benefits.

The ESB has supported EGA to avoid major modification cost, which was incurred in the past such as by increasing the number of bags in the compartment and adding fans or compartments. Figures 3 and 4 summarise the tangible benefits in addition to the major conversion cost savings. ESB saves 1573 MWh per year by reducing the fan amperage (in total of four fans). Therefore, energy cost was reduced by US\$ 81 796/year. Operating cost was also reduced by 81 976 US\$/year.

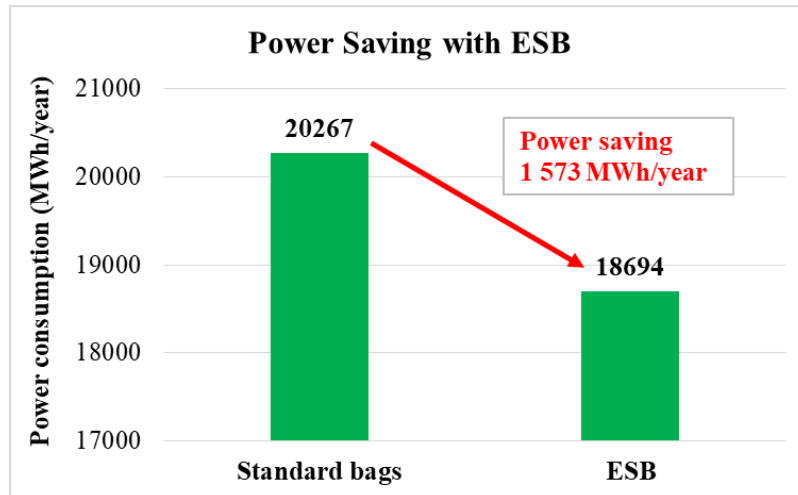


Figure 3. Energy consumption saving by ESB.

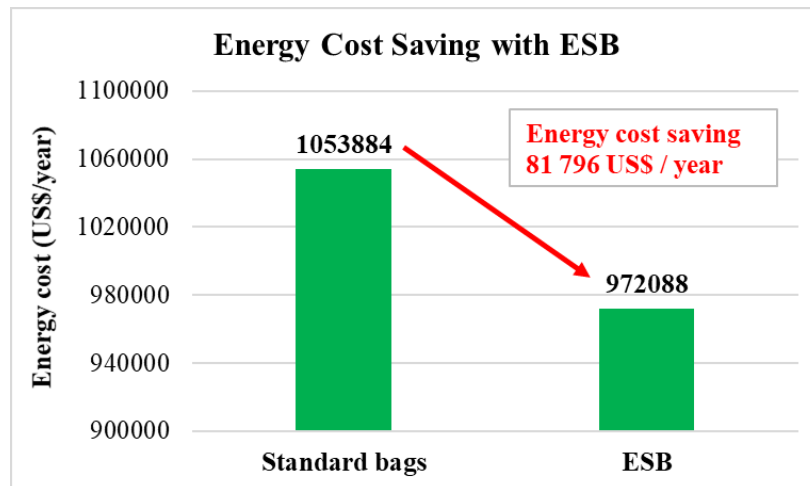


Figure 4. Energy cost saving by ESB.

7. Conclusions

EGA Jebel Ali smelter has successfully installed Extended Surface Bags (ESB) in order to keep HF and particulate emissions below emission standards in spite of amperage increase in the potline. In spite of many constraints that had to be taken into account, the installation was made during FTP in normal operation. During the analysis period of 6 months after ESB installation, the operating cost was reduced by 81 796 US\$ due to lower fan amperage.

8. References

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