Low Resistance, High Flow PrimaFlow® Filters - Latest Results in Carbon Bake Fume

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Abstract

Extended surface filter bags (ESB), also known as StarBags™, have been used for nearly twenty years in primary aluminium smelter gas treatment centres (GTC). They have repeatedly been used as a cost-effective way to increase the capacity of an existing GTC when potlines increase metal production with line amperage increase, thereby debottlenecking production increases without the need for capital upgrade in the GTC.

With the ever-increasing loads in GTCs with each incremental smelter amperage increase, the original and subsequently modified designs of ESB filters reached the limit of their capability in several primary aluminium smelters towards the end of the last decade. Low resistance, high flow PrimaFlow® ESB filters were developed to address this design limitation and continue to push through performance barriers in several aluminium smelter GTC applications.

Carbon bake fume gas treatment centres (FTC) sometimes also undergo increasing load with primary aluminium smelter amperage increases. FTC filter baghouses have their own technical challenges, meaning gas flow rate and filter differential pressure becomes increasingly difficult to maintain over the life of the FTC baghouse filters. Low resistance, high flow PrimaFlow® ESB filters have now also proven to be a cost-effective solution in aluminium smelter FTC baghouses, with long-term operational performance able to be maintained.

This paper will discuss the latest comparisons in computation fluid dynamics (CFD) modelling of ESB filter designs, which help explain the extended application capacity of the PrimaFlow® filters. This extended application capacity will be shown in the long-term operational performance of PrimaFlow® ESB filters in an aluminium smelter prebaked anode FTC application.

Keywords: Fume treatment centre, Alumina dry scrubber, ESB filters, StarBag™, PrimaFlow®.

1. Introduction

In the mid-1990s the first ESB filter (the StarBag™ [1]) was invented [2] but the initial commercialization was slow until Albany International (currently known as Solaft Filtration Solutions, Micronics Engineered Filtration Group) undertook the first pilot trial of StarBags™ and subsequent full GTC retrofit at Boyne Smelters in 2005-2006 [3].

As is common with many new developments, there were many design changes between the original patented concept and the fully commercialized product. These design modifications focused on maximising the available filter cloth area, enabling a product capable of mass production and providing sufficient structural integrity to the filter support cage.

Subsequent aluminium smelter GTC StarBag™ retrofit projects [4] proved StarBags™ to be a genuine and repeatable viable alternative to GTC capital equipment upgrade when the smelter increased metal production though amperage increase. However, in other later installations where total gas flow through the GTC was increased more significantly, application limitations of the current design ESB filters meant that some of the previously achieved process improvements were no longer achievable.

2. Design and Limitations of Established ESB Filters

The original filter cages of the ESB concept [5] incorporated pleated filter bag on a twin wire cage to support an eight pleat ESB filter. Subsequent ESB filter cages of the concept incorporated a pleated filter bag on a cage to support 10 or 12 pleat ESB filters [6]. The increase in number of pleats was to enable a further increase in available filtration surface area over prior art. Pressed metal horizontal support members were cut and pressed automatically with consistent quality, with a more robust cross-sectional shape to support the wire cage and this significantly reduced the difficulties in welding to the longitudinal components, Figure 1. These subsequent cages thus focused the design on maximizing filtration area and increasing the structural integrity and quality of the filter support cage.

Full conversion of GTCs to the pressed metal support cage design of the ESB technology in aluminium smelters were successful in several application cases. However, in some other full GTC conversions where more significant increases in gas flow to the GTC were implemented, or where subsequent embodiments of ESB filters where greater than 5 m in length, the ESB filters were unable to provide the same reduction in DP (Delta Pressure or pressure difference), emissions and pulse frequency and in some cases, actually added total gas flow resistance (increased DP).

3. Literature Review – ESB Filters

There have been several publications discussing the theory of each component of pressure drop across fabric filters. One study on ESB filters [7] stated that the pressure loss across the filter bag is attributable to just two causes: namely gas flow through the dust cake and filter media, and pressure loss caused by gas flow on the clean side of the filter.

Another study [8] more critically analysed with CFD modelling the non-uniform flow along the length of long filter bags. The results indicated that gas flow does not readily enter the filter at the bottom of long filters, and that it is possible that 70 % of the flow is filtered in just the top 30 % of a long bag filter. This study concluded that when designing a system to extend the operating life of a filter bag, an important design consideration that is often overlooked is the uniformity of gas flow when long filter bags are installed.

A further study [9] used CFD modelling to demonstrate the flow and subsequent pressure drop induced by multiple restriction orifices in a cylinder. This study concluded that double orifices produced a pressure drop largely from the abrupt change in the flow passage cross-sectional area causing high level of turbulence and thus creating a double peak in velocity and pressure co-efficient, and that these peaks were higher than the case of a single orifice. When the spacing of these orifices was at a distance of two times the pipe diameter, the peak velocity was higher than when the orifices were closer together.

A more recent study [10] stated that the filter cage within the pressed metal component ESB filter contains multiple flow restricting orifices and the spacing between these orifices is approximately two times the nominal external filter diameter. Logically, this study implies that in the clean side

7. Conclusions

When application limitations with the implementation of older design ESB filters were identified with respect to long length filters and high gas flow, a new system of ESB filter design was undertaken. Rather than single mindedly focusing on maximizing filter area, the new and more balanced design methodology optimized the filtration area of the ESB filter, managed the filter internal gas flow resistance and a combined this with a new generation of high capture low resistance filter media.

A recent CFD modelling study has demonstrated that this new design philosophy resulted in a more even gas flow and particulate distribution over the full length of the filter. The CFD calculated results correlated well with both the measured results from the horizontal gas flow chamber test rig used in product design, as well as the results achieved in more challenging applications where previous ESB embodiments had failed.

The PrimaFlow® system has continued to demonstrate long term results in full filter baghouse conversions, with the capability to provide significantly higher gas flow and lower differential pressure than any previous embodiment of the ESB filter concept. Successful long-term results have been achieved in both aluminium smelter potline gas treatment centres and anode bake carbon fume treatment centres.

8. References

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