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ENERGY- EFFICIENT GAS CLEANING - OPTIMAL DESIGN OF THE EXHAUST SYSTEM*

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Abstract

In steelmaking process, where up to 70% of variable cost of finished product is already incurred, energy and refractory costs account for 45-50% of the cost of production of crude steel and contribute significantly to the carbon footprint of the end product. Any attempt to control and reduce these costs will automatically lead to more competiveness and reduced carbon emissions. Leading the technology for ECOPLANT (characterized by the fact that the economic and ecological benefits are integral part of our products), SMS has developed innovative solutions which can be applied to both new and existing plants alike. This paper reviews one of the electrical and automation concepts. Tackling the secondary gas cleaning system and hence being applicable to almost all steel plants, the X-Pact® Gas Cleaning Assistant optimizes the control of individual dampers based on modelling of fluid resistances of ductwork in gas cleaning system. It guarantees the best dust removal from work place at minimum energy consumption.

Keywords: Energy Efficiency; Electric and Automation; Secondary Gas Cleaning; Basic Oxygen Furnace

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1 INTRODUCTION

In steelmaking process, where up to 70% of variable cost of finished product (coil, plates etc.) is already incurred, energy and refractory costs account for 45- 50% of the cost of production of crude steel and contribute significantly to the carbon footprint of the end product. Any attempt to control and reduce these costs will automatically lead to more competiveness and reduced carbon emissions.

As steel manufacturing plant operators with in-house maintenance resource, there are various challenges for the maintenance and operation of such systems. Maintenance requires a high level of personnel deployment and in some cases special expertise. The maintenance itself begins with the periodical cleaning of plant parts like pipe segments, dampers and blowers. In addition to these, the measuring and control technology is particularly important for smooth operation. Gas analysis is the heart of the gas recovery process in the primary gas cleaning of BOF converters. These are traditionally extractive types and require not only highly sophisticated sampling but also requires a comprehensive filtration technique, cooling lines, pump technology and gas analysis. Such systems require regular calibration and cleaning cycles. If the calibration is not carried out in time, most analyzers drift after a short time. These drifts have an influence on the process model functions and also a significant influence on the gas recovery operation – specifically related to starting and endpoint. To overcome these disadvantages many plant operators have opted for automated calibration and cleaning systems. However such systems require even more additional components and therefore more complex to maintain. Moreover these systems only reduces manual cleaning requirement but do not eliminate it.

Leading the technology for ECOPLANT (characterized by the fact that the economic and ecological benefits are integral part of our products), SMS Group has developed innovative solutions which can be applied to both new and existing plants alike. This paper reviews one of these electrical and automation concepts.

2 STRUCTURE OF AN EXHAUST SYSTEM - SECONDARY GAS CLEANING SYSTEMS

Conventional gas cleaning systems for secondary (Figure 1) and primary (EAF) gases are essentially divided into three segments.

Figure 1: Secondary Gas Cleaning System

1. The suction point with position-controlled damper for controlling the volumetric flow at the point of emission. The adjustments of the dampers are based on experience and is opened or closed depending on the process request.

2. Merge all pipeline segments into a main channel that often flows into a mixer. This is usually located in front of the filter house. In order to provide the necessary energy to the dedusting system, a constant pressure is set at this point by means of a pressure measurement.

3. The required pressure is regulated by the main fan (ID-Fan). Depending on the configuration, this is either speed-controlled by VVVF or alternatively equipped with a louver damper.

The disadvantage of this conventional method is the empirical determination of the damper position (refer Figure 3). When the commissioning is carried out, various damper positions are determined which are ideally suited for the respective process stage but which only partly considers or completely ignores the nearby process suction points. Another disadvantage is that the behavior of a damper is not linear. This means, if you try to adjust the half of the suction volume, the operator usually sets the damper to a 50% opening degree. 50% of the suction quantity at an

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extraction point would set the damper opening position to 67% and not to 50%. A further disadvantage which only becomes noticeable during operation is the lack of consideration of the adjacent Process suction points in the same network. What is behind this: As soon as two equal suction points (same pipeline diameter and same pipeline length) divide a volume flow of 100,000 m³ / h and both dampers are 100% open, the volume flow is split 50/50. If the first damper now completely closes, the 100,000m³ is sucked completely from the second strand. This effect occurs in any dedusting system with a distributed piping system. What does this mean for the operation of such a system? In order to suck out the emissions at one point at a desired volume without any fluctuations in a stable, the influence from the other suctions points need to be considered. But this task cannot be loaded onto an operator whose prime object is to produce steel.

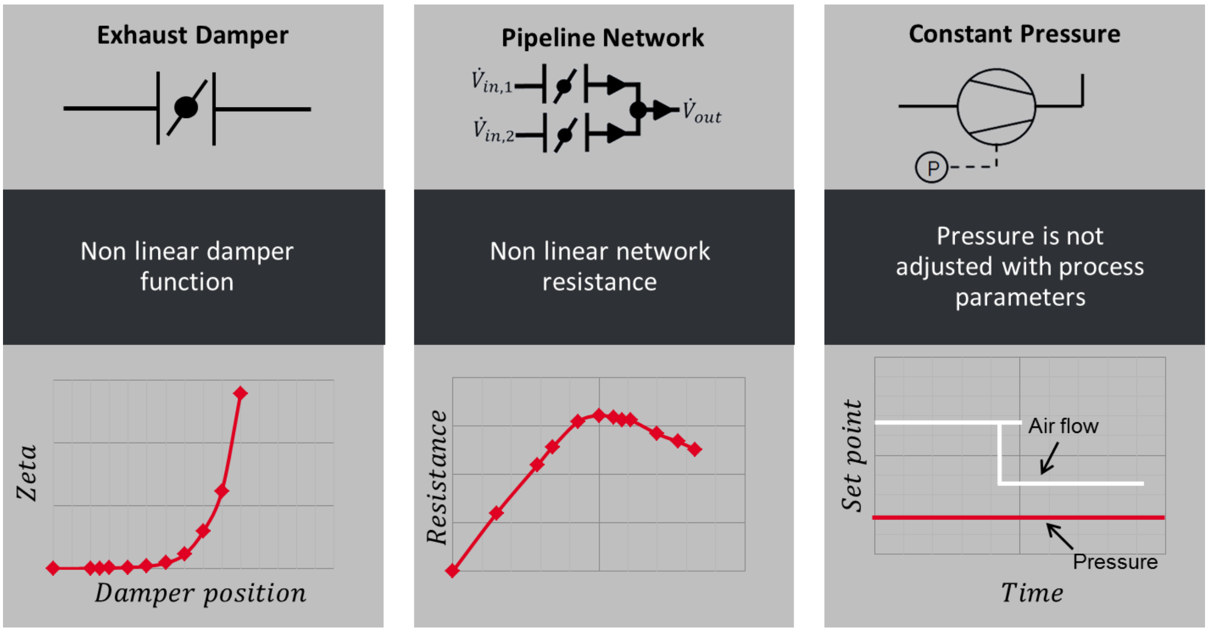

Figure 3: Problems in pipeline networks

The solution to the presented problem is to map the pipeline system including dampers in a mathematical model. The model itself is not a complete solution as it does not consider extraction of the gas in an efficient manner. Since this is a multi-dimensional problem, the pipeline resistance was first determined on the basis of the previously defined volume flows for the respective process step. The segment with the highest pressure loss is defined as the master segment. All other segments are optimized with the aid of the necessary volume flow using the Simplex algorithm until a minimum required negative pressure is established in front of the filter house. An advantage of this method is the independence of measurement technology since all calculations are performed on the model. The model is prepared in advance and checked during commissioning and, if necessary, optimized. This calculation can be performed on a PC or on a PLC and is calculated cyclically every 5 seconds. The boundary conditions such as the clogging of the pipeline segments are considered accordingly in the modeling. However, it is also possible to introduce further pressure sensors into the system in order to take account the pressure losses occurring due to actual site conditions which change over a period due to depositions. See the comparison shown in figure 4.

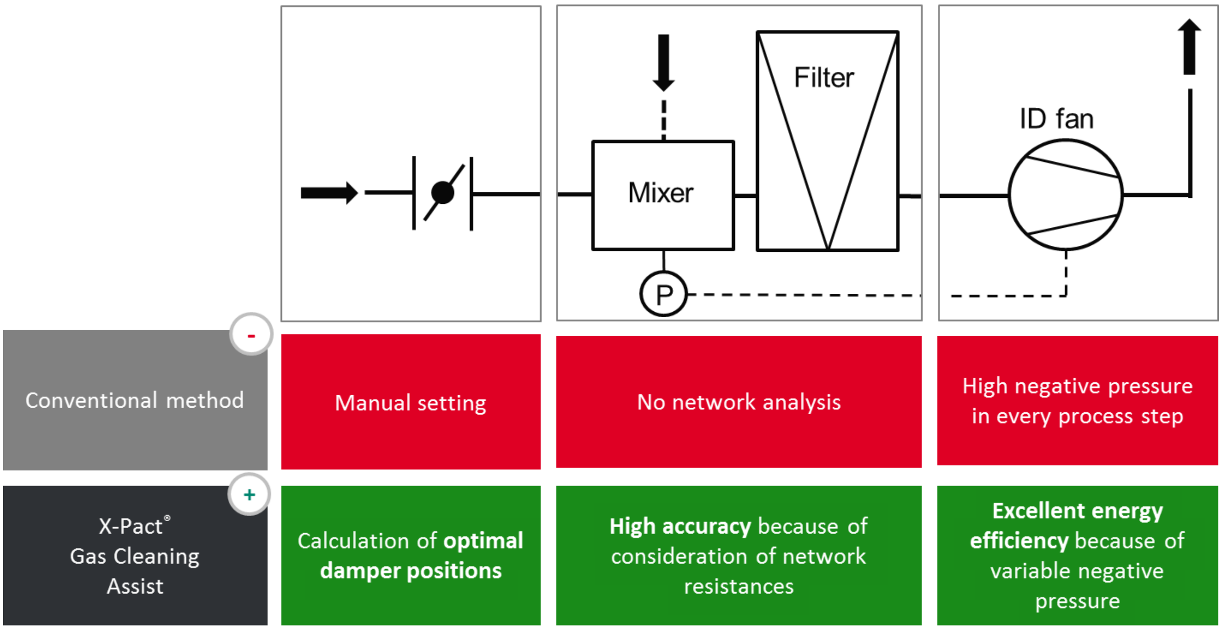

Figure 4: Compare “Conventional method” vs. SMS group “ X-Pact®Gas Cleaing Assist”

Flow-optimized extraction

Components at the extraction points and in the gas piping system which are not flow-optimized generate heavy turbulences and therefore impair the removal of the exhaust gases. To compensate for the pressure loss thus generated in the overall system, the performance of the induced-draft fan has to be increased. This in turn leads to a significantly higher power demand, while the quality of extraction decreases. That is why SMS Group uses special software to simulate the exhaust gas flows and detect ineffective bottlenecks and turbulences. Based on the results provided, the component design can be adapted in order to ensure an optimal gas flow. These measures minimize the pressure loss in the overall system. In this way, significantly lower fan speeds are sufficient to achieve the desired extraction quality, so that the power demand at the fans is noticeably reduced.

3 RESULTS AND DISCUSSION

Being applicable to almost all steel plants, the X-Pact® Gas Cleaning Assistant optimizes the secondary gas cleaning system. These systems are responsible for the extraction of dust-laden off-gases, which may also be poisonous, at their point of origin. They must also prevent the prescribed concentration of emissions at the workplace from being exceeded and, finally, must ensure that resources can be recovered. To enable all these tasks to be performed precisely, and with as little energy utilization as possible, SMS Group has developed a new system for the energy efficient control of gas cleaning systems. A model of duct network is stored in the plant control system and helps optimizing the process.

In Figure 5, the conventional control is compared to the Gas Cleaning Assistant. In the conventional control, the opening positions of the exhaust dampers are defined in a complex matrix, whereas with the Gas Cleaning Assistant their optimal position is calculated by an algorithm by the intelligent control to reach the optimal gas flow at all points (1). Also with the GCA, the required negative pressure is calculated by the system and replaces the often as constant set value in the conventional control (2). Since with the GCA, the pressure is adapted and optimized for each process phase, also the necessary power of the ID fan can be adapted (3), leading to a lower energy consumption (4) when using the Gas Cleaning Assistant compared to the conventional control.

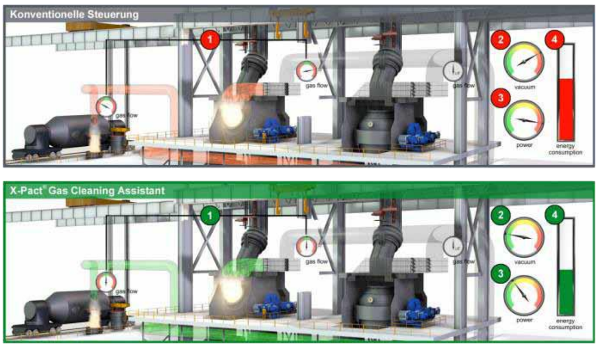

Figure 5: Example of a gas cleaning network and the advantages of the intelligent control of the Gas Cleaning Assistant.

The model's description of the pipework system enables the dampers to be positioned with a high degree of accuracy in the system. This has been shown in a reference plant where the model results could be compared to the volume flow measurements.

The algorithm reacts in a flexible and robust manner to the different process requirements and does not need any additional measuring technology. The model merely requires software update if changes are made to the pipework system. The system can therefore be easily added to an existing gas cleaning system and is an additional asset to modernizations.

Especially in existing plants, another feature of the Gas Cleaning Assistant is of great value. If the overall gas cleaning power is not sufficient even with the improvements in the intelligent control, the different dampers can be prioritized. If a deficit is recognized, exhaust positions of lower priority will be operated at lower suction power to ensure that the ones which are relevant for health or environmental reasons can operate properly.

It has shown in practice that with the same or better gas cleaning quality, energy savings of up to 39% can be reached, compare Figure 6. On an average, the savings were 21%.

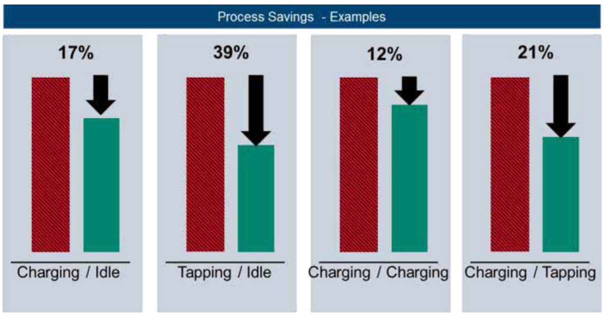

Figure 6: The Gas Cleaning Assistant was installed in an existing plant, being able to directly determine the improvement. The energy savings depend on the process phases, varying between 12% and 39%, with an average saving of 21%.

4 CONCLUSION

Different electric and automation systems combine advanced measurements with intelligent algorithms to control, manage and optimize the process in a smart way. Tackling different areas of a steel plant allows the automation systems to significantly increase the energy efficiency and reduce process and energy costs of the production.

SMS Group electric and automation department profits from its experience as a plant constructor and implements this product along with energy efficient drives, intelligent start-stop mechanism and other energy efficiency measures. Integrating energy and process efficiency measures in the modernization of the plants automation equipment further decreases its pay-back time

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