A NEW CLEANING APPROACH FOR BLACK POWDER REMOVAL

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1. Introduction

The occurrence of black powder is causing increasing concern in the natural gas industry worldwide. Although it is a relatively new phenomenon, a growing number of pipeline operators are now turning their attention to the problem, because of the substantial effects it has on their pipeline systems. In combination, these effects and the wide range of other difficulties are creating a major challenge for pipeline operators, notably for pigging activities (cleaning and inspection).

Black powder can be found in both dry and wet gas lines and in conjunction with any other contaminants found in gas pipelines such as water, liquid hydrocarbons, and sand etc. The powder mainly consists of iron and sulphur as well as iron oxide in different chemical combinations. Under dry conditions, it can take the form of a very fine powder or solid sediment, whereas under wet conditions it usually appears as a tar-like substance. Black powder not only influences the flow performance of the pipeline, but it can also impair the function of installations such as valves and pipeline measurement systems. Since the performance and efficiency of pipeline inspections can be significantly reduced due to the particular characteristics of the powder, the development of specific cleaning methods for black powder posed an urgent challenge (Ref. 1).

2. Cleaning Experience

Conventional cleaning methods involving standard cleaning tools showed both low efficiency and heavy wear on the polyurethane of the cleaning equipment used. Even the ROSEN cleaning tools, otherwise well proven for their high wear resistance in long gas pipelines, showed heavy wear in relatively short pipelines containing dry black powder (Figure 1). Under these particular conditions, even an increased volume of polyurethane on the cleaning tools did not remarkably improve the wear resistance of the cleaning tools. The combination of heavy wear and low cleaning efficiency means that a large number of cleaning runs are required, thereby causing both heavy operating efforts and high spare part costs.

Experience has shown that although the use of magnetic inspection tools provides better cleaning efficiency, it is still marked by heavy wear on the tool components. This causes high maintenance and spare part replacement for a tool which was originally built for pipeline inspection rather than cleaning.

Due to the urgency of the problem, other methods have been developed. These include, for example, cleaning procedures such as batch washing or gel pigging. While these procedures are more effective than standard cleaning, they are very laborious and expensive: usually a pig train with up to 8 single cleaning tools is required to separate the different fluids, solvents and chemicals. Moreover, the problem of high wear is not only virtually the same as in standard cleaning tools, but the inserted fluids can cause additional problems. For example, water may react with the powder either mechanically or chemically, whereby new contaminants with different characteristics are formed. Finally, all inserted fluids and chemicals must be removed from the pipeline completely by means of a complex procedure.

Figure 1: Cleaning tool after a 50-km inspection through black powder.

3. Development of a new cleaning tool for black powder

Faced with the new challenge of black powder, ROSEN has developed a new cleaning system which is especially efficient in dry gas lines. Combining the advantages of regular cleaning tools with those of magnetic inspection tools, the new technological approach also incorporates a specifically developed bypass system. Carried by support wheels which are sloped so as to create continuous rotation for the purpose of preventing one-sided wear of wall-touching or weight bearing components, the tool is sealed with polyurethane guiding and sealing discs. To improve cleaning capability, the tool is equipped with spring-supported magnetic brushes. All these mechanical components can be adapted to any pipeline properties, thereby optimizing cleaning efficiency under a wide range of different conditions.

The central feature of the new technology is a calculated bypass flow running through the middle of the tool. The negative pressure created as a result of the acceleration of the medium permits the use of suction tubes. These tubes are located in the space between the disks behind the brushes in the run direction. The evacuated medium flows into the bypass nozzle from where it is transported, together with the bypass flow, to the downstream area of the tool. In order to generate a defined suction flow, the evacuated volume has to be replaced continuously. This is done by a specially designed inlet channel. Due to the special flow guidance of the tool, a flow vortex is created in the brush / suction area. The specific dynamic of the tool's suction flow means that an optimized value of powder particles can be sucked off the pipeline wall. Moreover, the bypass flow through the middle of the tool transports additional powder particles.

As these explanations show, the new technology, which is the result of more than 20 years of pipeline cleaning and inspection experience, is based on several different components. All these components make a specific contribution to the cleaning process as a whole. The overall characteristics and performance of such complex interlinked processes must be calculated with extended methods of "Computational Fluid Dynamics". Thus the brush / magnet system not only ensures surface cleaning but also the required differential pressure.

Furthermore, the actual pressure and flow in the line has to be taken into account to optimize cleaning performance on the one hand but also to prevent run problems due to excessive bypass on the other. A particular challenge in this context is the passage of full bore tees. On account of the flow around the front disk package, the entire bypass value has to be calculated to allow for this situation. It is imperative therefore that all pipeline and run conditions are taken into account to ensure optimal preparation of these particular cleaning tools.

To monitor overall performance and function, each tool is equipped with the ROSEN "Pipeline Data Logger" (PDL) data acquisition system. The Data Logger measures temperature, absolute and differential pressure, and acceleration in three orthogonal directions with one data triple per second (minimum, maximum, average). To get a maximum of information about the differential pressures, two PDLs are used for each cleaning tool.

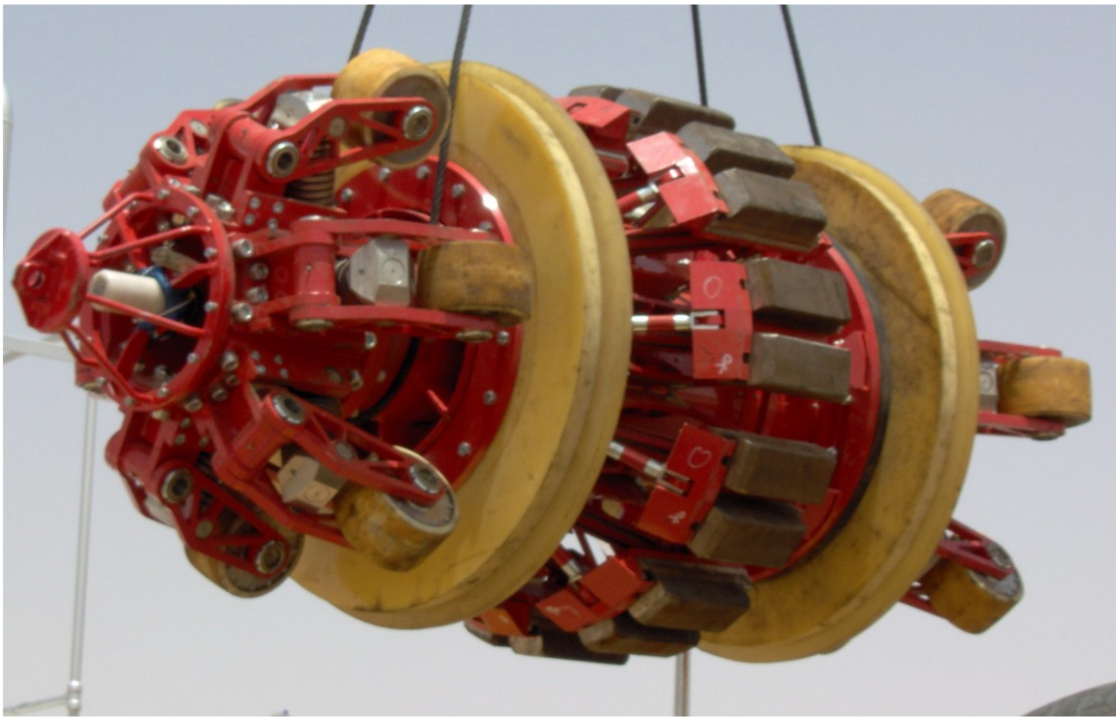

Figure 2: ROSEN 48" Black Powder Cleaning Tool before launching

4. Field Experience

On the basis of specifically developed technology, ROSEN has built a 48" and a 56" tool and performed numerous cleaning runs with both tool sizes. Figure 2 shows the 48" Black Powder Cleaning Tool just before launching in a 170-km natural gas pipeline in which the common problem of heavy black powder contamination is present.

Figure 3 shows the dust-filled receiver after one of the most effective runs. In the background, the front of the Cleaning Tool can be seen. The tool brought out 7800 liters of black powder in the receiver alone. The amount of dust blown through the offtake during the run can only be estimated.

Figure 3: Receiver filled with black powder

Perhaps even more impressive than its cleaning capacity was the tool's condition after the run: it was so good that it could be launched again without the need to replace any parts. Even the disks only showed minor signs of wear – and all this after a run in more than 170 km of dry black powder!

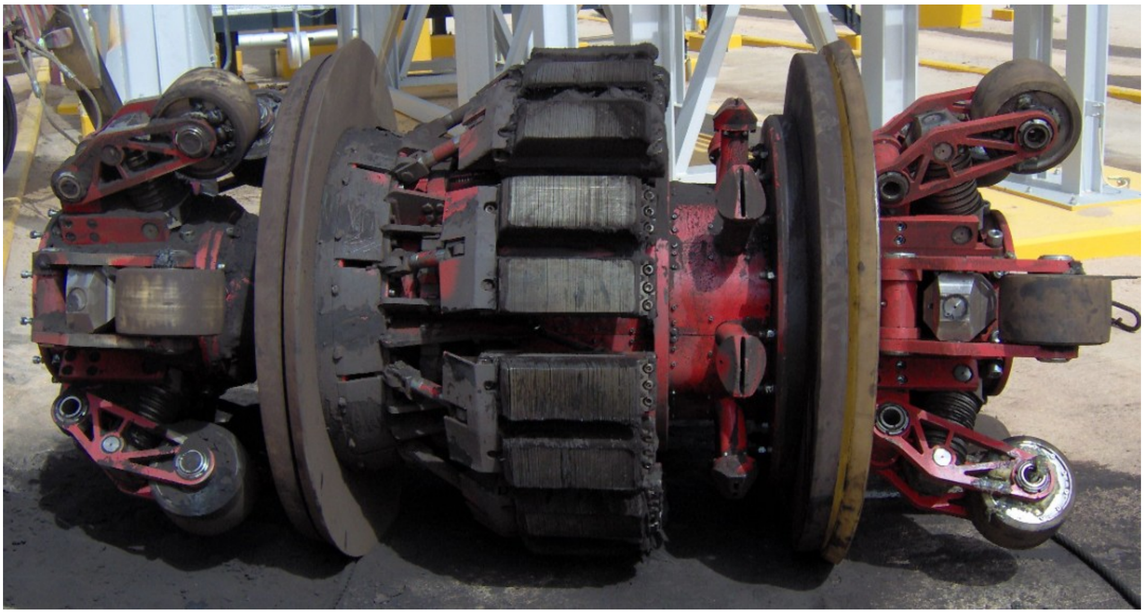

Figure 4: Cleaning tool after more than 170 km in a gas line containing dry black powder

But despite many successful runs, also runs without any significant volume of black powder being removed have been monitored. The details of which are described below.

5. Evaluation of Run Data and Tool Performance

To understand and monitor the function and performance of the cleaning tools, they are equipped with Pipeline Data Loggers (PDL). The measurements provide not only provide information about pressure, temperature and acceleration, the most important measures are the differential pressures along the tool and the suction system because they are monitoring the general function of the process.

The differential pressure at the tool is basically created by the friction of the brushes along the wall. This differential pressure creates bypass flow through the tool and therefore creates the suction flow from the cup-bounded cleaning volume. Below, some examples of this data is presented and discussed.

Figure 5 shows time based measurement of the differential pressure at the tool and suction area during a very effective cleaning run.

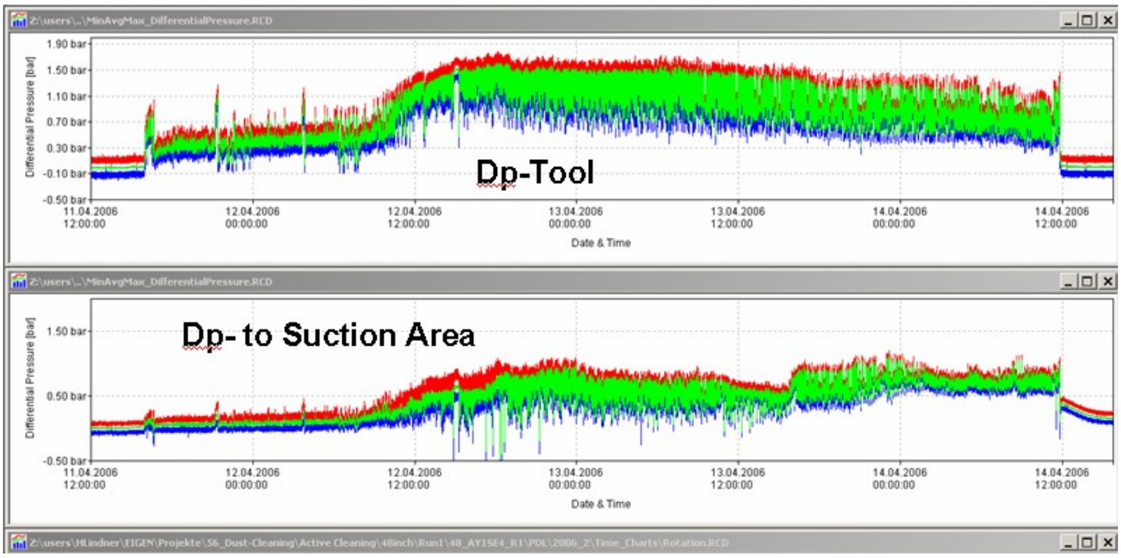

Figure 5: Differential pressure at cleaning tool and suction system

The diagrams in Figure 5 are showing the minimum, average and maximum values of data samples during the cleaning run. The tool differential pressure begins with a constant average value of about 0.3 bar for the first 12 hours (except the launcher area). This value is in the designed range for this project. But then one can see a remarkable increase of the differential pressure up to values of 1.5 bar in average. After the highest value the pressure decreases slightly without falling below 0.7 bar again. In the lower diagram it can be seen that the suction pressure is strongly correlated to the tool dp. It increases at the same time from a low value (0.1 bar) to an average of about 0.7 bar. These are the data from the cleaning run shown in Figures 3 and 4. Figure 5 clearly demonstrates one of the basic principles of this technique. The more the pipeline is contaminated and/or the more debris is accumulated in front of and around the tool the higher the differential pressure and the higher the cleaning efficiency.

6. Conclusions

This article presents a new cleaning technology for black dust removal from gas pipelines. It is shown that there is a high level of complexity, interdependency and interaction between pipeline surface, dust contamination, magnetic forces, brush friction, bypass area and operating conditions and that these complex functions are an area of ongoing research at ROSEN to continue to improve the overall efficiency of these black dust removal tools.

However, compared to other, more laborious, procedures or standard cleaning tool with no success, it represents a low effort solution for the pipeline operators. It can be used as a standard cleaning tool and as detailed above has shown very good to excellent cleaning results on many occasions.

7. References

1. Baldwin, Richard: The characteristics of black powder and how to combat the problem. (http://www.blackpowderforum.org/Baldwin%20paper.pdf).

