On the Difference in Pneumatic Conveying Properties of the Same Product from Different Manufacturers; a Case Study Based on Quicklime

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***Abstract*— Quicklime plays a crucial role in infrastructure projects such as soil stabilisation, modifying soil properties and optimising moisture content. It is often handled pneumatically due to its hazardous nature and reactivity. However, the design of pneumatic conveying systems must carefully consider the specific conveying characteristics of the bulk material. These characteristics can be obtained by undertaking conveying trials in a laboratory. Experience has shown that industrial systems designed for a specific grade of a material may experience unreliable performance when handling material of nominally the same specification, obtained from different sources. This occurs due to variations in the material's conveying characteristics, leading to challenges such as low throughput, pipeline blockage, particle degradation.**

Conveying trials were undertaken using an industrial-scale pneumatic conveying test rig that has 120 metre long, 100 mm NB (nominal bore) pipeline. Five grades of quicklime were tested, showing that each grade exhibits a different conveying behaviour.

When the conveying data was applied to design an industrial conveying system, it was observed that for the same airflow and pipeline pressure drop, throughput for different grades varies from +19% to -15% as compared to the benchmark grade. This study demonstrates the importance of testing the material in the conveying test pipeline and obtaining the conveying characteristics in determining key design parameters for reliable pneumatic conveying systems.

Keywords: pneumatic conveying characteristics; pressure drop; blow tank

1. Introduction

An accurate prediction of the pressure drop in the pneumatic conveying pipelines is a key factor to design efficient and reliable conveying systems [1]. Inaccurate prediction of the system pressure drop can lead to issues like pipeline blockages and reduced throughput [2]. Most conveying systems are designed based on the designer's previous experience or by using conveying data which is also known as conveying characteristics. If this data is not available, it can be generated by undertaking conveying trials on a sample of the product to be handled [3, 4]. Different materials behave differently in the conveying pipeline, resulting in distinct conveying characteristics unique to each material [5]. It is interesting to note that the conveying characteristics of the materials sourced from the different suppliers can have very different conveying characteristics that can influence the system performance.

This study aims to compare the conveying performance of five quicklime grades obtained from different suppliers when transported through a system designed for a specific quicklime grade.

2. Test Setup and Materials

The main test programme was performed using a bottom discharge blow tank, in conjunction with a pipeline of 100 mm NB schedule-40 pipe, with a total run of 120 m, incorporating 8 bends and a vertical section of 6 m. The test pipeline was instrumented to gather data on pressure drops in straight sections and bends, overall pressure drop, and flow rates of solids and air. Details of the test rig are shown in the Fig. 1.

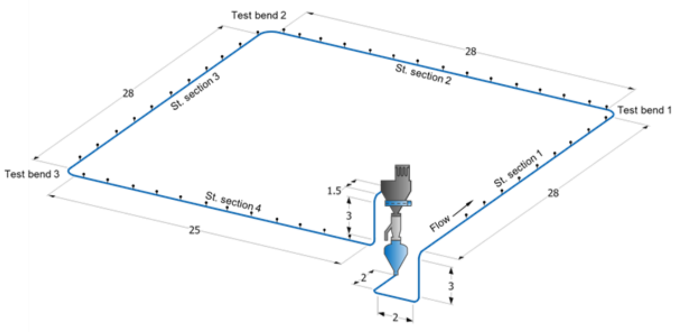

Figure 1. Layout of the 120 m long test pipeline

Five grades of quicklime were tested in the test program. These five grades were taken from five different sources, having similar particle size distribution and same chemical composition.

3. Experimental Programme

Conveying trials were undertaken on five grades of quicklime at three different air flow rates: 0.30, 0.32, and 0.35 kg/s. A minimum of 12 conveying trials were conducted for each grade to achieve a wide range of dilute phase conveying conditions, with inlet air velocities from 9 to 15.5 m/s, conveying pressures up to 2.4 barg, and throughputs up to 32 tonnes per hour. A desiccant dryer, installed immediately downstream of the compressed air supply, was employed to supply the dry air (nominally -40°C dew point) to avoid the build-up of lime inside the pipelines during testing.

4. Experimental Results and Discussion

Fig. 2 illustrates a comparison of the pressure drop and throughput achieved for the five grades of quicklime conveyed under 0.3 kg/s airflow in the test pipeline.

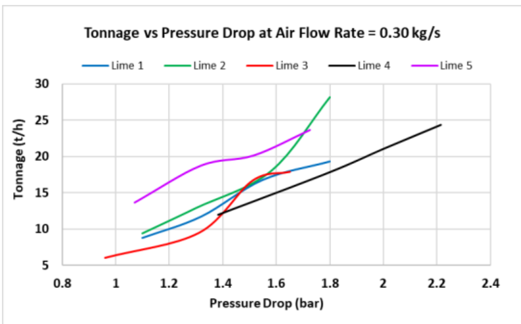

Figure 2. Tonnage vs pressure drop for lime grades in the test pipeline at an airflow of 0.30 kg/s

It can be seen that, with the same pressure drop and air flow rate, each grade yields a different tonnage in the test pipeline. This highlights how different grades of the same material can affect the system performance.

From an industrial installation prespective where the material may change or sourced from different suppliers, it is important to adjust the total airflow and operating pressure when switching between lime grades. Some quicklime grades yield the desired tonnage at a given airflow and pressure drop, however, handling a different grade in the same system will give a lower tonnage at the same operating conditions. To achieve the required duty, introducing more material in the conveying pipeline can lead to a higher pressure drop, reducing the conveying velocity and resulting in pipeline blockage.

Fig. 3 shows the effect of the blow tank air percentage on the tonnage for an airflow of 0.30 kg/s across different grades of lime.

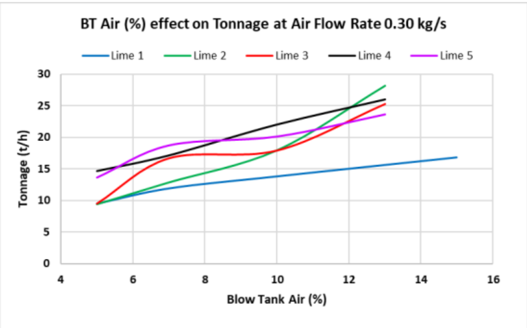

Figure 3. Tonnage vs blow tank air ratio for lime grades in the test pipeline at an airflow of 0.30 kg/s

It can be seen that each lime grade responds uniquely to blow tank air ratios and yield different tonnages in the test pipeline. This clearly shows that the materials with similar physical and chemical characteristics may respond differently to the blow tank air, thereby affecting the system performance.

This highlights the importance of adjusting blow tank air distribution when switching between lime grades in an industrial installation. Some quicklime grades demonstrate positive responsiveness to a given blow tank air ratio, potentially leading to higher tonnage. However, overfeeding of the material could lead to higher pressure drop, ultimately reducing conveying velocity and causing blockages in the pipeline.

The conveying characteristics of the five lime grades in terms of the bend and straight pipe loss coefficients in the test loop are shown in the Figures 4 and 5.

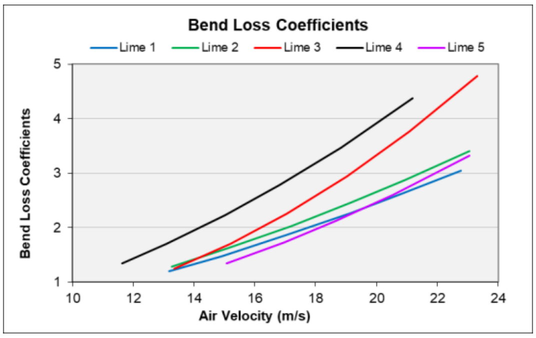

Figure 4. Bend loss coefficients as a function of air velocity

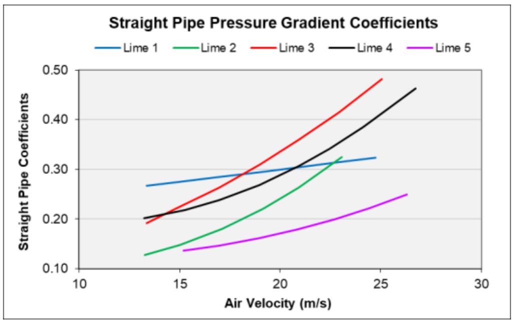

Figure 5. Straight pipe loss coefficients as a function of air velocity

It can be seen from the Figures 5 and 6 that all the lime grades exhibit different conveying characteristics for straight and bend pressure loss, which means that their throughput will vary if handled in the same system under identical operating conditions.

Conveying characteristics of the Lime 1 was used to design an industrial system. Figure 6 illustrates the effect of lime grade on throughput performance of the system at constant airflow and pressure drop for all five lime grades.

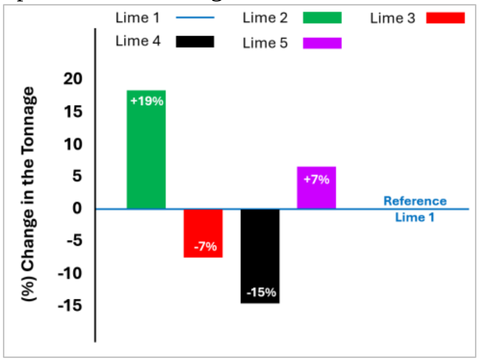

Figure 6. Straight pipe loss coefficients as a function of air velocity

It can be seen that Lime 2 performs the best, giving 19% more tonnage, whereas Lime 4 performance is worst, with 15% reduction in the tonnage compared to the reference Lime 1.

5. Conclusion

There are many conveying systems in the field that suffers from the poor performance that occur due to a change in the grade of the handled product. The result of this study highlights the need for undertaking conveying trials to determine the unique conveying characteristics of the various grades of the same product which serve as the foundation for a robust and efficient system design.

Acknowledgement

The authors express their sincere appreciation to Hargreaves Industrial Services, Barnsley, UK for their generous funding and provision of test materials, which made this study possible.

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