VARIATION OF THE AIR FLOW WITH THE PRODUCT FLOW DURING THE PNEUMATIC TRANSPORT OF INTERMEDIARY PRODUCTS IN THE MILLING INDUSTRY

— research paper —

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Abstract. The purpose of this work was to determine the variation of the air flow based on the variation of the product flow during the pneumatic transport of intermediary products in the milling industry. The products subject to analysis were harvested from a soft wheat mill with a cap. of 250 tons/24 h at B1. The installation which was used, included a system with a tubular screw conveyor operated with an electronic inverter, two pipes for pneumatic transport with diameters of 74 mm and 117 mm, a cyclone with air-lock and a high pressure fan for the pneumatic transport. The product flow was measured by capturing and weighing the sample on an electronic scale, and the air flow was measured with a Testo Term 452 device fitted with a Pitot tube .

Keywords: pneumatic transport, flour milling,

INTRODUCTION

Pneumatic conveying is used on a wide scale for the transport of intermediate products in the flour milling. Although it is preferable for various reasons to the mechanical transport it nevertheless has the disadvantage of registering a considerably higher specific electric power consumption than the mechanical transport.

For the calculation and dimensioning of a pneumatic conveying system components, there are within the specialized literature works, various methods and algorithms. The parameter conditioning in a great extent the

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installed power of a pneumatic conveying fan represents the air-product mixing ratio. In order to estimate the air flow, the specialized literature provides tables with recommended values for the mixing ratio. A wide approximation of the fan air flow often leads to higher installed powers of the fans, in other words, the flour producer pays some electricity just for the air conveying.

The air flow variation to a pneumatic conveying column is in close correlation with that column pneumatic conveying capacity. The correct estimation of the mixing ratio and subsequently of the pressure losses within the system ultimately conditions the installation economic efficiency.

Determining the exact air flow in the pipe, corresponding to a certain product flow, is fundamental for the working accuracy. For the same reason, knowing the fake air flow is essential. In order to prevent the fake air from entering the system, we paid a special attention to the sealing of the components, especially the junctions between two consecutive elements. We additionally sealed them using food silicone and waterproof adhesive tape.

However, what is left to be taken into consideration as a fake air entry is the unloading air-lock of the cyclone. The determination of the fake air flow through the air-lock is extremely difficult because the similar phenomenon is the air flow through the slots. The entry of fake air is produced both between the rotor and stator, and through the side parts and the longitudinal parts of the rotor. The fake air flow is caused due to various factors, such as the type of air-lock, that is the available length of the access slot air, the revolution speed of the air-lock, the pressure difference, in this case the depressurization in the system, depressurizing inside the cyclone.

Based on these considerations, the purpose of this work is to determine the variation of the air flow based on the variation of the product flow during the pneumatic transport of intermediary products in the milling industry.

MATERIALS AND METHODS

Materials

The harvesting of the samples was accomplished in normal operation of the flour mill, with properly cleaned and conditioned wheat (Moraru et al., 1988). The analyzed products came from a soft wheat flour mill with a capacity of 250 tons/24 h at B1 (Gerecke, 1991). The mill is configured with rollermills on the ground floor and the plansifters at the top floor of the building (Costin , 1983) (Hibbs and Posner, 1997).

The products from B1, B2, B3, B4M(coarse), B4m(fine) and Bran (Willm, 2009) are presented in Figure 1. Figure 2 shows the types of Semolina and middlings.

Product from B1 rollermill

Product from B2 rollermill

Product from B3 rollermill

Product from B4M(coarse) rollermill

Product from B4(fine) rollermill

Bran

Figure 1. The products from B1, B2, B3, B4M(coarse), B4m(fine) and Bran

Large / medium semolina K = 18 / 40

Medium / small semolina K = 40 / 52

Hard / mild middlings K = 54 / VII

Figure 2. The products Semolina and Middlings

In order to achieve representative results and determinations, we considered several granulometric classes of semolina and middlings, as follows:
-large/medium semolina with K = 18 / 40 (between 1.180 and 475 microns)
-medium/small semolina with K = 40 / 52 (between 475 and 335 microns)
-hard/mild middlings with K = 54 / VII (between 335 and 200 microns)

The experimental device

In order to achieve the results, an industrial scale installation was created (Figure 3).

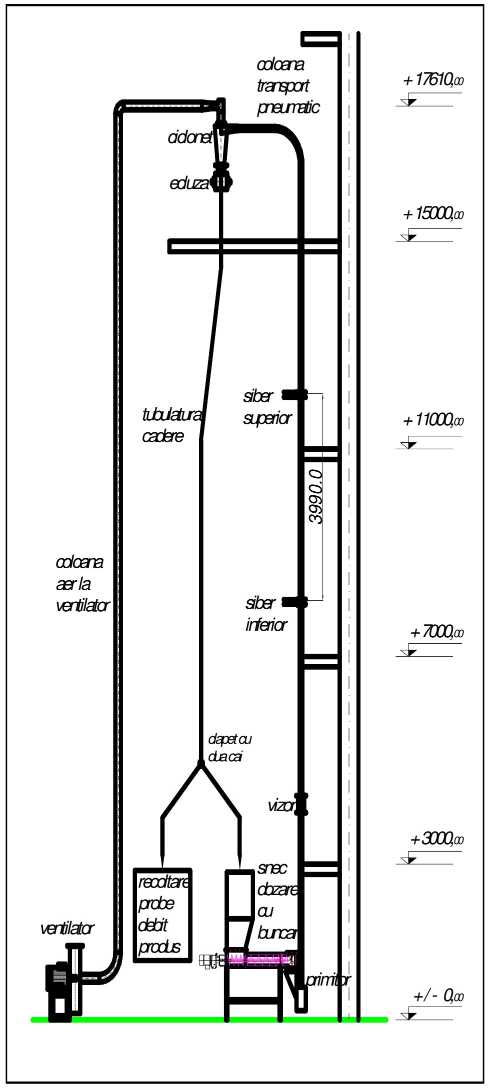

Figure 3. The experimental installation

completed with (Erling et al., 2008) (Gerecke, 1991):

- a dosage system with a screw tube operated with an electronic gear motor and inverter (Moraru et al., 1988);

- a column for the pneumatic transport with two diameter sizes fitted with a vertical receiver on the lower side and a transparent sight in order to visualize the process;
- a separating cyclone fitted with air control systems on the upper side and completed with an air-lock operated by a gear motor;
- a connection pipe from the cyclone to the fan;
- a high pressure fan for the pneumatic transport.

The measurements for the air flow were made according to the standard prescriptions 7466-84 :

- the tube diameter must be narrower than 1/30 D .
- the pipe must be circular, with allowed limit violations of 0.5 % D, on a 0.5D length on both sides of the measurement plan;
- the maximum speed must be under 70 m/s , and the minimum must exceed the adequate speed for the Reynolds number Re=500 (related to the Pitot tube diameter);
- the angle between the Pitot tube axis and the pipe must be less than 2^o.

Experimental design

In order to achieve representative results, we established some general working procedures and operation working procedures, as follows:
- procedures for harvesting and weighing the samples;
- procedures for measuring the flows (product and air), as well as synchronizing them.

The determinations were made on two types of pipe diameters, 74 mm and 117 mm.
The general working concept was the following:

- 1st phase: loading the pipe at a preliminary product flow;
- 2nd phase : loading the pipe at an intermediary product flow ;
- 3rd phase: loading the pipe at a considerably higher product flow and close to the conveying limit of the system ;
- 4th phase: loading the system to the clogging limit and the practical clogging conditions– failure of pneumatic transport;
- 5th phase: stopping the installation and unclogging the pipe;
- 6th phase: testing the clogging limit somewhere near the clogging limit.

For some of the analyzed products, we did not perform the 2nd phase and got directly to the 3rd and the 6th as follows:

- achieving the 1st phase;
- achieving the 4th phase;
- achieving the 5th phase;
- achieving the determinations at an average between the maximum product flow estimated through the 4th phase and the product flow in the 1st phase;
- achieving the 6th phase.

During each determination phase, we considered as being relevant the achievement of each determination three times.

For each set of values, we obtained the following:

- Product flow ;
- Air flow corresponding to that specific product flow.

Fake air

Some assumptions were made:

- The maximum fake air flow through the air-lock is reached when the "pressure voltage", the pressure difference between the volumes separated by the air-lock, reaches the maximum value of the static pressure generated by the fan in that point (interior of the cyclone);
- The air-lock used inside the installation for experimental determinations was new, unused;
- Manufacturing tolerances of the air-lock (rotor – stator) are of approx. 0,1 – 0,15 mm, which we actually checked;
- The determinations were made at an industrial scale;
- The determination of this dissertation is addressed mainly to the sizing fans/ blowers for applications of industrial pneumatic transport.

Based on these assumptions, we considered relevant, precise and exact, to determine the fake air flow through the air-lock, in conditions of maximum static pressure of the fan (measured on the connection pipe between the cyclone and the fan) through a specially designed graphic by the suppliers.

Based on the results, the static pressure, as a maximum value of vacuum reached, was of approx. 980 – 1020 mmCA. From this value of the differential pressure, from the graphic of fake air determination made by the manufacturer of the air-lock (Kilickan and Guner, 2010) (Klinzing et al., 2010), we extracted the value of the fake air flow for a speed regime of the air-lock of 40 rev/min equal to approx. 65 Nm3 / h, which means 1,1 Nm3/min.

RESULTS AND DISCUSSIONS

Experimental data was performed, as presented in the following graphics. On the abscissa we represented the product flow in kg/min, as an arithmetic mean of the three determinations within a functioning regime, and on the ordinate we represented the corresponding air flow. The air flow was calculated as an arithmetic mean of the three determinations, from their final value we figured out the fake air flow of 1.1 Nm^3/min. In the figures 4 - 12, the graphic representations of these variations are shown.

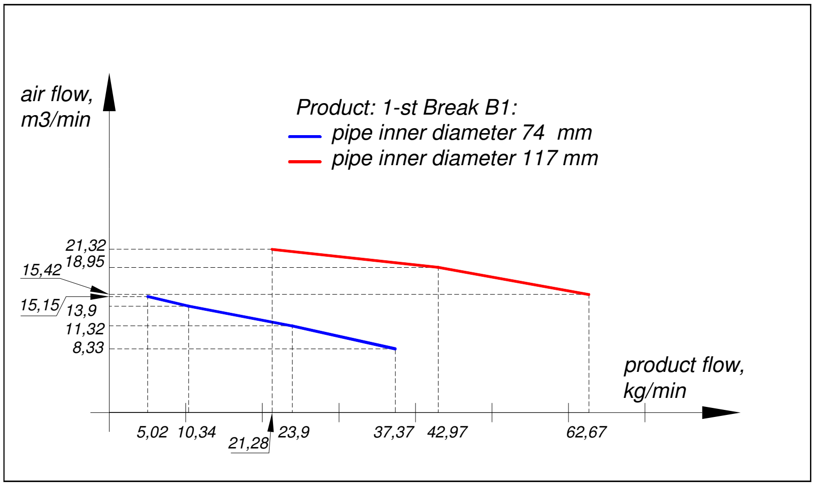

Figure 4. Variation of the Air Flow by Product Flow for the product from B1 rollermill

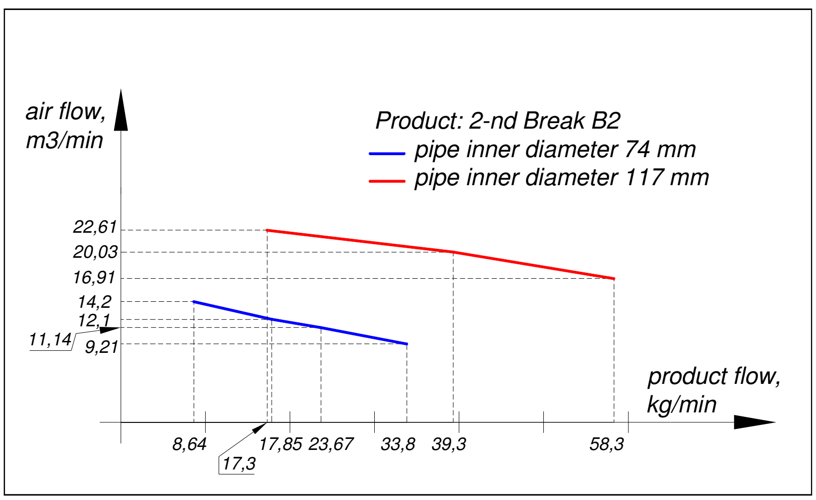

Figure 5. Variation of the Air Flow by Product Flow for the product from B2 rollermill

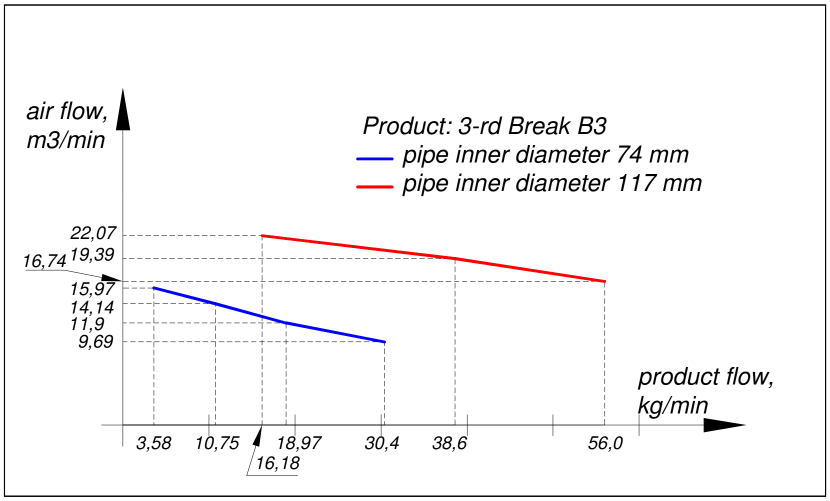

Figure 6. Variation of the Air Flow by Product Flow for the product from B3 rollermill

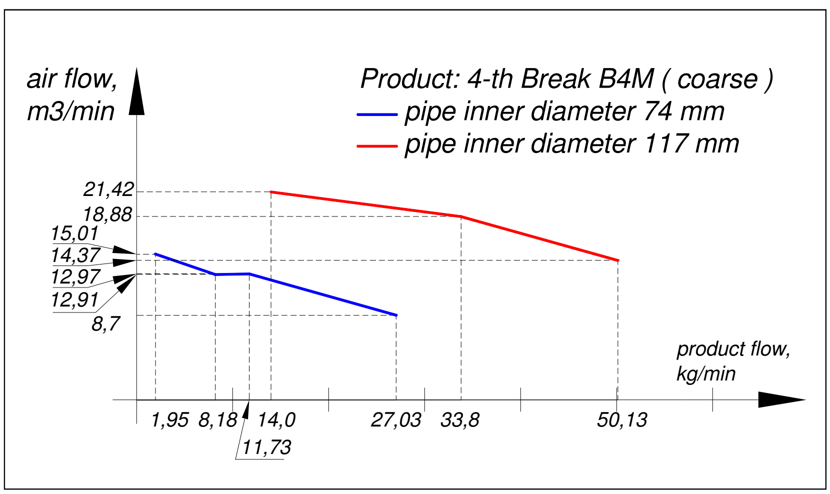

Figure7. Variation of the Air Flow by Product Flow for the product from B4 (coarse) rollermill

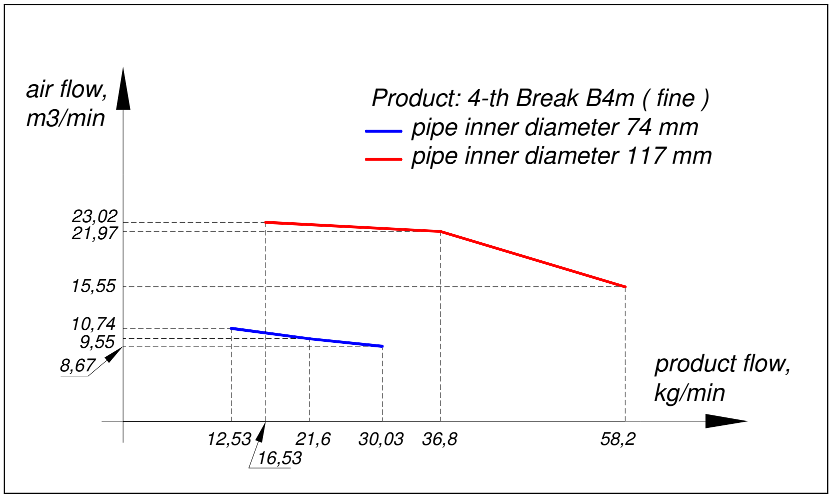

Figure 8. Variation of the Air Flow by Product Flow for the product from B4 (fine) rollermill

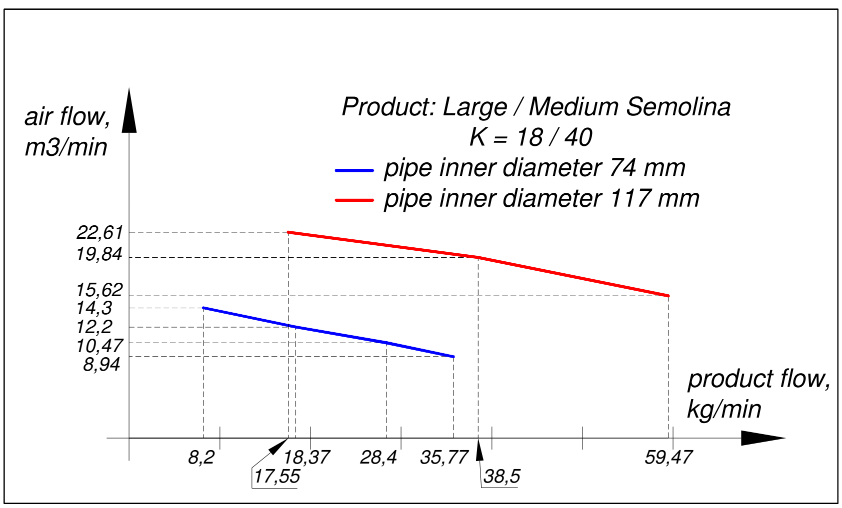

Figure 9. Variation of the Air Flow by Product Flow for the product Large/Medium Semolina K=18/40 (1180-475 micr.)

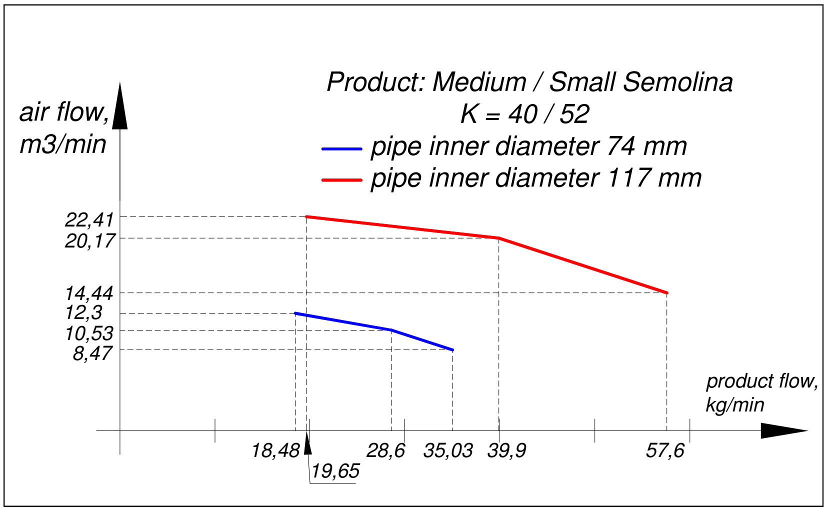

Figure 10. Variation of the Air Flow by Product Flow for the product Medium/Small Semolina K=40/52 (475 - 335 micr.)

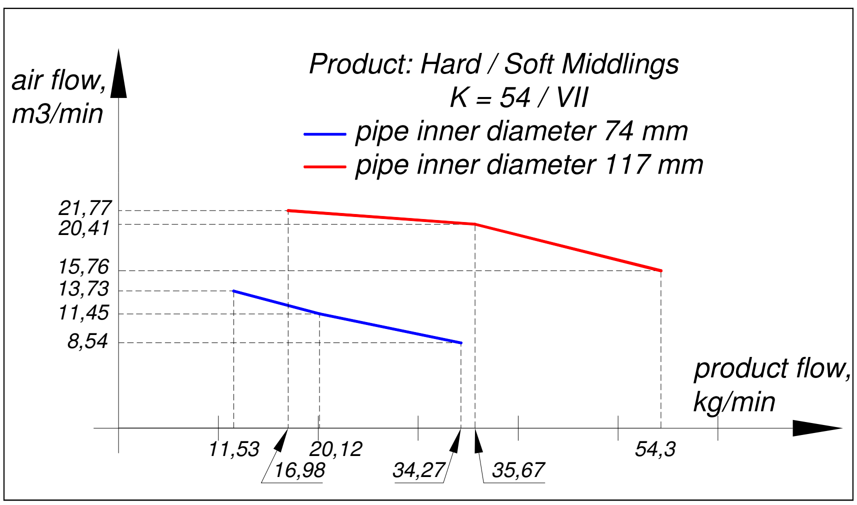

Figure 11. Variation of the Air Flow by Product Flow for the product Hard/Soft Middlings K=52/VII (335 - 200 micr.)

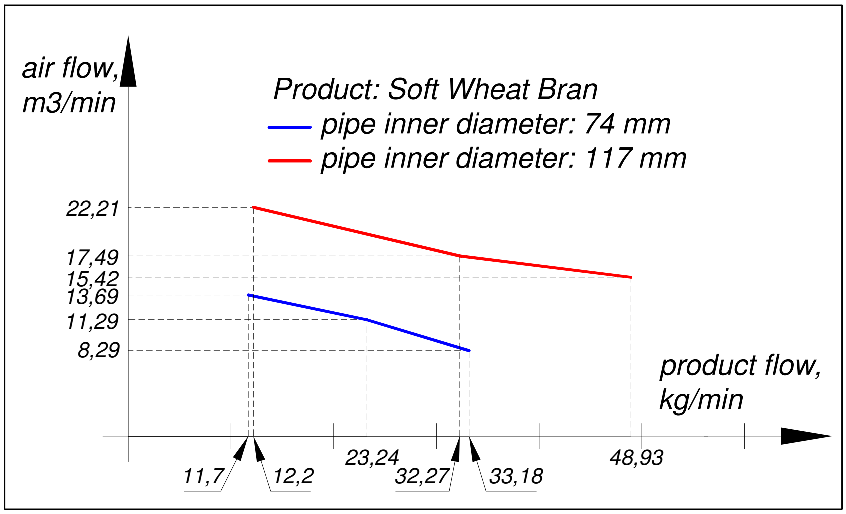

Figure 12. Variation of the Air Flow by Product Flow for the product Bran (all together) .

Before going to the presentation of several conclusions, I must mention that the loading of the pipes was made to clogging, that is the unfulfillment of the pneumatic transport (Willm, 2009). The determination of the clogging limit was made in a quasi-stable regime of transport, and yet accomplished.

CONCLUSIONS

For all the analyzed products, the increase of the product flow led to the decrease of the air flow. The variation curve of the air flow has the same quality profile for all the products, the flow amount of each product being variable.
The theoretical mixing ratio deduced by these curves, vary from product to product, that is they decrease at the same time as the hectoliter mass of the products, with some additional comments.

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