THE USE OF THE PRINCIPLE OF CASCADE PUMPS IN THE PNEUMATIC CONVEYING IN THE MILLING INDUSTRY

— original paper —

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Abstract. Due to its characteristics and its obvious advantages when compared to the mechanic conveying, excluding the specific consumption of electricity, the pneumatic conveyance is used on a large scale in almost all modern cereal grinding installations. The application of the solution presented in this paper, has as a direct effect the decrease of investment and maintenance costs for such an installation.

Keywords: cascade pumps, pneumatic conveying, mill

INTRODUCTION

From the point of view of how the installation of pneumatic conveying is interdependent of the aspiration systems of the grinding section, the following types can be differentiated: the classic pneumatic conveyor and the pneumatic conveyor with cascade fans.

The classic pneumatic conveyor within a grinding section is made up of a number of conveying pipelines that are connected to a main pipeline. It is generally made up of one or more pipelines that are connected to a high pressure fan (Moraru et al., 1988). After the air flow coming from different centrifugal air separators is evacuated, it is collected inside the main pipeline (Rohner, 1994). Depending on the configuration of the system, one can have one, two or more sections of collecting pipelines that converge in a single main collecting pipeline or they can be assisted by separate fans. The initial

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diameter of this pipeline takes into account the induced air flow from the first cyclone connected to it. The angle between the axis of the connecting joint of the cyclone and the axis of the main collecting pipeline is generally of 45^o. Theoretically, in order to have minimal pressure losses, these ramifications should be constructed the same way as the connections from within a vacuum installation. This would create in the end the need for a main pipeline with diameter differences from place to place, which would make the project a lot more difficult to apply and would cause an unjustifiable increase of the installation costs.

For this particular reason, the main collecting pipelines are constructed in a tapered shape, with a minimal diameter at the first cyclone and with a maximal diameter after the last cyclone of the system (Costin, 1983).

The air flow speed is generally calculated for values of 16-18 m/sec, in order to avoid the accumulation of residual material on its length (Gerecke, 1991).

The calculation of the initial and final diameters of the installation is performed in such manner that the air flow speed maintains an increasing pace all along the pipeline.

This paper has as main goal to unify the installation of aspiration with those of pneumatic transport.

THE CLASSICAL PNEUMATIC CONVEYOR INSTALLATION FOR THE GRINDING SECTION

Figure 1 presents the classical pneumatic conveyor installation for the grinding section. The calculation of the pressure loss on the main pipeline of a pneumatic conveyor network, of the kind presented here, is performed by means of the following formula:

$$DH_c = 1,2 \times 10^{-3} \times (v^{1,75} / d^{1,25}) \qquad (1)$$

where:

DH , [mm CA], pressure loss meter of length of the main collecting pipeline;

V , [m / s] , air flow speed in the large diameter section

D [m] , maximum diameter of the main collecting pipeline

The ratio (1) is derived from the fundamental equation of the calculus of pressure losses which is also known as the Fanning – Darcy ratio. The pipeline being of cylindrical shape, the Hyrdraulic Radius R has been replaced with the ratio F / P (the area of the pipeline section / perimeter of the pipeline).

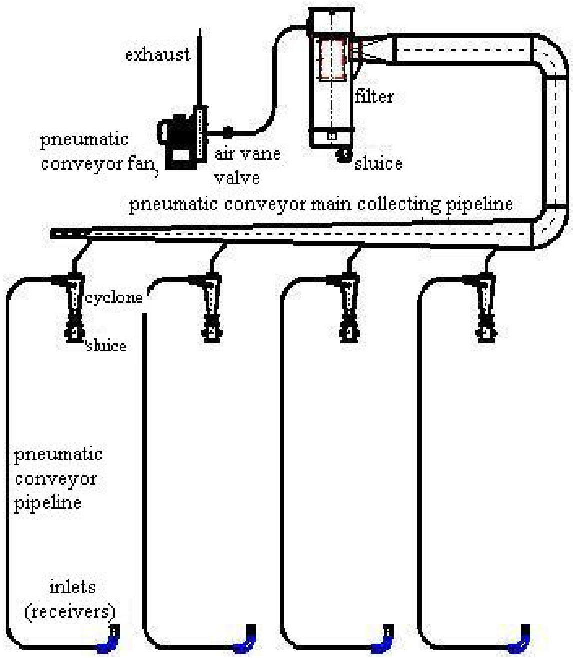

Figure 1. Classical pneumatic conveyor installation for the grinding section

The friction coefficient l from within the Fanning – Darcy formula (Bulat, 1962), has been replaced with the ratio proposed by Blasius (Klinzing, 2010):

$$l = 0{,}3164 / Re^{0,25} \qquad (2)$$

and the dynamic viscosity coefficient n has been considered equal to 15,1 x 10^{-6}, for an air temperature of 20°C and a pressure of one atmosphere.
From a personal experience, the pressure losses on the main collecting pipeline of an pneumatic conveyor, in a classic grinding section, strictly related to the tapered section of the collecting pipeline, do not exceed 2-3 mmH_2O / meter of length of tapered pipeline.

THE PNEUMATIC CONVEYOR INSTALLATION WITH CASCADE FANS

The principle that resides at the basis of this application is the „Principle of cascade pumps". In order to optimize the investment costs for a grinding mill unit, by reducing the number of equipment items required, a new concept has been developed for pneumatic conveyors from within a grinding section (Figure 2). This involves the use of a single filter that services at the same time the pneumatic conveyor and also the vacuum installation of the grinding section.

The pneumatic conveyor fan is positioned between the main collecting pipeline and the separating filter, while the vacuum fan is positioned after the filter. Both the evacuation of the pneumatic conveyor fan and the vacuum installation of the grinding section are connected to the entrance joint of the non-purified air in the filter.

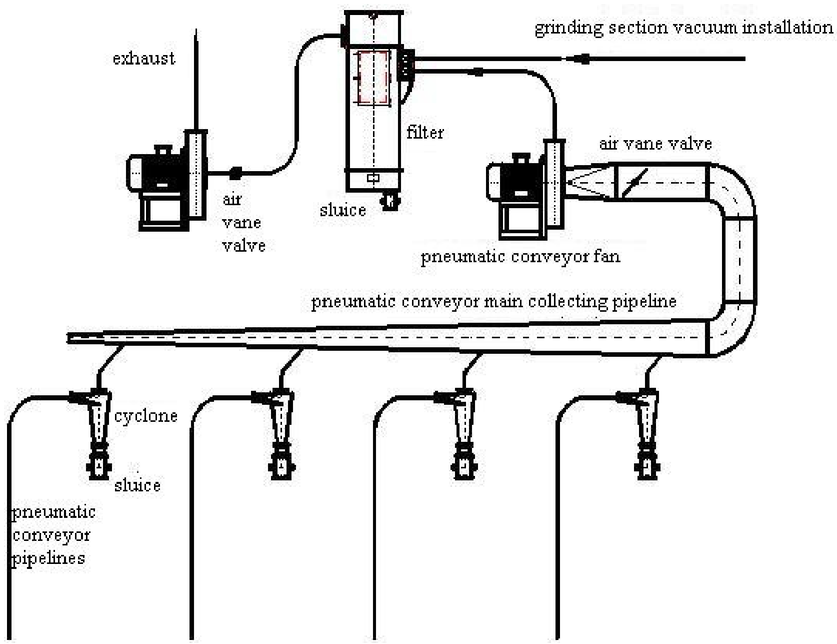

Figure 2. Pneumatic conveyor installation based on the principle of cascade pumps

The dimensioning of the work capacity of the fans and of the filter is performed as follows:

1. The fans

First of all, the pneumatic conveyor fan measure is determined as follows:

a. The size of the pneumatic conveyor pipelines is determined and the air flow required for every pipeline is established. The air flow values are added up, then 15% of the sum obtained is added on top of that and the resulted air flow value is noted as *Lp* (Pavlov, 1988).
b. The pressure losses are calculated for every one of these pipelines.

c. The heaviest pipeline, i.e. the pipeline with the largest pressure loss, is identified, and 15% is added on top of the obtained value and then is noted as Hp.
d. The air flow necessary for the vacuum installation is calculated, it is noted as La and 15% is added on top of that to compensate for the infiltrated air in the system.
e. The pressure losses are calculated on the heaviest branch of the vacuum installation, and 15% is added on top of the obtained value and is noted as Ha.
f. The pneumatic conveyor air flow Lp is added up to the necessary air flow of the vacuum installation La and the necessary air flow for the vacuum fan is noted as Lv.
g. The pressure necessary for the pneumatic conveyor fan is calculated as follows:

$$Htp = Hp - Ha \text{ , [mm CA] ,} \qquad (3)$$

h. The pneumatic conveyor fan is chosen by taking into account the Htp and Lp parameters.
i. The vacuum fan is chosen by taking into account the Lv and Ha parameters.

2. The filter

As opposed to the classic pneumatic conveyor, where values of specific loads of 2.5 – 3.0 m^3 air / m^2 of filter surface / min are applied to the filter, the use of this configuration allows for a larger load of the filter, similar to that from the vacuum installation, of around 4-5 m^3 air / m^2 of filter surface / min. The air flow that has to be vacuumed by the filter is:

$$L_v = (L_p + L_a) \text{ ,} \qquad (4)$$

where :
L_v , [m^3/ min] , total air flow that has to be vacuumed by the filter
L_p , [m^3/ min] , the air flow of the pneumatic conveyor fan
L_a , [m^3/min] , the air flow required to be induced by the vacuum installation
The pressure of the vacuum fan will be equal to the pressure required in the vacuum installation. This pressure will also be generated in the pipeline connecting the pneumatic conveyor fan to the filter. This way, the total generated pressure in the pneumatic conveyor system will be the sum of the pressures of the two fans.
An increased attention will be paid to the manner in which the installation is turned on and off. Hence, when turning the installation on, the vaccum fan

will be the first one to be turned on and then the pneumatic conveyor fan will be turned on, and for turning the installation off the process will be performed in reverse.

CONCLUSIONS

When compared to the classic system, the advantages of this system are obvious:

- A decrease of the investment value through the reduction of the number of filters necessary for the installation.
- A decrease in air flow consumption needed to clean the filter.
- A decrease of the size of the buildings and spaces necessary to house the installation.
- A decrease of the maintenance costs.

The calculation of such a system does not present any large challenges, but a correct equilibration of the two installations is required. The system has been applied successfully to a series of grinding mills all around the country, with capacities of 50 TPD and up to and including 250 TPD of wild wheat at Grit 1 of the installation.

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