Energy consumption and simulation of pneumatic conveying lateritic mineral in dense and fluid phase

Eduardo J. Díaz, Enrique T. Tamayo, Diana M. Vélez, Diego R. Salazar, César M. Díaz and María P. Cedeño

Abstract: The mineral pneumatic conveying efficiency depends of different equipment that makes considerable impact on energy-saving. The systems are frequently operated in the dilute-phase regime or in the high air velocity region and cause higher power consumption, pipe erosion and particle degradation. Therefore even small reductions in pressure drop and conveying velocity can obtain improvements in energy-saving, pipe wear and particle degradation. The pneumatic conveying should keep the pressure drop and conveying velocity as low as possible. In order to reach this purpose, some energy-saving techniques have been developed.

To observe the relationship between the parameters involved in the pneumatic transport of lateritic mineral and obtain the necessary information about the behavior of the variables, it is necessary to simulate the transport characteristics, for which was used the mathematical model in horizontal and vertical pipes, and the losses in elbows. The simulation of pneumatic conveying systems is developed with the use of experimental - theoretical models to predict areas of lower energy consumption and make the correct selection of the systems. It plays the important role in the research of fluid and dense-phase gas solid flow. This article gave the numerical simulation conclusions based on the experimental and theoretical research.

The behavior of the specific energy consumption in function of concentration show the tendency to reduced energy consumption with increased concentration of the mixture and therefore the amount of material transported. This increased concentration is limited by the conveying characteristics depending on the system parameters and air feeder. The consumption values range from 4.23 MJ/t to 14.55 MJ/t, the latter values corresponds with the lower values of gas-solid concentration (10 to 20 kg/kg).

***Keywords**:* Energy consumption, Pneumatic conveying, Pressure drop, Conveying characteristic.

E. J. Díaz is with Equinoccial Technological University, Quito City, Ecuador Republic (e-mail: eduardo.diaz@ute.edu.ec).

E. T. Tamayo is with, Cotopaxi Technical University, Latacunga City, Ecuador Republic (e-mail: enrique.torres@utc.edu.ec).

D. R. Salazar is with Equinoccial Technological University, Quito City, Ecuador Republic (e-mail: diego.salazar@ute.edu.ec).

D. M. Vélez is with, Cotopaxi Technical University, Latacunga City, Ecuador Republic (e-mail: diana.marin@utc.edu.ec).

C. M. Díaz is with Julio Moreno Espinosa Technological, Santo Domingo de los Tsáchilas City, Ecuador Republic (e-mail: cesardiazk@yahoo.es).

M. P. Cedeño is with Julio Moreno Espinosa Technological, Santo Domingo de los Tsáchilas City, Ecuador Republic (e-mail: mariapaulina1980@hotmail.com).

I. INTRODUCTION

The pneumatic transport in the nickel companies has higher ecological indices to other mechanical conveyors. The use has been limited by excessive energy consumption. The causes of this difficulty are: the incorrect selection of the transport air speed and the infinite variety of physical and aerodynamic characteristics of materials to transport.

Pneumatic conveying is one of the most advanced means of solids transport. The most used are in the nickel industry and the transport of cement, coffee and grains.

The pneumatic conveying efficiency in the nickel industries depend of different equipment that make considerable impact on energy-saving. The systems are frequently operated in the dilute-phase regime or in the high air velocity region and cause higher power consumption, pipe erosion and particle degradation. Therefore even small reductions in pressure drop and conveying velocity can obtain improvements in energy-saving, pipe wear and particle degradation. Then as an important design criterion, the pneumatic conveying should keep the pressure drop and conveying velocity as low as possible. In order to reach this purpose, some energy-saving techniques have been developed.

The simulation of pneumatic conveying systems is developed with the use of experimental - theoretical models to predict areas of lower energy consumption and make the correct selection of the systems. It plays the important role in the research of dense-phase gas solid flow. This article gave the numerical simulation conclusions based on the experimental and theoretical research. By associating with experimental condition and the applicability of experimental equations, transport equation was deduced by using time averaged method based on instantaneous equation of gas and solid.

Two-fluid model of gas-solid turbulence in process of dense-phase gas solid two phase flow was founded, so did the corresponding numerical solution and calculating flow. The model could mention reciprocity between gas and solid, collision of particles and interaction between particle and wall.

The model development for lateritic mineral pneumatic conveying in dilute and dense phases in horizontal and vertical pipes was developed taking in consideration the variety of physical and aerodynamic characteristics the materials to transport. The principal parameters of the model are: difference of speed between the gas and the solid and flotation speed. To obtain the parameters of the model was used the differential equations solution method, Runge - Kutta fourth order [1].

In order to reduce power consumption and conveying velocity, Rinoshika and Suzuki [2] developed an experimental study of energy-saving pneumatic conveying system in a horizontal pipeline. The maximum reduction rates of the minimum velocity and power consumption by the dune model are about 19 % and 34 %, respectively.

Yan and Rinoshika [3] applied a new pneumatic conveying system where soft fins are horizontally mounted on the center plane of pipe. The maximum reduction rates of the power consumption by using soft fins are about 25.5 %. Li and Tomita [4] applied the swirling flow to pneumatic conveying system for reducing power consumption. Their studies concluded that the application of swirling flow could reduce the critical and minimum conveying velocities, the pressure drops, the fluctuations in the wall static pressure, and the power consumption.

Wypych and Yi [5] proposed a description for dense-phase pneumatic conveying and its boundaries based on a 3-layer-model. They also established a method to predict the pressure drop in a horizontal pipeline by slug-flow pneumatic conveying. The effects of air inlet velocity and the conveying capacity on the flow behavior were also discussed. Both parameters played a significant role in the conveying flow pattern and also the pressure drop.

Liu [6], Vasquez [7], Santos [8], establish the behavior of dense and fluid phase and its effect on pressure drop. They take in consideration Visual analysis and distribution the particle over the pipe cross-section.

Sarrami and Mohsen [9] perform the simulation of gas-solid flow through pipelines. They analyses the effects of air inlet velocity and the conveying capacity on the flow behavior. Both parameters played a significant role in the conveying flow pattern and also the pressure drop. Numerical Simulations of dilute and dense phase in pneumatic conveying were developed in different investigations [10]-[13]. The authors take in consideration diverse conditions: conveying in long-distance pipe, horizontal and vertical pipes, particles through a 90 degrees elbow, and gas-solid heat transfer.

In this paper, to reduce power consumption and conveying velocity, with the values of the pattern parameters, the pneumatic conveying after the lateritic mineral milling process is simulated. The behavior of the current parameters is compared with those obtained through the simulation. Transport characteristics are constructed and rational work area is established from considerations on energy consumption.

The objective of the article is get values less energy consumption from transport characteristics of lateritic mineral.

II. METHOD DEVELOPMENT

The model development for lateritic mineral pneumatic conveying in dilute and dense phases in horizontal and vertical pipes is elaborated from the simultaneous use of mass, momentum and energy balance equations.The expression (1) constitutes the theoretical model for calculation the pressure losses in lateritic mineral pneumatic conveying in function of the pipe length [1].

$$\left[-1+\frac{\varepsilon\cdot\rho_G\cdot V_g^{\,2}}{P}+\frac{1}{2}\cdot\varepsilon\cdot\rho_G\cdot\mu\cdot\frac{V_g\cdot(V_g+V_S)}{P}\right]\frac{dP}{dx}=\frac{\lambda_G}{D}\cdot\frac{\varepsilon\cdot\rho_G}{2}\cdot V_g^{\,2}+ \quad (1)$$

$$+\varepsilon\cdot\rho_G\cdot g\cdot sen\delta\cdot\left(1+\mu\cdot\frac{V_g}{V_S}\right)+\mu\cdot\varepsilon\cdot\rho_G\cdot\frac{V_g}{V_S}\cdot\left(g\cdot\frac{V_f}{V_g}\cdot\cos^2\delta+\frac{0{,}1625}{D}\cdot V_S^{\,2}\right)$$

The simplifications of these expressions in horizontal and vertical pipes are in the equations (2) and (3).

In horizontal pipes, the inclination angle is zero, for this reason

$$\left[-1+\frac{\varepsilon\cdot\rho_G\cdot V_g^{\,2}}{P}+\frac{1}{2}\cdot\varepsilon\cdot\rho_G\cdot\mu\cdot\frac{V_g\cdot(V_g+V_S)}{P}\right]\frac{dP}{dx}= \quad (2)$$

$$\frac{\lambda_G}{D}\cdot\frac{\varepsilon\cdot\rho_G}{2}\cdot V_g^{\,2}+\mu\cdot\varepsilon\cdot\rho_G\cdot\frac{V_g}{V_S}\cdot\left(g\cdot\frac{V_f}{V_g}+\frac{0{,}1625}{D}\cdot V_S^{\,2}\right)$$

In vertical pipes, the inclination angle is ninety, for this reason

$$\left[-1+\frac{\varepsilon\cdot\rho_G\cdot V_g^{\,2}}{P}+\frac{1}{2}\cdot\varepsilon\cdot\rho_G\cdot\mu\cdot\frac{V_g\cdot(V_g+V_S)}{P}\right]\frac{dP}{dx}=\frac{\lambda_G\cdot\varepsilon\cdot\rho_G\cdot V_g^{\,2}}{2\cdot D}+ \quad (3)$$

$$+\varepsilon\cdot\rho_G\cdot g\cdot\left(1+\mu\cdot\frac{V_g}{V_S}\right)+\mu\cdot\varepsilon\cdot\rho_G\cdot\frac{V_g}{V_S}\cdot\frac{0{,}1625}{D}\cdot V_S^{\,2}$$

In table 1 the results of flotation and relative velocity are exposed for each one of particles diameters. The flotation velocity was determined experimentally in [1]; the relative velocity is determined by adjustment of the model.

Table 1 Relative and flotation velocity values for different diameters of particles.

	Horizontal pipe			Vertical pipe		
dx (mm)	V_{gA}-V_{SA} (m/s)	Vf_A (m/s)	E (%)	V_{gA}-V_{SA} (m/s)	Vf_A (m/s)	E (%)
0,250	4,27	5,21	7,84	2,32	5,21	7,10
0,1875	3,6	4,74	8,02	1,97	4,74	8,53
0,1075	3,39	3,83	9,31	1,51	3,83	10,07
Mezcla	5,18	5,21	9,54	2,74	5,21	7,04

In the nickel company there are three main groups of pneumatic conveying systems:

- Pneumatic conveying from the drying to the mills process (system 1).
- Pneumatic transport from the mills process to the silos (system 2).
- Pneumatic conveying from silos to the reduction furnaces process (system 3).

Details of the systems shown in Table 2.

Table 2 Details of lateritic mineral pneumatic conveying systems.

System	Diameter (mm)	Length (m)		Number of elbows	Amount of material (t/h)
		Horizontal	Vertical		
1	250	356	16	4	280
2	250	87	30	6	440
3	250	232	42	5	440

For the construction of lateritic mineral pneumatic conveying characteristics is necessary also to know the losses in elbows. The equation to determine the losses in elbows is the following.

$$\Delta P_{CT} = \Delta P_C + \Delta P_r \quad (4)$$

When the material arrive to the inlet of the elbow, continues moving straight ahead to the first impact zone (ΔP_C). The material is deflected at an angle toward the outlet of the elbow. The deflection angle is determined by the elbow design, the product's characteristics, the conveying velocity, and the specific load. The product will hit the secondary impact zone before exiting the elbow (ΔP_r).

Losses in the first impact zone are obtained by the equation

$$\Delta P_C = \Delta P + \Delta P_S \quad (5)$$

Losses due to the material are obtained by equation

$$\Delta P_S = \xi_S \cdot \rho_S \cdot \frac{V_g^{\,2}}{2} \quad (6)$$

The resistance coefficient, ξ_S

$$\xi_S = A\cdot\left(\frac{R}{D}\right)^{0,5}\cdot \mathrm{Re}^{0,1}\cdot \mathrm{Re}_s^{\,0,35}\cdot\left(\frac{D}{d}\right)^{0,2}\cdot F_{rs}^{\,-0,65}\cdot F_r^{\,0,35}\cdot\mu^{-1,09} \quad (7)$$

Losses in the secondary impact zone are obtained by the equation

$$\Delta P_r = \beta \cdot \rho_G \cdot \frac{V_g^{\,2}}{2} \quad (8)$$

For the vertical configurations

$$\beta = 1,55\cdot 10^2 \cdot \mathrm{Re}_s^{\,-0,15}\cdot\left(\frac{\rho_S}{\rho_G}\right)^{-0,45}\cdot\left(\frac{D}{d}\right)^{-0,1}\cdot\mu^{2,59} \quad (9)$$

For the horizontal configurations

$$\beta = 0,28\cdot 10^2 \cdot \mathrm{Re}^{0,4}\cdot \mathrm{Re}_s^{\,-0,8}\cdot Fr^{0,3}\cdot\left(\frac{\rho_S}{\rho_G}\right)^{-0,9}\cdot\left(\frac{D}{d}\right)^{-0,5}\cdot\mu^{3,81} \quad (10)$$

Energy cost

The energy consumption of mineral pneumatic transport systems depends fundamentally on the air and material feeder. Considering the pressure losses in the supply chamber and the separator, the power demand is estimated from the following expression.

$$N = 177 \cdot M_g \cdot Ln\left(\frac{P_1}{P_2}\right) \quad (11)$$

If the above equation is divided by the amount of transported material, the specific energy demand is obtained. With these results and the transport characteristics are estimated of rational parameters of lateritic mineral pneumatic conveying systems and predict the behavior of any other system.

III. Results and Discussion

The behavior of the pressure loss for different pipe diameters, horizontal and vertical configurations was simulated with the use of models obtained by Torres et al [1]. The figures 1 and 2, examine the influence of gas velocity in Pressure Loss during pneumatic transport of lateritic mineral.

In Figure 1 the low gas velocity values are observed for the low pressure losses, this area corresponds with the transition between the fluid and dense phase. From these values the pressure losses increase with increasing gas velocity and a rapid reduction in the concentration of the mixture occurs. In horizontal pipes the average value of the transport speed is 6.12 m/s.

In the zone of low pressure drop, reducing the gas speed causes a rapid increase in the concentration of solid. The gas cannot transport all the material and collect in the bottom of the pipe. In Figure 2, for vertical pipes, the average value of the transport speed is 5.21 m/s. In the systems is necessary to choose the conveying minimum speed.

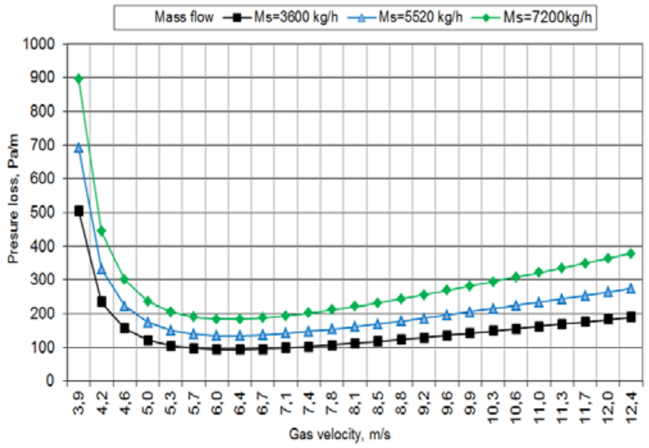

Fig. 1 Pressure drop behavior in function of the gas speed for horizontal pipes

Once these results are known, in addition to setting the speed of change between dense and fluid phases, can be built characteristics of pneumatic conveying in industrial conditions, determine the rational parameters, define the specific energy consumption and simulate the behavior of any other system working.

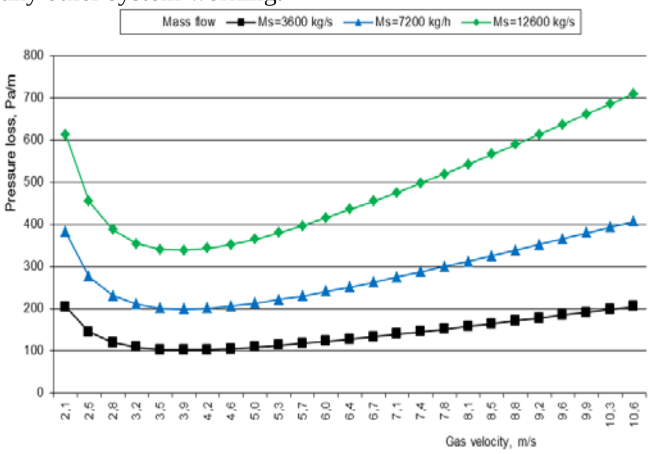

Fig. 2 Pressure drop behavior in function of the gas speed for vertical pipes

The pressure drop in the elbows increases with mass flow and concentration of the mixture (figure 3). The highest values of pressure losses correspond to concentrations of 60 kg/kg. The values of pressure drop reach $2.3\text{x}10^3$ Pa/m when gas mass flow is 0.8 kg/s.

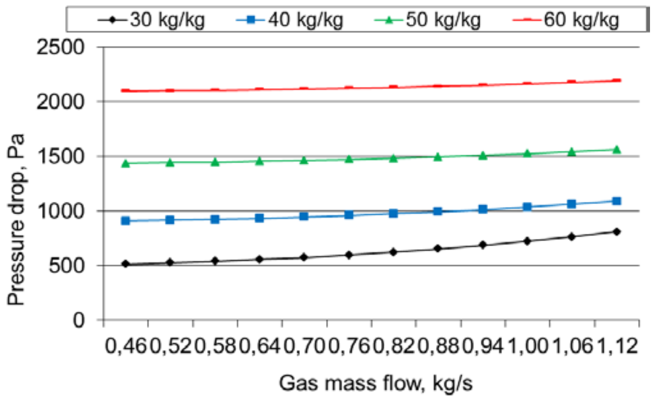

Fig. 3 Pressure drop behavior in function of the gas speed for elbows

Simulation of transport characteristics in horizontal and vertical pipes

In the analysis of losses elbows is necessary to consider the position in which it is placed, can be horizontal or vertical; although the influence of the position is not significant in losses for industrial systems. These results are not sufficient to define the parameters of pneumatic transport, although allow to obtain preliminary criteria, which are complemented by the analysis of transport features, and energy specific consumption of the systems.

To observe the relationship between the parameters involved in the pneumatic transport of lateritic mineral and obtain the necessary information about the behavior of the variables, it is necessary to simulate the transport characteristics, for which was used the mathematical model in horizontal and vertical pipes, and the losses in elbows (equations 2-10).

The operating point of a pneumatic conveying system can be specified by three fundamental parameters:

- The variation of the solid mass flow through the pipe.
- The variation of gas mass flow used for transporting solids.
- The pressure drop required to transport the flow.

The first parameter specifies the point of system performance and the other, the operating point of the air feeder (usually the most expensive component of the system). With the use of the three possible range of operating conditions achieved by a bulk material in a particular system is defined, this behavior is known as the transport of materials feature.

The behavior of the solid mass flow depending on gas mass flow and pressure drop necessary to convey the material is exposed to different concentrations in the transport characteristics. These are simulated for horizontal, vertical pipes and elbows.

In horizontal pipes this behavior is observed in Figure 4. The values of rational work of pneumatic conveying systems are to the left of the figures, where the highest concentration values and lower pressure losses are achieved. With increasing concentration of the mixture, increases the solid mass flow, but this is accompanied by increased pressure drop in the system. The selection of rational parameters and working with the graphs of transport characteristics is necessary to consider the energy specific consumption.

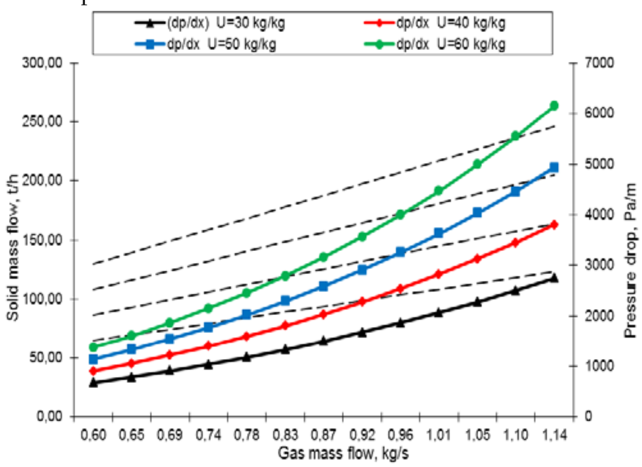

Fig. 4 Pneumatic conveying characteristic of lateritic mineral in horizontal pipes, D=200mm

The highest values of pressure drop correspond to concentrations of 60 kg/kg. The pressure drop increases with the mixture concentration and the mass flow of gas. The minimum values of the pressure drop (below to $3x10^3$ Pa/m), correspond with the values of the mass flow of gas, less than 0.8 kg/s. The values of solids mass flow reach 120 t/h, allowing transport the quantity of material needed at each stage of the process (Figure 4).

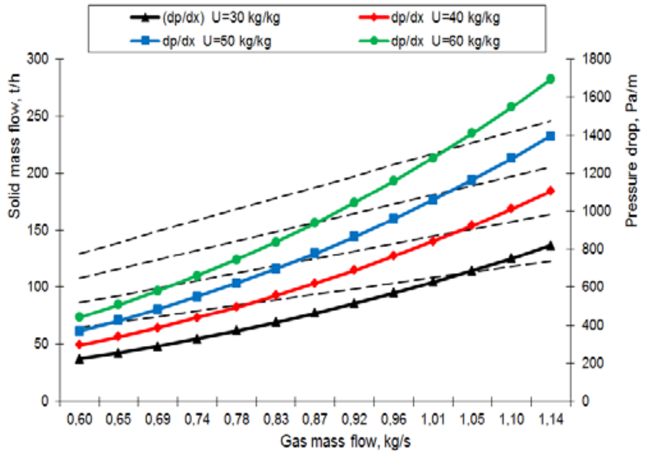

Fig. 5 Pneumatic conveying characteristic of lateritic mineral in horizontal pipes, D=250mm

Transport speed of the solid-air mixture in horizontal pipes is reduced with increasing pipe diameter. Pressure drop in pneumatic conveying of solids also is reduced. Comparing figures 4 and 5 show that is possible to reduce the pressure drop around 30 %, when increase pipe diameter from 200 mm to 250 mm in the transport of lateritic mineral.

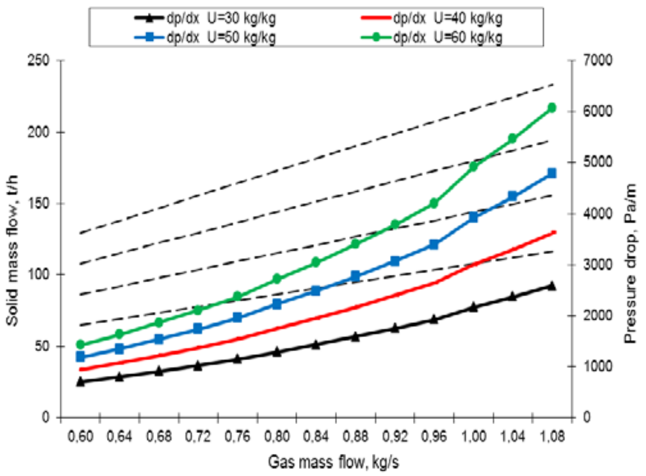

Fig. 6 Pneumatic conveying characteristic of lateritic mineral in vertical pipes, D=200mm

Pneumatic conveying characteristic of lateritic mineral in vertical pipes is observed in Figure 6. The pipe diameter is 200 mm. Comparing figures 4 and 6 for the same diameter; the pressure losses in the vertical transport are bigger than the horizontal one. The values of pressure drop for a vertical transport reach $3.5x10^3$ Pa/m when gas mass flow is 0.8 kg/s. The values in horizontal conveying are less than $3.5x10^3$ Pa/m.

In vertical pneumatic conveying, the total pressure drop is due to acceleration, gravity, and wall friction. Comparing figures 6 and 7, for a fixed solid mass flow rate, reducing the gas flow rate (increasing the pipe diameter from 200 mm to 250 mm) the frictional resistance of the flowing mixture is reduced.

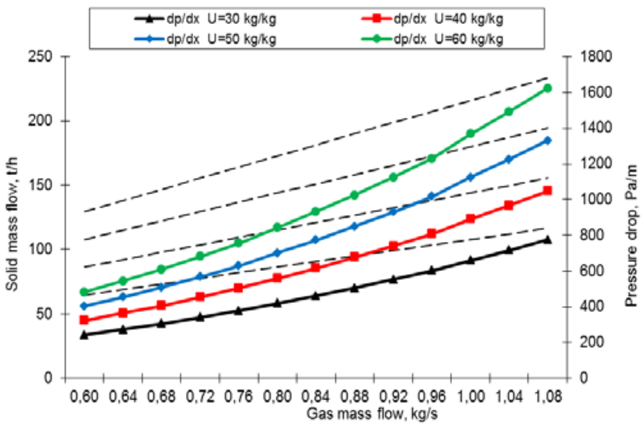

Fig. 7 Pneumatic conveying characteristic of lateritic mineral in vertical pipes, D=250mm

When decreasing the gas velocity the change in the frictional resistance predominates and the pressure drop decreases. A further lowering of gas mass flow causes a rapid rise in solid mass flow and static head that produces an increase in pressure drop. This opposition of forces that change with flow rate in the opposite direction results in the occurrence of a minimum in the pressure drop curve, which is known as chocking behavior.

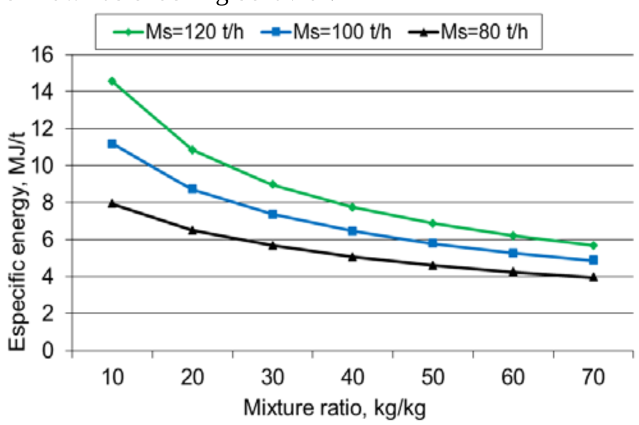

Fig. 8 Behavior the specific energy consumption depending on the mixture ratio

The behavior of the specific energy consumption in function of concentration is shown in Figure 8. The tendency to reduced consumption with increased concentration of the mixture and therefore the amount of material transported can be observed. This increased concentration is limited by the conveying characteristics depending on the system parameters and air feeder. The consumption values range from 4.23 MJ/t to 14.55 MJ/t, the latter values corresponds with the lower values of gas-solid concentration (10 to 20 kg/kg).

IV. CONCLUSIONS

In the analysis of losses elbows is necessary to consider the position in which it is placed, can be horizontal or vertical. The values of pressure drop reach $2.3 x 10^3$ Pa/m when gas mass flow is 0.8 kg/s.

The pressure drop increases with the mixture concentration and the mass flow of gas. The minimum values of the pressure drop (below to $3 x 10^3$ Pa/m), correspond with the values of the mass flow of gas, less than 0.8 kg/s. The values of solids mass flow reach 120 t/h, allowing transport the quantity of material needed at each stage of the process.

The pressure losses in the vertical transport are bigger than the horizontal one. The values of pressure drop for a vertical transport reach $3.5 x 10^3$ Pa/m when gas mass flow is 0.8 kg/s. The values in horizontal conveying are less than $3.5 x 10^3$ Pa/m.

In vertical pneumatic conveying, the total pressure drop is due to acceleration, gravity, and wall friction. For a fixed solid mass flow rate, reducing the gas flow rate (increasing the pipe diameter from 200 mm to 250 mm) the frictional resistance of the flowing mixture is reduced. When decreasing the gas velocity the change in the frictional resistance predominates and the pressure drop decreases.

The behavior of the specific energy consumption in function of concentration show the tendency to reduced energy consumption with increased concentration of the mixture and therefore the amount of material transported. This increased concentration is limited by the conveying characteristics depending on the system parameters and air feeder. The consumption values range from 4.23 MJ/t to 14.55 MJ/t, the latter values corresponds with the lower values of gas-solid concentration (10 to 20 kg/kg).

Nomenclature:

$\mathcal{E}$ - mixture porosity
δ- angle of pipe
Vg - gas velocity, m/s
V_f- flotation velocity, m/s
ρ_G - air density, kg/m^3
λ_G - gas friction coefficient
ρ_s - solid density, kg/m^3
ξ_S - resistance coefficient
μ- mixture ratio, kg/kg
D- Pipe diameter, m
d- material diameter, m
ΔP_{CT} - total losses in the elbow; Pa
ΔP_c - losses in the first impact zone; Pa
ΔP_r - losses in the secondary impact zone; Pa
ΔP- losses for clean air; Pa
ΔP_s - losses due to the material; Pa
A- Coefficient depending on the elbow position
Re, Re_s- Reynolds number for air and solid
Fr, Fr_s- Froude number for air and solid
R- elbow radius, m
β- loss coefficient in the secondary impact zone
N- power demand, kW
R- air mass flow, kg/s
P_1, P_2- inlet and outlet pressure, bar

REFERENCES:

[1] Torres T. E., et al. Consideration about lateritic mineral pneumatic conveying in dense phase. International Journal of Mechanics (2015), vol. 9, pp. 343 – 348. ISSN: 19984448.
[2] Rinoshika, A.; Suzuki, M. An experimental study of energy-saving pneumatic conveying system in a horizontal pipeline with dune model. // Powder Technology. 198, (2010), pp. 49-55.
[3] Yan F., A. Rinoshika. An experimental study on a horizontal energy-saving pneumatic conveying system (2015). The 7th World Congress on Particle Technology (WCPT7). Procedia Engineering 102, pp. 1056 – 1063. http://www.elsevier.com/locate/procedia.
[4] Li H., and Y. Tomita, An Experimental Study of Swirling Flow Pneumatic Conveying System in a Vertical Pipeline (1998), Trans. ASME, J. Fluids Eng., 120, pp. 200-203.
[5] Wypych P. W. and J. Yi. Minimum transport boundary for horizontal dense-phase pneumatic conveying of granular materials (2003). Powder technology, Vol.129, pp111-121.
[6] Liu S. et al. Characteristics of gas-solid two-phase flow in axial and swirling flow pneumatic conveying. Tehnički vjesnik 21, 4(2014), pp. 741-750.

[7] Vasquez et al, (2008), “Visual analysis of particle bouncing and its effect on pressure drop in dilute phase pneumatic conveying”, Powder Technology, 179, 170 – 175.
[8] Santos S. M. et al. Dilute-phase pneumatic conveying of polystyrene particles: pressure drop curve and particle distribution over the pipe cross-section (2011). Chemical Engineering 28 (1), pp. 81 – 88.
[9] Sarrami A F., Mohsen N. CFD Simulation of Gas-Solid Two-Phase Flow in Pneumatic Conveying of Wheat (2015). Chemical Engineering Vol. 34, Issue 4, pp. 123-140.
[10] Laín S., M. Sommerfeld, and B. Quintero (2009). Numerical simulation of secondary flow in pneumatic conveying of solid particles in a horizontal circular pipe. Chemical Engineering 26 (3), pp. 583 – 594.
[11] Zongming Liu, Guangbin Duan and Kun Wang (2011). Numerical Simulation of Dense Phase Pneumatic. Conveying in Long-Distance Pipe, Computational Simulations and Applications ISBN: 978-953-307-430-6, InTech, pp. 373-394.
[12] Vashisth, S. and Grace, J.R. (2012). Simulation of Granular Transport of Geldart Type-A, -B, and -D Particles through a 90 Degrees Elbow. Industrial & Engineering Chemistry Research, 51, 2030-2047.
[13] Rajan, K.S., Srivastava, S.N., Pitchumani, B. and Mohanty, B. (2006) Simulation of Gas-Solid Heat Transfer during Pneumatic Conveying: Use of Multiple Gas Inlets along the Duct. International Communications in Heat and Mass Transfer, 33, 1234-1242. .

Eduardo Javier Díaz Chicaiza (M'2016). He was born in Ecuador, Year 1977, graduate of Mechanical Engineer (2004) in Polytechnic Higher School of Chimborazo, Ecuador. Electromechanical Master (2015) in Cotopaxi Technical University, Latacunga City, Ecuador. Currently working in the Electromechanical Engineering Department, Engineering Faculty, Equinoccial Technological University, Quito City, Ecuador Republic. He is expert in thermal and fluids process, has developed investigations related with heat transfer in industrial processes, transport of two-phase and single-phase fluids; modeling and simulation of thermal processes and transportation of fluids with the employment of finite elements method.

Enrique Torres Tamayo (M'2015). He was born in Cuba, Year 1966, graduate of Mechanical Engineer (1993) and Electromechanical Master (1999) in the Mining and Metallurgical Higher Institute of Cuba, Doctor in Technical Sciences (PhD) in the Cuban Sciences Academy (2003).
He worked in Mechanical Engineering Department at Mining and Metallurgical Higher Institute of Cuba from 1993 to 2014, currently working in the Electromechanical Engineering Department, Cotopaxi Technical University, Latacunga City, Ecuador. He is expert in thermal and fluids process, has developed investigations related with heat transfer in industrial processes, transport of two-phase and single-phase fluids; modeling and simulation of thermal processes and transportation of fluids with the employment of finite elements method.