EVALUATION OF PRESSURE DROP IN FIXED BED FLOW OVER POROUS

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Abstract. *Many studies are conducted about the dynamics of fluids in porous media, which generates a number of factors and issues have been resolved. In particular the phenomenon of pressure drop in flows over a fixed bed, although fairly well in the form of the Ergun equation, still has certain inconsistencies with regard to the types of materials to be employed in the packaging of the beds. The objective of this work is to study this phenomenon using some experiments reported in the literature to determine the pressure drop in fixed bed consisting of porous particles of açaí seeds. Experimental studies were performed to predict, being taken into account losses resulting from friction and inertia which showed a strong dependence on speed.*

Keywords: *pressure drop, fixed bed, Ergun's equation, bed porosity, açaí's seeds.*

1. NOMENCLATURE

D_p	(m)	Particle Diameter	$V_{reactor}$	(m³)	Reactor Volume
f_p	(-)	Particle Friction Factor	V_{Seed}	(m³)	Particle Volume
L	(m)	Bed Length	x	(m)	Cartesian axis direction
M_{bed}	(g)	Bed Mass	y	(m)	Cartesian axis direction
m_{seed}	(g)	Particle Mass	z	(m)	Cartesian axis direction
Re_p	(-)	Reynolds Number of Particle	**Greek symbols**		
U	(m/s)	Superficial Velocity	ε	(-)	Porosity
V_{bed}	(m³)	Bed Volume	ρ	(m³/kg)	Fluid Density
V_{empty}	(m³)	Volume of Void	μ	(m²/s)	Fluid Viscosity dynamic

2. INTRODUCTION

In the dynamics of fluids in porous beds many studies are focused on different applications including flow fixed bed which we can draw important information, among them the application of these beds in the art gasification. How important is determining the pressure drop caused by the bed is the target of study in the first instance the data base search with equations conductors in the literature. In the regional overview gasification comes to using native biomass peculiar being one of the Biomass legitimate açaí Amazon studied the art of gasification.

Keyser et al. (2006) pressure drop and flow distribution of gas through packed carbon layers. This knowledge is fundamental helpful in better understanding the operational performance of fixed bed gasifiers dry bottom. The results show a general observation is that the known Ergun equation for the pressure drop of fluid through the packed bed is not suitable if the size distribution of coal becomes too large. In this case, the decrease of actual pressure exceeds the pressure drop provided by the Ergun equation.

Macdonald et. al (1979) (Churchill, 1988; Kaviany, 1995) used successfully Equation Forchheimer and correlating the data separately for different porous beds in terms of various parameters including the surface roughness of the particle. To implement these models for the gasifiers, remaining uncertainties varying the diameter of the tube to particle beams and drag due to the wall of the reactor.

Methodologies are sought including Sharma et al. (2004) developed an interesting fluid analysis by relating the flow of air and gas through the porous bed of biomass gasifier within creasing fluid flow and a particle size decreasing in the direction of flow.

This work examined the theory based on the Ergun equation and its forecast to a range of particle Reynolds number in various lengths distributed bed. The theoretical equation was compared with experimentally obtained data. For this research, it took several parameters such as diameters of açaí seeds, seed weight and volume occupied by the bed that will provide us with the area not occupied by the seeds. This study also determined the porosity of the bed which has to be the foundation in the theory of differential flows in fixed beds.

3. METHODOLOGY

3.1 Analytical solution according to the Ergun equation

Ergun (1952) combined the Carman (1937)-Kozeny (1927) equation and Blake Plummer (1928) in the form of the Forchheimer equation, which provided the following equation:

$$\frac{\Delta P}{L} = 150\frac{(1-\varepsilon)^2}{\varepsilon^3}\frac{\mu U}{D_p^2} + 1.75\frac{(1-\varepsilon)}{\varepsilon^3}\frac{\rho U^2}{D_p} \quad (1)$$

The equation counts the energy losses viscous and inertial relates to dynamic variable, the fluid velocity, as well as the structure of the bed, as characterized by the average porosity of the bed. There is no specific equation for the case in this study, so we seek the possibility to use it. It is used in the dimensionless form of the same by the friction coefficient.

$$f_p = 1.75 + \frac{150(1-\varepsilon)}{\mathrm{Re}_p} = \frac{\Delta P D_p}{\rho L U^2}\frac{\varepsilon^3}{(1-\varepsilon)} \quad (2)$$

$$\mathrm{Re}_p = \frac{\rho U D_p}{\mu} \quad (3)$$

3.2 Porosity

Porosity (ε) is determined as a relation between the dimensionless spaces not occupied by particles (V_{empty}) at a given total volume ($V_{reactor}$) to be filled (Nield and Bejan, 1992). For the analysis of voidage has the relationship is:

$$\varepsilon = \frac{V_{empty}}{V_{reactor}} = \frac{V_{reactor} - V_{açaí}}{V_{reactor}} \quad (4)$$

Where $V_{açaí}$ is the volume occupied by the açaí's seeds in the reactor obtained by:

$$V_{açaí} = V_{seed}\frac{M_{açaí}}{m_{seed}} \quad (5)$$

Two variables are properties corresponding to the volume and weight of each seed açai respectively (V_{seed} and m_{seed}) separate experiments performed in large populations in order to obtain a lowest possible error using the *Student-t test* method for evaluating errors. The volume of açaí as determined according to three directions X, Y and Z shown in fig.1.

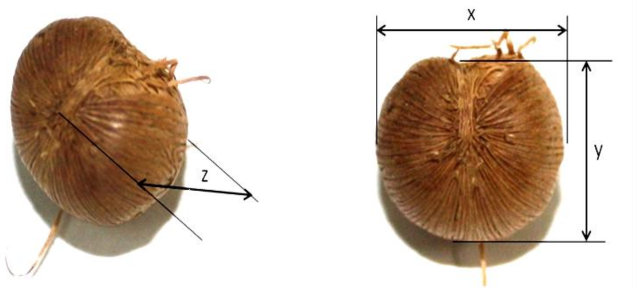

Figure 1. Three directions of measures for the diameters from açaí.

The determination of $M_{açaí}$ is performed through an experiment to determine the density of the particles measuring several volumes occupied by weight.

3.2 Data collection

The experiments were performed in a wind tunnel of low turbulence and in the outlet was interconnected a PVC pipe, fig.2. The pressure drop data were collected using a micro digital manometer. The data were all saved in files in spreadsheets by which facilitated the handling and processing of these data.

The bed length variation were arranged in order to grow arithmetically to the internal diameter of the tube, the length range is from 0.5D up to 3.5D. For this experimental study seven different lengths of beds were used. The diameter of the PVC used in this experiment is the same diameter of the gasifier downdraft reactor used on the laboratory for gasification phenomena study.

Figure 2. View of the PVC pipe coupled to a wind tunnel.

4 RESULTS

4.1 Results of porosity

The analysis of seeds followed for measuring various populations to the average diameter was used to 100 seeds, for the evaluation of the mean weight of 230 seeds were collected. The results are shown in Table 1.

Table 1. Measurements of Açaí's seeds.

Property	Value
Medium diameter (cm)	1.013975 ± 0.01436
Medium Volume (cm³)	0.574483 ±0.000003
Average mass (g)	0.693109 ± 0.027869

Then the calculations for the various bed porosity used in the experiment presented in a curve shown in fig.3.

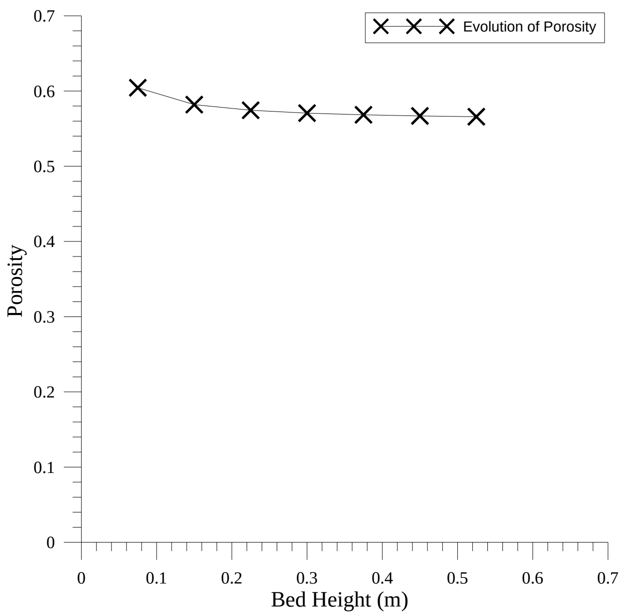

Figure 3. Evolution of Porosity.

4.1 Results of pressure drop.

The results obtained from the pressure drop data collection were all subjected to statistical treatment in order to obtain the average behavior of the phenomenon. The use of Student's t test showed up to meet the requirements to minimize measurement error and obtain more accurate data. It was obtained about 112 500 data of pressure drop and superficial velocity. To facilitate data interpretation, the pressure drop will be presented in dimensionless form of the particle Reynolds number and friction factor, shown in fig.4.

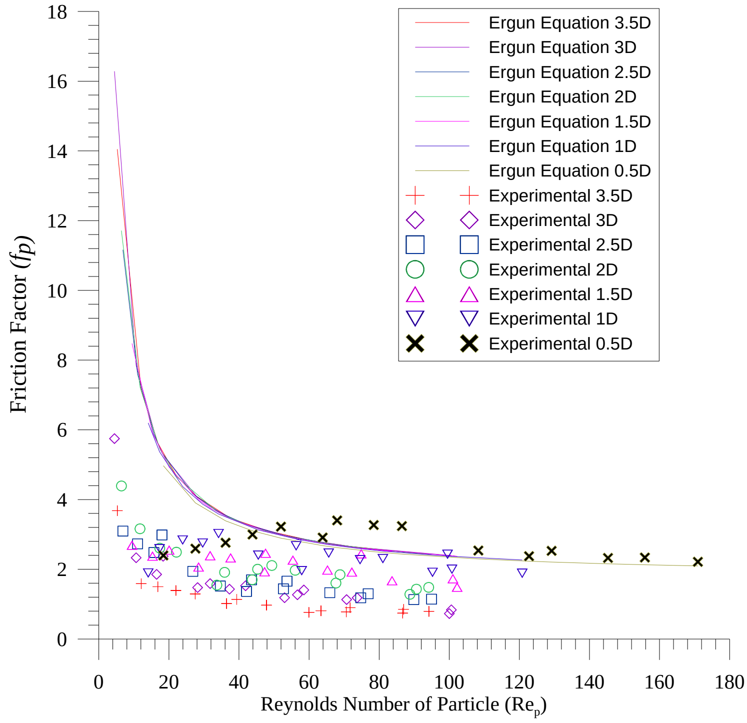

Figure 4. Comparison of experimental Ergun equation

The experiment clearly shows how much lower the bed away from the longer perspective that gives us the equation, so as not to answer satisfactorily, considering that as the process unfolds in his bed gasifier decreases, which leads us to suppose that the equation of Ergun only meets the beginning of the process, when the bed is about three times the diameter. Below this equation to derive values begins.

5. CONCLUSIONS

The experiment to collect pressure drop proceeded satisfactorily to meet the requirements of the gasifier operating under cold. We note that the respective flow rates are adjusted to meet the demand provided by the bed, so that the flow flowed closer to a duct with a decrease in bed.

The data shown in pressure drop due to the friction factor second Ergun equation shows that although different values of speed and pressure drop there is a tendency of factors in the same direction. But it should be noted that experience shows us that the behavior of the bed changes as we vary the bed and speed, thus concluding that the case of flow over a fixed bed composed of açaí's seeds does not enter into arrangements in equation Ergun doing so requires a more detailed study of how a relationship could serve this flow and so to predict its corresponding pressure drop.

6. ACKNOWLEDGEMENTS

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