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HEAD LOSSES IN VALVES AND FITTING

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ABSTRACT
Experimental teaching is very important in the education of engineering students. This activity promotes the interactivity and the participation of the students, propitiating that they acquire knowledge, skills, habits and attitudes. In this work we present an experiment in flow of fluids to get the values of K and equivalent lengths, to help the students achieve meaningful learning in this subject.

KEYWORDS: *Empirical models, flow of fluids, problem solving, experimentation.*

I.INTRODUCTION

It is accepted that the scientific method is the maximum achievement that has made it possible to use science, and that in certain cases it is applicable in some problems of everyday life. Therefore, it is desirable that the students know it, which implies its use in science and engineering (Estany 2007 [3]). The experimental method is mainly applied in the so-called natural sciences and is based on the observation of phenomena and experiments. In the experimental method, given a series of observations, we can built a model or a hypothesis, which is analyzed to find out its consequences. This model is used to make predictions that can be verified by means of experiments (Rivero, 1982[7]).

Experimental teaching is one of the most important and significant learning because it is the moment when the student related his previous knowledge with the new learning (new information). Another important role of the experimental work is to promote interactivity and participation of students, providing that they acquire not only knowledge, but skills, habits and attitudes.

1.1. Flow of fluids in the laboratory of chemical engineering:-

In the Chemical Engineering laboratory II an average of 100 students of chemical engineering, in the sixth semester in our faculty (Chemistry Faculty, UNAM) , apply their knowledge in flow of fluids. This laboratory has been built, deliberately, with appliances and equipment in which experiments that clarify the concepts stated in theoretical classes can be made.

In this laboratory, from about 10 years ago, has been thought that it is important that students develop through experimentation, models representing different phenomena of the subject. Currently, in some experiments, the students must deal with a problem, so they will develop a mathematical model for some of the phenomena under study and they must produce a script that contains the experimental development and a series of questions that guided them to the solution of the problem.

1.2 Proposed experimental work:-

Show that in the calculation of the losses due to friction in the valves and accessories depend on the geometry of design, the diameter of the pipe where they are installed and the speed of the fluid; that these losses can be evaluated as the coefficient of discharge and/or equivalent lengths.

The pressure losses in the transport of fluids are not only due to the viscosity of the fluid and to friction against the walls of the pipe, called primary losses, also occur when valves are and accessories lines, called secondary losses. When a fluid moves uniformly in a straight, long pipe and constant diameter, the configuration of the flow indicated by the distribution of velocity adopts a permanent regime. Any accessory in piping as elbows, coils, valves, reductions or enlargements that change the direction of the current or restrict its passage, alters the initial configuration flow, causing turbulence, causing a loss of additional energy that normally occurs in a flow in a straight pipe. This loss of friction energy is dissipated in swirls and additional turbulence of the fluid and it is eventually lost as heat. Accessories losses are proportional to the fluid velocity. Frequently, these losses can be evaluated using data reported in the literature from terminated experiments.

1.3. Pipe fittings:-

It is the set of castings, joining pipe to change the direction of the flow, the diameter of the pipe, or restrict the amount of flow and form the structural lines of a process plant piping. The types of the most common accessories include: flanges, elbows, tees, reductions and bottlenecks or couplings, valves, gaskets, screws and pipe nipples. Features include: type, size, alloy, strength, thickness and dimension.

1.4. Velocity heads:-

A method to calculate the friction losses the accessories cause in a pipe is the equation of D'Arcy:

$$\frac{\sum F}{M} = \frac{\Delta P}{\rho} = f_D \frac{u^2 L}{2gc\, D} \quad \text{ec. (1)}$$

f_D *frictionl factor*

$\frac{u^2}{2}$ *amount of kinetic energy in the fluid*

gc *convertion factor ……*

$\frac{L}{D}$ *leght /diameter ratio*

The equation 1 has the dimension of

$\frac{\overrightarrow{kg}}{kg} m$ *or* $\frac{\overrightarrow{lb} ft}{lb}$ *that is* [FL/M].

If equation 1 is multiplied by the factor gc / g it will have dimensions of length in meters or feet [L], and is called heads or pressure load.

Equation (1) can be rewritten as: $\frac{\sum F}{M} = \frac{\Delta P}{\rho} = K \frac{u^2}{2gc}$ (2)

Where the term K is known as the coefficient of resistance with a specific value for each accessory and every valve. Comparing equation 2 with 1 gives:

$$K = f_D \frac{L}{D} \quad (3)$$

The coefficient of resistance K is dimensionless f_D depends on the roughness of the pipe or accessory, its diameter and the Reynolds number. For valves and accessories instead of L (length of tubing is used the term Le (equivalent length).)

The pressure drop of a valve or an accessory is made equivalent to the pressure drop resulting from a straight section of pipe.

K coefficient is obtained experimentally by passing a fluid (usually water) through an accessory or a valve and measuring the pressure drop and the velocity.

The valves can offer a great resistance to flow. The pressure losses mainly depend on their design and therefore their use. For example, a gate valve is not used to regulate flow; a globe or a needle valve can regulate the amount of flow.

II. FLOW OF FLUIDS IN THE LABORATORY OF CHEMICAL ENGINEERING

In the experimental subjects that are taught in the Chemistry Faculty of the UNAM, the professors have developed scripts with a defined academic objective. These scripts include a problem, experimental development and a series of questions that guide them to the solution of the problem. It is intended that students develop models that represent different phenomena.

This article is based on the results of the script: "Determination of the discharge coefficient (K) for a 1 in commercial steel globe valve and various accessories. The experiments are conducted in a device similar to the one shown in Figure 1.

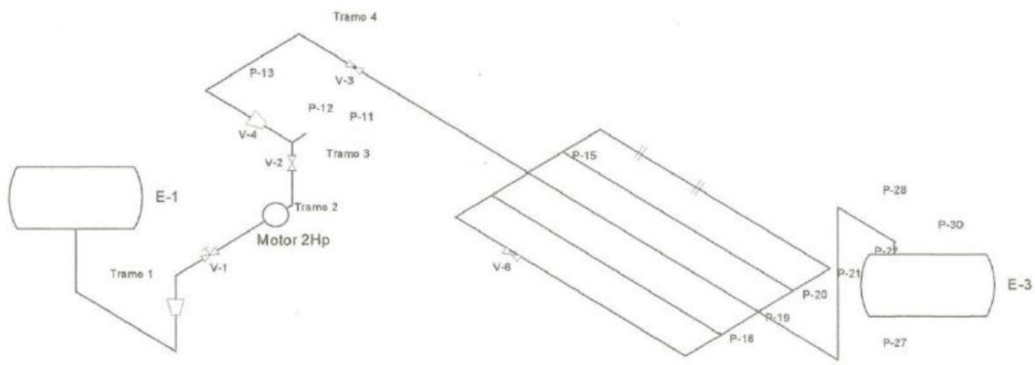


Figure 1

In such a system, water is used and the variables that can be managed are: the diameters of the pipes, the type of accessory and valves that are placed in the system. The system has two centrifugal pumps of different diameter of impeller and 3 interchangeable 1, 2 and 3 HP motors.

The reasons that led to the implementation of this script are:

- The texts explain little about the meaning of the coefficient of resistance for valves and fittings.
- The student accepts the data reported and replaces them in the equations without understanding its meaning.

2.1. Development of the experimental work to determine the coefficient K of a globe valve and some accessories:-

Academic script goal: The student will understand that the coefficient K is not a fact, and the concept of transformation of energy defined as a number of losses of pressure due to the passage of fluid through valves and accessories.

Pump, motor 2 HP and Worthington pump with impeller of 4 7/8 in diameter.

Di pipeline = 0.024308 m cross-sectional Area = 4,638 x 10^{-4} m^2

Commercial steel globe valve.

2.2. Experimental development:-

In order to perform the experiments the students have to follow the following steps.

1. Make the connection of the differential meter.
2. Remove trapped air in the hoses that connect attachment with the differential gauge type...
3. For a given globe valve, fix valve opening 0 %: 25%, 50%, 75% and 100%, measuring the pressure drop in kPa, corresponding to each of the following flows: 20, 30, 45, 55 and 60 LPM.
4. Is requested in the script that the student, determine, for each opening, the phenomenological equation between the variables: ΔP (Kg f/m^2) and v (m/s), the correct function will be when the value of R^2 is close to 1.

2.3. Experimental data:-

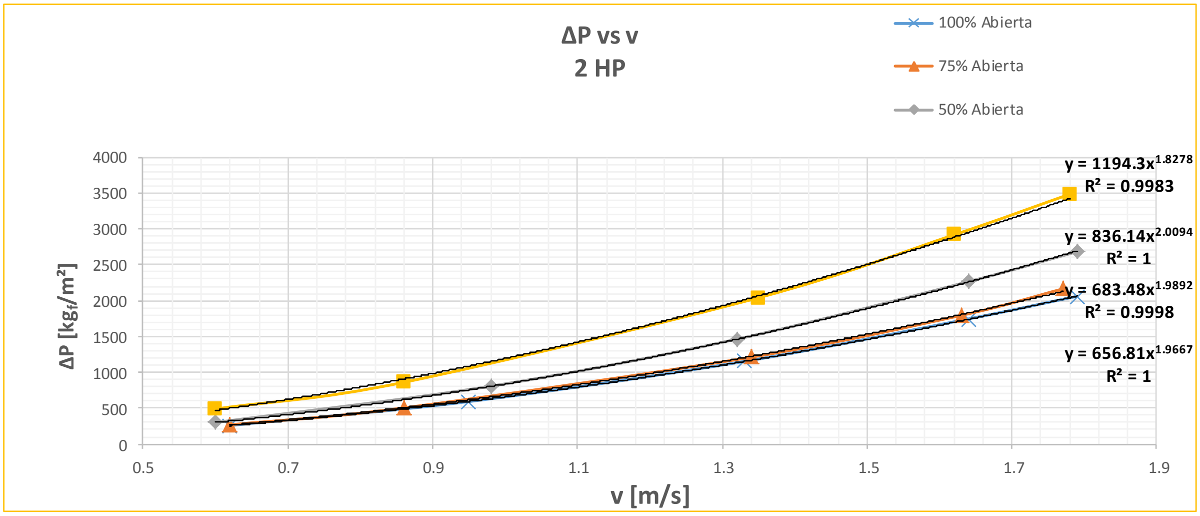
In a particular experiment the students obtained the following results:

Table 1 Data obtained for different openings of a globe valve.

Q (L/min)	ΔP (kPa)	V (m/s)	ΔP (kgf/m²)
	100 % Open		
20.7	2.52	0.62	257.04
31.7	5.8	0.95	591.6
44.6	11.28	1.33	1150.56
54.9	17.1	1.64	1744.2
59.9	20.2	1.79	2060.4
	75 % open		
20.7	2.61	0.62	266.22
28.9	4.93	0.86	502.86
44.9	11.87	1.34	1210.74
54.6	17.59	1.63	1794.18
59	21.2	1.77	2162.4
	50% open		
19.9	2.93	0.6	298.86
32.6	7.9	0.98	805.8
44	14.33	1.32	1461.66
54.8	22.2	1.64	2264.4
59.7	26.3	1.79	2682.6
	25% open		
19.9	4.78	0.6	487.57
28.7	8.43	0.86	859.86
45	20	1.35	2040
54	28.6	1.62	2917.2
59.5	34.17	1.78	3485.34

2.4 Analysis of results:-

With the results showed in the former table, the students analyzed the data and build the following graph (Fig. 2). Then, they try to find the relationship between the variables and the meaning of the exponent founded.



1 Potential relationship *y=kx^2*

Fig. - 2

The student observes in the graph that the exponent has a value approximate to 2, i.e.:

$$\frac{\Delta P}{\rho} = K\frac{v^2}{2g}$$

According to the phenomenological equation, there are two closely related variables. Then, the professor asked the student which set the new function between these variables such as energy, could use the same units: [F L/m].

Then the students try to explain the meaning of the slope of each new feature. Figure 3.

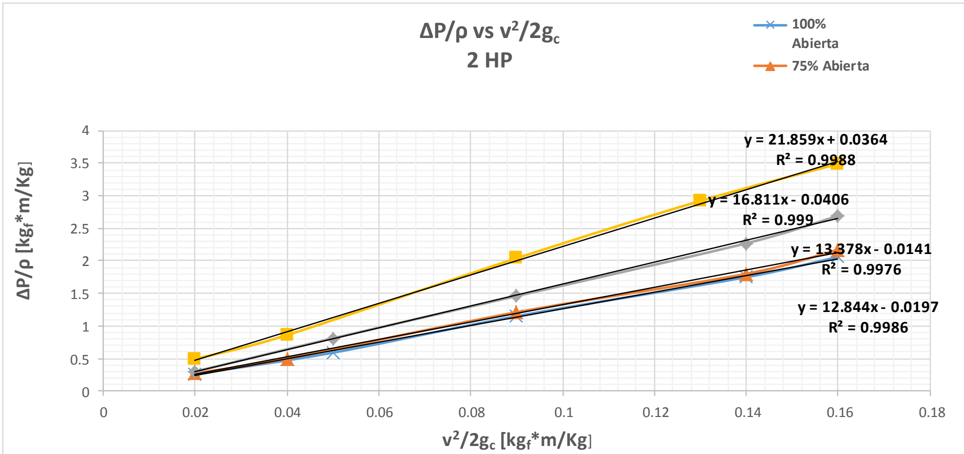


Figure 3, Lineal relationship y= *K x*

As shown in Fig. 3

$$\frac{\Delta P}{\rho} = K\frac{v^2}{2gc} = \frac{\sum F}{M} \quad (4)$$

The student follows the equation of D, Arcy

In the same way they obtained the values of K for other accessories

Elbows of 45 y 90°

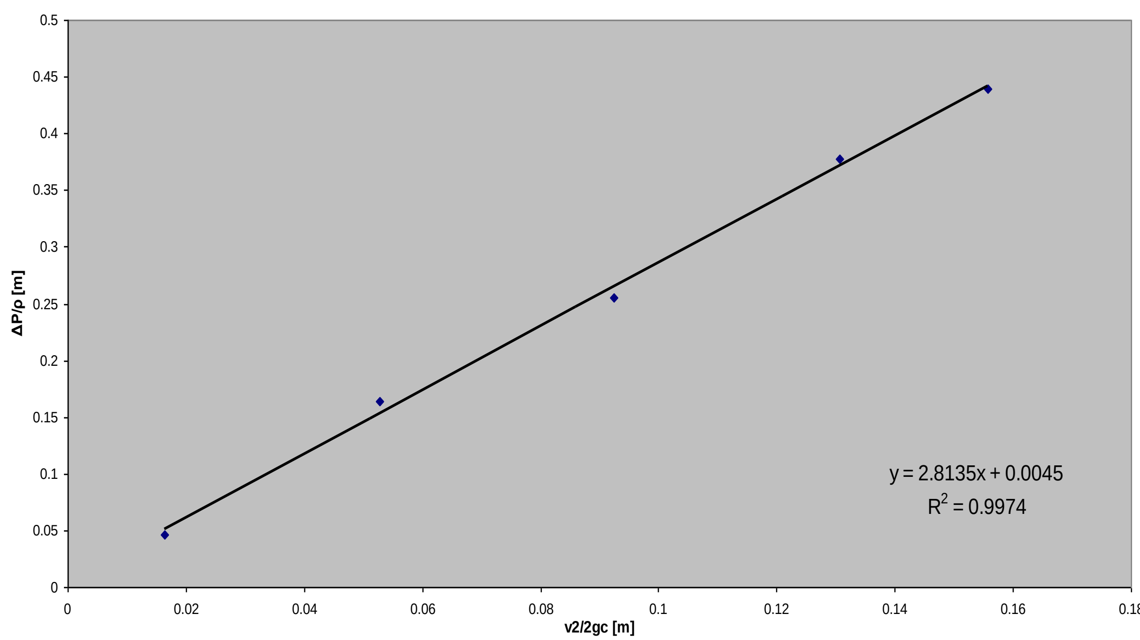


Figure 4. Elbow of 1 in 45°

$\Delta P/\rho$ vs $v^2/2g_c$

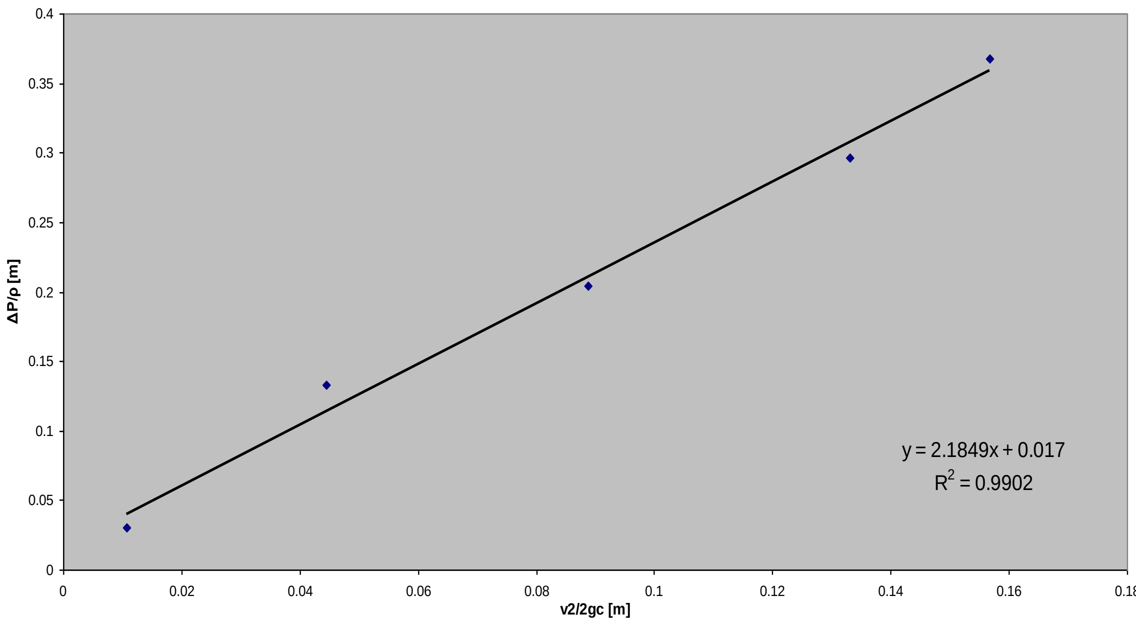


Figure 5 Elbow 1 in 90° $\Delta P/\rho$ vs $v^2/2g_c$

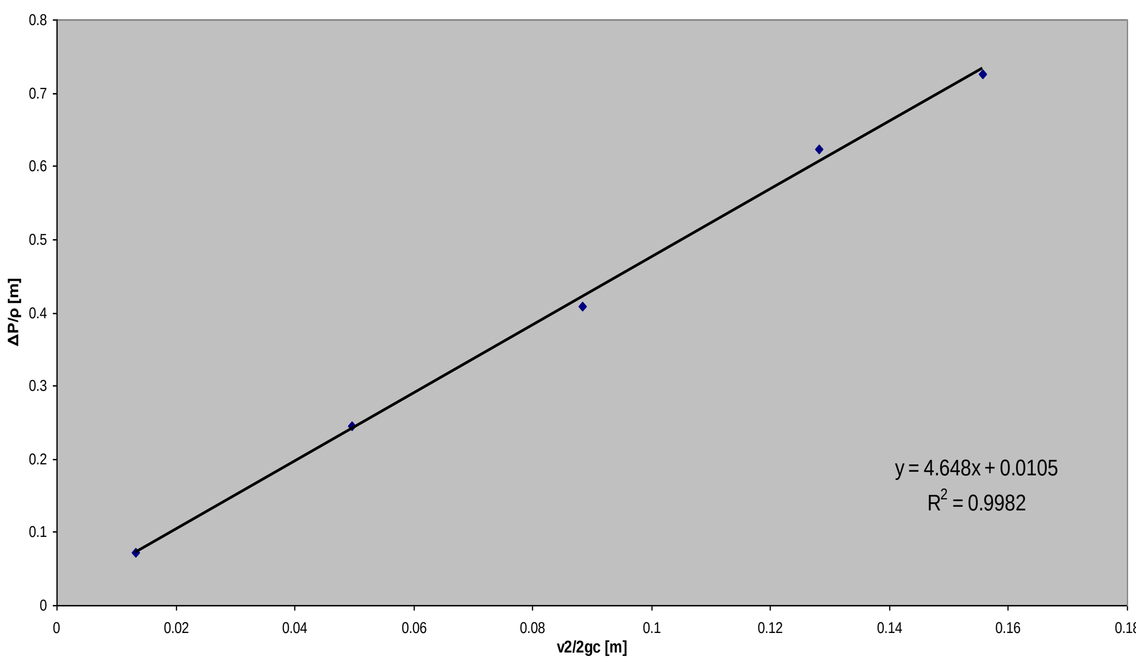


Figure. 6. - T lateral flow

III. CONCLUSIONS

Through the experimental determination of the mathematical relationship between the pressure energy and kinetic energy the students will understand that the coefficient K is a constant of proportionality between two powers and not a mere reported data.

The experiments carried out by students during their practice in the Unit Operations Laboratory show coefficients of K losses similar to those reported in the literature (Mataix [6], Azevedo [1], Crane [2], Guaycochea [4], and Ludwig [5]). However, large discrepancies were found in relation to the K for globe valves partially open.

If the engineer acquired the habit of using incorrect equations its calculations will be little consistency.

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