Data analysis of the experimental results

Two set of experiment were made on the hydraulic bench, one with the already equipped U manometers and the other one with the PASCO PS-2164 unit. This two set were made in order to prove that the experiment were achievable on the bench. It also served as a test for the every devices used for the bench.

1. flow meter comparison

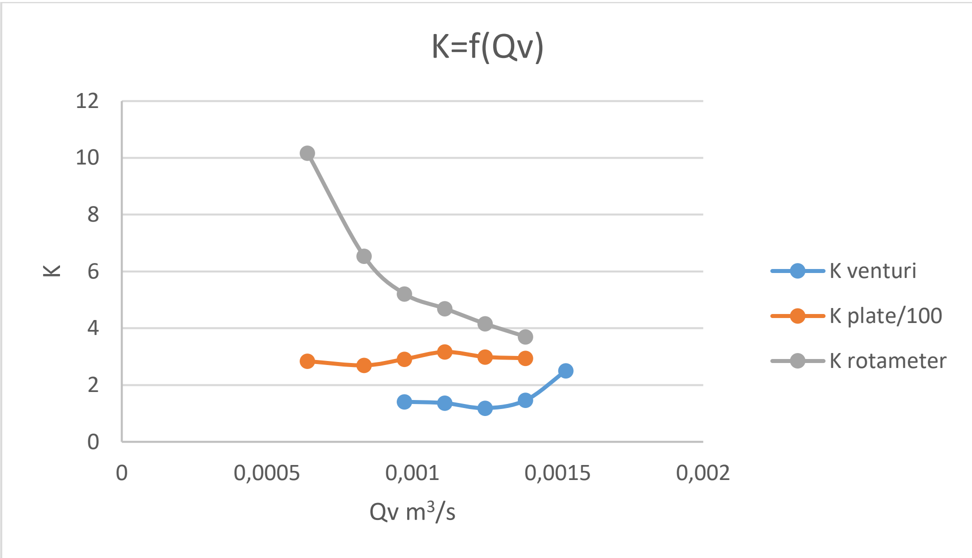

Figure 1 flow meter comparison with the quad pressure sensor

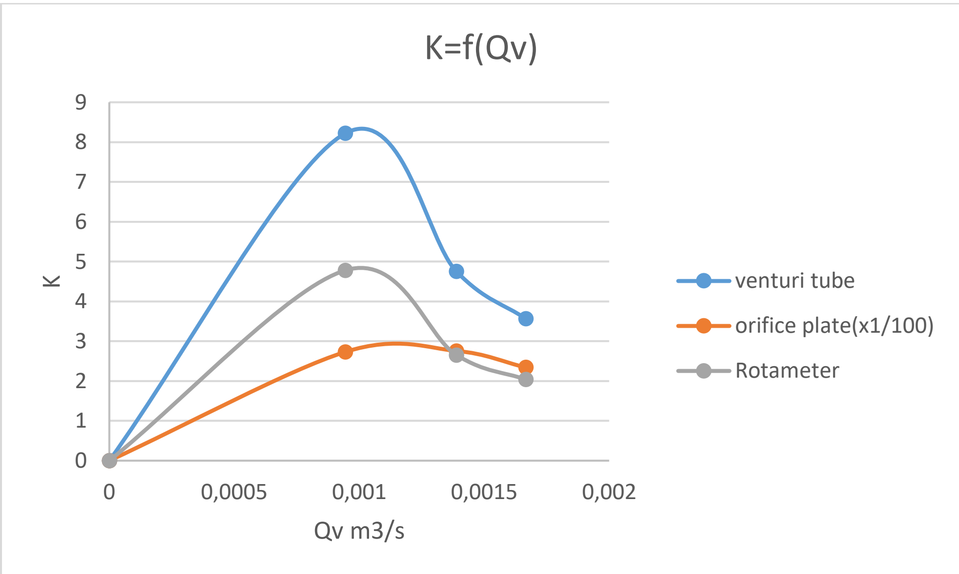

Figure 2 flow meter comparison with the embedded instrumentation

The comparison between the flow meter prove that the venturi tube have a smaller impact on the circuit, the rotameter is in second place, the third place for the orifice plate could have been predicted due to the shape of the flowmeter itself: the plate reduce considerably and abruptly the flow of water. For the experience realized with the U manometers, the head losses of the flow meter is reduced when the flow rate increase, despite multiple attempt of the experiment, the same result happen. In the other and, the quad pressure sensor show are more logical result (except for the rotameter) the head losses of the flow meters seems to be constant.

2. Head losses

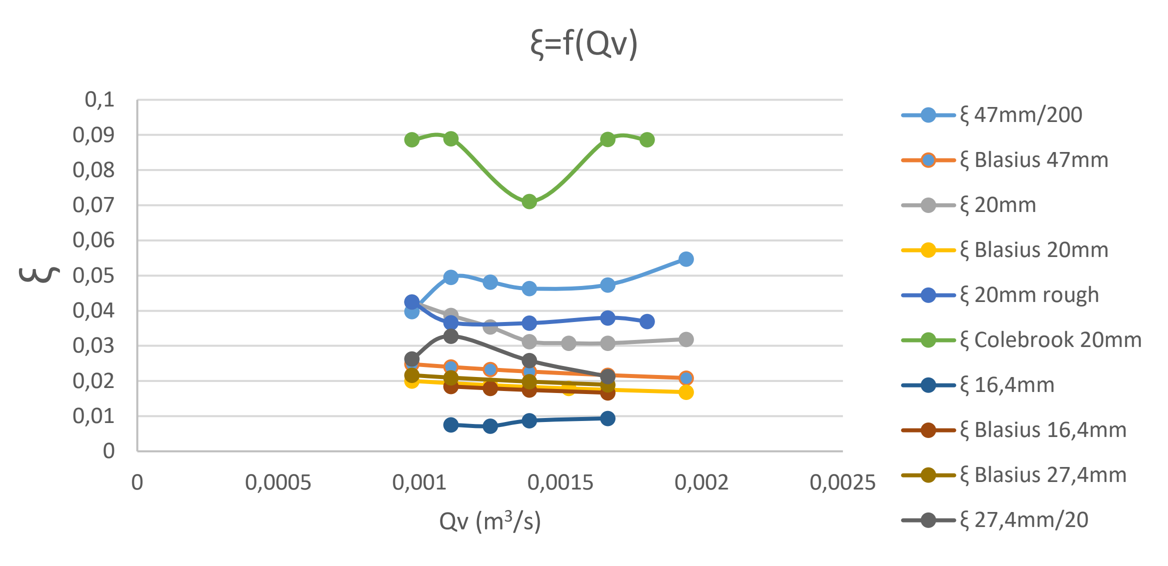

Figure 3 linear hed losses coefficient measured with embeded devices

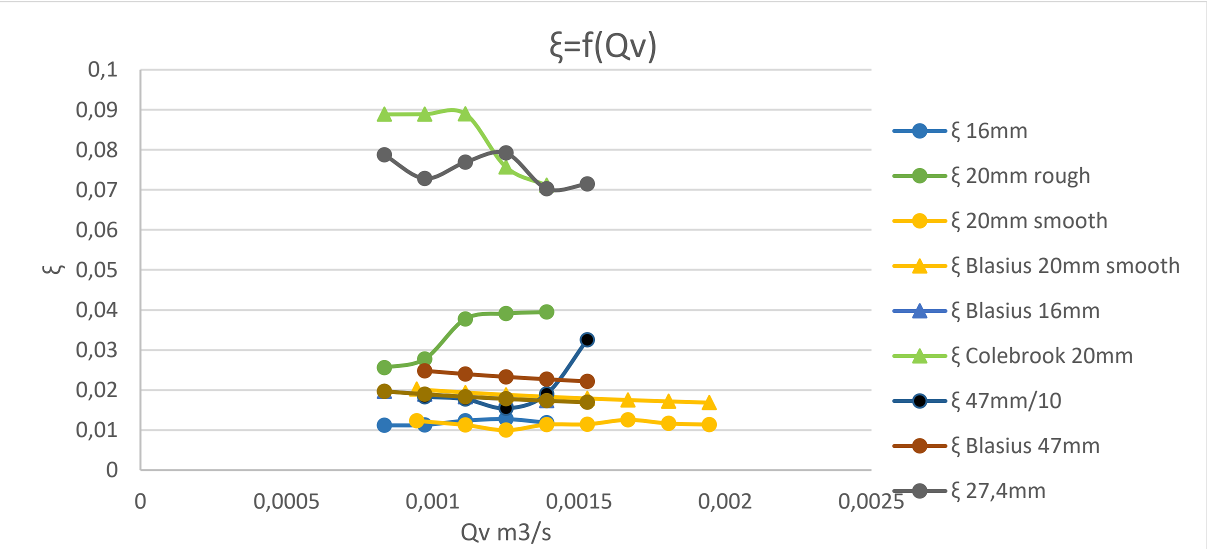

Figure 4 linear head losses comparison with quad pressure sensor

Whit this result, we can see that the 47mm pipe is in violation of the Blasius formula with each device, the 27.4mm pipe is also in the same condition. This can be a result of the placement of the pressure connector, the proximity with a singularity (the entry valve for the 27.4mm pressure connector and the pipe enlargement for the 40mm pressure sensor) can be altering the flow in this way. This theory can be supported by the fact that the 27.4mm pipe and the 40mm pipe are the only pipes with this pressure captor placement.

The second conclusion on the comparison of the two measuring systems is that the U manometers seem the overestimate the pressure losses due to the fact that every experimental ξ coefficient is above the one given by the Blasius formula related.

3. Hydraulic resistance

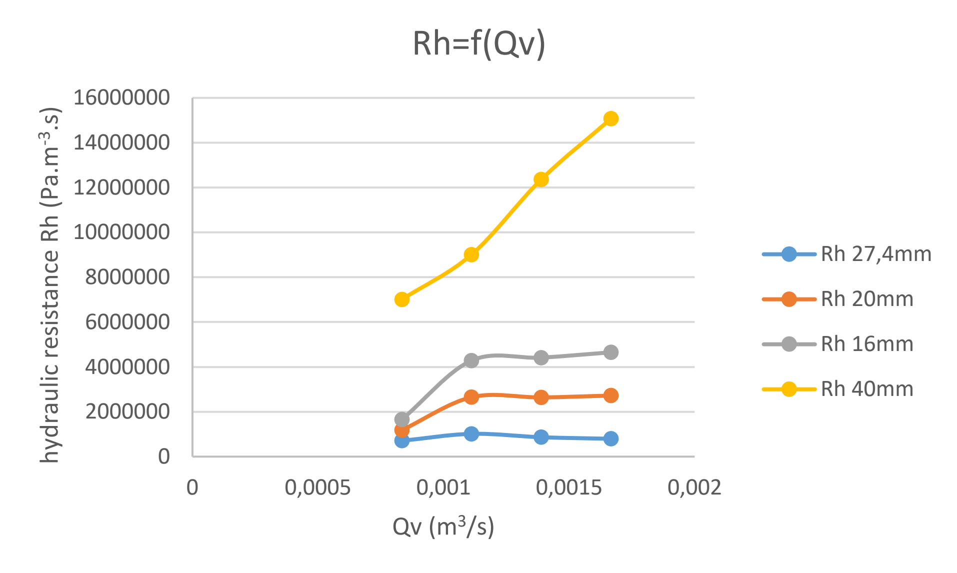

Figure 5 hydraulic resistance comparison of different pipes

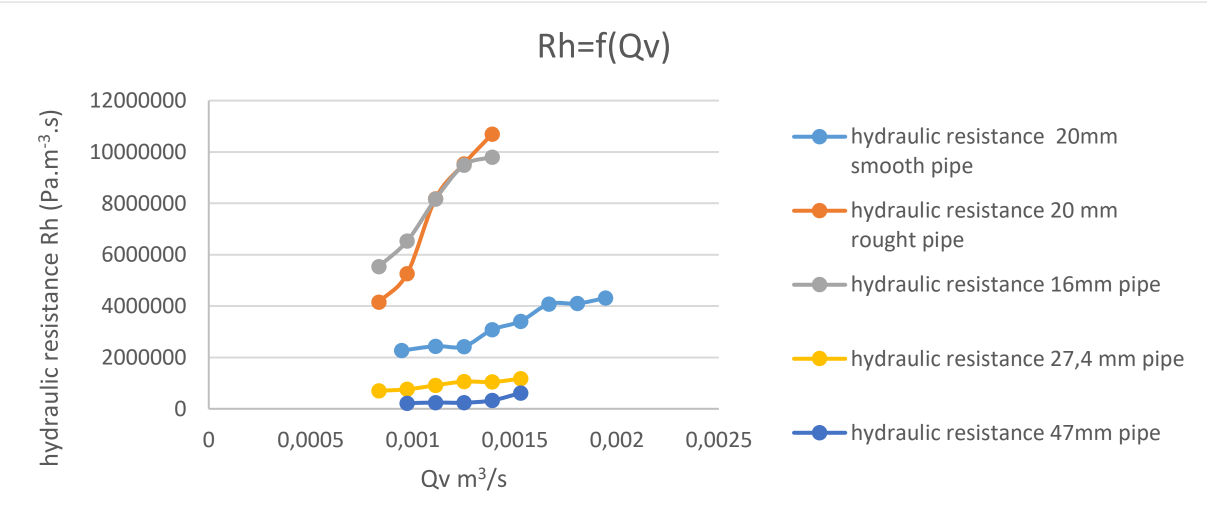

Figure 6 hydraulic resistance comparison with the quad pressure sensor

The measure realised with the quad pressure sensor are close to the expected result: we can see that the more important is the diameter, the lesser is the hydraulic resistance. The measure realised with the embedded equipment does not show this expectation for the 40mm pipe. More the values of the experiment made with the U manometer seem a bit overestimated. Thereby, the quad pressure sensor is more appropriate in regard to the conclusion: the expected result are present within the experiment.

4. Comparison of experimental head losses

With the result displayed in the 3rd experiment, we can see that the Blasius formula is followed however, in laminar flow, the Poiseuille's formula is not respected. That mean the either the pressure measure is false or the laminar flow is not reached.

5. Technical solution comparison

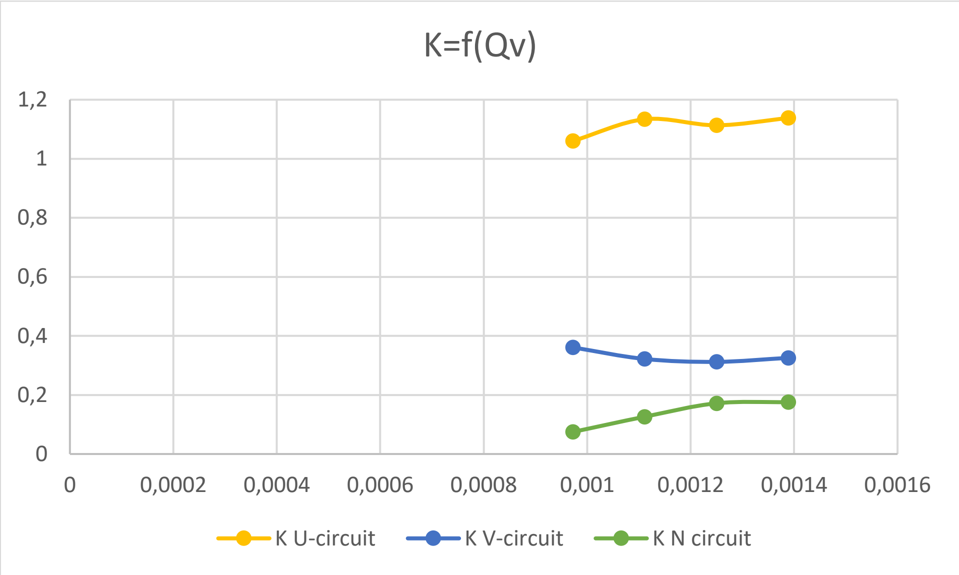

Figure 7 cicuit comparison with the quad pressure sensor

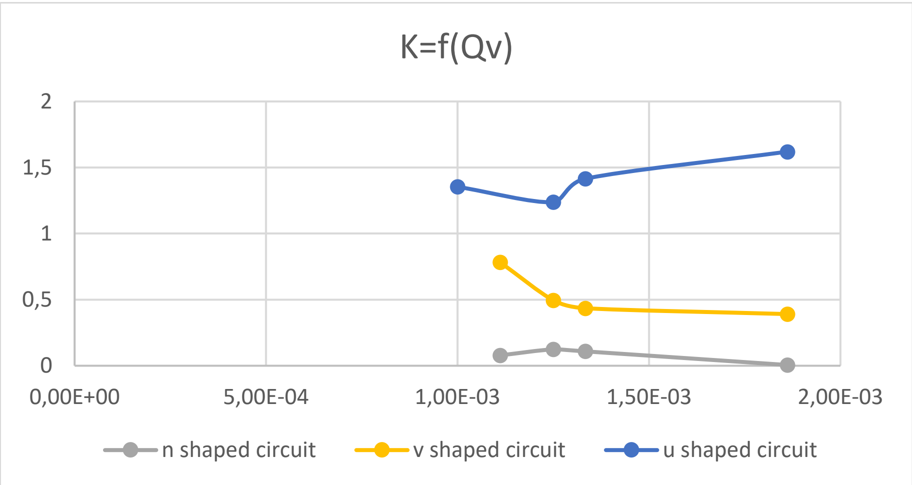

Figure 8 solution comparison with the U manometers

The result indicate that the U shaped circuit generate more head losses in the circuit than the two other circuit.

6. Valves authority

Following the realisation of the experiment, the average authority measured for the blue valve was 0.5185 which is quite close to the 0.50 of an efficient valve. For the yellow valve, the average authority is 0.162, not enough for the 20mm pipe where the valve is plugged.

The comparison with other pipes showed that this valve is best suited on a 16.4mm pipe (the average authority is 0.443).

7. singular head losses for laminar and turbulent flow

The two set of experiment resulted in close result for the head losses coefficient of some singularity on the bench for the experience performed with the embedded equipment, the head losses coefficient measured for the 90° elbow, the 135° elbow and the 90° long elbow is respectively: 0.4837, 0.2664, and 0.087. For the other experience, the result are for the same singularity are respectively: 0.3993, 0.1784, and 0.0808.

8. Flow meter behaviour in turbulent and laminar flow

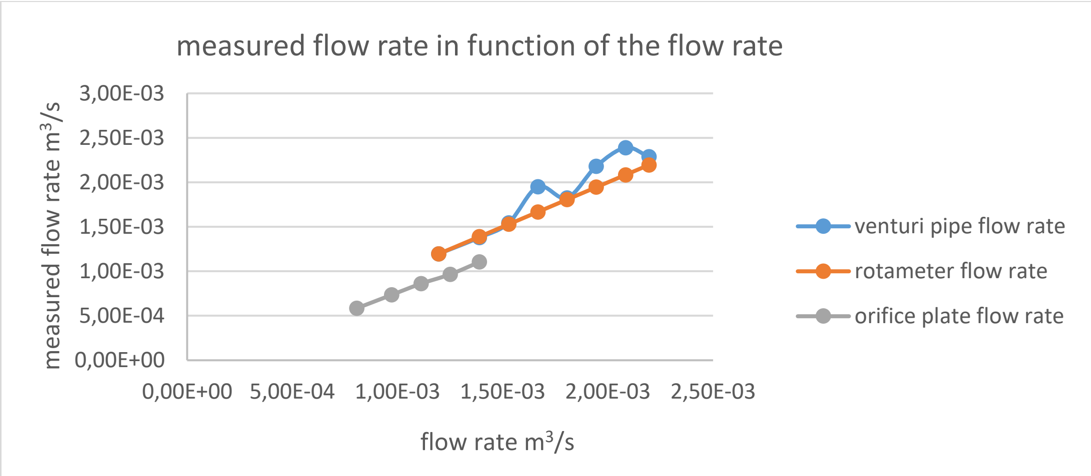

Figure 9 flow rate comparison measured with U manometers

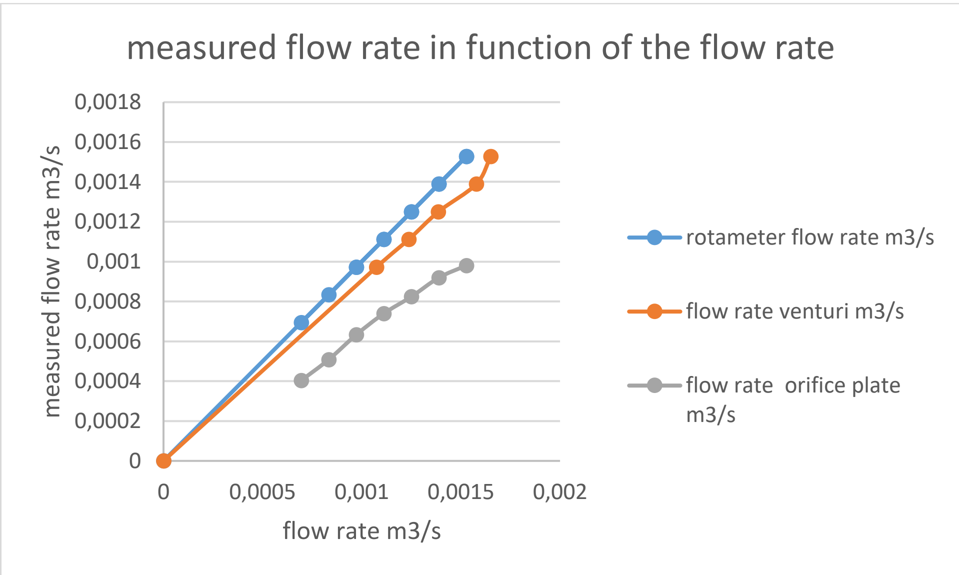

Figure 10 flow rate comparison measured with the quad pressure sensor

The experiment demonstrated in both case that the venturi tube is closer to the rotameter than the orifice plate in terms of accuracy. In both case the orifice plate will underestimate the flow rate. For the experiment performed with the U manometers, the venturi tube seems to overestimate the flow rate when it goes beyond 0.0015m^3/s, the same point on the second chart indicate the venturi tube stay close to the rotameter. The last point of the experience done with the U manometer, indicate a value close to the one given by the rotameter. Therefore, the overestimated value can be the result of a malfunction of the U manometer, or a misreading.

9. Power of the pump

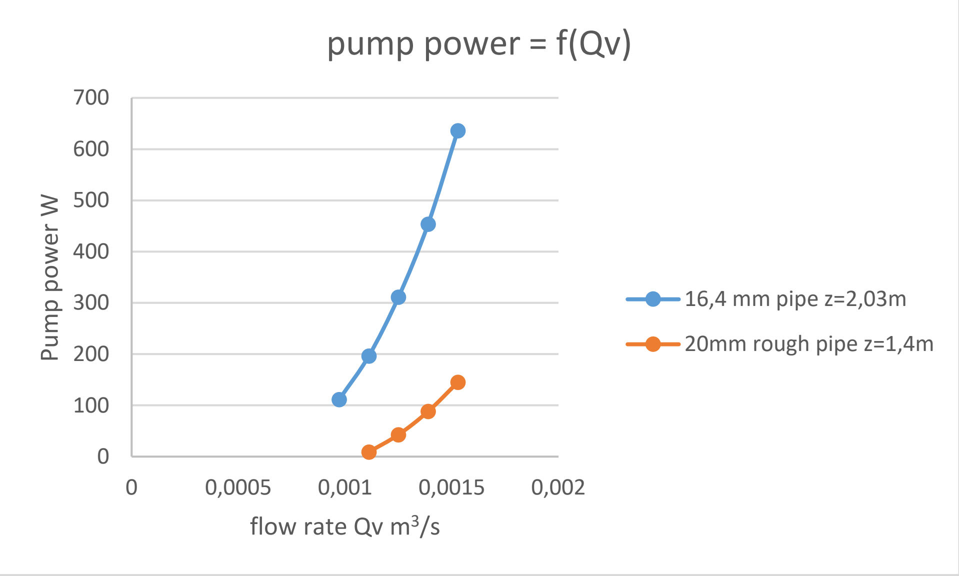

Figure 11 pump power determined with the quad pressure sensor

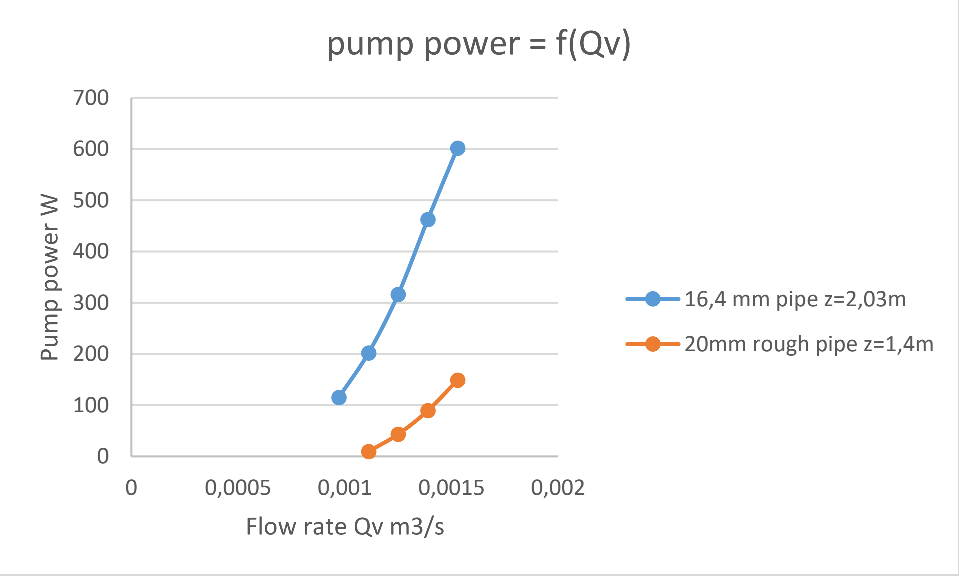

Figure 12 pump power determined with embedded manometers

The two experiment produced the same result, we can conclude that the pump is adapted to the bench due to the fact that the power needed to put in motion the fluid in the higher pipe at a high flow rate is under the power of the pump (750W). As expected, the power increase when the altitude increase. Alongside the more hydraulic resistance there is, the more power is needed.

10. Critical Reynolds number

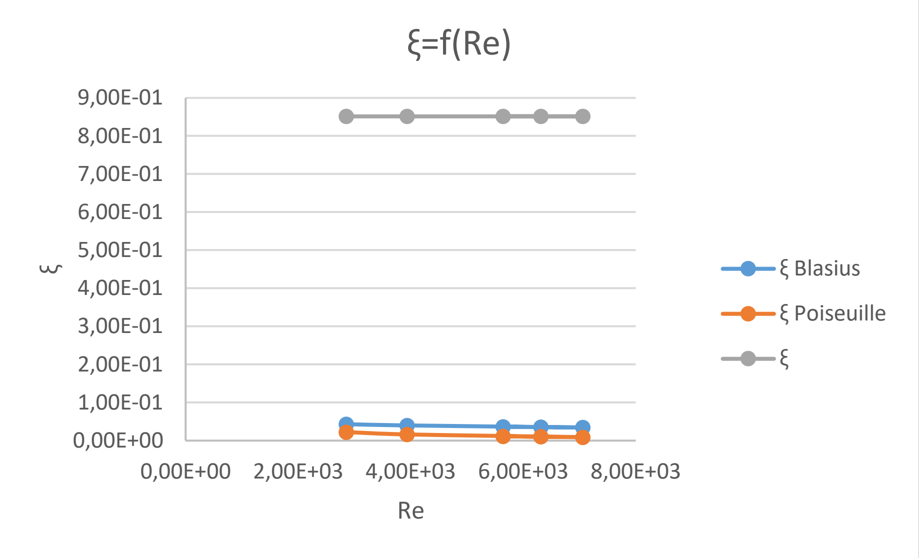

Figure 13 Critical Reynolds number determination with the quad pressure sensor

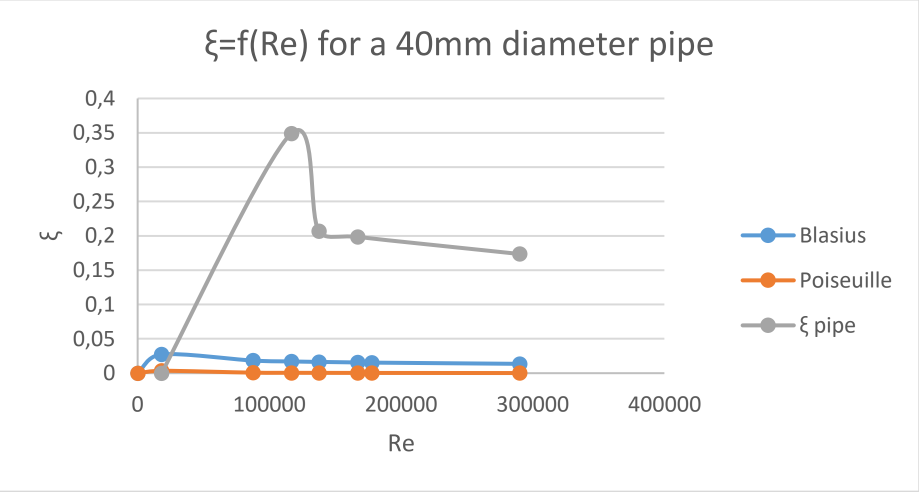

Figure 14 determination of the critical Reynolds number with U manometers

In both case the critical Reynolds number is not found with the measure however a visual check of the venturi tube placed downstream the 40mm pipe indicate a laminar flow for the lowest flow rate. Therefore we can suppose that the critical Reynolds number for this pipe is around 2850.