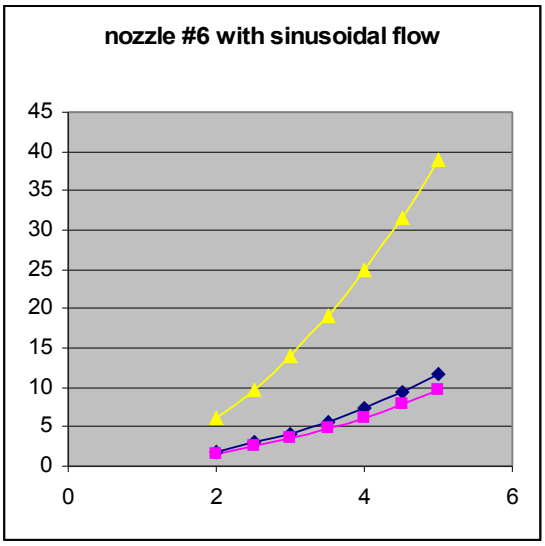
Why do we measure more than the theoretical thrust?

Example of measurement:



In purple the theoretical mean thrust versus frequency.

In blue the measured thrust.

In yellow (for information) the maximum theoretical thrust; i.e. the peak value.

Thrusts are in mN and frequencies in Hz.

The thrust measuring test bench indicates <u>always</u> (we ran approx hundred tests) a thrust that is bigger (by 10 to 40%) than the theoretical mean value. This could be caused by at least two phenomena:

<u>1°) Lack of filtration (frequency filter).</u>

The thrust indication was fluctuating between 1 and 4mN, depending on the nozzle. (2mN for our example). We always used the arithmetic mean value, but doing that we introduced a small error. ===>The measuring pendulum is to be completed by a dash-pot or by inertia.

However, the lack of filtration cannot explain so big discrepancies between theory and practice.

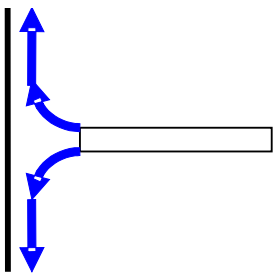
<u>2°) Recirculation of the water in the tank</u>.

This phenomenon was evoked in a previous report. Here, we set it as evident.

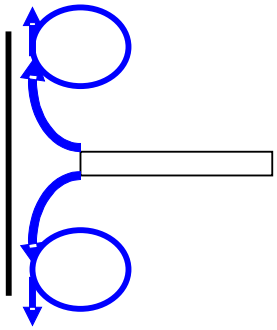
a) First we observed vortexes thanks to (unexpected) impurities into the water.
b) Then we built a micro mooring buoy.

This device is made of a small weight (2g), a piece of sewing thread and a small polyurethane foam float (diameter 8mm) adjustable along the thread thanks to a little wedge. We placed this device in the tank at various places and we observed the inclination of the thread, and most of all the movements of the float. It was clearly visible that some water was re-circulated towards the target; therefore, the momentum was bigger than what it would have been in air.

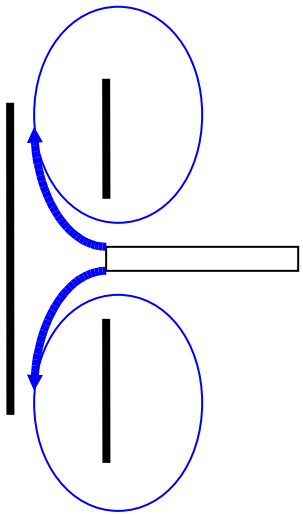
Dans l'air T=q.V



Dans l'eau T>q.V



c) Then we placed some screens (chicanes) at various places inside the tank (not on the direct jet flow) and we saw a decrease of the thrust indication. The *right* thrust was got with a screen arranged as shown on the following scheme.



Such a screen doesn't prevent vortexes, but they are large and the water which comes again towards the target has lost most of its velocity.
Our screen had a hole in the middle of approximately 3.5 times the nozzle diameter.

Another alternative could be to decrease the target size, but in that case you must be sure that the jet is well oriented.

Note: This recirculation phenomenon could be perfectly known by hydrodynamics specialists, but we didn't find it in the books we read.