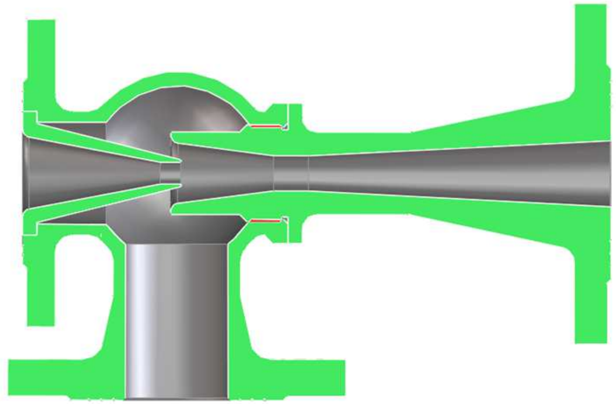
# CFD study
# with Venturi Liquid ejector
# for
# ONDA 248

VALFONTA
valve design and manufacturing

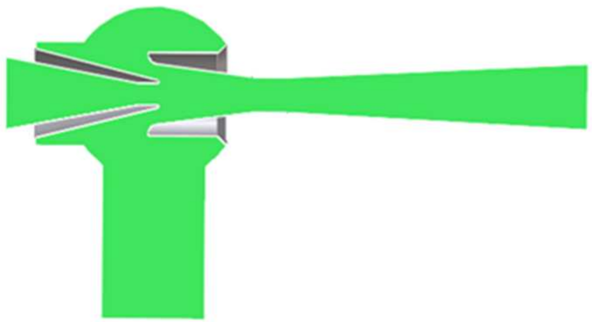
# Geometry

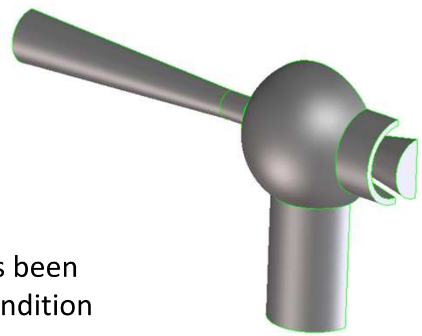
Original geometry



For CFD analysis the only the fluid need to be modelled

CFD geometry



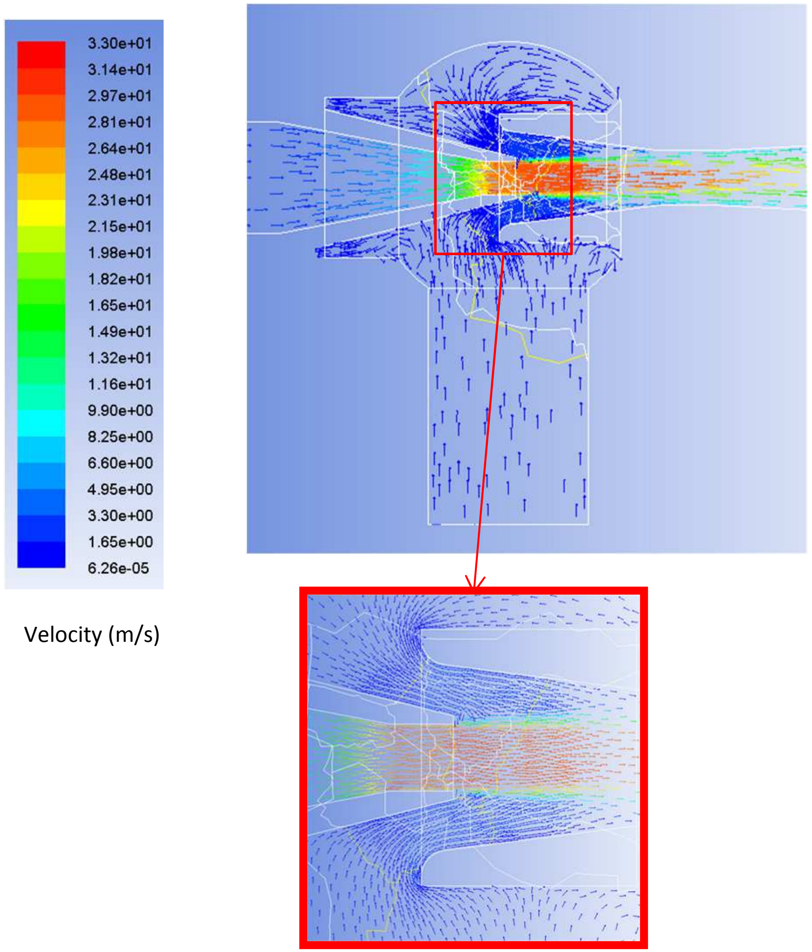


Only half geometry has been used since symmetry condition has been applied

# Results

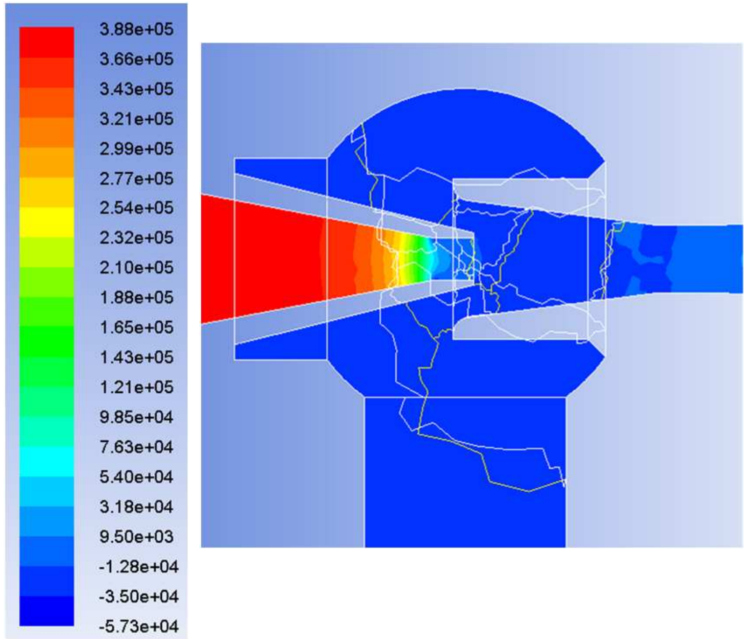
<u>Some plots to show general behaviour</u>

**Velocity Vectors**




Velocity (m/s)

**Pressure Contours**



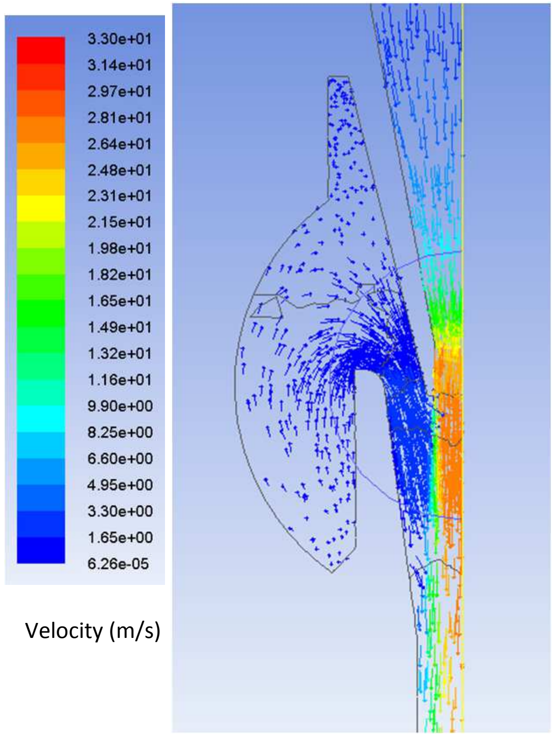

Pressure (Pa)

(Results for a specific case of 248-5)

Some plots to show general behaviour

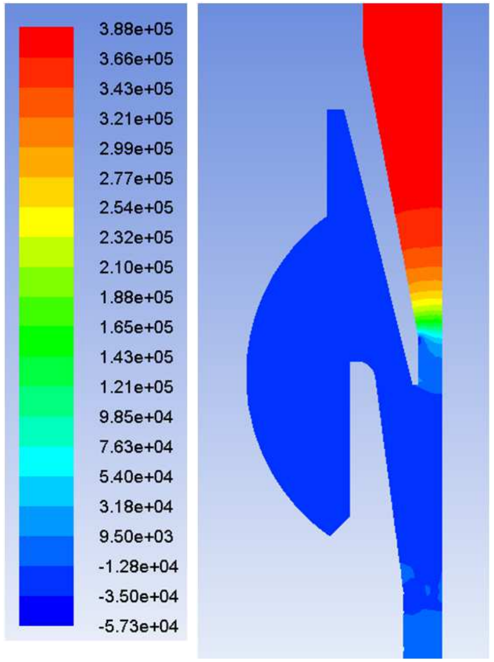
# Results

**Velocity Vectors** (top view)



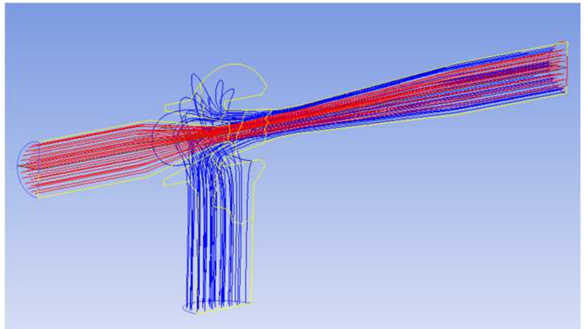

Velocity (m/s)

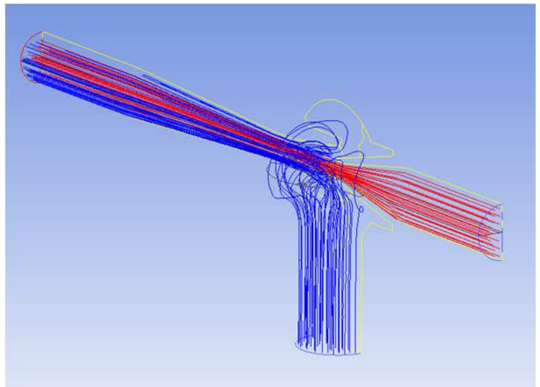
**Pressure Contours** (top view)




Pressure (Pa)

**Streamlines**
(colored by fluxes)

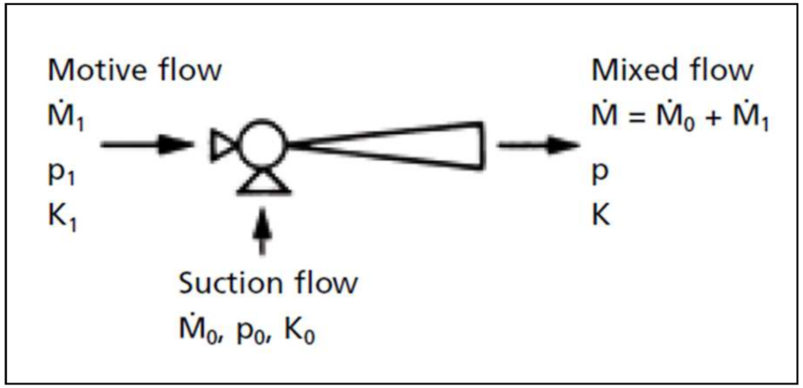




# Results

**Explanation of ejector behaviour:**

The follow scheme will be used to define the different variables involved:




- 5 independent variables: p1, p0, p, M1, M0 (M = M1+M0)

- The "**height pressure" to overcome** is (p-p0), since p>p0.

- The **motive pressure is p1**, so that p1 must be the greatest pressure.

Therefore, always: **p1 > p >p0**

- What really matter is the difference (p-p0) and not the value of p and p0 itself. That is, if we only change the variables p and p0 the results will be the same if (p-p0) remains constant

- The flow rate M1 only depends (approximately) of the difference (p1-p0). This relation gives us the curve (p1-p0) vs M1, that is showed later on.

# Results

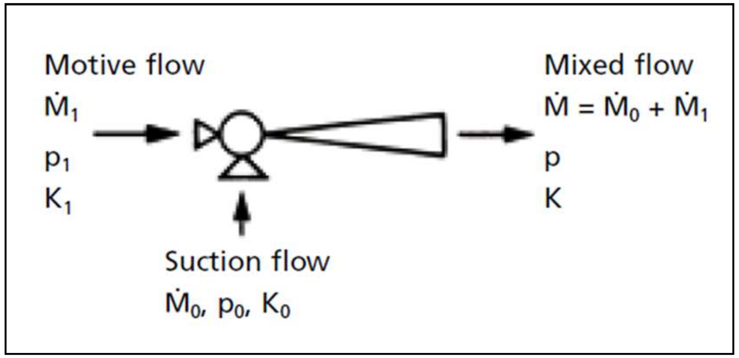
**5 independent variables**: p1, p0, p, M1, M0
(M = M1+M0)

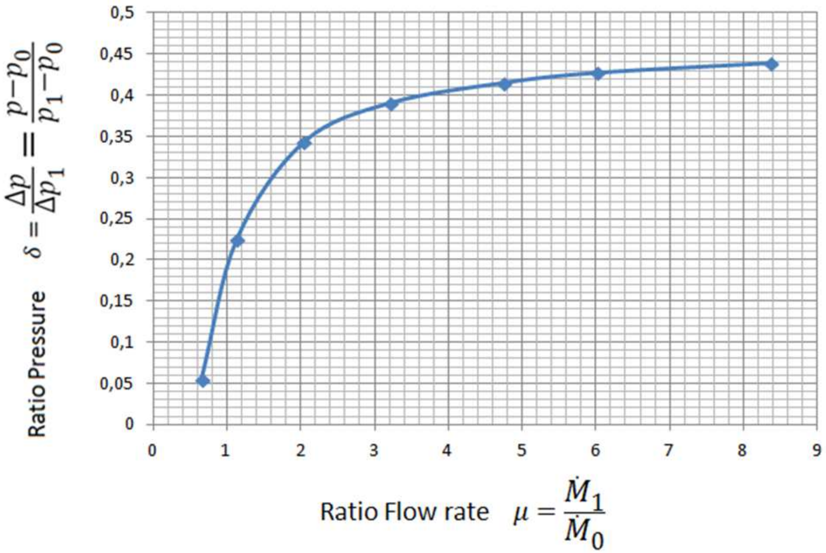
Therefore, many relations and graphs can be described.

But there **is only one graph that define the overall behaviour**: the graph [Ratio pressure – Ratio Flow rate] (Rp-Rq)

Note that this **graph also shows the ejector efficiency** in a certain way.
A more efficientet ejector will have:

- **Greater Ratio pressure** (smaller motive pressure p1 for same p and p0)
- **Smaller Ratio Flow rate** (smaller motive flow M1 for same suction flow M0)

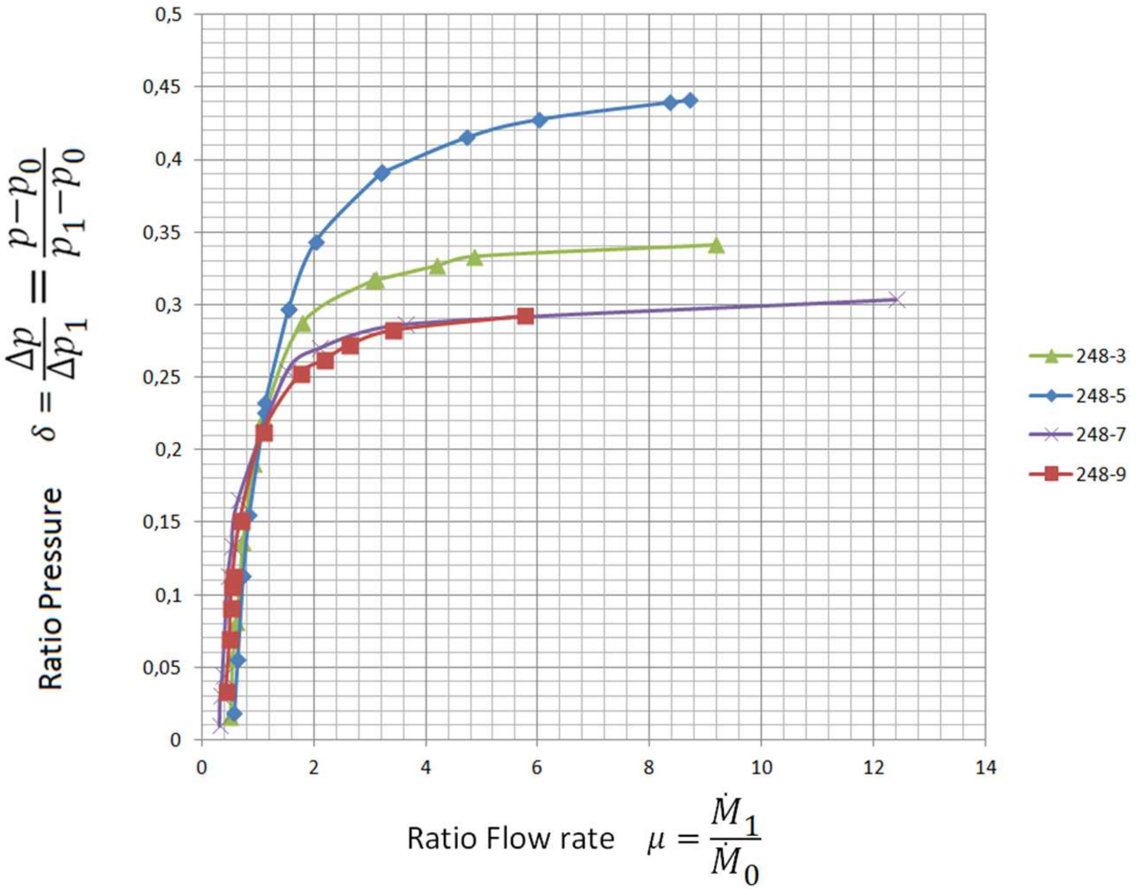



*- Results for 248-5 -*

# Results

**Graph Rp-Rq (Ratio pressure – Ratio flow rates) for all 4 ejectors**




Different curves for each ejector Model

**Some Models are more "efficient" than others** depending on the part of the graph considered

For greater Flow rate Ratio M1/M0, Models 5 and 3 show more efficiency (lower p1 required), while for lower flow ratio, Models 7 and 9 are more efficient*

* Lower part of the graph is better observed with logarithmic scale. It is showed in Appendix 1

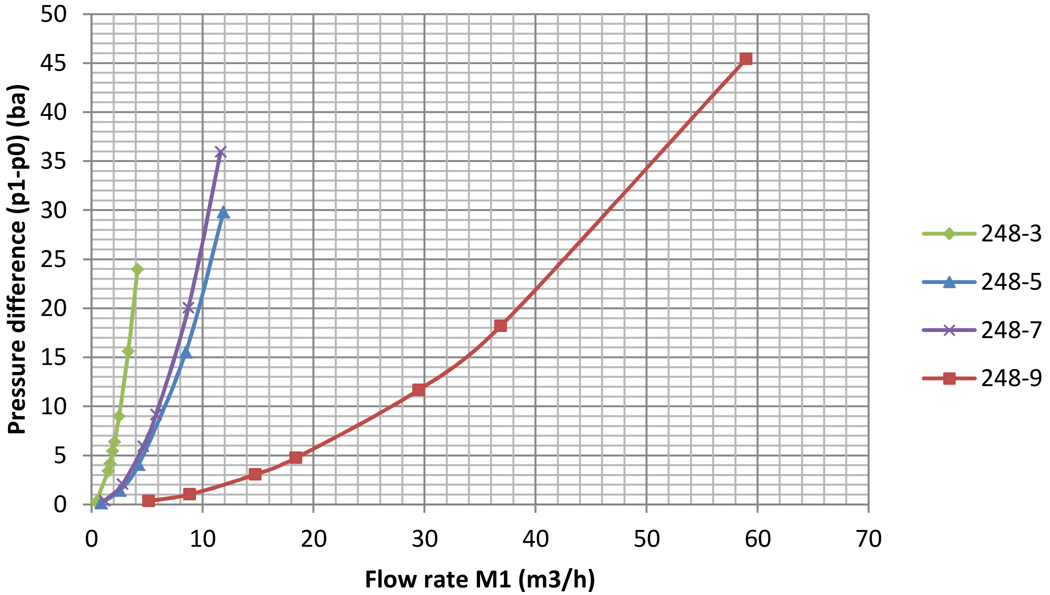
# Results

As observed in the previous graph, **each ejector presents a different curve**

However, **NO relation is found between the size of the product and the curves obtained**. Even it can be observed that 248-9 and 248-7 models present very similar curves

Nevertheless, **greater sizes work with greater flow rates and smaller sizes work with higher pressures**, although these graphs do not show this consideration

Therefore, additional information is required: the **curve (p1-p0) vs M1 (Motive flow rate)**




This graph defines completely the problem

Moreover, it is helpful for choosing the correct range of flow rates and even helpful for the **upstream installation requirements**

# Results

- We have got, for each ejector model, **2 graphs**
  - Graph [Rp-Rq] (Ratio pressures- Ratio flow rates)
  - Graph (p1-po) vs M1
- As mentioned before, the problem has **5 independent variables**: p0, p1, p, M1 and M0

**Therefore we need 3 variables** (together with a specific ejector model) **to define completely the problem**

- This information can be **used for the final client** in order to help them in choosing the ideal ejector
- The process would be to **defining the 3 variables and then using the graphs** to define completely the problem.

- At the **Appendix** of this document, **3 examples of different situations** (depending on the 3 variables chosen) **are explained**.

# Conclusions

- A CFD simulation has been performed in order **to evaluate and characterize the 4 Venturi liquid ejector** as well as to **understand the ejector behaviour**

- **Two graphs** have been obtained for each model:

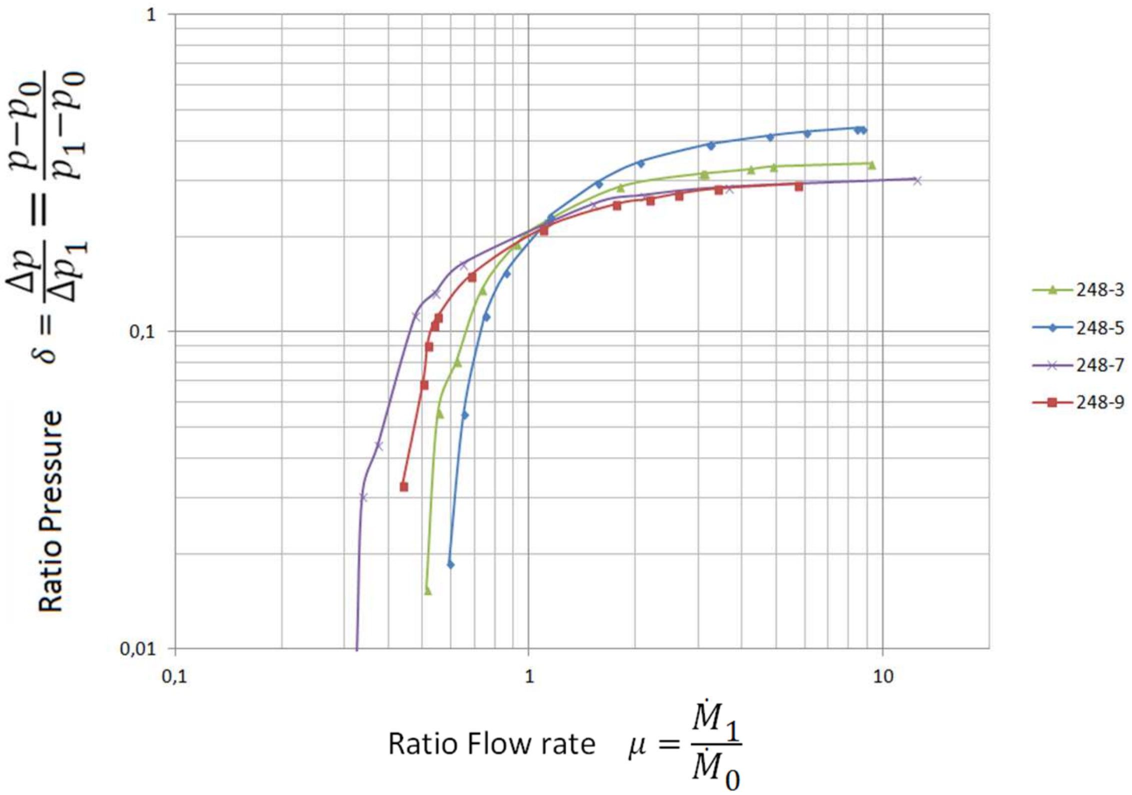
  - **Rp-Rq (Ratio pressure – Ratio flow rates**): explain the **overall behaviour** of the product and its efficiency

  - (**p1-po) (motive drop pressure) VS M1 (motive liquid)**: shows the relation between the motive pressure and motive flow. It is useful to know the **range of working** for each model and it can be helpful for knowing the **upstream installation requirements.**

- Both graphs define completely the fluid problem. 3 variables must be defined among de 5 independent variables (p, p0, p1, M0, M1). Three examples of how using the graphs have been provided.

- **CFD simulation** could be used also for **design assessment**
  - Improving ejector efficiency
  - Evaluating working range

# APPENDIX 1, Graph Rp-Rq in logarithmic scale




Logarithmic scale shows better the graph specially at lower values

Logarithmic scale shows better the graph specially at lower values

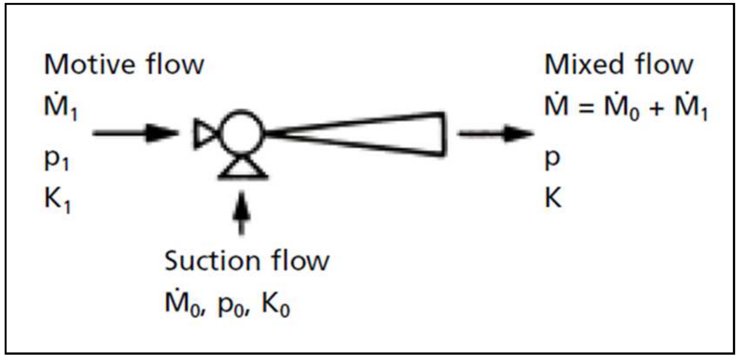
# APPENDIX 2, Use of graphs with Examples

As explained before:

- 5 independent variables are found: p, p0, p1, M1 and M0

- 2 graphs are obtained: Rp-Rq and (p1-po) vs M1

- Therefore 3 variables must be defined




In the following slides, the **use of graphs** in order **to solve completely the problem** will be explained

Usually, p0 (suction pressure) and p (discharge pressure) are known variables. Therefore, 3 examples will be showed, depending on the third defined variable: c

- **Case A**: 3 variables defined -> **M1**, p0 and p
- **Case B**: 3 variables defined -> **p1**, p0 and p
- **Case C**: 3 variables defined -> **M0**, p0 and p

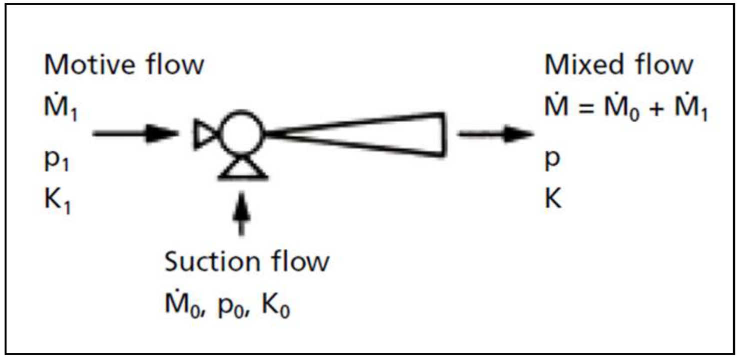
# APPENDIX 2, Use of graphs with Examples

**CASE A**: 3 variables defined -> **M1**, p0 and p

**p0** = -0.2 bar (equivalent to 2 meters suction)

**p** = 1 bar (equivalent to 10 meters after ejector)

**M1** = 8 $m^3/h$




And we choose for example jet **Model 248-5**

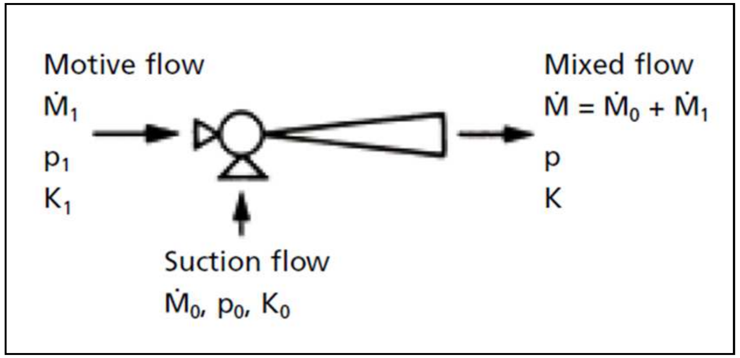
- With M1 —*Graph (p1-p0) vs M1*→ (p1-p0) = 14 bar → **p1 = 13.8 bar**

- Then: $\frac{\Delta p}{\Delta p_1} = \frac{p - p_0}{p_1 - p_0} = 0.087$ —*Graph Rp-Rq*→ $\frac{M_1}{M_0} = 0.77$ —M1 = 8→ **M0 = 10.4 $m^3/h$**

# APPENDIX 2, Use of graphs with Examples

**CASE B**: 3 variables defined -> **p1**, p0 and p

- **p0** = -0.2 bar (equivalent to 2 meters suction)
- **p** = 1 bar (equivalent to 10 meters after ejector)
- **p1** = 13.8 bar




- First: $\frac{\Delta p}{\Delta p_1} = \frac{p - p_0}{p_1 - p_0} = 0.087$

If we choose jet Model 248-5

$\frac{\Delta p}{\Delta p_1} = 0.087$ → *Graph Rp-Rq Model 248-5* → $\frac{M_1}{M_0} = 0.77$

$(p_1 - p_0) = 14\ bar$ → *Graph (p1-p0) vs M1 Model 248-5* → M1 = 8 $m^3/h$

→ M0 = 10.4 $m^3/h$

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If we choose jet Model 248-9

$\frac{\Delta p}{\Delta p_1} = 0.087$ → *Graph Rp-Rq Model 248-5* → $\frac{M_1}{M_0} = 0.55$

$(p_1 - p_0) = 14\ bar$ → *Graph (p1-p0) vs M1 Model 248-5* → M1 = 32.3 $m^3/h$

→ M0 = 58.73 $m^3/h$

# APPENDIX 2, Use of graphs with Examples

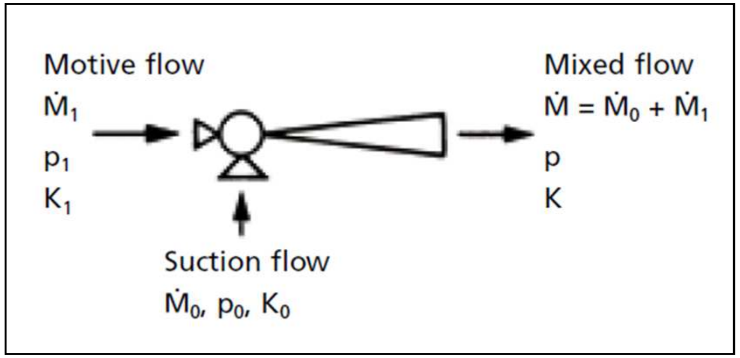
**CASE C**: 3 variables defined -> **M0**, p0 and p

**p0** = -0.2 bar (equivalent to 2 meters suction)

**p** = 1 bar (equivalent to 10 meters after jet)

**M0** = 10.4 bar

And we choose jet **Model 248-5**




In this situation we cannot use directly any of the two graphs since we don't know p1 nor M1.

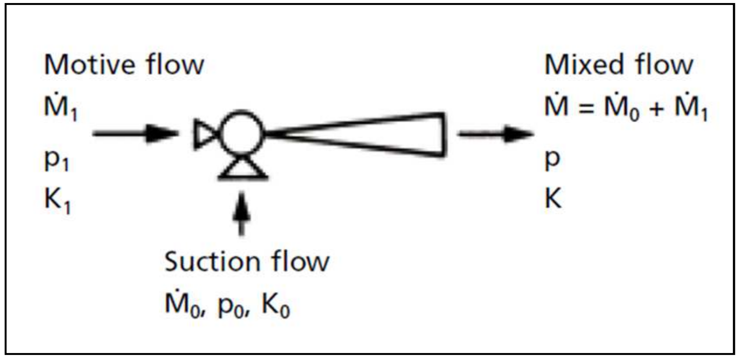
The task now is to find the correct values of p1 and M1 so that the both graphs give coherent results

As we don't know a priori the values of p1 nor M1, we will have to suppose them and then modify them iteratively by using the two graphs until getting the coherent values, as showed in next slides.

# APPENDIX 2, Use of graphs with Examples

**CASE C**: 3 variables defined -> **M0**, p0 and p

- **p0** = -0.2 bar (equivalent to 2 meters suction)
- **p** = 1 bar (equivalent to 10 meters after jet)
- **M0** = 10.4 bar




- Iteration 1: We suppose any value of p1 -> p1 = 10 bar

$\frac{\Delta p}{\Delta p_1} = 0.12$ → ***Graph Rp-Rq*** → $\frac{M_1}{M_0} = 0.85$ → M0 = 10.4 → M1 = 8.9 $m^3/h$

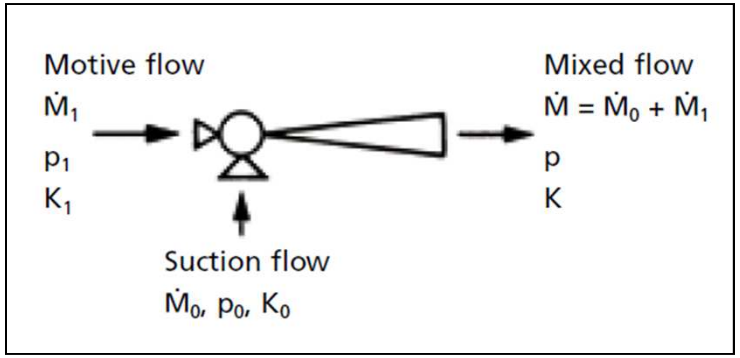
M1 = 8.9 $m^3/h$ → ***Graph (p1-p0) vs M1*** → (p1-p0) = 17.5 → p1 = 17.3 bar — It's different from initial guess p1 = 10 bar ⇒ Therefore, new p1 value: p1 = 17.3 bar

- Iteration 2: New value of p1 -> p1 = 17.3 bar

$\frac{\Delta p}{\Delta p_1} = 0.069$ → ***Graph Rp-Rq*** → $\frac{M_1}{M_0} = 0.7$ → M0 = 10.4 → M1 = 7.28 $m^3/h$

M1 = 7.28 $m^3/h$ → ***Graph (p1-p0) vs M1*** → (p1-p0) = 11.7 → p1 = 11.5 bar — It's different from last value p1 = 17.3 bar ⇒ Therefore, new p1 value: p1 = 11.5 bar

# APPENDIX 2, Use of graphs with Examples




**<u>CASE C</u>**: 3 variables defined -> **M0**, p0 and p

- **p0** = -0.2 bar (equivalent to 2 meters suction)
- **p** = 1 bar (equivalent to 10 meters after ejector)
- **M0** = 10.4 bar

- <u>Iteration 3</u>: New value of p1 -> p1 = 11.5 bar

$\frac{\Delta p}{\Delta p_1} = 0.102$ → ***Graph Rp-Rq*** → $\frac{M_1}{M_0} = 0.8$ → M0 = 10.4 → M1 = 8.32 m$^3$/h

M1 = 8.32 m$^3$/h → ***Graph (p1-p0) vs M1*** → (p1-p0) = 15 → p1 = 14.8 bar

It's different from last value p1 = 11.5 bar ⇒ Therefore, new p1 value: p1 = 14.8 bar

- <u>Iteration 4</u>: ...
- <u>Iteration 5</u>: ...

⋮

*Note that at each iteration, the values of p1 and M1 are closer to the correct ones*

After some iterations, the correct values are obtained: p1 = 13.8 bar | M1 = 8 m$^3$/h