Energy from water: Hydroenergy (POR-FESR 2007/13) and Hydrocar (PRIN 2010/11) projects

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HYDROPOWER

- Hydropower covers in the world 90% of all renewable energy sources;

- In South America more than 58% of the produced energy comes from hydropower;

- Countries where hydropower provides more than 50% of electricity: Austria, Canada, Iceland, Norway, New Zeland, Sweden, Switzerland.

- The plant nominal hydropower has a huge range from few KW to the 18 GW of the 3 gorges hydropower station on the Yangtze river in China.

Micro-Hydro:

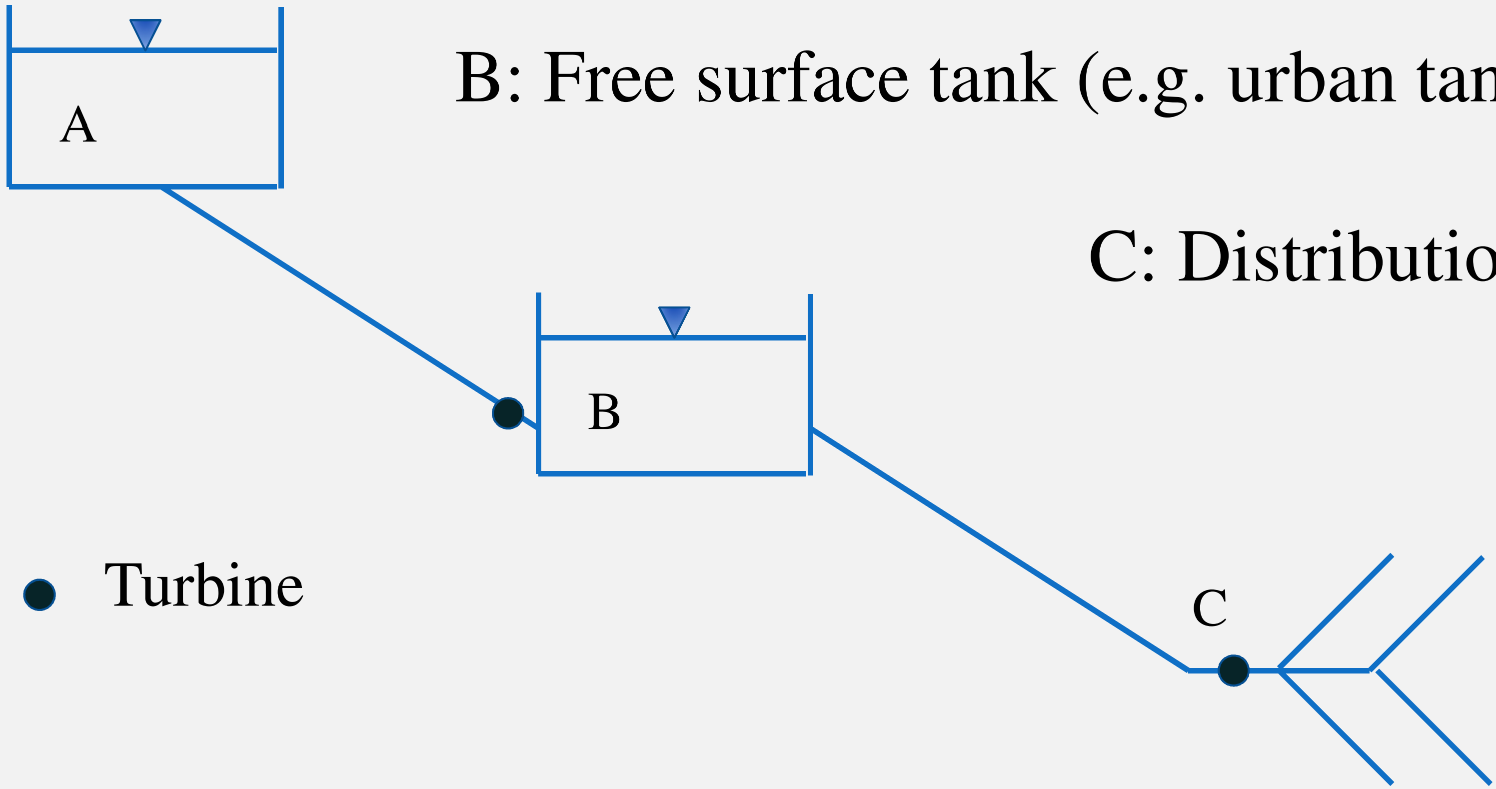
- In the aqueducts of the water distribution system
- Immediately after wastewater treatment plants
- Immediately after weirs or dams, to turbine the minimum discharge guaranteed for river species survival

Micro-hydro in aqueducts of the water distribution system

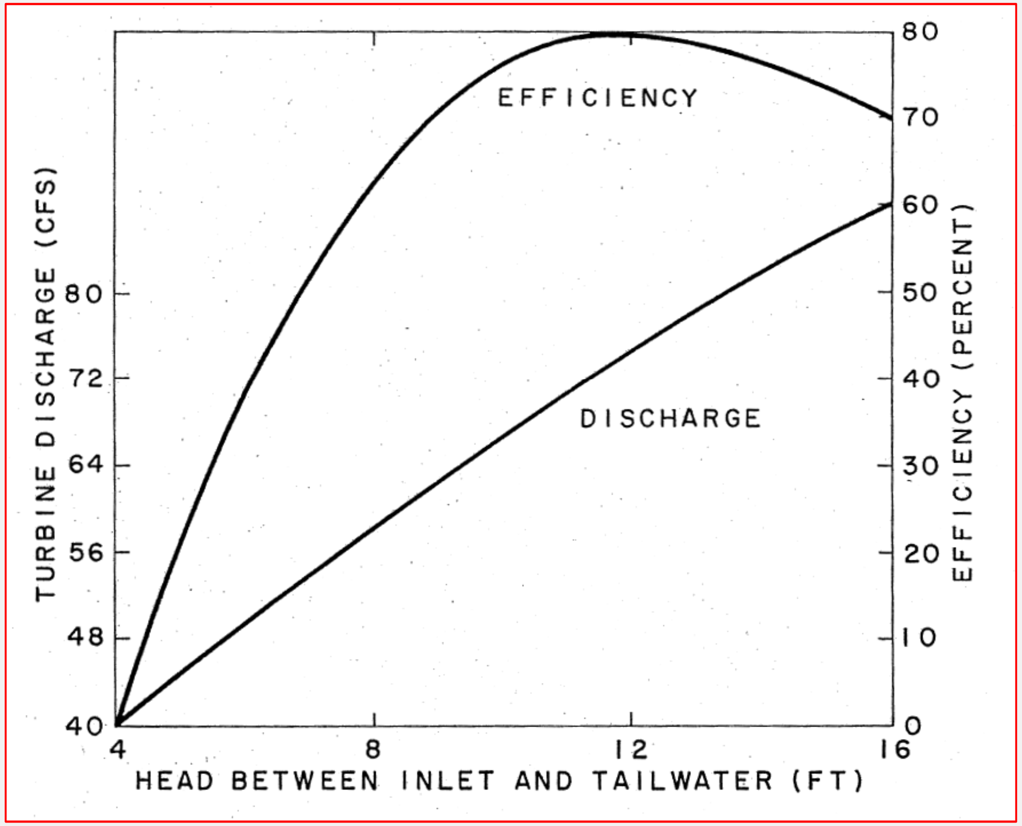
A: Water source (reservoir, spring or river discharge)

B: Free surface tank (e.g. urban tank)

C: Distribution



Discharge and efficiency curves

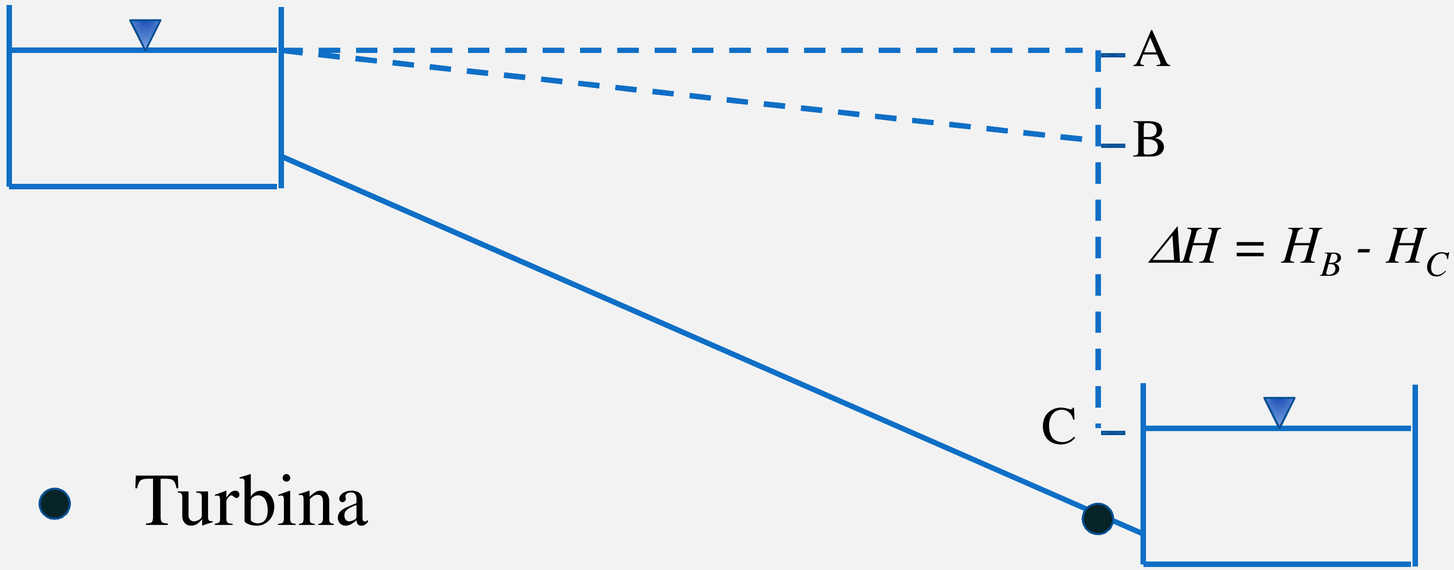


$$\eta = \frac{P}{\gamma\, Q\, \Delta H}$$

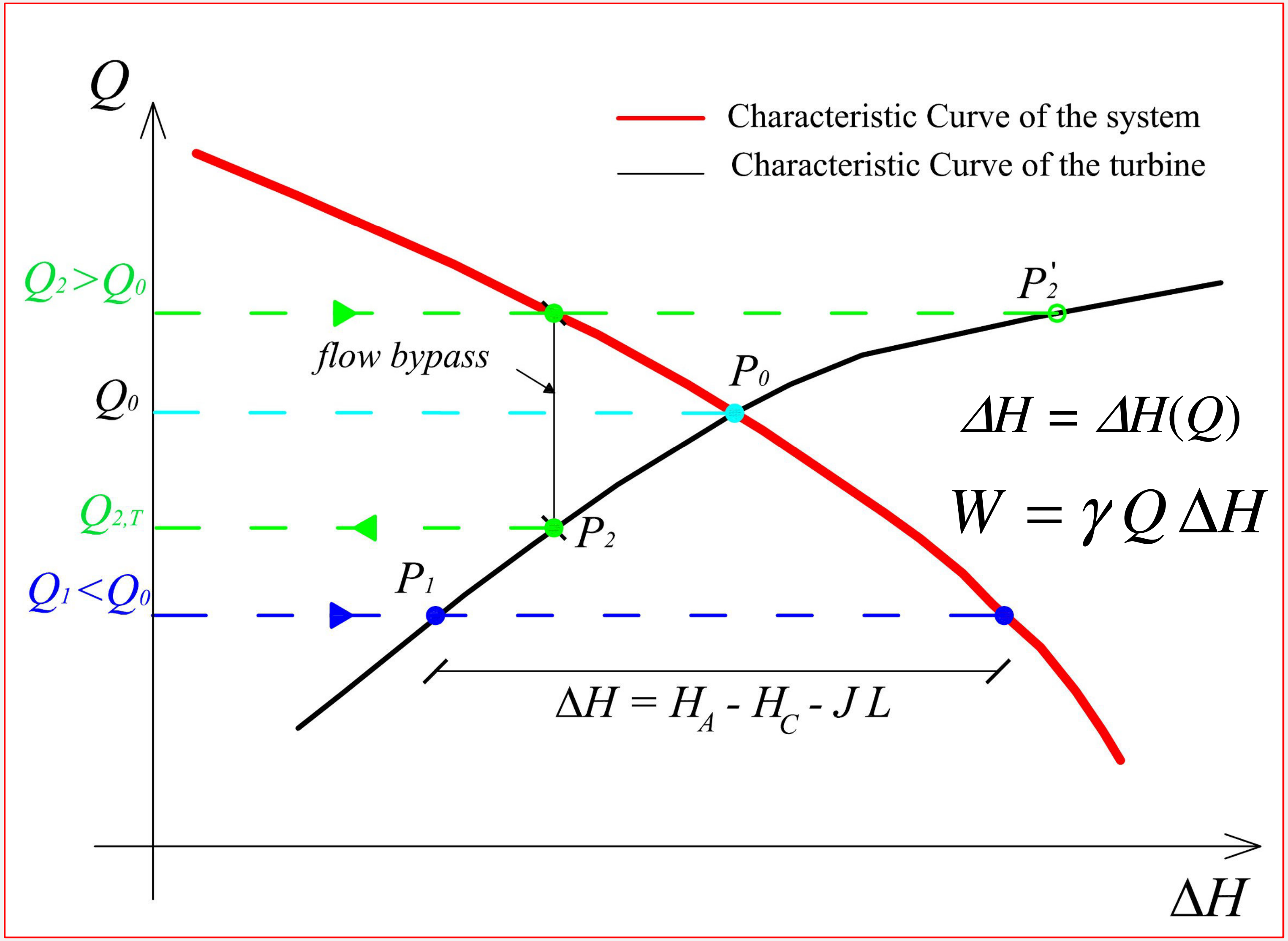
Choice of the turbine with given characteristic curve

$$\Delta H = H_A - H_C - JL$$

$$\Delta H = \Delta H(Q)$$

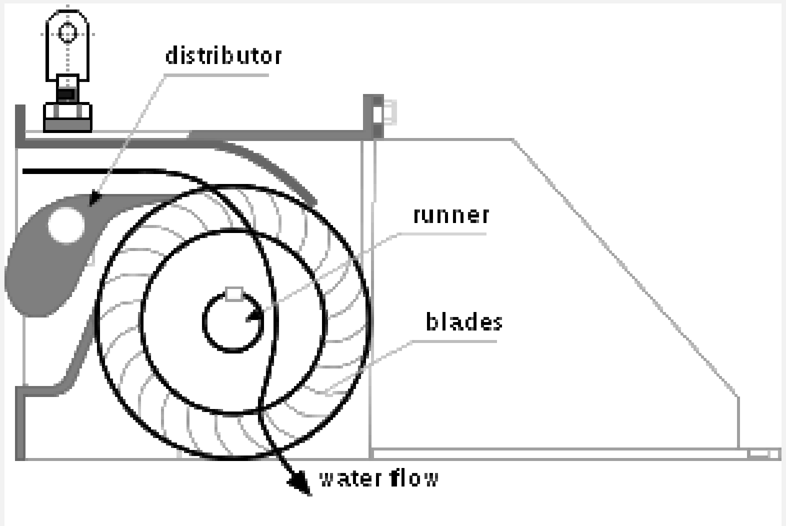


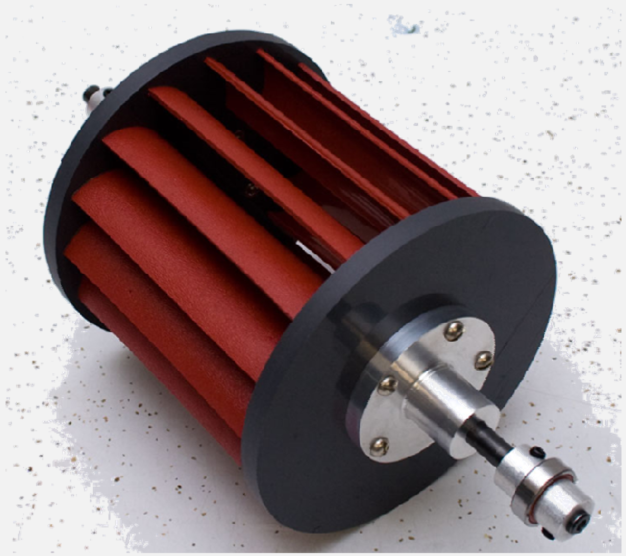
- Turbina


Q
Characteristic Curve of the system
Characteristic Curve of the turbine
Q2>Q0
P'2
flow bypass
P0
Q0
ΔH = ΔH(Q)
W = γ Q ΔH
Q2,T
P2
P1
Q1<Q0
ΔH = HA - HC - J L
ΔH

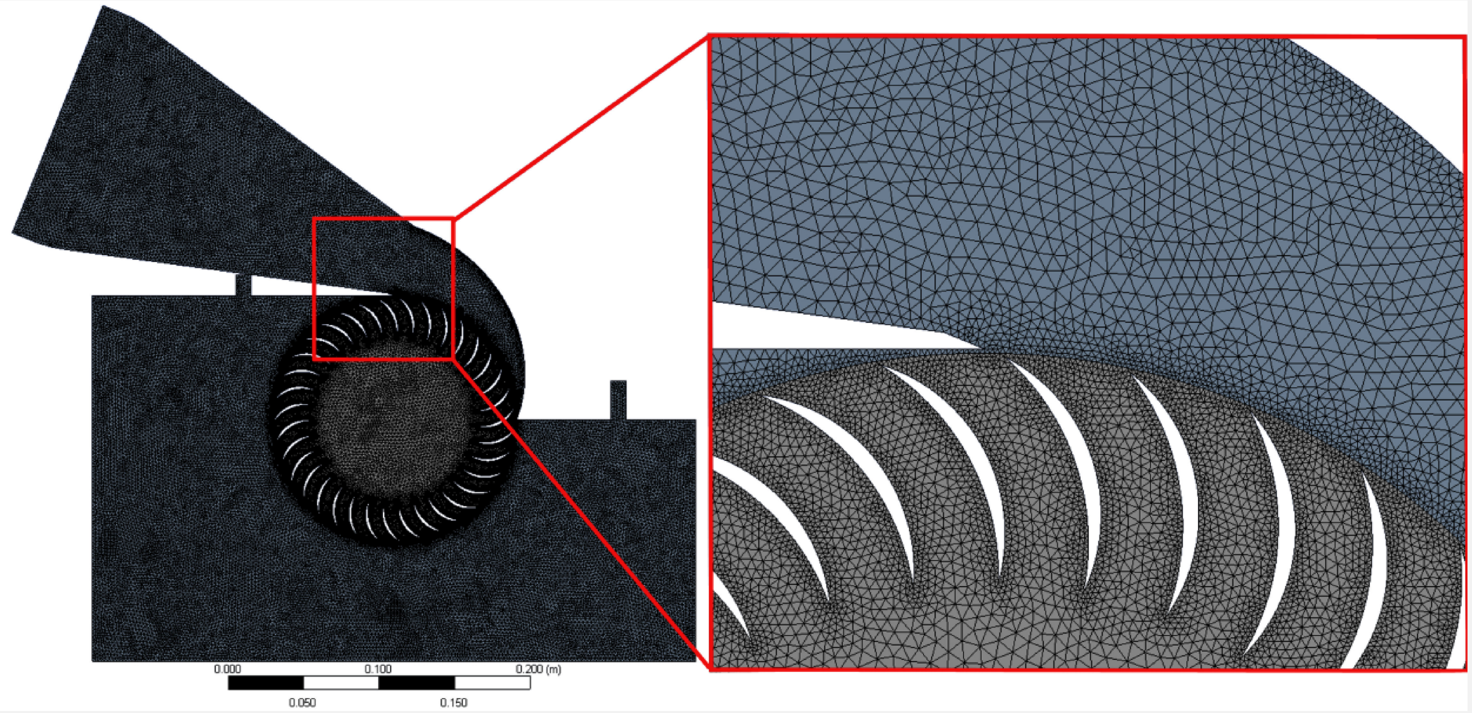
Banki (Cross Flow) Turbine

- Low construction and maintenance costs
- Small size.
- Suitable for small power



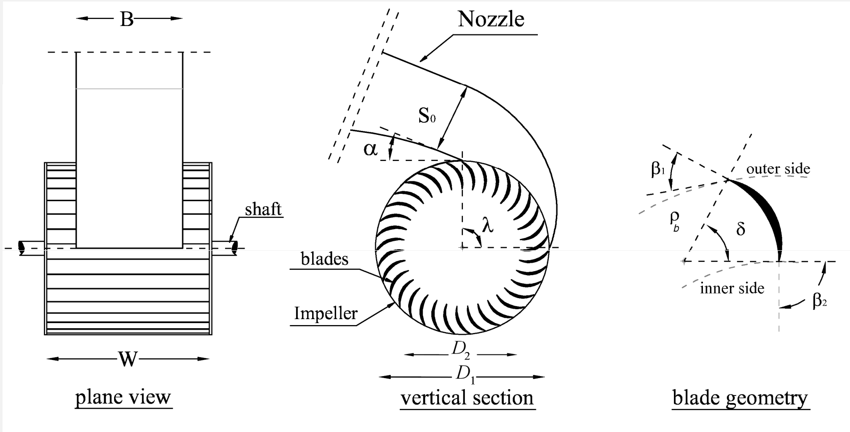


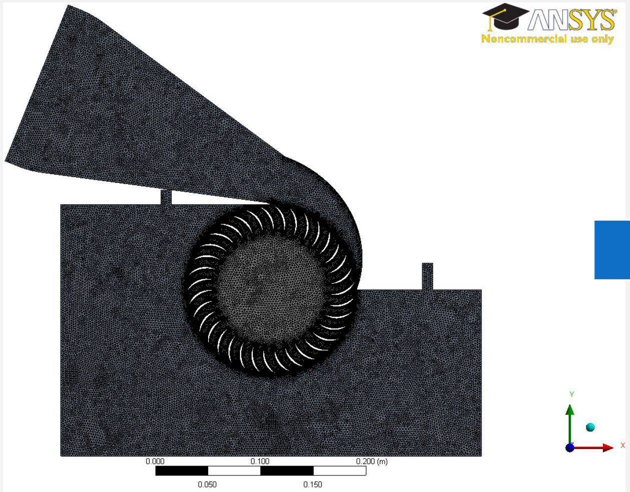
2D and 3D modeling by means of CFX-ANSYS code

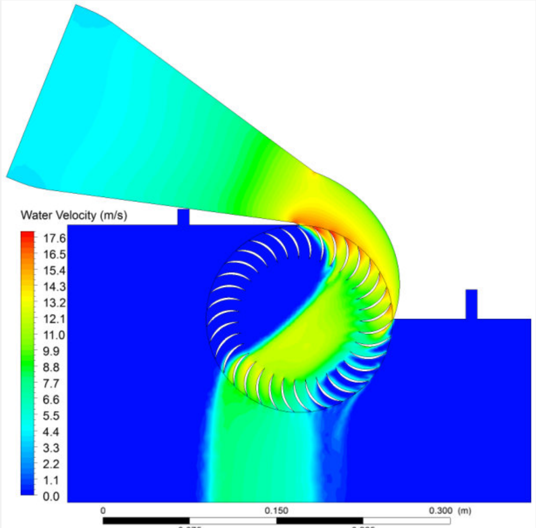


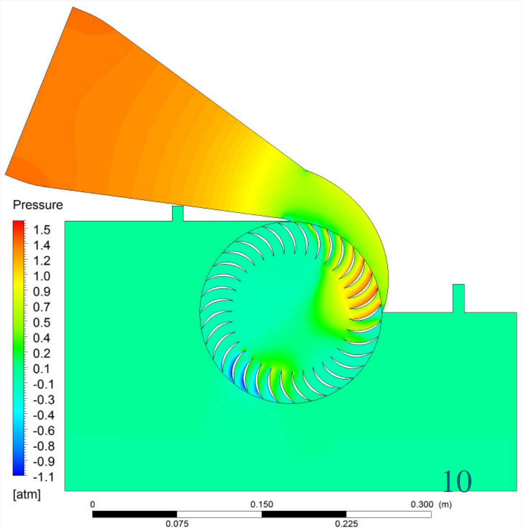
• Design of a Banki (Cross- Flow) turbine starting from hydrodynamic analysis, given Q and ΔH

• Validation and optimization by means of 2D and 3D numerical symulations of CFX (Ansys)



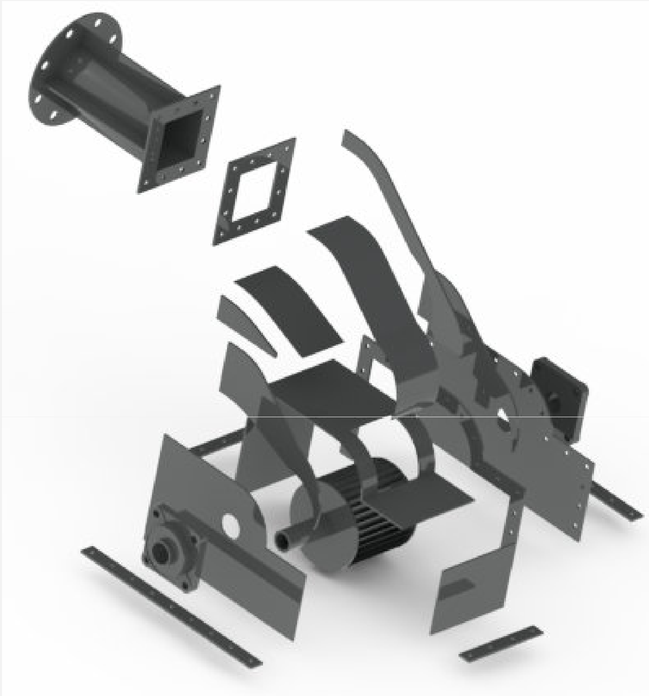


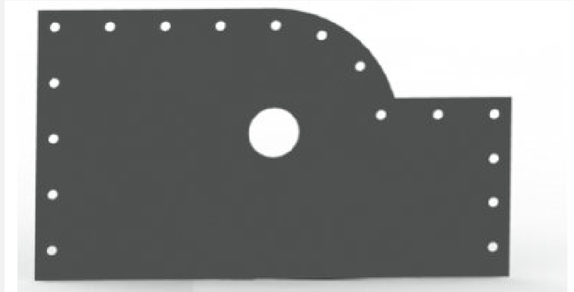


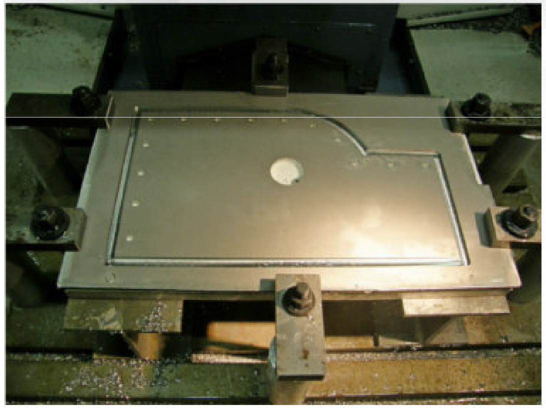


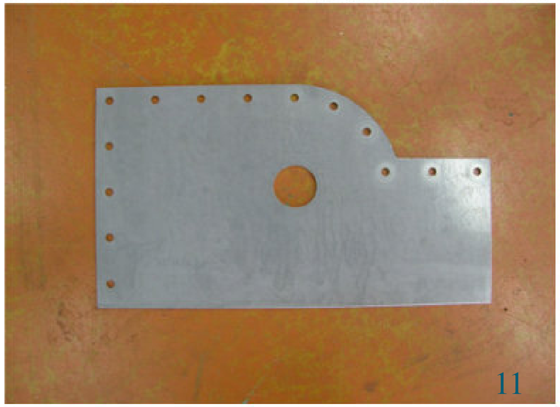
• **Construction of a prototype with the help of INAF mechanical laboratory**

•**3D design of the prototype components to be made by machines with numerical control of the object shape**



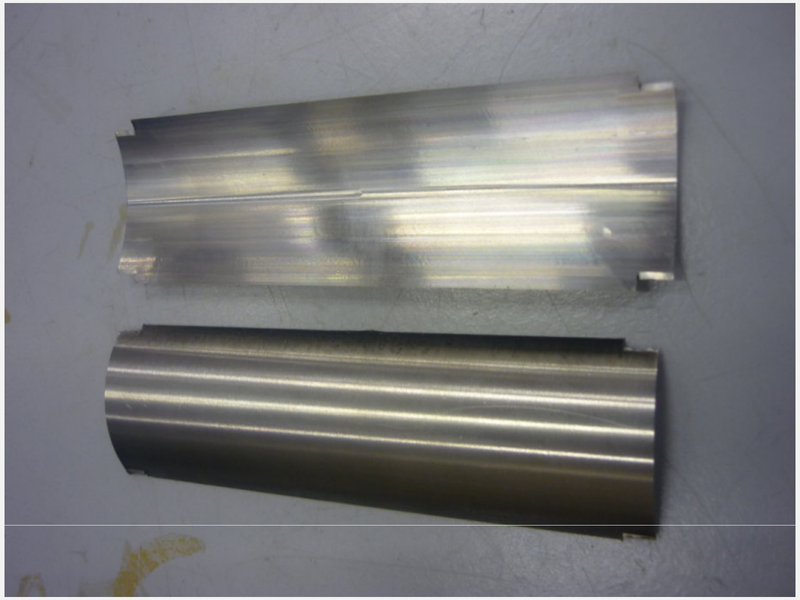


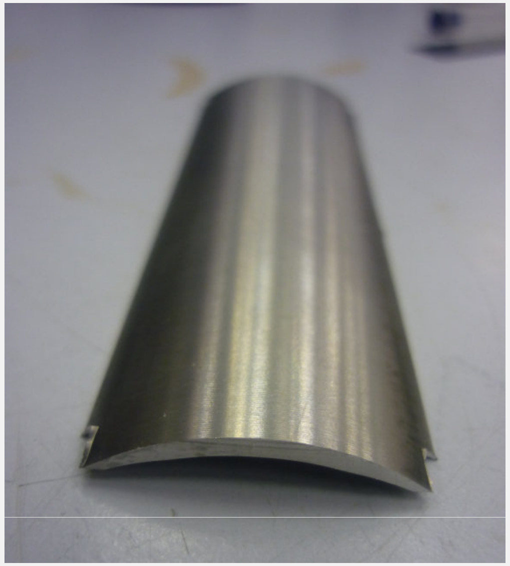


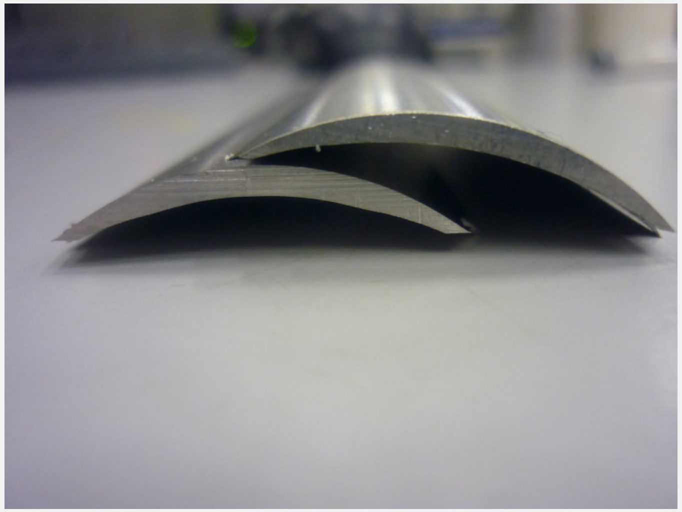


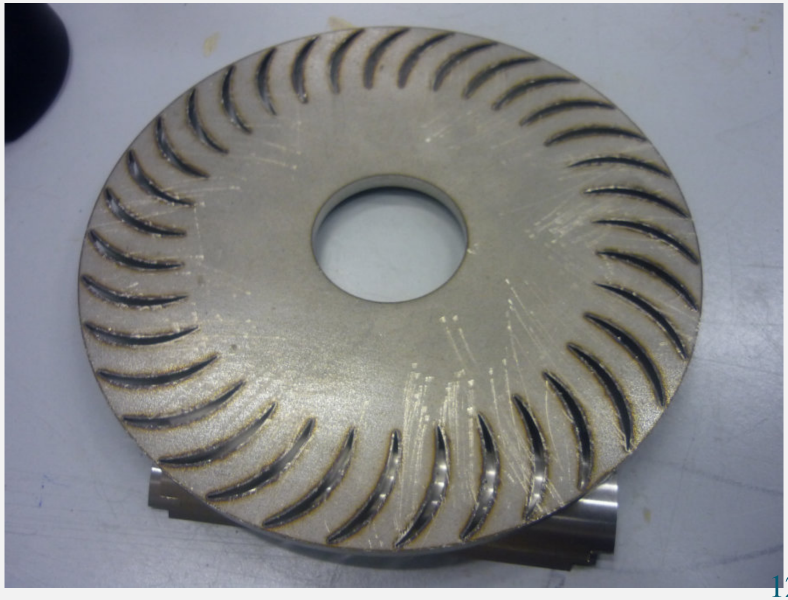
Turbine parameter	Value
Material	INOX Steel
Impeller outer diameter (mm)	160
Impeller inner diameter (mm)	104
Number of blades (-)	35

Turbine components







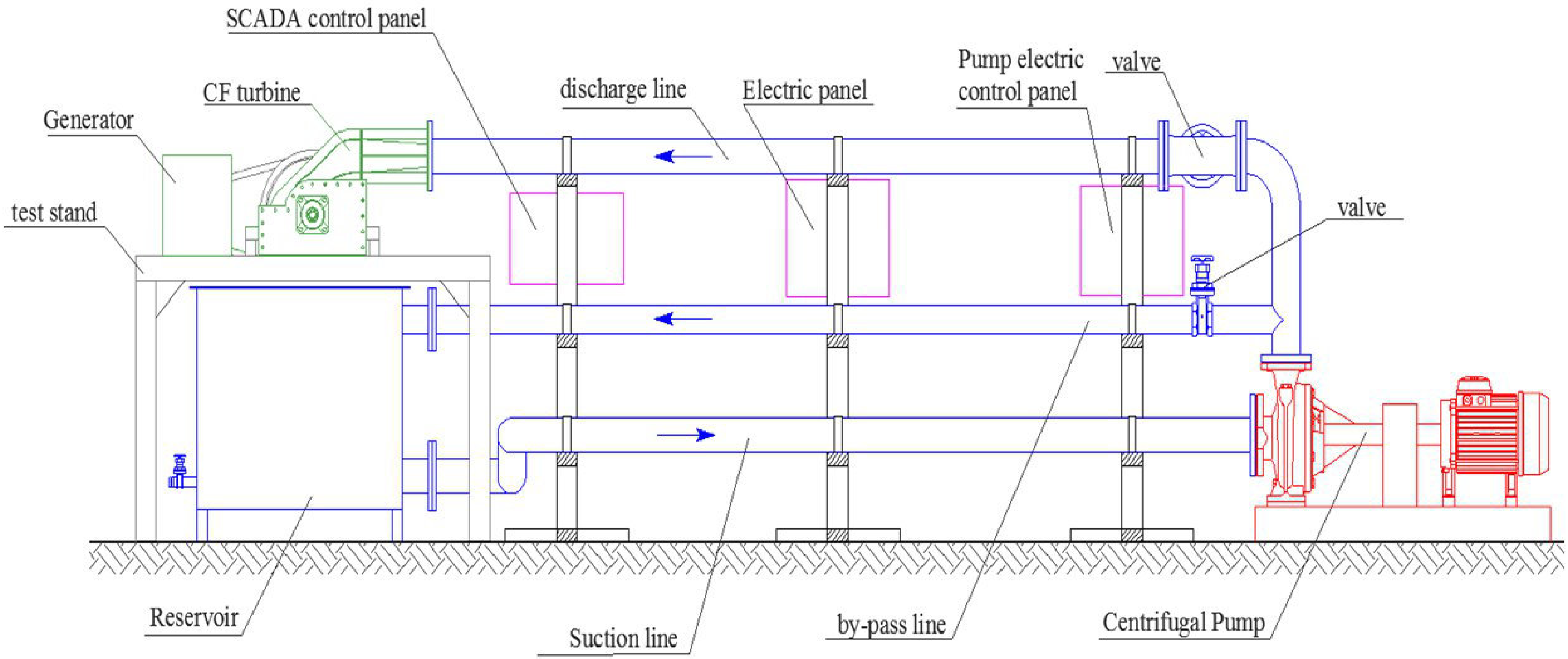


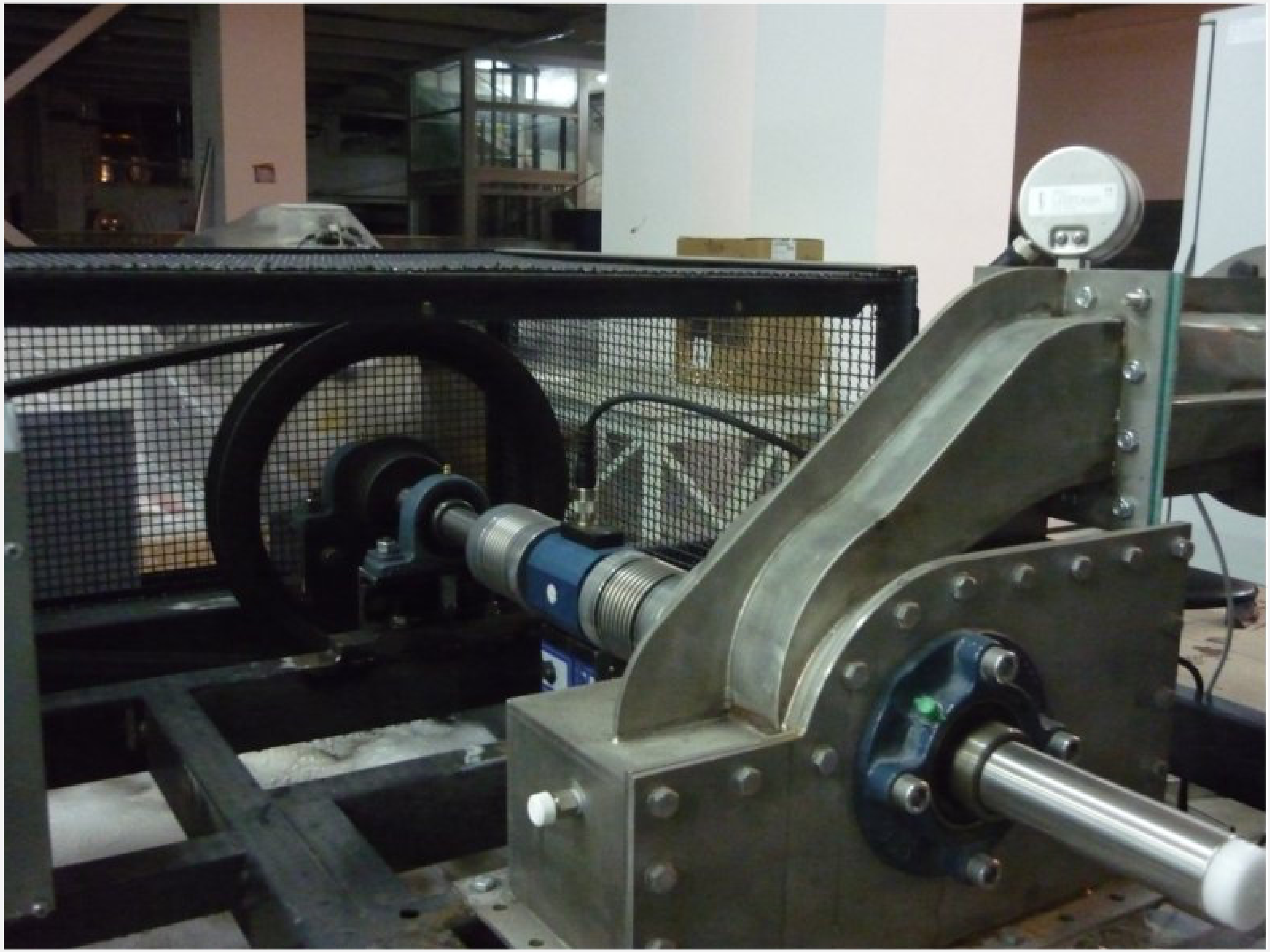
- Prototype characteristics

Turbine planned working point	values
Discharge (l/s)	60
Head (m)	10
Impeller angular velocity (rpm)	750
Generator angular velocity (rpm)	1500
Numerically estimated efficiency (%)	86
Power (kW)	5

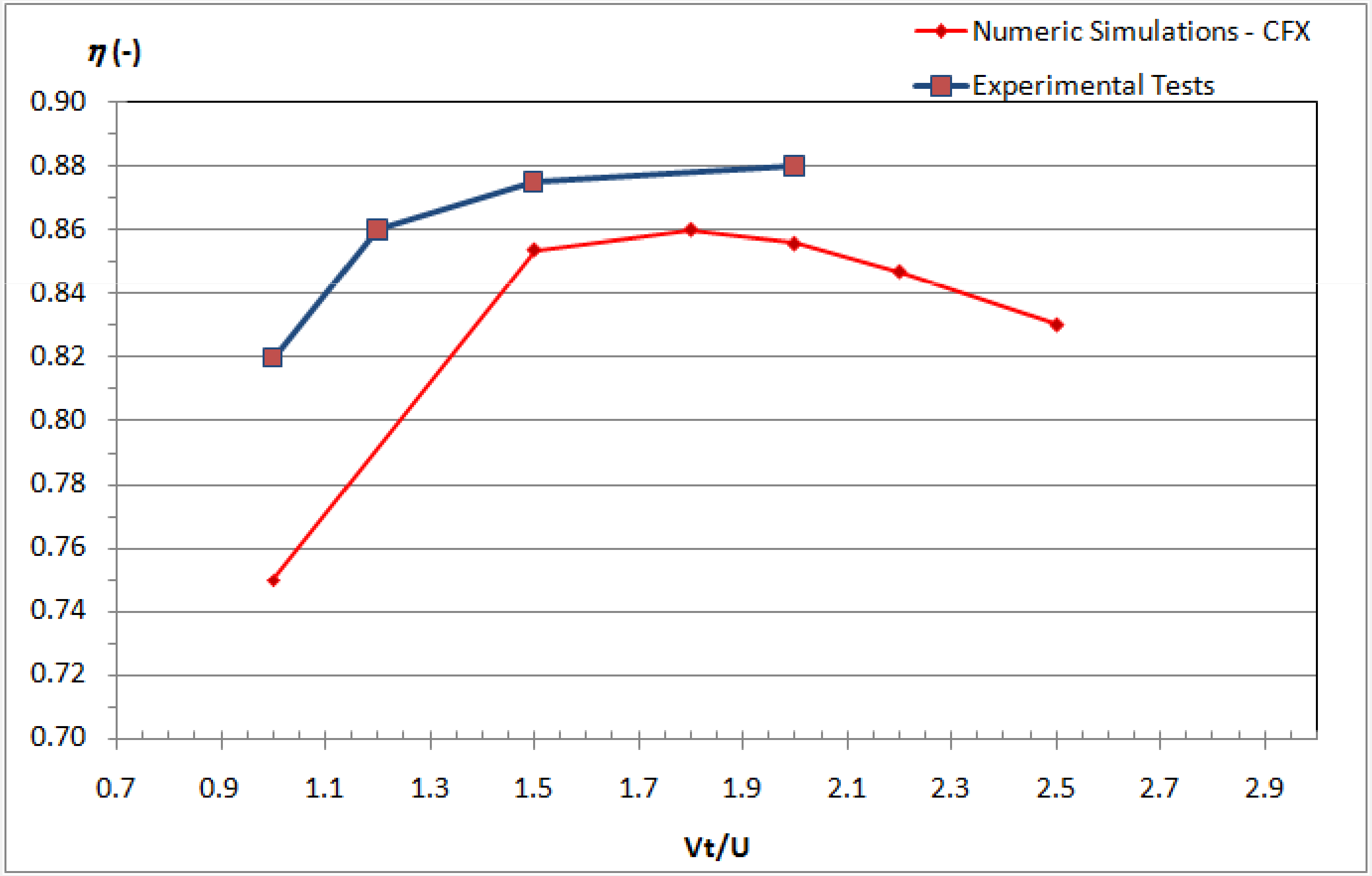
Monitoring devices
Ultrasonic flow meter
Digital manometer
Torquemeter
Rotational velocity sensor
PLC datalogger - Labview

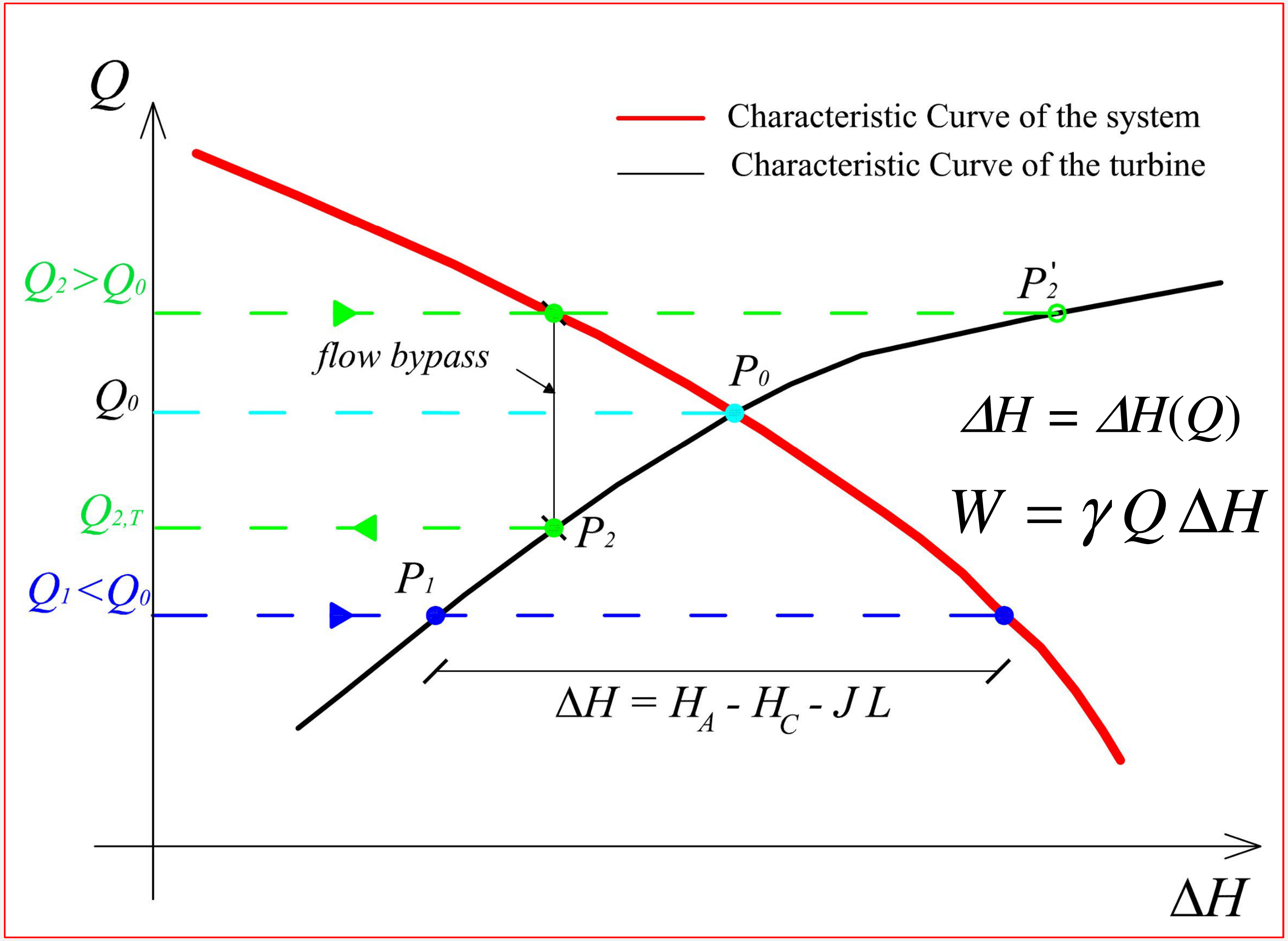
Laboratory test plant



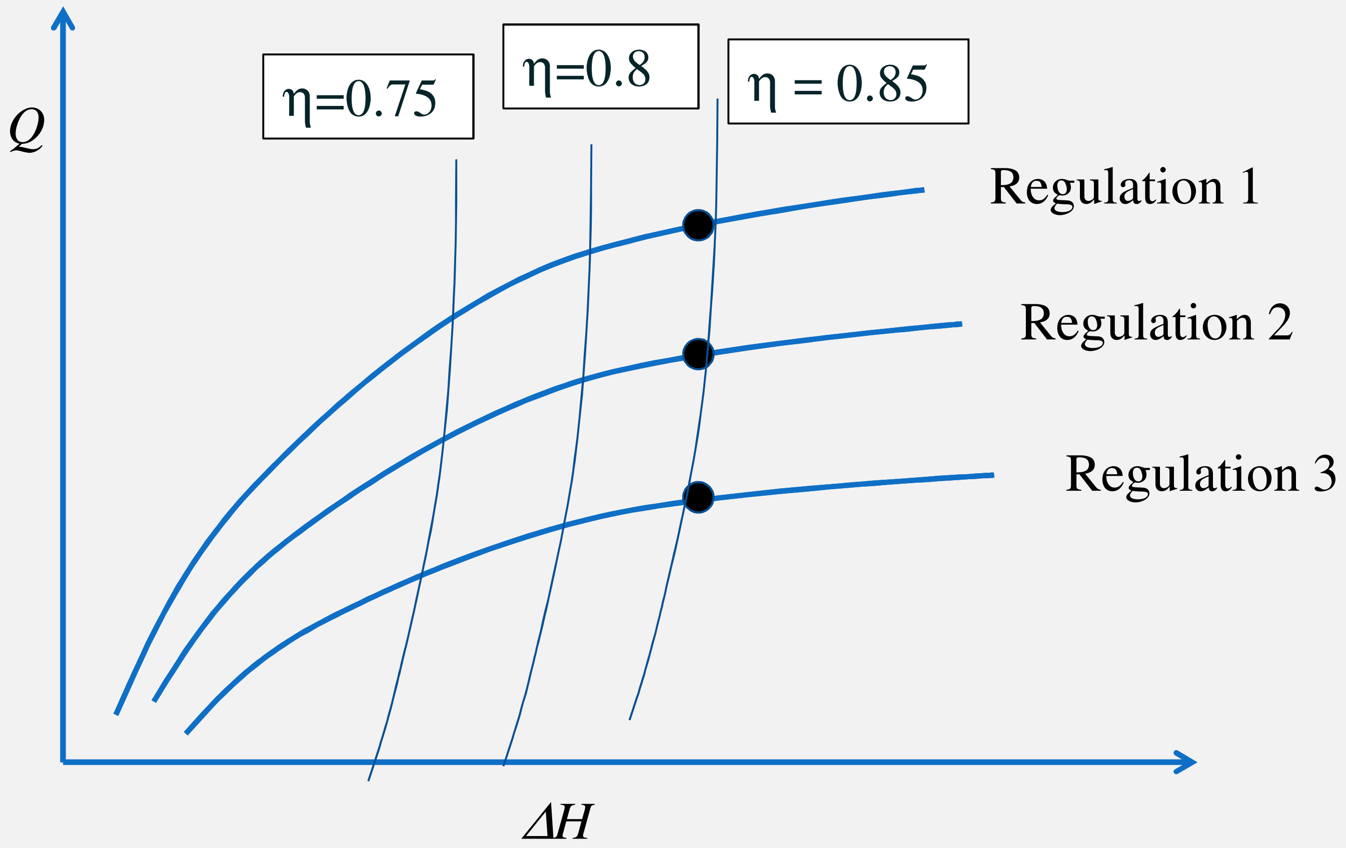


Computed and measured efficiencies

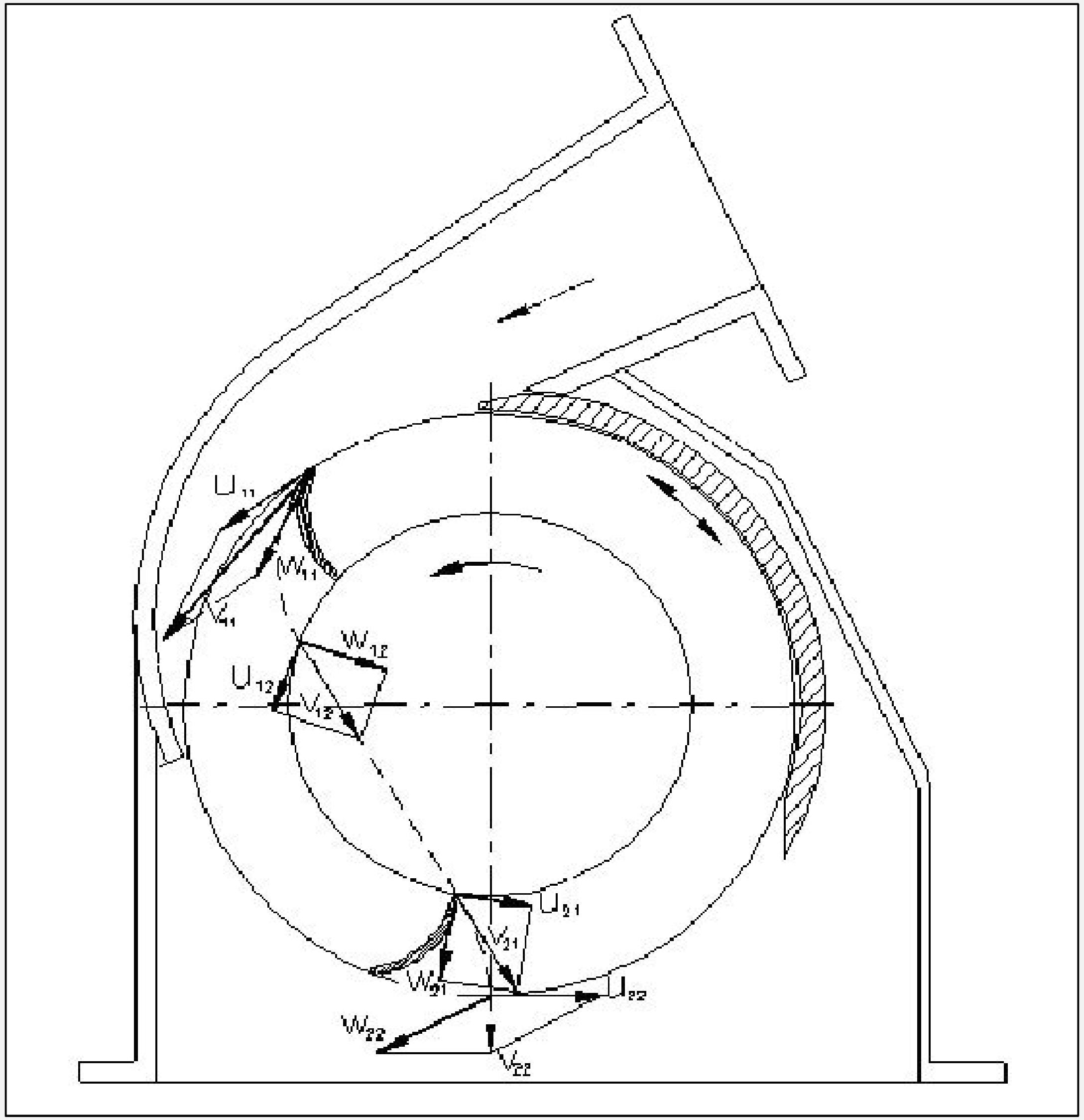


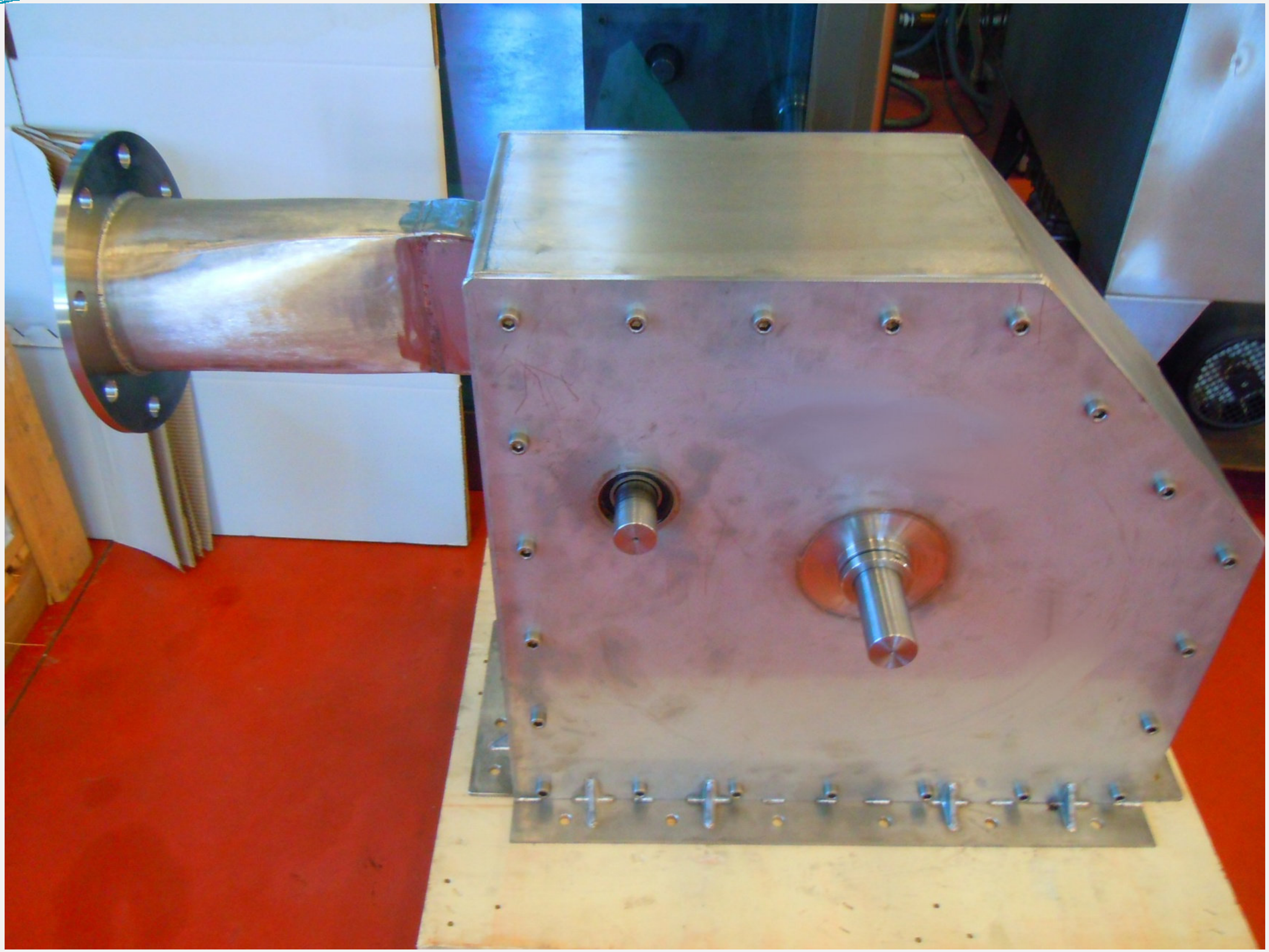

Characteristic Curve of the system
Characteristic Curve of the turbine
Q
$Q_2 > Q_0$
Q_0
$Q_{2,T}$
$Q_1 < Q_0$
flow bypass
P_0
P_1
P_2
P_2'
$\Delta H = \Delta H(Q)$
$W = \gamma Q \Delta H$
$\Delta H = H_A - H_C - J L$
ΔH

Alternative: use of hydraulic regulation

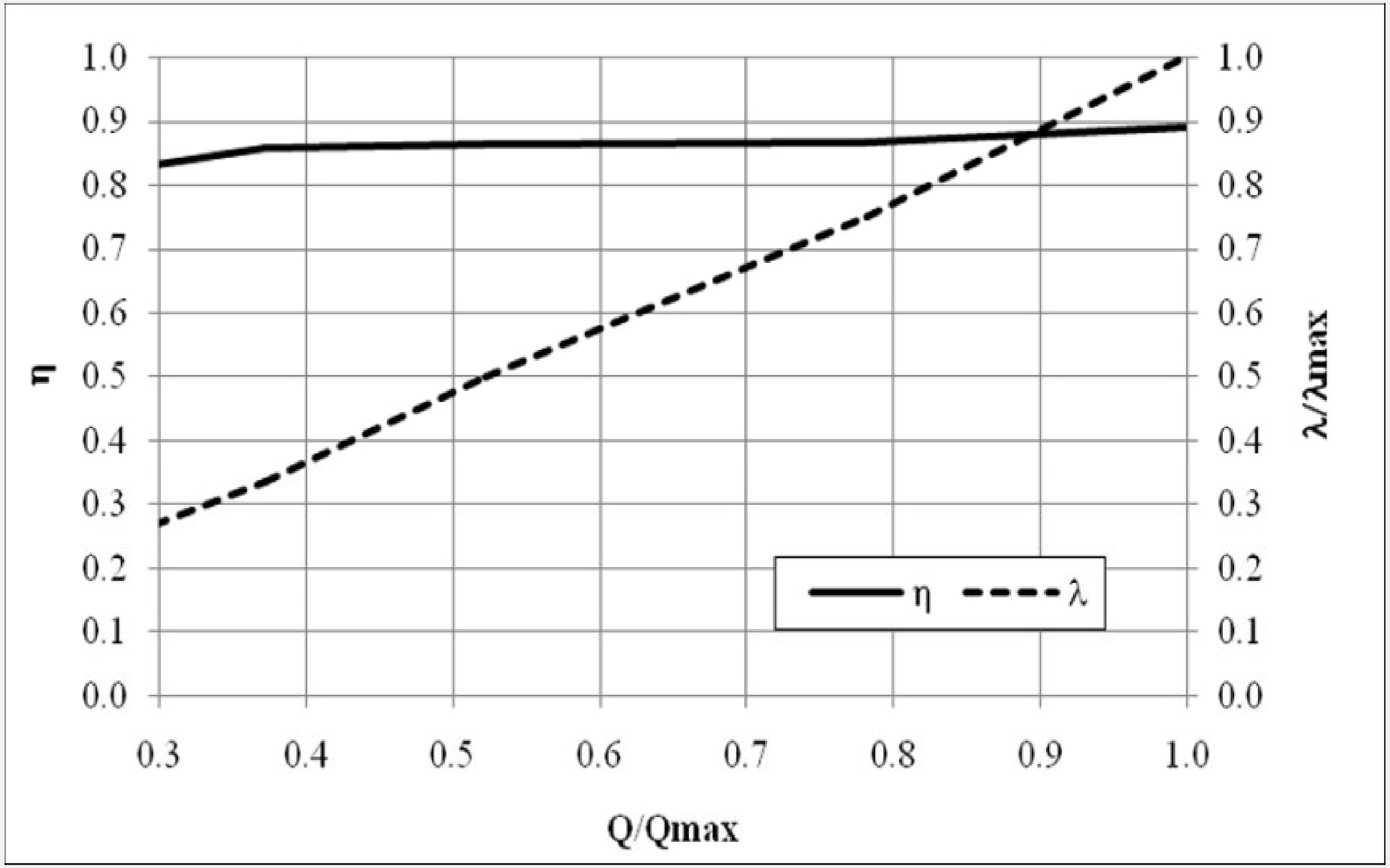


Cink Company regulation system





EXPECTED RESULTS



CONCLUSIONS

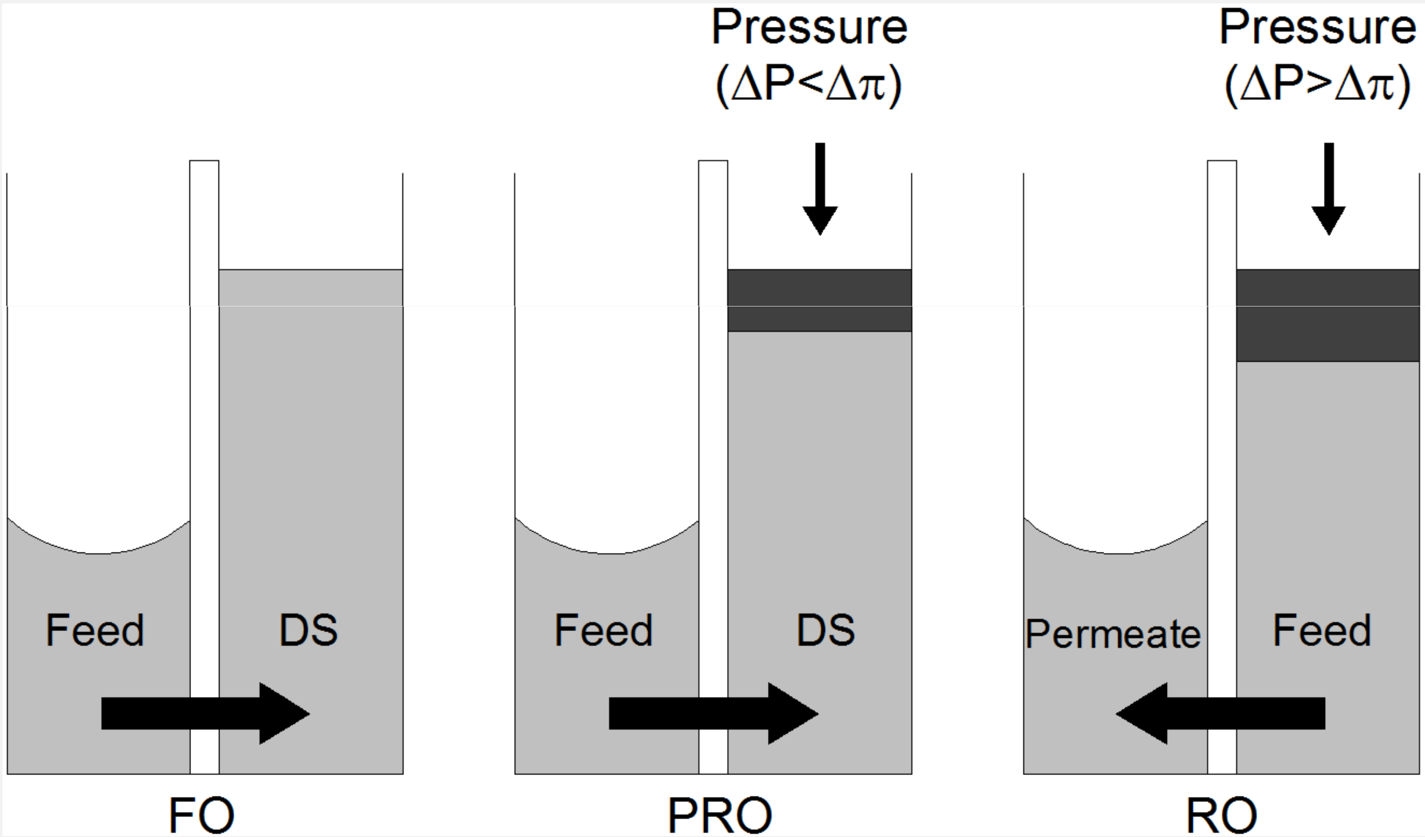
✓ A Cross-flow turbine with a simple but efficient regulation system has been designed, constructed and tested;

✓ Experimental results match very well with the ones computed by means of the CFX – Ansys code;

✓Within the "Hydroenergy" project three of theese turbines should be placed at the end of three small sicilian aqueducts;

✓ The return capital time of a 10 KW turbine is less than one year .

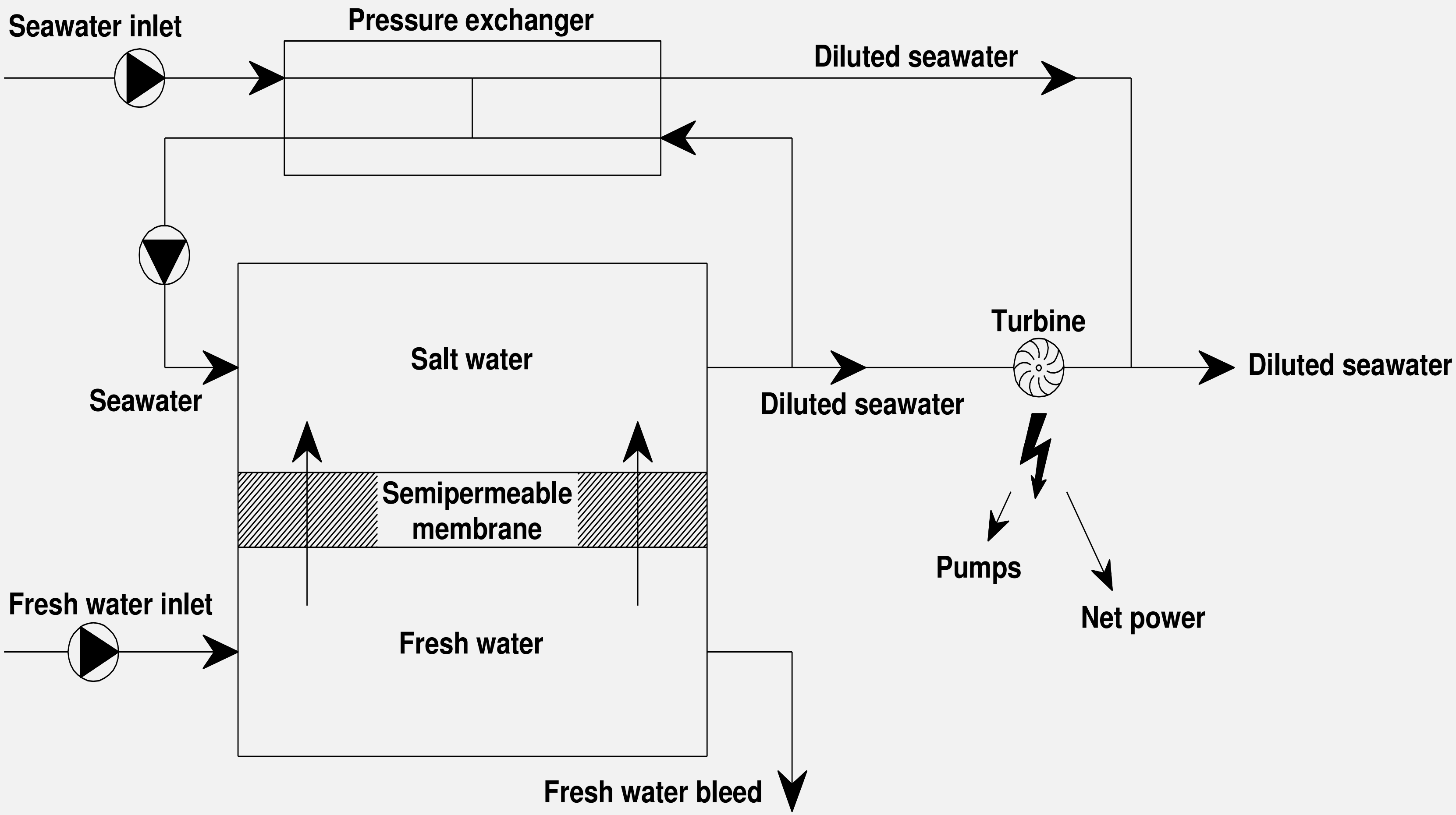
Osmotic Pressure



- Osmotic pressure between freshwater and saltwater: 270 m
- Average discharge of a small river: 100 mc/s
- Theoretical available power: $\gamma\, q\, \Delta H = 270$ MW

Practical limit: filtration velocity through the semi-permeable membrane: $2 \bullet 10^{-6}$ m/s

PRO plant scheme



Conclusions

- ✓ Osmotic energy seems not competititive, at the present time, with respect to other forms of renewable energies, specially if large amounts of power are required;

- ✓ Osmotic energy could be very actractive for the production of small quantities of energy in locations where:
  a) the electric grid is missing or located far away
  b) a continuous production is required and visible devices could be easily stolen or damaged.

Freshwater from saltwater in coastal aquifers