BRAZILIAN TEAM

17th IYPT - AUSTRALIA - Brisbane - 24th June to 1st July
14. **Fountain**

Construct a fountain with 1m ‘head of water’. Optimise the other parameters of the fountain to gain the maximum jet height by varying the parameters of the tube and by using different water solutions.

By Luíza de Almeida Aoki
Introduction

I. Applications of the study

Irrigation

Fuel injection
Methodology

I. Bibliographic research

II. Theory and experiment for maximum jet height

III. Determination of the Relevant Parameters

IV. Maximization of the jet height
General View

I. Tank -> Mariotte siphon
II. Tube -> Wide diameter
III. Nozzle -> Smooth
IV. Jet
   a) Thin
   b) Thick
I. Jet escape speed on the nozzle

From Bernoulli Eq.
\[ P_1 = P_A + \frac{1}{2} \rho V^2 \]

Hidrostatics
\[ P_1 - P_0 = \rho g Y \]

a) Laminar flow

Poissonelle Law
\[ Q = VS = \frac{\pi r^4 \Delta P}{8\eta L} \]

\[ V = \sqrt{2gY + b^2 - b} \]

Where
\[ b = \frac{8\eta L}{r^2 \rho} \]

b) Turbulent flow

\[ \frac{(P_A - P_0)r}{L \rho V^2} = 0.079 \ Re^{-0.25} \]

From Prandtl one-seventh power law

\[ \text{Turbulence discussion} \quad Re = \frac{d\rho V}{\eta} \]
II. Jet height dependence

\[ \rho = \frac{3m}{4\pi R^3} \quad V_o = \sqrt{V^2 - 2gh_0} \]

From Stokes Law: \[ \vec{F} = -6\pi \eta R \vec{v} \]

Motion:

\[ m \frac{d^2x}{dt^2} = -mg - 6\pi \eta \nu R \frac{dx}{dt} \]

Solving:

\[ x(t) = \frac{(g + aV_0)(1 - e^{-at}) - gat}{a^2} \]

Where \( a = \frac{9\eta \nu}{2R^2 \rho} \)

Finally

\[ H = \frac{1}{a} \left[ V_0 - \frac{g}{a} \ln \left( 1 + \frac{aV_0}{g} \right) \right] + H_0 \]

Other influences on jet height
Water Solutions

I. Density

II. Viscosity

III. Surface tension (temperature)

IV. Viscoelastic solutions (polymers)
Experiment

Calibration of the Mariotte Siphon

General Schematic

Detail of the Mariotte Siphon
Experiment

- Practical measure
- Jet escape
- Jet top detail
- Nozzle detail
I. Theory validity

II. Proposition of the optimal parameters

<table>
<thead>
<tr>
<th>Water at temperature (°C)</th>
<th>Average jet height (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>85</td>
</tr>
<tr>
<td>50</td>
<td>84</td>
</tr>
<tr>
<td>75</td>
<td>81</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solutions</th>
<th>Average jet height (cm) at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detergent solution (about 0.2g/L)</td>
<td>83</td>
</tr>
<tr>
<td>Detergent solution (about 1g/L)</td>
<td>82</td>
</tr>
<tr>
<td>Salt solution (density about 1.2g/cm³)</td>
<td>85</td>
</tr>
<tr>
<td>Salt solution (density about 1.5g/cm³)</td>
<td>86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tube diameter (mm)</th>
<th>Average jet height (cm) at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0.6</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>85</td>
</tr>
<tr>
<td>6</td>
<td>78</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
</tr>
</tbody>
</table>
Source of Errors

- Loss of energy
- Imprecision on the measure
- Air resistance