

Ring Fountain Dynamics

Petra Szücs

petraszucs05@gmail.com

Deutsche Schule Budapest, Hungary

1. INTRODUCTION

This study investigates how the fountain effect is generated when a flat metal ring falls into a water tank, creating a vertical jet of water. Specifically, examining how different geometric parameters of the ring, along with its falling height, influence the maximum velocity of the resulting jet. By systematically varying the ring's shape and fall conditions, we identify key parameters that optimize jet velocity, allowing us to apply this knowledge to chemical stirring systems, where the strongest jet can facilitate efficient mixing with minimal energy input.

2. AIMS

The motivation for this study is the observation that the resulting water jet can rise significantly higher than the initial falling height of the ring. This unusual behavior suggests potential practical applications, for example in mixing processes where strong fluid motion is required but energy input should remain low.

3. METHODS AND MATERIALS

My experiments utilised various flat metal washers with different internal/external radius and height. The falling height of the rings varied (2-20 cm), while the water depth in the tank was adjusted (1-10 cm) to investigate in different parameters. For small falling heights, the rings were released manually, whereas for larger, a custom-built mechanical launcher was employed to ensure a parallel impact. All experiments were recorded using a phone at 240 fps and the resulting videos were analyzed using the software Tracker. Each experiment was repeated three times.

The physical theory of the fountain effect is based on the conservation of momentum. The process can be approximated by Δt , between the momentum before the impact and after where the ring's surface coincides with the water surface [Figure 1]. During this short interval, the ring-water system can be treated as an isolated system.

$$v_{wj} = \sqrt{\frac{\rho \left(\frac{-m_r \pm \sqrt{m_r^2 + 4\rho \Delta t (m_r v_{r0} + m_r g \Delta t) A_R}}{2\rho \Delta t A_R} \right)^2 \cdot \Delta t \cdot A_R - m_r \left(\left(\frac{-m_r \pm \sqrt{m_r^2 + 4\rho \Delta t (m_r v_{r0} + m_r g \Delta t) A_R}}{2\rho \Delta t A_R} \right) - v_{r0} \right)}{\rho \Delta t A_{wb}}}$$

Here m_r is the mass of the ring, ρ the density of the water, v_{r0} the ring's velocity before the impact, A_R the surface of the ring, A_{wb} the surface of the rings opening and v_{wj} is the velocity of the water jet.

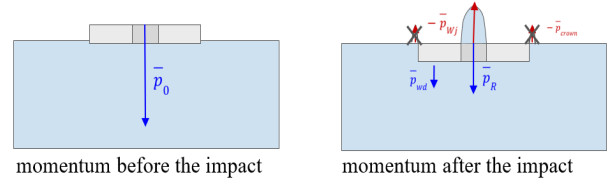


Figure 1. Momentum before and after the impact

4. RESULTS

The experiments showed that decreasing the ring's inner diameter (to an optimum) and increasing its thickness and mass generally lead to a higher maximum water jet. Increasing the falling height of the ring also increases the jet height, while water depth had negligible influence within the tested range [Figure 2].

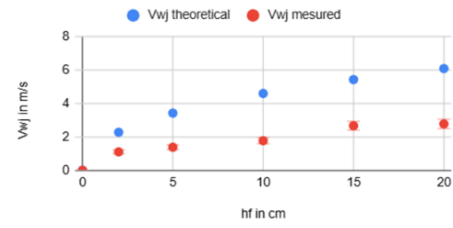


Figure 2. Jet's maximum velocity at different falling heights

5. DISCUSSION

Experimentally measured jet velocities were slightly lower than theoretical due to a model simplification, such as neglecting the momentum of the splash of the water that goes around the ring.

6. CONCLUSIONS

The maximum water jet depends mainly on the ring's geometry and falling height, while water depth has no effect. Experimental results agree reasonably with theory, with little deviations due model simplification

7. ACKNOWLEDGEMENT

I would like to thank my physics teacher Dr. Mihály Hömöstrei for his guidance and support and my father for his help with the experiment

8. REFERENCES

- <https://www.leifiphysik.de/mechanik/impulserhaltung-und-stoesse/grundwissen/impuls-und-impulserhaltungssatz>
- [https://de.wikipedia.org/wiki/Kontinuit%C3%A4tstheorie_\(Geschichtswissenschaft\)](https://de.wikipedia.org/wiki/Kontinuit%C3%A4tstheorie_(Geschichtswissenschaft))