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Research Article

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Water Jet Applied to an Object Floating on Water. Part 2: Cylindrical and Spherical Shape Object. Investigation of an Attraction and Entrainment Phenomenon by the Coanda and Magnus Effects.

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Abstract
The action of a jet of water on an object of rectangular, cylindrical and spherical shape causes its attraction under the effect of the creation of a depression due a priori, to the effect Venturi, Coanda, Magnus etc. known in fluid mechanics. The real observation has been made. We are trying here to find an explanation for this paradoxical phenomenon. Apart from braking, the phenomenon can be applied for recoil, propulsion of an object floating on the water, as well as its rotation in one direction and the other.

Keyword: Braking, Coanda effect, Cylindrical shape, Depression, Floating, Magnus, Spherical shape, Water jet.

Introduction

A paradoxical phenomenon was observed under the effect of the action of a water jet at the back of a floating object: instead of making it grow, it makes it move back. The parallelepiped shape was treated in part 1. In this second part, we treat the forms which can rotate, both cylindrical and spherical.

Figure 1: Attraction of an floating object on water by a water jet. Photo Ben Slama R . 2017

Many photos and videos have been taken on this phenomenon and for objects of different shapes: parallelepiped, cylindrical and spherical. The latter are even provided with a rotational movement by adding to an axis inclined with respect to the direction of the water jet of about 60 °. Attempts to explain the phenomenon have taken place. At first it was thought that it was the turbulence of the air in water emulsion which was under the floating object caused enough force to make it brake.

Subsequently, it has been found that similar phenomena are described in the bibliography and known as the Venturi effect, Coanda, Magnus, Robin, Teapot and levitation.

Bibliographic studies

The movement of a fluid around an object creates different pressures on both sides: depression on one side and overpressure on the other side. This phenomenon turns out to be well known in fluid mechanics and designated by the Venturi, Coanda, Robin effects for fixed objects and water or air circulation. If, in addition, the object rotates relative to itself, we speak of the Magnus effect.

The Venturi effect

The Venturi effect has been covered in part 1.

The Coanda effect (discovered in 1934)

The Coanda effect was similarly observed by Thomas Young around 1800, followed by Henri Bonasse (1930) regarding the deflection of a gas stream by a rounded obstacle. In the 1950s, this theme became interesting in understanding flexion phenomena in aviation. Coanda only uses air. However, C. Duez uses water: Concrete application with the coffee maker.

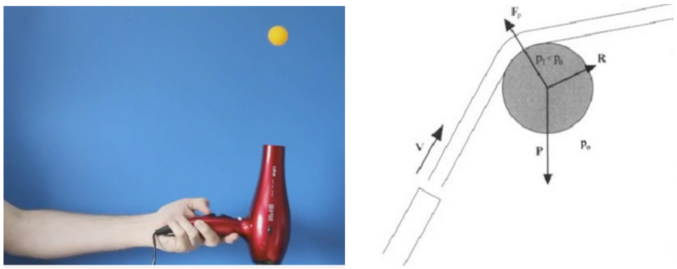


Figure 2: Deviation of an air jet by a rounded obstacle [4].

Even air diffusers (air outlets) use the Coanda effect and are sold under this name (specific profile of the diffusers fins).
Magnus Force (1802-1870) Heinrich Gustave Magnus, German physicist

Principle

The Magnus effect is a physical principle that explains the tangential force experienced by a rotating object moving in a fluid.

Applications:
Balloon lifted (raised): depression created above it.
A free kick (penalty): deflected ball trajectory.
Boat fitted with two Flettners rotors (rotating cylinders).
Expression of the force due to the Magnus effect: www.eswb-sebl.org

$$F = \frac{1}{2}.\rho.V^2.S.\left(\frac{\omega.d}{V}\right).C_N.\sin\propto$$

V: cylinder rotation speed
The air speed is higher on the side of the cylinder where the tangential speed is the same direction as that of the air.

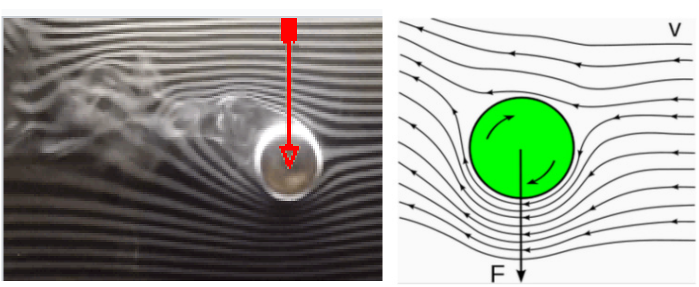


Figure 3: Depression created by the rotation of the cylinder and under the effect of the wind [5].

Application to the boat

This involves equipping boats with rotating cylinders to create a forward depression from the side wind.

Figure 4: Boats fitted with cylinders rotating to create a forward depression under the effect of the side wind [6,7].

History: The first test of a system using the Magnus effect is that of the German Anton Flettner. It was carried out in the 1920s on the Buckau, a ship driven by force developed by two large vertical rotating cylinders mounted on the deck.

This unique boat represents one of the best solutions for the navigation of the future.
The Alcyone is an experimental ship, imagined by Cousteau whose concept was to be applied to the "future" Calypso… Unfortunately, the disappearance of its promoter (like the judicial pantalonnade which followed) did not allow the realization of the project.

- The building, designed by the Mauric Design Office, is 31 m long with a displacement of 76 t. It was launched in the 1985s. It is a hybrid grouping together 2 classic 200 HP and 2 turbojet engines, whose tall "chimneys" give it an immediately identifiable silhouette. These two large towers are its sails…

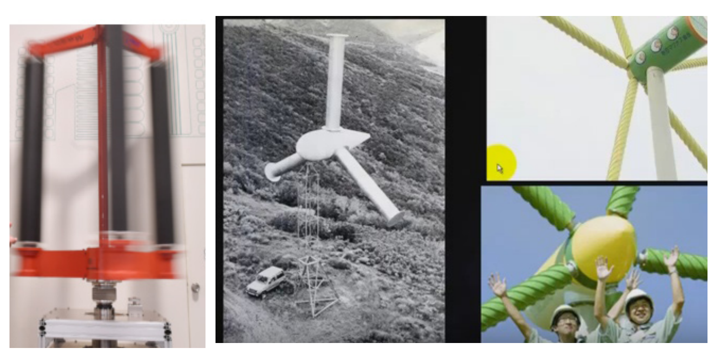
- Its greatest originality is obviously the use of this very special propellant, which owes very little to the Magnus effect already used by Fletner in the 1920s. (It was a propulsion system composed of large vertical cylinders in rotation, capable of producing a longitudinal thrust). The turbo sail is not a rotating cylinder. It is a thick sail with greater lift than a conventional sail. Oval in shape, it is extended by a movable flap allowing to form a lower and upper surface, like an airplane wing. This sail is oriented according to the wind direction, just like a classic sail.

The thick profile tends to create turbulence on the upper surface, which is very detrimental to its operation; this drawback is avoided by an internal suction system in the sail, consisting of an alternately masked or unmasked flap, ensuring a laminar air flow.

Wind turbine

This very particular vertical wind turbine consists of an axis around which rotates, not blades, but a kind of turnstile carrying three rotating cylinders. The advantage of the solution is to be omnidirectional: the machine does not need to be oriented in the wind direction. The "blades" are therefore these cylinders set in rotation and on which the moving air generates a lateral force by Magnus effect.

https://www.youtube.com/watch?v=LoneCLNmqt0



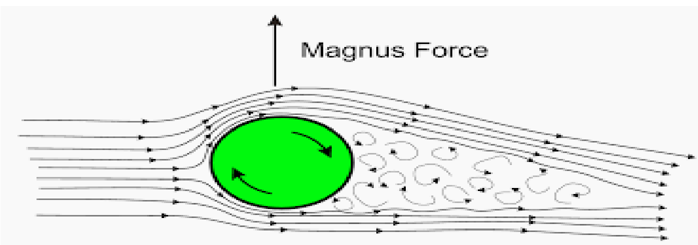
https://www.youtube.com/watch?v=LoneCLNmqt0

Figure 5: Wind turbines using the Magnus force [10].

Robin effect

It's like the Magnus effect, except that if the latter is rather general, the Robin effect is rather reserved for spherical shapes.

In football, a type of ball hitting known as "wrapped hitting" aims to give the ball a curved trajectory. This type of strike is often used during free kick shots to bypass the defensive wall formed by a row of opposing players placed between the ball and the goal and to return the ball to the goal. This strike, by spinning the ball on itself, gives it an effect that changes its trajectory during its stroke. Another type of strike, colloquially known as "banana strike", amplifies this phenomenon, the curvature of the trajectory then sharply increasing at the end of it, accompanied by an acceleration of the ball.



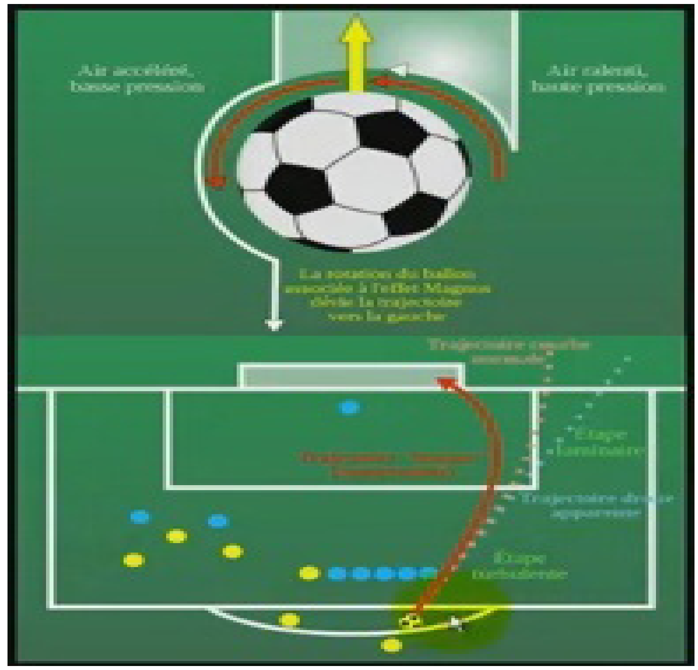


Figure 6: Deviation of the rotating ball on the side where the air speed is higher [11].

Attempt to explain the action of a water jet on the braking of a floating object

Action of the water jet on a parallelepiped floating object

The case of parallelepipedic objects has been dealt with in part 1

Action of the water jet on a floating cylinder

We wanted to see the effect of the jet of water on a floating object of cylindrical shape and carried out the following experiment.

As in the case of the parallelepipedic object, it seems that it is the difference in speed upstream and downstream of the cylinder that creates its suction towards the rear. In addition, the water jet drives the cylinder in rotation in a direction which tends to make it move back.

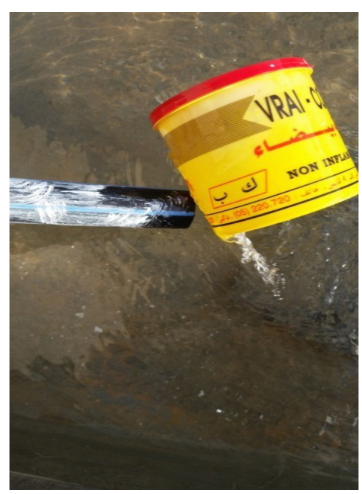


Figure 7: Attraction and rotation of a floating cylindrical object on water by a water jet. Photo Ben Slama R. 2018

The cylinder, under the effect of the jet of water, rotates relative to its axis, but inclined relative to the direction of the jet of water by an angle of 30 degrees.

Action of the water jet on a floating sphere

The sphere behaves in its rotation in the same way as the cylinder. As in the two previous cases: parallelepipedal and cylindrical objects, it seems that it is the difference in speed upstream and downstream of the sphere (balloon) that creates its aspiration towards the rear. In addition, the jet of water drives the sphere in rotation in a direction which tends to make it move back, it behaves as in the case of the cylinder. The axis of rotation is normal to the direction of the water jet.

However, when the water level in the basin rises, then the axis of rotation takes an inclined direction with respect to the direction of the water jet of about 45 degrees.

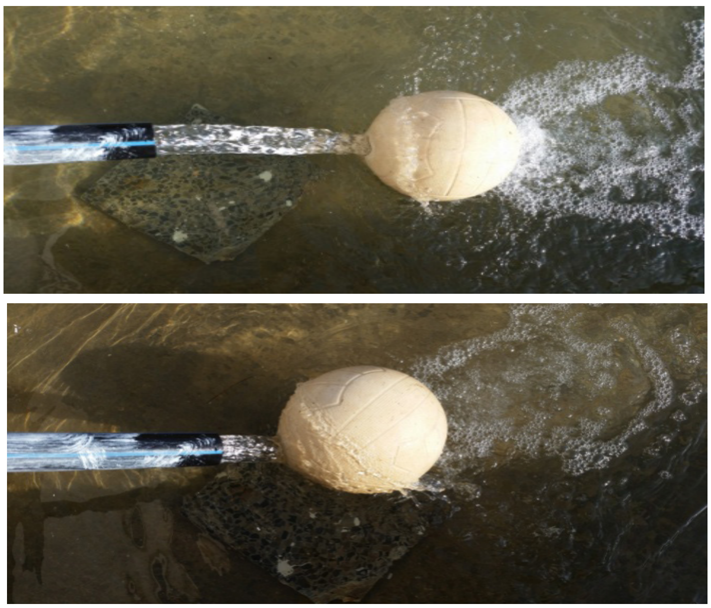


Figure 8: Attraction and rotation of a floating spherical object on water by a water jet. Photo Ben Slama R. 2018

Conclusion

The braking of a floating object by water jet is actually due to the depression created by the speed of the water on one side of the object greater than the other. So this is not due to the turbulence created below the object as we can see, which is misleading. The value of the braking force remains to be determined.

The braking effect is still visible on the cylinder, which is also rotated along an axis inclined to the axis of the jet.

Similarly, for a sphere, in addition to its translational braking, it is rotated along an axis inclined relative to the jet.

As a possible application, mention may be made of.

A deepening of this theme is to be followed both theoretically and experimentally.

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