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The Whirlpool Splitting

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Abstract

An unusual phenomenon called "whirlpool splitting" by analogy with an axe splitting wood logs was experimentally observed. In this experiment, a metal ruler, set vertically on the bottom of the aquarium on the hole axis during flowing out of water has led to the separation of a whirlpool into two formed on both sides of the rule and existed until the end of draining. The paper describes some results of experiments based on the research of this phenomenon

Keywords: water flowing-out from the tank, whirlpool, separator, whirlpool splitting.

Whirlpool appearance [1] is a serious problem in a lot of devices, where liquid is following-out from the tank through the drain holes. It leads to a serious decrease of drain hole throughput [2] and prevents devices from normal functioning (penetration of air into the tubing, changing the characteristics of the flow and etc).

Research into the appearing and development of whirlpools phenomenon has been conducted on the basis of the scientific-educational hydrodynamic laboratory of Sarov Physical&Technical Institute with the participation of school students of Sarov's schools since 2008 [3]. In one of the experiments, there was observed an unusual phenomenon called "whirlpool splitting" by analogy with an axe splitting wood logs. In this experiment, a metal ruler, set vertically on the bottom of the aquarium on the hole axis during flowing out of water has led to the separation of a whirlpool into two formed on both sides of the ruler and existed until the end of draining.

The results of experiments based on the research of this phenomenon demonstrate some of the new features, which slow down the beginning of the whirlpools appearance and, as a consequence, reduce its negative effects.

The experiments were carried out with the help of a water tank with the square bottom 1×1m, and height 0.5m, with a 16mm-diameter hole in the center of the bottom (Fig.1).

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Fig. 1. Experimental tank. 1 – the water supply tube, 2 – a ruler,3 – the separator is placing above the drain hole.

The tank was filled with water up to the level of h_o = 80 mm (the level of water, when one whirlpool appear). To make some start rotation, the same for all experiments, the water was flown into tank along one of the horizontal edge through the tube (1). The level of water in the tank was detected by a metal ruler (2) installed inside the tank on the front wall and reaching the bottom of the aquarium.

The influence of hole separating into two and four parts by the separator and the time of flowing-out was researched in the experiments. The separator was a steel plate 2cm width and 0,5mm thickness (one side of the plate was touched the bottom of tank). The fourfold separator was made of four tin plates by soldering and in the sectional view resembled a four-beam star.

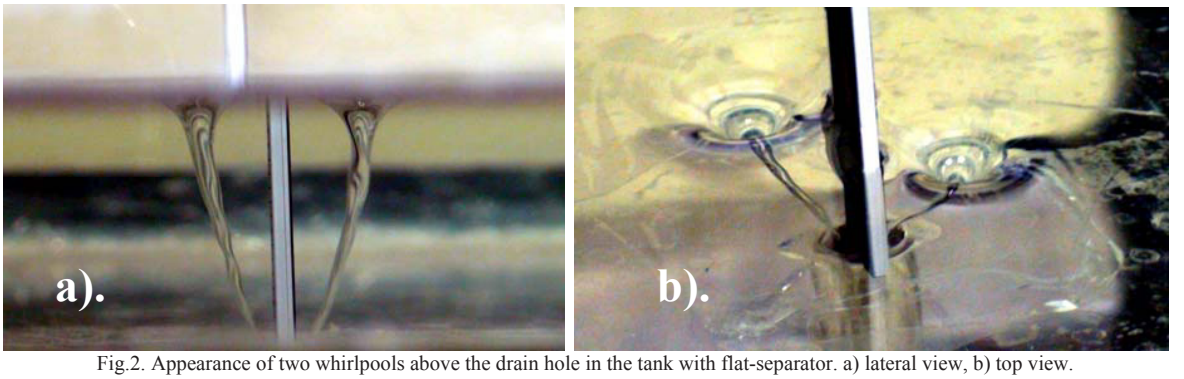

Fig.2. Appearance of two whirlpools above the drain hole in the tank with flat-separator. a) lateral view, b) top view.

The photographs (fig 2) show the appearance of two whirlpools above the drain hole in the tank with a flat-separator. The separation of the drain hole into the four parts leads to appearance of four whirlpools (fig 3).

All whirlpools twirl in same direction (the direction was determined by the start rotation of the water in the tank). In all cases there was an individual rotation of water in each of the whirlpools and the overall rotation of the water in the peripheral region of the tank. In the case of two whirlpools the division between the peripheral overall rotation and the rotation of individual whirlpools was on radius 4÷5 cm.

We have found out that if the separator is placed above the drain hole, it takes the whirlpool more time to appear (fig.4) and the flowing-out time decreases (fig.5). It was observed that several whirlpools simultaneously appearing above the different parts of the hole.

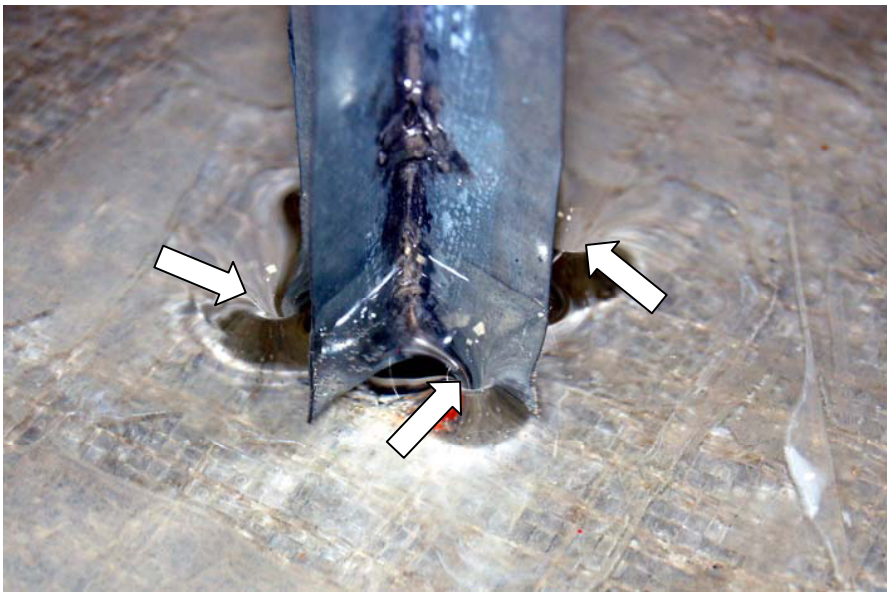

Fig.3. Appearance of four whirlpools. The arrows point to three of them, the fourth whirlpool situates behind the separator.

The dependence of whirlpool appearance level h^* on the whirlpool number is shown on fig.4. One whirlpool (without separator) appears on level $h^* \approx 78$ mm, two whirlpools appear on level $h^* \approx 55$ mm, four whirlpools appear on level $h^* \approx 25$ mm. The process of flowing-out from the tank is shown on fig. 5.

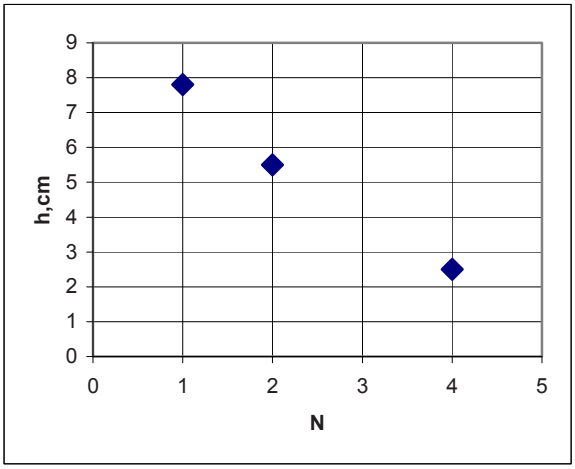

Fig. 4. The dependence of whirlpool appearance level h^* on the whirlpool number N.

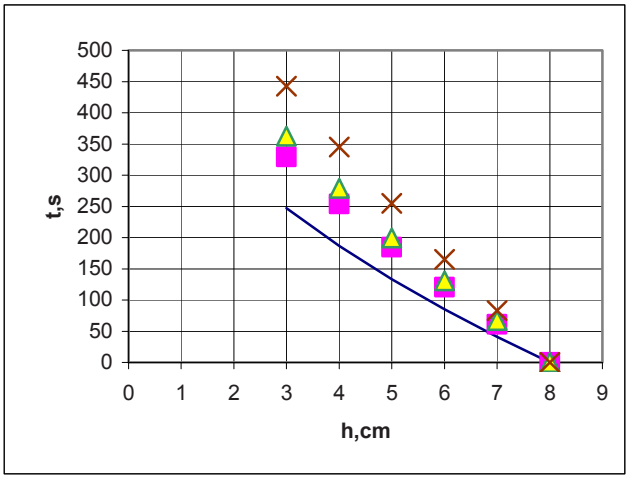

Fig. 5. The $t(h)$ diagram of the process of flowing-out from the tank
(×)without separator (with appearance of one whirlpool), (▲) with separator with appearance of two whirlpools
(■) and with four whirlpools. The dependence corresponding to Torrichelly's equation $v = \sqrt{2gh}$ is shown here (line).

If the fourfold separator is placed above the drain hole, the water flowing-out is faster than the other ways by 25%.

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