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INVESTIGATION OF THE EFFICIENCY OF WATER-JET EJECTORS

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ABSTRACT
This paper investigates the water aeration process with the aid of different in design jet ejectors. It is established that vortex flow ejectors ensure sufficient increase of the concentration of dissolved air in the water as compared with conventional Venturi tube ejectors. It is obtained that blade ejector creates optimal conditions for aeration of the fluid. It is established that air solubility ratio of this ejector is reached a level 0.76:1.
Keywords: aeration, water-jet ejector, air solubility

1. INTRODUCTION
Jet pumps are one of the most common devices used to transfer and mix gases and fluids, increase stream pressure, saturate the fluid with oxygen and atomize the stream of the fluid. Mentioned processes are widely used in practically all branches of industry.
Jet pumps have several advantages over other types of pumps. The main advantage is that there are no moving parts. Jet pumps are characterized with a high degree of reliability and durability, they have simple design and are simple to operate and maintain.
Ejector systems are widely used in environment protection industry [1]. One important field of application for jet pumps is biological wastewater treatment. Ejector systems can be used for wastewater aeration, to introduce the air required for further treatment process into the wastewater stream. In such a case fluid and air are mixed without additional input of mechanical energy, only kinetic energy of the flow is utilized [2]. Ejector systems are also used to prepare the drinkable water. In such a case Iron oxide FeO is replaced by FeO_3 oxide, the last can be more easily removed from water [3].
Incorrectly designed aeration system are not able to supply adequate amount of air (oxygen) into the wastewater, this can complicate further treatment processes and operation of biological treatment equipment [4].
Therefore, three different designs of ejectors were developed with the purpose to improve water aeration efficiency. The aim of this work is to compare efficiency of three different types of ejectors and find the optimum design of the ejector.

2. OBJECT OF INVESTIGATION
Schemes of the tested water-jet ejectors are presented in Figures 1–3. First of them shown in Figure 1 utilizes the spiral grooves to induce vortex motion of the fluid, second (shown in Figure 2) – twisted blades and the last has tangential stream inlet (Figure 3).

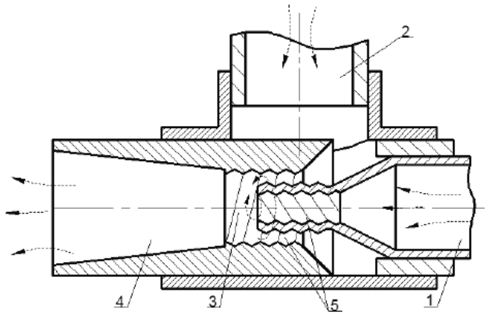

Figure 1. Scheme of the spiral ejector: 1 – stream inlet; 2 – air intake; 3 – mixing chamber; 4 – diffuser; 5 – spiral grooves

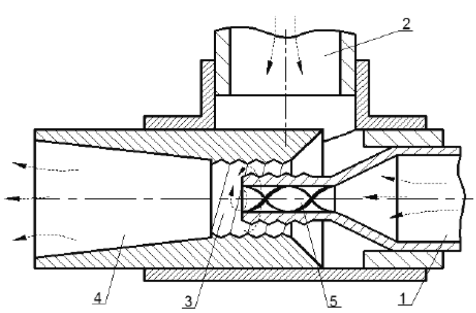

Figure 2. Scheme of the blade ejector: 1 – stream inlet; 2 – air intake; 3 – mixing chamber; 4 – diffuser; 5 – twisted blades

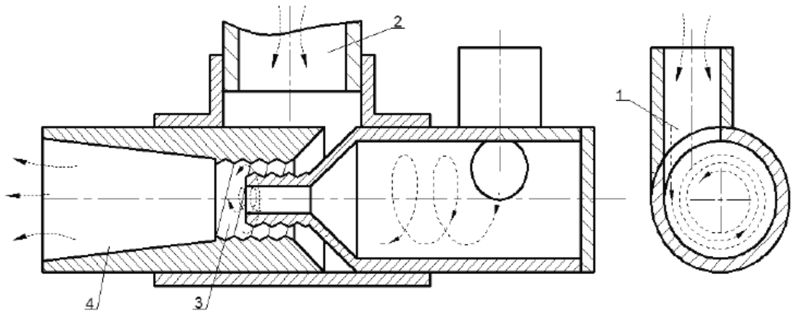

Figure 3. Scheme of the ejector with the tangential stream inlet: 1 – stream inlet; 2 – air intake; 3 – mixing chamber; 4 – diffuser

3. EXPERIMENTAL STAND AND TECHNIQUE

In order to investigate efficiency of ejectors the test stand has been developed. Its scheme is given in Figure 4. Stand consists of the water tank 1 (Figure 4). Pump 3 feeds the ejector 2. Pressure of the liquid was measured with manometer 4. Flowmeter 5 was used to measure the flow rate of water. Quantity of the ejected air was established with the aid of anemometer 7 (Testo, mod. 435). Photo of the stand is presented in Figure 5.

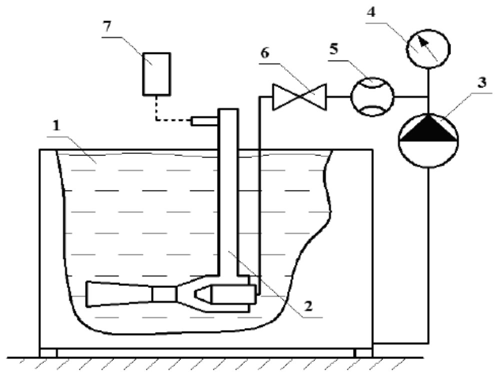

Figure 4. Scheme of the experimental stand: 1 – water tank; 2 – tested jet ejector; 3 – water pump; 4 – manometer; 5 – flowmeter; 6 – adjustable valve; 7 – anemometer

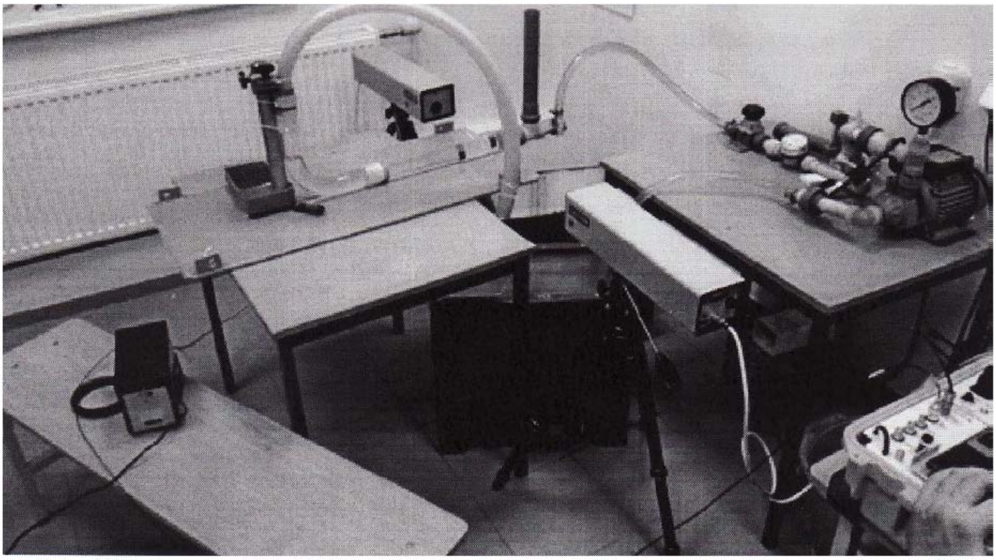

Figure 5. Photo of the experimental stand

The experiments were carried out in the following order:

♦ Pump was turned on and the valve was adjusted to the flow rate 0.7 m^3/h.

♦ The length of the air torch (Fig. 6) of the ejector was measured with the aid of ruler then torch area (Fig. 7) was calculated.

♦ Flow rate of ejected air was measured.

♦ Water flow rate was increased gradually from 0.7 to the 1.5 m^3/h with increment of 0.2. At each step length and area of the air torch were measured as well as flow rate of the ejected air.

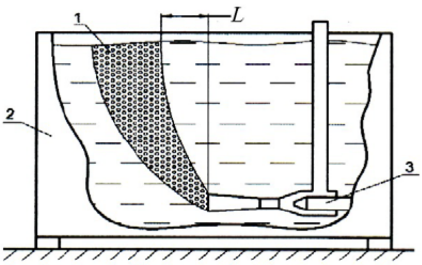

Figure 6. Torch length L measurement scheme: 1 – air torch; 2 – water tank; 3 – tested ejector

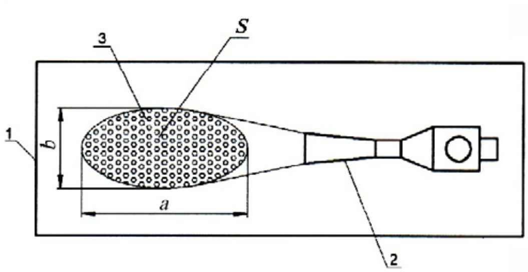

Figure 7. Torch area S measurement scheme: 1 – water tank; 2 – tested ejector; 3 – air torch area

4. RESULTS AND DISCUSSION

Results of experiments are presented in Figures 8–10. It is obvious from Figure 8 and Figure 9 that length and area of the torch of the ejector depends on fluid flow rate. Ejector with twisted blades provides a longer contact time between water and air. This ejector also ensures larger contact area between air and water.

As may be seen in Figure 10 ejector with twisted blades provides the best aeration efficiency. This can be explained by higher degree of dispersion of air in the water due to the vortex motion of the fluid in the ejector.

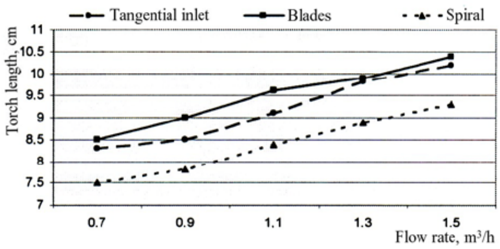

Figure 8. Air torch length of the ejector as function of water flow rate

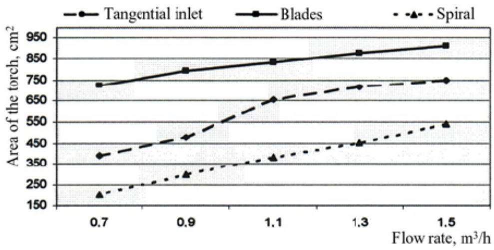

Figure 9. Torch area of the ejector as function of water flow rate

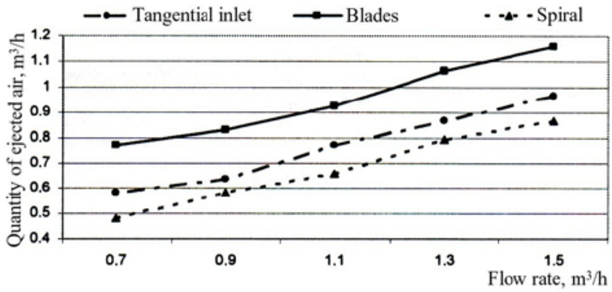

Figure 10. Quantity of ejected air as function of water flow rate

5. CONCLUSIONS

In accordance with the results of experiments we may draw the following conclusions:

- It is established that blade ejector (causes fluid and air to flow in opposite directions) creates optimal aeration conditions due to the longer air torch and bigger number of the air bubbles at the same water flow rate. Ratio of the flow rates of the ejected air and fluid reaches value of 0.76.
- At the low flow rates (less than 0.7 m^3/h) blade ejector ensure a 20% increase of quantity of ejected air as compared with aerators of another design.
- Blade ejectors can be successfully utilized in the biological treatment systems. These ejectors can be used in new equipment as well as to modernize existing equipment and increase its productivity.

6. REFERENCES

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