Energy Efficiency of the Hydrodynamic Heat-Generator

The research develops an energy effective and environmentally appropriate technology of volumetric non-contact liquid heating.

In order to heat liquid in heat-and-power engineering, petrochemical and food technologies, it is necessary to use contact heating by applying convection heat exchangers or electrical heaters. But using this method causes scale crusts and burnt pieces on heating surfaces. This can reduce the heater's efficiency factor and the final product's quality. As a result, for maintaining the required temperature, it is necessary to increase the energy consumption. This may cause heater element damage. To prevent this, it is necessary to perform a repeating chemical-mechanical washing using special chemical substances. This increases the maintenance costs and does not guarantee descaling.

The volumetric non-contact liquid heating method can solve this problem. This heating method is performed by hydrodynamic heat-generators. The heater's action is based on dissipative liquid heating in a high-gradient flow. The hydrodynamic heat-generators do not have convection heating surfaces, so they can heat all liquids, including highly explosive or organic fluids.

Rotor-type hydrodynamic heat generators are more often used.

Structurally this apparatus includes two coaxial drums. **Figure 1** shows the internal revolving rotor #**2** and the external stator #**1** which form an intercylinder gap **δ**. For high-frequency rotor rotation the high-gradient thin-film liquid flow is created in the intercylinder gap. A high velocity gradient condition produces appreciable dissipative liquid heating, that is the main thermal source of the rotor-type hydrodynamic heat generators.

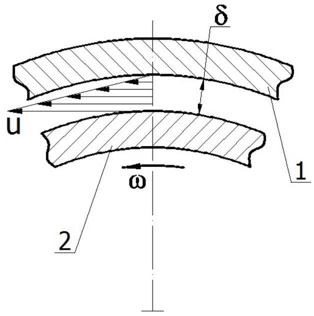

Figure 1. Intercylinder Gap is formed by Revolving Rotor and Stator:
1 is the stator, 2 is the revolving rotor, and δ is the intercylinder gap.

A mathematical model for thermal field calculation has been developed for performing a theoretical study of high-gradient flow in the intercylinder gap. Numerical results have been shown for fluid motion in the heat-generator gap by appreciable local overheating of the liquids to the boiling point which can appear as a result of dissipative heating. The mathematical model may predict liquid overheating in the active core of the rotor-type hydrodynamic heat-generator.

In the intercylinder gap, stabilized laminar and turbulent incompressible viscous liquid motion was evaluated for dissipative heating efficiency. Quantitative results showed that the dissipative liquid heating efficiency of laminar flow increases to 100%, with intercylinder gap width reduction. In the turbulent flow, the dissipative heating efficiency decreases with growth of the Reynolds number.

It was found experimentally that rotor speed, intercylinder gap width, Prandtl numbers, and rotor surface roughness impact on the dissipative heating power of the rotor-type hydrodynamic heat-generator. It was determined that rotor speed and intercylinder gap width appreciably influence heating capacity. Thus, the rotor speed growth or intercylinder gap width reduction in $\boldsymbol{k}$ causes an increased value of specific dissipative heating power $\boldsymbol{k^2}$.

Using deduced formulas, an average integral specific power quantitative assessment of dissipative heating was performed. It was shown that using the hydrodynamic heater concept with a revolving rotor produces high-level specific dissipative heating power from about 10^6 to 10^7 W/m^3.

Thus, theoretical and experimental research results have allowed us to identify the required dimensions and optimal operating conditions of the rotor-type hydrodynamic heater (**Figure 2**). As a result of this research, the heater's efficiency became 91% (**Figure 3**).

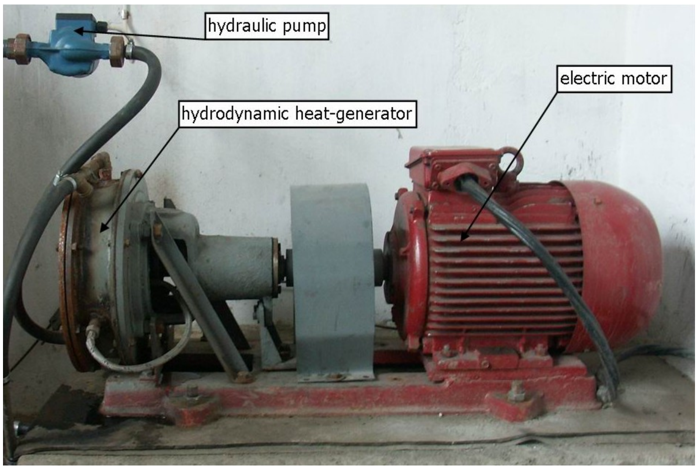

Figure 2. Rotor-Type Hydrodynamic Heat Generator

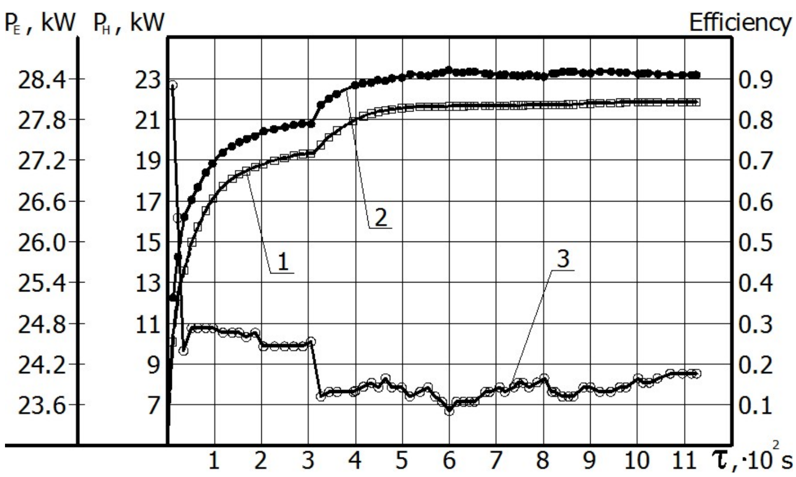

Figure 3. Rotor-Type Hydrodynamic Heat Generator's Energy Characteristics: 1 is generated heat power, 2 is efficiency value, 3 is motor's electrical power.

Currently, this research project is completed.

Keywords: liquid, laminar flow, turbulent flow, dissipative heating, hydrodynamic heat-generator.