Influence of design and mode parameters on pump performance curve of heat generating aggregate

O Barykin¹, S Kovalyov¹, M Ovcharenko¹, A Papchenko¹
¹ Sumy State University, R-Korsakova str., 2, 40007, Sumy, Ukraine
E-mail: barakudapgm@gmail.com

Abstract. Classification of multi-functional heat generating aggregates according to the function is considered in this article. Analysis of operating process mathematical model was implemented and methods for its refinement were proposed. Results of physical investigation of heat generating aggregate design and mode parameters influence on its power and head were presented.

1. Introduction

Multi-functional heat generating aggregates (HGA) – machines of vortex operating principle, where milling process of operating medium solid inclusions, their active mixing, pumping and hydrodynamic heating are implemented in the hydraulic flow part. These machines are widely used as technological equipment of most branches of industry (food, chemical, pharmaceutical, agriculture, municipal engineering and etc.) [1]. Concerning functionality of heat generating aggregate there is possibility of specific process intensification (milling, mixing, heating) by means of some design changes. 

Classification of heat generating aggregates according to the function is given in Figure 1.

Results of research of heat generating aggregates, hydromills and homogenizers are detailed given in [2-4]. But the most widely spread are heat generating aggregates HGA, where heating of operating medium is dominating process. Previous results of machines research are given in [1].
2. Problem statement
During manufacture of heat generating aggregates and their application it was determined that there is possible to adjust its operation not only by means of alteration of impeller design parameters and its rotating speed but by means of alteration of design parameters of stator apparatus. Moreover in some cases it is necessary to forecast pumping effect of aggregate for the purpose of technological requirements provision concerning operating medium transportation. Earlier obtained mathematical model doesn’t permit to include mentioned parameters. For these conditions the decision was taken concerning experimental research of stator apparatus design and diameter influence on power and head performance curve of heat generating aggregate.

3. Description of research implementation
Hydraulic test bench (Figure 2) was developed for research implementation, this bench operates on closed circuit.

![Figure 2. Experimental test bench of heat generating aggregate.](image1)

Hydraulic principle scheme of hydraulic test bench is given in Figure 3.

![Figure 3. Hydraulic principle scheme of experimental test bench.](image2)

The bench consists of tank T (1.5 m³), to which investigated heat generating aggregate is connected by means of suction and pressure piping. Aggregate drive is implemented by means of pendulum DC motor. Valve V₂ is installed for adjustment of liquid flow rate. Measuring equipment provides
possibility to implement power trials of aggregate according to [5]. Set of measuring equipment consists of: sensor of pressure difference «Safir M», sensor of excess pressure «Safir M», tensometric sensor ZEMIC L6D-C3-5kg, inductive tachometer, digital-analogue inverter L-Card E14-140MD for conversion of analogue signals of sensors into digital signals for PC, PC Lenovo V570 for signals collection and analysis.

Design of hydraulic flow part of investigated aggregate is given in Figure 3. Investigated specimen of heat generating aggregate consists of arm on which shaft is installed by means of bearings. Casing is fixed on bearing flange of arm. Impeller is installed on the shaft (Figure 5), which is fixed by means of nut-fairing. Intake is installed at the casing. Stator apparatus are installed at both sides of the impeller (Figure 6). By means of spacer rings there is possibility to adjust gap between impeller and stator apparatus. Mechanical seal is installed for shaft hermetic sealing.

**Figure 4.** Design scheme of investigated heat generating aggregate.

![Figure 4](image_url)

**Figure 5.** Design of operating elements: (a) – impeller; (b) – stator apparatus without dividing ring; (c) – stator apparatus with dividing ring.

Experimental research was implemented for the following parameters: impeller diameter – 170 mm, impeller width - 40 mm, width of stator apparatus – 20 mm, rotating speed - 1500 rev/min, quantity of impeller vanes – 8, quantity of stator apparatus vanes – 9, gap 2.5 mm. Variating parameters – external diameter of stator apparatus – 160-185 mm, liquid flow rate – 0-4.5 m³/hour.
Defined parameters – power, head, pumping effect (percentage of energy, which is consumed for pumping).

4. **Results of experimental research**

Results of experimental research are given in form of performance curves in Figure 6.

![Performance Curves](image)

**Figure 6.** Experimental performance curves of heat generating aggregate.

After analysis of obtained results it can be stated that stator apparatus diameter increase relating to impeller diameter up to 10% leads to head increase up to 5% and provision of more effective hydraulic interaction of vortex flows, which leads to aggregate power increase up to 5%. Head increase can be proved by flow kinetic energy (angular component of speed) conversion to potential energy. Besides it should be mentioned that application of dividing rings for stator apparatus installed at internal diameter leads to head increase up to 3 times. For this case consumed power increases up to 25%.

5. **Conclusions**

Implemented experimental research allows producing the following general conclusions:

- it is reasonable to apply stator apparatus with dividing rings at internal diameter of vanes for increase of pumping effect of heat generating aggregate and providing more effective energy interaction in hydraulic flow part. For this case it can be obtained head increase up to 200-300%, and energy effectiveness increase up to 25%;

- variation of external diameter of stator apparatus in range of 0.95-1.08 impeller diameter leads to head variation up to 5% and power – up to 5%.

- it is reasonable to research influence of stator internal diameter and dividing rings installation at stator external diameter on head and power performance curve of heat generating aggregate.

By means of generalization of analytical, experimental and computational research of heat generating aggregate provides possibility to obtain semiempirical mathematical model for forecast of operating characteristics of heat generating aggregates.
References

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