Investigation of Self-Oscillations in Hydrodynamic Systems

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Overheating of the reactor in case of emergency is one of the main problems of water-cooled nuclear power plants. Passive safety systems operated by natural forces are used to improve the reliability. But heat transfer in such systems is relatively slow. The work purposes were to investigate the properties of self-oscillation in a hydrodynamic system and to check the possibility of usage self-oscillations in passive safety systems. For an example of a simple hydrodynamic system, we considered theoretically and tested experimentally the conditions when self-oscillations occur. The experimental data were collected from video recording with the Tracker software and from Fourier Multilab digital sensors with the author's program in C++. We built a mathematical model of the system and proposed to build diagrams, which would show the dependence of the system behavior on its parameters. The diagrams allow to determine whether self-oscillations exist before the experiment. It was found that under certain conditions the average liquid flow rate during self-oscillations overcomes the rate of direct flow. We proposed to use this feature to improve passive safety system performance of nuclear power plants. A model installation that simulates an emergency cooling system for a nuclear reactor was made. It was shown with the model installation and by numerical simulation that the self-oscillation mode can provide more efficient heat transfer than the direct natural circulation. Future investigations are needed to check the proposed model for industrial design of nuclear power plants.