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Streszczenie pracy doktorskiej w języku angielskim

„ Influence of acoustic conditions on the operation parameters of the thermoacoustic Stirling engine”

(„Wpływ warunków akustycznych na parametry pracy termoakustycznego silnika Stirlinga”)

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Thermoacoustics is one of recently developed alternative energy technologies. In thermoacoustic devices occurs a direct conversion of heat into acoustic energy, which is a form of mechanical energy. With an electroacoustic transducer it can be converted further into a more useful electrical energy. It may also directly drive a thermoacoustic refrigerator or heat pump. The main advantage of thermoacoustic devices is a low temperature difference needed to start and operate. Latest research shows that even heat supplied from a source at temperature of 100-200°C can drive such devices. This makes the thermoacoustic technology possible to be used for low-temperature waste heat recovery. Recent research and development issues in field of thermoacoustics are addressed exactly to this kind of applications.

One of such devices is a thermoacoustic engine with a looped-tube resonator of a length equal to a wavelength λ. Gas oscillating in the engine performs a thermodynamic cycle close to the theoretical Stirling cycle. Energy conversion occurs in a regenerator, which together with adjacent heat exchangers: a heater and a cooler, forms a thermoacoustic core. Inserting the core section into the resonator causes acoustic reflections of an original travelling wave, which is demanded for effective engine operation. To reduce these disturbance an acoustic field adjustment is needed. In multi-stage engines an acoustically symmetric system adjusts itself. The opposite reflections are compensated by each other. In order to eliminate harmful reflections, single-stage devices need an additional element which acts like an acoustic filter.

Although the method is well known, there is lack of comprehensive study concerning functionality of filters which adjust acoustic conditions, and their influence on the performance of a single-stage thermoacoustic engine. Previously conducted research of systems with adjusting acoustic filters were quite cursory. The main result of this work is a detailed analysis of functionality of various acoustic filters. Influence of their geometrical parameters on the acoustic field adjustment was thoroughly investigated. On this basis, it was also possible to examine influence of the acoustic field in both the regenerator and the resonator on the performance of the thermoacoustic Stirling engine.

The comprehensive parametric study of the system was carried out numerically with the software DeltaEC. Simulation of many variable parameters, including geometrical, acoustic and thermal ones, based on this model, led to better understanding of thermoacoustic phenomenon occurring in the engine, as well as to recognition of their mutual dependencies and their

influence on the engine power and efficiency. Different types of acoustic filters were also compared within numerical simulation.

It was possible to validate the results achieved numerically by the experimental investigations carried out on the real thermoacoustic engine, which was especially designed and constructed for this purpose. Tuning of acoustic conditions was realized by changing geometrical dimensions of the acoustic filter with a widened cross-sectional area, which was assembled in a waveguide.

Final results achieved from both the simulations and the experiment confirmed that a single-stage thermoacoustic engine can be applied for utilisation of the low-temperature heat. However, to ensure effective energy conversion process an optimal acoustic field is demanded. For this purpose an acoustic filter has to be installed in a proper position in a resonator. In this way it is possible not only to adjust the important for the process acoustic conditions in a regenerator, but also to affect the whole acoustic field distribution, having significant influence on acoustic losses in the remaining part of the waveguide. Finding an optimal engine operation point needs a compromise between the theoretically ideal conditions in a regenerator and the acoustic field in a resonator which induces the lowest losses.