Bi-Directional Impulse Turbine for Thermo-Acoustic Generator

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Abstract : The paper is devoted to one of engine types with external heating – a thermoacoustic engine. In thermoacoustic engine heat energy is converted to an acoustic energy. Further, acoustic energy of oscillating gas flow must be converted to mechanical energy and this energy in turn must be converted to electric energy. The most widely used way of transforming acoustic energy to electric one is application of linear generator or usual generator with crank mechanism. In both cases, the piston is used. Main disadvantages of piston use are friction losses, lubrication problems and working fluid pollution which cause decrease of engine power and ecological efficiency. Using of a bidirectional impulse turbine as an energy converter is suggested. The distinctive feature of this kind of turbine is that the shock wave of oscillating gas flow passing through the turbine is reflected and passes through the turbine again in the opposite direction. The direction of turbine rotation does not change in the process. Different types of bidirectional impulse turbines for thermoacoustic engines are analyzed. The Wells turbine is the simplest and least efficient of them. A radial impulse turbine has more complicated design and is more efficient than the Wells turbine. The most appropriate type of impulse turbine was chosen. This type is an axial impulse turbine, which has a simpler design than that of a radial turbine and similar efficiency. The peculiarities of the method of an impulse turbine calculating are discussed. They include changes in gas pressure and velocity as functions of time during the generation of gas oscillating flow shock waves in a thermoacoustic system. In thermoacoustic system pressure constantly changes by a certain law due to acoustic waves generation. Peak values of pressure are amplitude which determines acoustic power. Gas, flowing in thermoacoustic system, periodically changes its direction and its mean velocity is equal to zero but its peak values can be used for bi-directional turbine rotation. In contrast with feed turbine, described turbine operates on un-steady oscillating flows with direction changes which significantly influence the algorithm of its calculation. Calculated power output is 150 W with frequency 12000 r/min and pressure amplitude 1,7 kPa. Then, 3-d modeling and numerical research of impulse turbine was carried out. As a result of numerical modeling, main parameters of the working fluid in turbine were received. On the base of theoretical and numerical data model of impulse turbine was made on 3D printer. Experimental unit was designed for numerical modeling results verification. Acoustic speaker was used as acoustic wave generator. Analysis if the acquired data shows that use of the bi-directional impulse turbine is advisable. By its characteristics as a converter, it is comparable with linear electric generators. But its lifetime cycle will be higher and engine itself will be smaller due to turbine rotation motion.

Keywords : acoustic power, bi-directional pulse turbine, linear alternator, thermoacoustic generator
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