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Numerical Investigation on Outlet Design of Cascade-Combined Tesla Turbine

(翼列複合型テスラタービンの出口設計における数値解析)

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Abstract

In recent years, Micro fluid device is greatly required in many fields. However, the efficiency of bladed turbine drops sharply with its downsizing. On the other hand, Tesla turbine is predicted to keep a high efficiency even at a small scale. So, it is considered to be very promising in the application to small fluid machines. It has a structure of multiple thin rotating CD-shape, connected with spacing small gaps. The working fluid comes into the rotor tangentially from the nozzles, passing through the narrow gaps between the disks centripetally and spirally. However, in spite of a long history of invention and expectancy of its high performance, there exists many issues and the efficiency is less than 30% in the experiments of tesla turbine.

To improve tesla turbine rotor efficiency, a concept of cascade-combined tesla turbine is proposed [1]. It is aimed to absorb residual kinetic energy at the inner diameter area. Improvement of rotor efficiency confirmed by CFD simulation and maximum 12.48% improvement by optimizing the blade parameters [2]. However, according to the previous research, [3] inappropriate turbine outlet design may lead to a lower turbine performance. The simulations above were carried out for only one passage of the rotor with an ideal turbine outlet, though there is a big difference in velocity profile at rotor outlet between original Tesla turbine and cascade-combined Tesla turbine. Therefore, the objective of this study is to gain knowledge about how to get optimized design of turbine outlet part by numerical simulation. Simulations of the cascade-combined Tesla turbine and original tesla turbine with different turbine outlet height are carried out.

Simulations of different Δr (height of outlet passage) of original Tesla turbine and cascade-combined Tesla turbine with 13 flowing passages in their rotors are carried out using the commercial code of FLUENT. The rotor outer diameter is 80 mm, and inner diameter is 27 mm. 60 pieces of blade [2] which are designed referring to accelerating blade are added to each disk of the rotor. Parameters are set as the design point of Tesla turbine in this laboratory. (rotor rotation speed of 35,800 rpm, inlet tangential velocity 150m/s, radial velocity 3m/s).

Based on the simulation results, the following conclusions can be drawn:

- For the original tesla turbine outlet, as height of outlet passage increases, output power and viscous loss both decrease in turbine outlet. There exists an optimal design of width of outlet passage for original tesla turbine balancing the outlet viscous loss and outlet turbine output power.
- For the cascade combined Tesla turbine outlet, as outlet height increases (shaft diameter decreasing), turbine output power decreases and viscous loss increases. Therefore, the hang-over type turbine outlet (shaft diameter is 0) would be more suitable than the shaft type to the cascade-combined Tesla turbine.

Reference

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