Numerical Analysis of Nozzle Clearance’s Effect on Turbine Performance

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Abstract: Variable nozzle turbine (VNT) has become a popular variable geometry turbine (VGT) technology for the diesel engine application. Nozzle clearance, which can’t be avoided on the hub and shroud side of the VNT turbine due to the pivoting stators, can lead to turbine performance deterioration. However, its mechanism is still not clear. In this paper, numerical investigation, which is validated by experiment, is carried out to study the mechanism of the nozzle clearance’s effect on the turbine performance. Firstly, performance of the mixed flow turbine with fixed nozzle clearanceis tested on flow bench. Performance of the tested turbine with the same nozzle clearance is numerically simulated. The numerical result agrees well with the test data, which proves correct of the numerical method. Then the turbine performance with different nozzle clearances is numerically analyzed. The research showed that with nozzle clearance, flow loss in the nozzle increases at first and it reaches the maximum value when the clearance ratio is 5%. Flow at the exit of the nozzle becomes less uniform with nozzle clearance. The negative incidence angle of the rotor also increases with nozzle clearance and leads to more incidence angle loss in the rotor. The low energy fluid formed in the nozzle due to the nozzle clearance migrates from hub to shroud side in the rotor, which is another main reason for the rotor’s performance degradation. The present research exposed the mechanism of the dramatically decrease of the turbine performance with nozzle clearance: (a) The loss associated with the nozzle leakage increases with the nozzle clearance; (b) The flow loss grows up quickly in the rotor due to the incidence angle loss and migration of the low energy fluid from hub to shroud side.

Key words: nozzle clearance, variable nozzle turbine (VNT), mixed flow turbine

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