1. Compressor surge based on a 1D-3D coupled method – Part 2: Surge investigation

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Abstract: Compressor characteristics and system parameters, which include pipe lengths, plenum volumes, and throttle coefficients, greatly affect compressor surge. The one-dimensional-three-dimensional (1D-3D)coupled method, is established in Part 1, combines a 3D solver for compressor internal flows and a 1D solver for pipe, plenum, and throttle flows to simulate compressor surge in a compression system. In this paper, the capability of the method to reflect changes of compressor characteristics and system parameters will be demonstrated. Given a centrifugal compressor, variable inlet prewhirl and variable diffuser vanes are employed to adjust compressor characteristics; based on the setup of a datum test rig, the pipe length, plenum volume and throttle coefficient in the 1D solver are modified to get different system setups. Thus, the compressor system can be numerically configured with various compressor characteristics and system parameters, and the 1D-3D coupled method is applied to simulate compressor surge in various configurations. Simulation results show that compressor surge flow rates decrease, and surge periods prolong in the case of positive inlet prewhirl, which is consistent with known results concerning inlet prewhirl; if the diffuser vanes are closed by 5 degrees, the compressor would get out of surge and operate stably, which aligns with expectations. In terms of system parameters, simulation results indicate that the surge period is shortened and the trajectory of surge cycle on the performance map shrinks if the pipe length or plenum volume reduces. Mild surge, mixed surge, and deep surge are captured while the throttle is set with big, moderate and small openings, respectively. Thus, the 1D-3D coupled method is proved being sensitive to changes of compressor characteristics and system parameters, justifying using the 1D-3D coupled method to explore several research topics concerning compressor characteristics and system parameters in compressor surge. This paper lays a foundation of using the 1D-3D coupled method to investigate the relation between compressor surge and stall, compressor surge in a dynamic compression system, structures and dynamics during compressor surge, and the flow instability boundary. © 2019 Elsevier Masson SAS (34 refs)
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