Parametric Study of the Scavenging Process in Marine Two-Stroke Diesel Engines

Large commercial ships such as container vessels and bulk carriers are propelled by low-speed, uniflow scavenged two-stroke diesel engines. The integral in-cylinder process in this type of engine is the scavenging process, where the burned gas from the combustion process is evacuated through the exhaust valve and replaced with fresh air for the subsequent compression stroke. The scavenging airtenders the cylinder via inlet ports which are uncovered by the piston at bottom dead center (BDC). The exhaust gas is then displaced by the fresh air. The scavenging ports are angled to introduce a swirling component to the flow. The in-cylinder swirl is beneficial for air-fuel mixture, cooling of the cylinder liner and minimizing dead zones where pockets of exhaust gas are re-trapped. However, a known characteristic of swirling flows is an adverse pressure gradient in the center of the flow, which might lead to a local deficit in axial velocity and the formation of central recirculation zones, known as vortex breakdown. This paper will present a CFD analysis of the scavenging process in a MAN B&W two-stroke diesel engine. The study included a parameter sweep where the operating conditions such as air amount, port timing and scavenging pressure are varied. The CFD model comprised the full geometry from scavenger receiver to exhaust receiver. Asymmetric inlet and outlet conditions were included as well as the dynamics of a moving piston and valve. Time resolved boundary conditions corresponding to measurements from an operating, full scale production, engine as well as realistic initial conditions are used in the simulations. The CFD model provides a detailed description of the incylinder flow from exhaust valve opening (EVO) to exhaust valve closing (EVC). The study reveals a close coupling between the volume flow (delivery ratio) and the in-cylinder bulk purity of air which appears to be independent of operating conditions, rpm, scavenger air pressure, BMEP etc. The bulk purity of air in the cylinder shows good agreement with a simple theoretical perfect displacement model.

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