# In-cylinder flow simulations in large marine two-stroke engine

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Large commercial ships such as container vessels and bulk carriers are propelled by low-speed, uniflow scavenged two-stroke diesel engines. An integral in-cylinder process in this type of engine is the scavenging process, where the burned gases from the combustion process are evacuated through the exhaust valve and replaced with fresh air for the subsequent compression stroke. The scavenging air enters the cylinder via inlet ports which are uncovered by the piston at bottom dead center (BDC). The exhaust gases are then displaced by the fresh air entering the cylinder. The scavenging ports are cut with an angle to introduce a swirling component to the flow [1]. The other dominant process is the combustion in which the directly injected fuel auto-ignites and burns in the cylinder.

Ever more stringent emission legislations over the last 10-15 years have changed the engine lay out diagram in the pursuit of an engine which is both fuel effective and within the current emission legislations. To achieve this goal, a fundamental understanding of the in-cylinder processes, and the interactions between them is needed. Computational Fluid Dynamics (CFD) offers the possibility to access this knowledge. The complexity of the simulation varies depending on the process investigated. On the one hand, modeling the scavenging process requires handling of complex mesh motion for piston and valve with Arbitrary Mesh Interface (AMI), Arbitrary Connection Mesh Interface (ACMI) and dynamic addition and removal of cell layers. This is achieved by a coupling PoliMi libraries [2,3] together with OpenFOAM+. On the other hand, modeling direct injection combustion processes requires advanced and dedicated physical models. Therefore the ECFM-3Z model [4] has been implemented at MAN Diesel & Turbo specifically for these applications in OpenFOAM+.

This presentation will introduce some application examples of in-cylinder simulations performed at MAN Diesel & Turbo as well as the underlying simulation processes.

[1] Andersen F. H., Integrated Analysis of the Scavenging Process in Marine Two-Stroke Diesel Engines, Ph.D. thesis (2015)

[2] Montorfano, A., Piscaglia, F., and Onorati, A. SAE Technical Paper 2015-01-0384, 2015.

[3] F. Piscaglia. ``Developments in transient modeling, moving mesh, turbulence and multiphase methodologies in OpenFOAM''. Keynote lecture, ESI conference 2016.

[4] Colin O., Benkenida A., The 3-Zones Extended Coherent Flame Model (ECFM-3Z) for computing premixed/diffusion combustion. Oil & Gas science and technology, 59(6), 593-609