Fuel/water mixing in ship's compensated fuel/ballast tanks

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CFX results using the homogeneous free-surface model have revealed that most of the mixing occurs during 'buoyant flow events'.

THE NSWC is using CFX to describe the flow in compensated fuel/ballast tanks on applicable US Navy ships in order to reduce their potential for pollution during refuelling. When 'full', the compensated tanks hold fuel which is replaced by water as it is consumed. CFX is being used to analyze the fluid dynamics and fuel/water mixing which occurs during refuelling.

This is a complicated problem for CFD because (1) the tank geometry is large yet complicated with many compartments connected by manholes through which the flow must pass, inducing turbulence and separation; (2) the filling simulations are transient, leading to long run-times; and (3) two fluids are involved, for which the interface physics need to be modelled.

NSWC selected CFX-4 because of the ease with which complex meshes can be built and because it has the basic multi-fluid algorithms upon which more complex mixing models can be imposed. Experiments are being conducted to obtain physical data, such as droplet size distributions as a function of Richardson number. These are necessary to model the mixing and entrainment processes in CFX.

CFX results using the homogenous free-surface model indicate that most of the mixing could occur during 'buoyant flow events.' The simulations show that, during these events, fuel fills up behind the internal tank structure, before advecting beneath it into a mostly water-filled compartment where it is forced upwards by buoyancy. With this knowledge, CFX is being used to analyze modified tank designs, and to determine which are most effective at eliminating these events and the potential for fuel/water mixing.

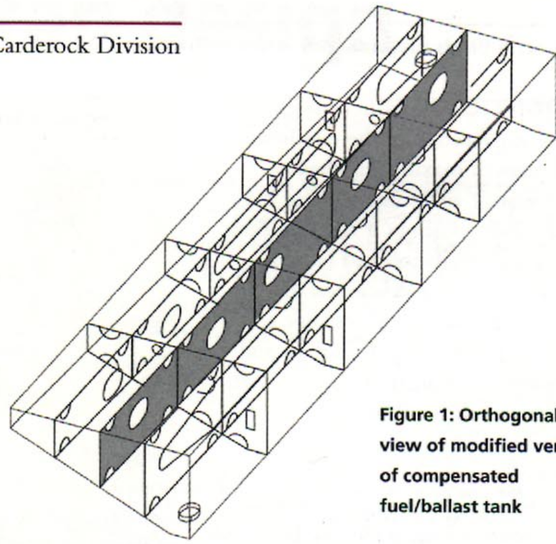

Figure 1: Orthogonal view of modified version of compensated fuel/ballast tank

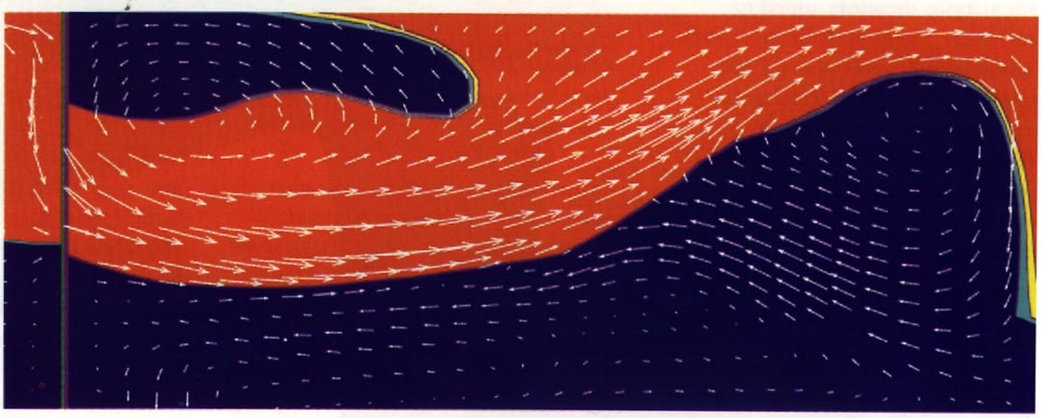

Figure 2: Volume fraction and velocity vectors for fuel/water flow through a manhole for an existing tank. This shows a 'buoyant flow event' which is thought to be the major contributor to fuel/water mixing

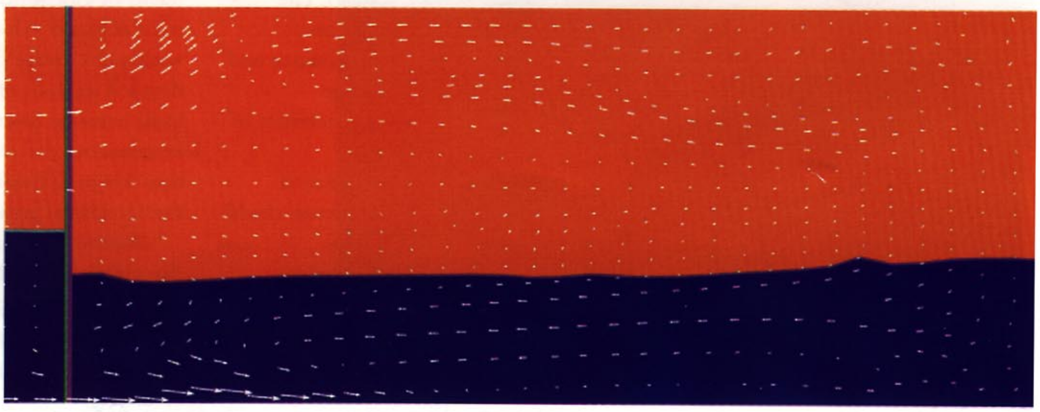

Figure 3: Volume fraction and velocity vectors for fuel/water flow through a manhole for a modified tank. This shows that the 'buoyant flow event' has been eliminated