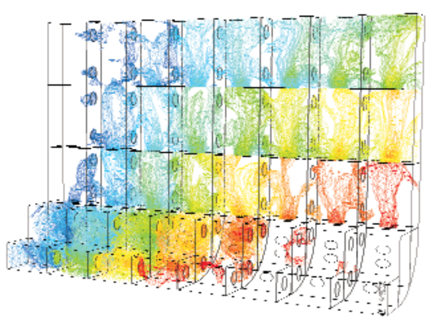
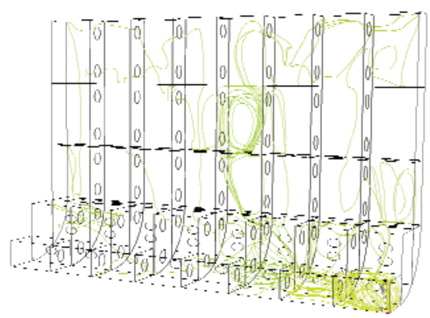
Clean Bill of Ballast Water Health

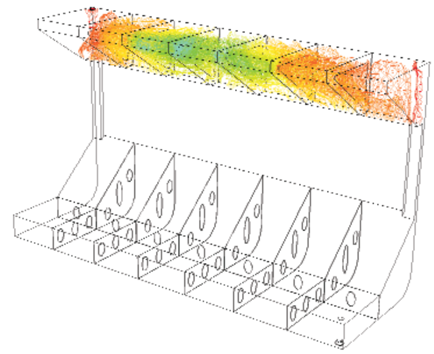
By Chris Kent, Department of Naval Architecture & Marine Engineering, University of Michigan, Ann Arbor, Michigan



Volume fraction contours of flushing water for the J-type bottom and side ballast tank with two vents after more than 65 minutes of pumping; the red regions are almost completely flushed and the blue regions are almost completely original water



Path lines colored by static pressure showing the complex flow within the J-type bottom and side ballast tank with two vents



Volume fraction contours of flushing water for a hopper side and upper wing tank pair with two vents and two inter-tank trunks for a longitudinally-framed ship after three tank volumes of pumping; the absence of red contours suggests that the flushing is not complete

FLOW-THROUGH BALLAST EXCHANGE is one of the current options for ballast water treatment on ocean-going vessels. It reduces the risk of non-indigenous aquatic species being introduced into the Great Lakes and U.S. coastal waters. In the flow-through exchange process, outside water is pumped through a bell-mouth opening located in one of the lower corners of a tank. The water is allowed to overflow through the tank vents and exit overboard the vessel. The flushing process is usually carried out for three tank volumes, with the goal of having less than 5% of the original fluid present in the tank at the end of the flushing cycle. Flow-through exchange is generally carried out on vessels that do not have enough structural strength or stability to completely empty and then refill tanks or pairs of tanks in sequence.

Since most of the organisms of interest are planktonic in nature, the biological effectiveness of this process is directly related to the mechanical (fluid flow) effectiveness. Thus, to evaluate the biological effectiveness of the flow-through ballast exchange method for various tank configurations, fluid dynamics simulations using FLUENT were performed. The mixture model was used for the original and flushing fluids, even though the densities were assumed identical. The mesh sizes were in the one- to two-hundred thousand cell range, with computations carried out on a single processor workstation in a couple of days. Analyses were performed for a rectangular, double bottom tank; a J-type bottom tank; and a side ballast tank, typical of many container vessels. Hopper side and upper wing tank pairs with longitudinal and transverse framing, typical of Seaway-size dry bulk carriers to which this problem is of particular importance, were also studied. In each case, various combinations of one or two tank vents were considered. In the latter cases, one or two inter-tank trunks were considered as well. Due to computation time limitations, a separate modeling study was performed to show that the small tank details and the smallest level of longitudinal or transverse framing can be neglected in the CFD modeling. These details, such as snipe holes in the frames and longitudinal or transverse stiffeners (strips of steel or angle steel that are welded onto the plate to prevent buckling) cause a small detrimental effect due to flow blockage near the bell mouth.

The results show that the current requirement that three tank volumes be pumped through the tanks is generally acceptable, but care is needed in detailed tank design to ensure the expected exchange by this method. Furthermore, some tank configurations should not be permitted to use flow-through ballast exchange without an extended flushing time, which should be established by a careful flow analysis using the actual tank geometry. For example, the case of a hopper side and upper wing pair for a longitudinally-framed ship only met the requirement in one configuration of the four simulated. ■

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