Computational Fluid Dynamics Modeling of Compensated Fuel/Ballast Systems to Minimize Overboard Discharge of Fuel

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ABSTRACT

Compensated fuel/ballast tanks (CFBTs) are used by the US Navy in four of its combatant classes of ships to maintain trim and draft. In such ships, when fuel is consumed, it is replaced by seawater in order to maintain approximately the same ship displacement and center of gravity. However, the compensating water discharged overboard during refueling often contains concentrations of (fuel) oil in excess of local environmental regulations. The US Navy has undertaken an extensive research and development (R&D) effort to assess the current performance of CFBTs during refueling operations and to develop and propose improvements to their design which could be implemented in ship classes currently under construction or in the design stage. This paper describes the computational fluid dynamics (CFD) analysis efforts performed by Carderock Division, Naval Surface Warfare Center (CDNSWC) to assess the complex flows in the CFBTs of the Arleigh Burke (DDG 51) class of US Navy guided missile destroyers. As currently designed, DDG 51 CFBTs have a large amount of internal structure that promotes fuel/water mixing and, thus, entrainment of fuel in the seawater. CFD analyses, however, have shown that with relatively minor modifications to the structure, the mixing can be minimized and even eliminated. Further analyses and experiments designed to validate and refine models for fuel entrainment also will be described. With the right analysis tools, there is a high probability that compensated fuel/ballast tanks can be designed in future ship classes to reliably meet stringent world-wide oily waste discharge regulations.