Hydrodynamic Analysis of Payload Bay Berthing of an Underwater Vehicle With Vertically Actuated Thrusters

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Abstract : - In recent years, large unmanned underwater vehicles such as the Boeing Voyager and Anduril Ghost Shark have been developed. These vessels can be structured to contain onboard internal payload bays. These payload bays can serve a variety of purposes – including the launch and recovery (LAR) of smaller underwater vehicles. The LAR of smaller vessels is extremely important, as it enables transportation over greater distances, increased time on station, data transmission and operational safety. The larger vessel and its payload bay structure complicate the LAR of UUVs in contrast to static docks that are affixed to the seafloor, as they actively impact the local flow field. These flow field impacts require analysis to determine if UUV vessels can be safely launched and recovered inside the motherships. This research seeks to determine the hydrodynamic forces exerted on a vertically over-actuated, small, unmanned underwater vehicle (OUUV) during an internal LAR manoeuvre and compare this to an under-actuated vessel (UUUV). In this manoeuvre, the OUUV is navigated through the stern wake region of the larger vessel to a set point within the internal payload bay. The manoeuvre is simulated using ANSYS Fluent computational fluid dynamics models, covering the entire recovery of the OUUV and UUUV. The analysis of the OUUV is compared against the UUUV to determine the differences in the exerted forces. Of particular interest are the drag, pressure, turbulence and flow field effects exerted as the OUUV is driven inside the payload bay of the larger vessel. The hydrodynamic forces and flow field disturbances are used to determine the feasibility of making such an approach. From the simulations, it was determined that there was no significant detrimental physical forces, particularly with regard to turbulence. The flow field effects exerted by the OUUV are significant. The vertical thrusters exert significant wake structures, but their orientation ensures the wake effects are exerted below the UUV, minimising the impact. It was also seen that OUUV experiences higher drag forces compared to the UUUV, which will correlate to an increased energy expenditure. This investigation found no key indicators that recovery via a mothership payload bay was not feasible. The turbulence, drag and pressure phenomenon were of a similar magnitude to existing static and towed dock structures.

Keywords : underwater vehicles, submarine, autonomous underwater vehicles, auv, computational fluid dynamics, flow fields, pressure, turbulence, drag
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