Investigation of Hydrodynamic Ship-Tug Interaction Effects during Harbour Maneuvers

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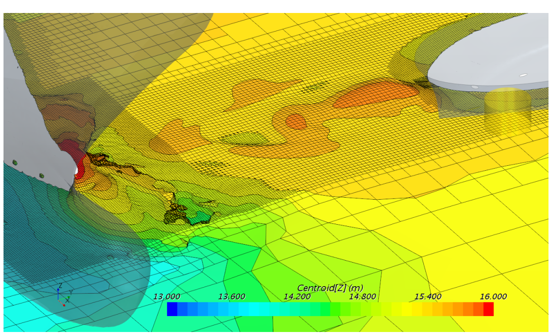
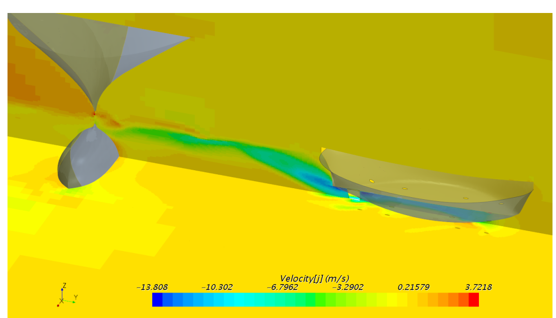
ABSTRACT

Introduction The permanent increasing size of vessels and the autonomous operation of ships are two major driving factors for new research activities in the maritime industry. Maneuvering of ultra-large container vessels inside harbour areas is a challenge for masters, pilots and tugs. Modern ship handling simulators offer the possibility for the involved persons to practice and optimise the maneuvering in restricted water areas. Hence, the further development of simulator models can have a substantial share in enhanced safety of navigation. One important field of improvement is the consideration of interaction effects between seagoing vessels and tugs. Major ship-to-tug effects occur during close-by operations (line handover) especially at the bow of the seagoing vessel. The propeller-ship interaction has a remarkable contribution to the induced forces, when the tug's propeller slipstream reaches the vessel's hull (pull operations). For the development of accurate simulator models, extensive and precise data about the maneuvering and interaction characteristics of all vessels participating in the maneuver is a key factor. Even more when it comes to remote-controlled or semi-autonomous tug operations, a large database is the basis for all decisions taken by the automation system. Modern CFD methods offer the possibilty to generate maneuvering coefficients for all types of ships, see for example [1].

Approach An extensive CFD study on the maneuvering characteristic of a 70 tons bollard pull harbour tug is carried out. The focus is set on the consideration of the interaction effects with a 14000 TEU container vessel during typical harbour maneuvers. The tug used in the study is a 30 meters RAVE tug, driven by two in-line Voith-Schneider propellers (VSP), the seagoing vessel is the well-known Duisburg Test Case (DTC). The commercially available solver STAR-CCM+ is used for the computation of the flow field. To take the propeller-ship interactions into account, a body force model for VSPs in the RAVE-setup is developed, tested and implemented.



(a) Water surface elevation



(b) Propagation of the slipstream to the bow

Figure 1: VSP slipstream at the bow during pull operations

Results Numerous CFD simulations with varied speed, distance and orientation between the DTC and the tug are carried out, also the thrust direction and magnitude of the tug's VSPs in the body force model are modified. The evaluation of the computed forces show a large transverse force and yaw moment on the tug when it is operating in the pressure field close to the ships bulbous bow and the forward shoulder. Especially during pull maneuvers, the VSPs of the tug interact with the DTC hull. Figure 1 shows the propagation of the slipstream generated by the implemented body force model in STAR-CCM+ during a turning maneuver. The slipstream impinges on the bulbous bow of the seagoing vessel and induces a significant pressure field. First calculations show that the added transverse resistance due to this force is up to 20 percent of the tug's pulling force. Hence, the consideration of these interaction effects is mandatory for reliable results from the ship handling simulator.

REFERENCES

[1] Stern, F. and Agdrup. K. (editors) *Proceedings of the Workshop on Verification and Validation of Ship Manoeuvring Simulation Methods SIMMAN 2008*. FORCE Technology, Lyngby, Denmark