ITTC Quality System Manual Recommended Procedures and Guidelines

Benchmark Database for CFD Validation for Resistance and Propulsion

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Updated / Edited by	Approved
Specialist Committee on Combined CFD/EFD Methods of 30th ITTC	30th ITTC 2024
Date 06/2024	Date 09/2024
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Abstract

Benchmark data has long been used as "weights" for the calibration of experimental facilities as well as "rulers" for the validation of CFD methods. Over the past decades, many well-known benchmark models such as DTMB 5415, KCS, REGAL, etc., have been designed and shared worldwide. These benchmark data are mainly derived from various CFD workshops and published papers; thus it is necessary to organize and summarize their lists and sources. This procedure provides a listing of the surface-ship benchmark database for CFD validation for resistance and propulsion. Benchmark cases are categorized into cargo containers, combatants, tankers, and bulk carriers, with information about the facilities, conditions, and test type that are summarized in tables. The procedure will be continuously updated in the future to cover, as far as possible, all the available benchmark databases for CFD validation.

Benchmark Database for CFD Validation for Resistance and Propulsion.

1. PURPOSE OF PROCEDURE

Provide a listing of the benchmark database for CFD validation for resistance and propulsion.

2. BENCHMARK DATABASE FOR CFD VALIDATION FOR RESISTANCE AND PROPULSION

Rapid advancements in the development of CFD and EFD provide the necessary tools for realization of simulation based design. However, validation and calibration are also required, which creates the need to maintain a current evaluation of databases for CFD validation with regard to status and future uses and requirements. This has been a continuing goal of the Resistance Committee (RC) with specific focus on the surface-ship model-scale database and on data of relevance to resistance and propulsion and validation of RANS codes. The present evaluation provides an update over that reported by the 21st RC (ITTC, 1996) and is recommended for adoption. The effort was important in preparation for future Workshops on CFD in Ship Hydrodynamics, as an aid in selection of benchmark cases. These kinds of Workshops are devoted to compare viscous CFD codes and data for cargo/container, combatant, and tanker hull forms with and without a free surface. A database evaluation was also done in the past for aerospace applications (Marvin, 1995); however, the emphasis is more on building block experiments than practical geometries.

The previous evaluations were updated by down selection and inclusion of both unbeknownst and newly acquired data. The down selection is based on the recommendations of the 21st RC for cargo/container [Hamburg Test Case (HTC)], combatant [David Taylor Model Basin (DTMB) model 5415 (5415)], and tanker [Ryuko-Maru (RM)] geometries which required that full-scale data and/or ship existed along with the Series 60 C_B=0.6 (S60) cargo/container and HSVA tanker geometries since the data and previous use are extensive. Unbeknownst data for a tanker (DAIOH) and newly acquired data for cargo/container (KCS) and tanker (KVLCC) geometries are also included since the data is extensive and holds promise for CFD validation.

The evaluation procedures followed those described by the 21st RC (ITTC, 1996). The data was organised in summary and detailed tables and evaluated using criteria developed for geometry and flow, physics, CFD validation, and full scale as well as past uses. Conclusions are also provided with regard to the available data and past uses and recommendations provided for future uses of the available data and future data procurement. The evaluation was fairly extensive and therefore was only summarised in the 22nd RC report mainly with regard to the summary table and recommendations. Stern et al. (1998) provides the complete evaluation, including references. The 28th RC report includes a new benchmark database, which is a Bulk Carrier hull form with and without an energy saving device (ESD). The first Workshop on Ship Scale Hydrodynamic Computer Simulation (2016) hosted by Lloyd's Register included a new benchmark database for a 16900DWT general cargo vessel “REGAL” in 2018. The updated summary table and references are also provided below.

	Facility, propulsor, and data → ↓ Database entry ↓	Facility	Propulsor	ESD	F/M	Self-propulsion	Sinkage and trim	Surface pressure	Wave profile	Wave elevation (l)	Wave elevation (t)	Mean velocity	Mean pressure	Turbulence
	Cargo-container													
	Series 60 C_B=0.600 (S60) Full-scale ship does not exist													
1.1	Cooperative Experimental Program													
	ITTC (1984, 1987, 1990b)	tt, wc	wo		√		√	√	√	√	√	√		
	Fry and Kim (1985)	tt	wo							√				
	Ogiwara and Kajitani (1994)	tt	wo		√		√	√	√					
1.2	Osaka University & Iowa Institute of Hydraulic Research													
	Toda et al., (1990)	tt	w, wo		√	√		√	√			√	√	
1.3	Iowa Institute of Hydraulic Research													
	Toda et al., (1992); Longo et al., (1993)	tt	wo		√				√	√	√	√	√	
1.4	Iowa Institute of Hydraulic Research													
	Longo and Stern, (1996)	tt	wo		√		√		√	√	√	√	√	
1.5	National Technical University of Athens													
	Garofallidis, (1996)	tt	wo		√			√	√	√	√	√	√	
1.6	Osaka University Suzuki et al., (1998a)	wt	wo									√		√
	Hamburg Test Case C_B=0.645 (HTC) Full-scale ship exists													
2.1	HSVA													
	Lammers et al. (1989)	s	w									√		
2.2	HSVA													
	Bertram et al. (1992)													
	Bertram et al. (1994)	tt	w, wo		√	√	√	√	√	√	√	√		√
2.3	University of Hamburg													
	Gietz and Kux (1995)	wt	wo									√		√
2.4	Osaka University													
	Suzuki et al. (1998c)	wt	wo									√		√
	KRISO 3600 TEU CB=0.651 (KCS) Full-scale ship does not exist													
3.1	Korean Research Institute of Ships & Ocean Engineering													
	Van et al. (1997)													
	Van et al. (1998b)	tt	w, wo		√	√	√	√	√	√	√	√	√	
3.2	Pohang University of Science and Technology													
	Lee et al. (1998b)	wt	wo									√		√
3.3	China Ship Scientific Research Center													
	Liu et al. (2022)	tt	w	wo			√			√		√		
	REGAL Full-scale ship exists													
4.1	First Workshop on Ship Scale Hydrodynamic Computer Simulation													
	Ponkratov D., (2016)	s	w	wo		√								

	Facility, propulsor, and data → ↓ Database entry ↓	Facility	Propulsor	ESD	F/M	Self propulsion	Sinkage and trim	Surface pressure	Wave profile	Wave elevation (l)	Wave elevation (t)	Mean velocity	Mean pressure	Turbulence
	Combatant													
	DTMB model 5415 C_B=0.506 (5415) Full-scale ship does not exist													
5.1	David Taylor Model Basin Fry and Kim (1985) Ratcliffe (1998b)	tt	w, wo		√	√	√	√	√	√	√	√	√	
5.2	Iowa Institute of Hydraulic Research Longo and Stern (1999)	tt	wo		√		√		√			√	√	
5.3	INSEAN Avanzini et al. (1998) Olivieri and Penna (1999)	tt	wo		√		√	√	√	√	√	√	√	
	ONRT C_B=0.535 (5415) Full-scale ship does not exist													
6.1	Iowa Institute of Hydraulic Research Sanada et al. (2013) Sadat Hosseini et al. (2015) Sanada et al. (2019)	tt	w	wo		√								
6.2	Seoul National University Towing Tank Laboratory (SNU) Seo et al. (2018)		w	wo	√	√								
	Tanker													
	HSVA CB=0.850 (HSVA) Full-scale ship does not exist													
7.1	University of Hamburg Hoffmann (1976)	wt	wo										√	√
7.2	University of Hamburg Knaack (1984) Knaack (1990)	wt	wo									√		√
	Hull-form variation Dyne tanker CB=0.850 (Dyne)													
8.1	University of Hamburg Denker et al. (1992) Knaack (1992)	wt	wo									√		√
8.2	Chalmers University of Technology Lundgren and Åhman (1994)	tt	wo											
	Dyne (1995)	tt	w, wo		√	√				√		√	√	
	Ryuko-Maru C_B=0.830 (RM) Full-scale ship does not exist													
9.1	Ishikawajima-Harima Heavy Industries Co., Ltd. Ogiwara (1994)	s, tt	w, wo		√							√	√	
9.2	Osaka University Suzuki et al. (1997) Suzuki et al. (1998c)	wt	wo									√		√
	DAIOH C_B=0.837 (DAIOH) Full-scale ship does not exist													
10.1	Osaka University, Akashi Ship Model Basin, and Nippon Kokan K. K. Tanaka et al. (1984) Kasahara (1985)	s, tt	w, wo		√	√		√				√	√	
	KRISO 300K VLCC C_B=0.810 (KVLCC) Full-scale ship does not exist													

11.1	Korea Research Institute of Ships & Ocean Engineering Van et al. (1998a) Van et al. (1998b)	tt	w, wo		√	√	√	√̲	√	√	√	√	√	
Hull-form variation *VLCC2 C_B=0.810 (KVLCC2)*														
12.1	Korea Research Institute of Ships & Ocean Engineering No reference available	tt	w, wo		√	√	√	√̲	√	√	√	√	√	

Facility, propulsor, and data → ↓ Database entry ↓		Facility	Propulsor	ESD	F/M	Self propulsion	Sinkage and trim	Surface pressure	Wave profile	Wave elevation (l)	Wave elevation (t)	Mean velocity	Mean pressure	Turbulence
Bulk Carrier														
Japan Bulk Carrier CB=0.858 (JBC) Full-scale ship does not exist														
13.1	National Maritime Research Institute No reference available	tt	w, wo	w, wo	√	√	√		√	√	√	√		
13.2	Osaka University No reference available	tt	w, wo	w, wo	√	√	√					√		
13.3	Technical University of Hamburg P. Sumislawski et al. (2022)	wt	wo	wo	√							√		√
Ferry														
Marin Ferry Full-scale ship does not exist														
14.1	Maritime Research Institute Netherlands (MARIN) No reference available	tt	w	wo	√	√	√							

tt, wt, wc, s: Towing tank, wind tunnel, water channel, and sea, respectively
w, wo: With and without, respectively
√: Data available
√̲: Data under procurement
NA: Data not available
%: Percentage range of variable

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4. KEYWORDS

Benchmark database, surface-ship, ship resistance, ship propulsion