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Date	Date

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 realisation 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 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 the upcoming Gothenburg 2000 Workshop on CFD in Ship Hydrodynamics (Gothenburg, 2000) as an aid in selection of benchmark cases. The Gothenburg 2000 CFD Workshop will 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 recently 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 (including Gothenburg 2000) and future data procurement. The evaluation is fairly extensive and therefore is 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 summary table and references are also provided below. Table 4.

Facility, propulsor, and data → / ↓ Database entry ↓	Facility	Propulsor	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 C_B=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								√		√
Combatant												
DTMB model 5415 C_B=0.506 (5415)												
Full-scale ship does not exist												
4.1 David Taylor Model Basin												
Fry and Kim (1985)												
Ratcliffe (1998b)	tt	w, wo	√	√	√	√	√	√	√	√	√	
4.2 Iowa Institute of Hydraulic Research												
Longo and Stern (1999)	tt	wo	√		√		√			√	√	
4.3 INSEAN												
Avanzini et al. (1998)	tt	wo	√		√	√	√	√	√	√	√	
Olivieri and Penna (1999)												

Facility, propulsor, and data → ↓ Database entry ↓	Facility	Propulsor	F/M	Self propulsion	Sinkage and trim	Surface pressure	Wave profile	Wave elevation (l)	Wave elevation (t)	Mean velocity	Mean pressure	Turbulence
Tanker												
HSVA C_B=0.850 (HSVA)												
Full-scale ship does not exist												
5.1 University of Hamburg												
Hoffmann (1976)	wt	wo								√	√	
5.2 University of Hamburg												
Knaack (1984)	wt	wo								√		√
Knaack (1990)												
Hull-form variation *Dyne tanker C_B=0.850 (Dyne)*												
5.3 University of Hamburg												
Denker et al. (1992)												
Knaack (1992)	wt	wo								√		√
5.4 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												
6.1 Ishikawajima-Harima Heavy Industries Co., Ltd.												
Ogiwara (1994)	s, tt	w, wo	√							√	√	
6.2 Osaka University												
Suzuki et al. (1997)												
Suzuki et al. (1998c)	wt	wo								√		√
DAIOH C_B=0.837 (DAIOH)												
Full-scale ship does not exist												
7.1 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												
8.1 Korea Research Institute of Ships & Ocean Engineering												
Van et al. (1998a)	tt	w, wo	√	√	√	√̲	√	√	√	√	√	
Van et al. (1998b)												
Hull-form variation *VLCC2 C_B=0.810 (KVLCC2)*												
8.2 Korea Research Institute of Ships & Ocean Engineering	tt	w, wo	√	√	√	√̲	√	√	√	√	√	
No reference available												

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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