ITTC Quality System Manual

Recommended Procedures and Guidelines

Procedure

Benchmark Database for CFD Validation for Resistance and Propulsion

7.5	Process Control
7.5-03	CFD
7.5-03-02	Resistance and Flow
7.5-03-02-02	Benchmark Database for CFD Validation for Resistance and Propulsion

Updated / Edited by	Approved
Resistance and Propulsion Committee of 29th ITTC	29th ITTC 2021
Date: 02/2020	Date: 06/2021

Table of Contents

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 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 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. Table 4.

	Facility, propulsor, and data → ↓ Database entry ↓	Facility	Propulsor	ESD	F/M	Self propulsion	Sinkage and trim	Surface pressure	Wave profile	Wave elevation	Wave elevation	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									√		√
	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 (c)	Mean velocity	Mean pressure	Turbulence
	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) Olivieri and Penna (1999)	tt	wo		√		√	√	√	√	√	√	√	
	Tanker													
	HSVA CB=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) Knaack (1990)	wt	wo									√		√
	Hull-form variation Dyne tanker CB=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) Van et al. (1998b)	tt	w, wo		√	√	√	√	√	√	√	√	√	
	Hull-form variation *VLCC2 C_B=0.810 (KVLCC2)*													
8.2	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														
9.1	National Maritime Research Institute No reference available	tt	w, wo	w, wo	√	√	√		√	√	√	√		
9.2	Osaka University No reference available	tt	w, wo	w, wo	√	√	√					√		
9.3	Technical University of Hamburg No reference available	wt	wo	wo	√							√		√

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

3. REFERENCES

Avanzini, G., Bennedetti, and Penna, R., 1998, "Experimental Evaluation of Ship Resistance for RANS Code Validation," ISOPE '98, Montreal, Canada, May.

Bertram, V., Chao, K.Y., Lammers, G., and Laudan J., 1994, "Experimental Validation Data of Free-Surface Flows for Cargo Vessels," Proceedings of CFD Workshop Tokyo 1994, Vol. 1, pp. 311-320.

Bertram, V., Chao, K.Y., Lammers, G., and Laudan J., 1992, "Development and Verification of Numerical Methods for Power Prediction," HSVA Rept. 1579 (in German).

Denker, J., Knaack, T., and Kux, J., 1992, "Experimental and Numerical Investigations of HSVA-Tanker 2 Flow Field," Institute of Shipbuilding (IfS) Rept. 521, Uni. Hamburg.

Dyne, G., 1995, "An Experimental Investigation of the Tanker Model "Dyne" in a Towing Tank," Chalmers University of Technology Rept. CHA/NAVR/-95/0036.

Fry, D.J. and Kim, Y.H., 1985, "Bow Flow Field of Surface Ships," Proceedings of the 15th ONR Symposium on Naval Hydrodynamics, Hamburg, pp. 319-346.

Garofallidis, D. A., 1996, " Experimental and Numerical Investigation of the Flow around a Ship Model At Various Froude Numbers Part II: Uncertainty Analysis for Measurements," PhD Thesis, Dept. Of Naval Architecture and Marine Engineering, National Technical University of Athens.

Gothenburg, 2000, "Gothenburg 2000 Workshop on CFD in Ship Hydrodynamics," www.iihr.uiowa.edu/gothenburg2000

Gietz, U. and Kux, J., 1995, "Flow Investigations on the Hamburg Test Case Model in the Wind Tunnel," Institute of Shipbuilding (Ifs) Rept. 550, Uni. Hamburg (in German).

Hoffmann, H.P., 1976, "Investigation of 3-Dimensional Turbulent Boundary Layer on a Ship Double Model in Wind Tunnel," Institute of Shipbuilding (IfS) Rept. 343, Uni. Hamburg (in German).

ITTC, 1984, "Report of the Resistance and Flow Committee," 17th International Towing Tank Conference, Goteborg, Sweden, pp. 75-138.

ITTC, 1987, "Report of the Resistance and Flow Committee," 18th International Towing Tank Conference, Kobe Japan, pp. 47-95.

ITTC, 1990, "Report of the Resistance and Flow Committee," 19th International Towing Tank Conference, Madrid, Spain, pp. 55-107.

ITTC, 1996, "Report of the Resistance and Flow Committee", 21st. International Towing Tank Conference, Trondheim, Norway, pp. 439-514.

Kasahara, Y., 1985, "An Experimental Investigation of the Scale Effect on Nominal and Effective Wake Distribution Using Geosim Models of Two Different Ships," Proceedings 1st Osaka International Colloquium on Ship Viscous Flow, Osaka, Japan, pp. 432-449.

Knaack, T., 1984, "Laser Doppler Velocimetry Measurements on a Ship Model in Wind Tunnel," Institute of Shipbuilding (IfS) Rept. 439, Uni. Hamburg (in German).

Knaack, T., 1990, "LDV-Measurements of Reynolds-Stresses in Wake of a Ship Model in Wind Tunnel," Institute of Shipbuilding (IfS) Rept. 499, Uni. Hamburg (in German).

Knaack, T., 1992, "Investigation of Structure of Reynolds Tensor Fields in a Three-Dimensional Flow," Institute of Shipbuilding (IfS) Rept. 527, Uni. Hamburg (in German).

Lammers, G., Laudan, J., and Strohrmann, H., 1989, "Correlation of Wake and Cavitation and their Consequences," HSVA Rept. 1565 (in German).

Larsson, L., Stern, F., Visnneau, M., Hirata, N., Hino, T., and Kim, J., 2015, A Workshop on CFD in Ship Hydrodynamics, Tokyo

Lee, J., Lee, S.J., and Van, S.H., 1998, "Wind Tunnel Test on a Double Deck Shaped Ship Model," 3rd International Conference on Hydrodynamics, Seoul, Korea.

Longo, J., Stern, F., and Toda, Y., 1993, "Mean-Flow Measurements in the Boundary Layer and Wake and Wave Field of a Series 60 C_B=0.60 Ship Model - Part 2: Scale Effects on Near-Field Wave Patterns and Comparisons with Inviscid Theory," Journal of Ship Research, Vol. 37, No. 1, pp. 16-24.

Longo, J. and F. Stern, 1996, "Yaw effects on model-scale ship flows," Proceedings of the 21st ONR Symposium on Naval Hydrodynamics, Trondheim, Norway, pp. 312-327.

Longo, J. and Stern, F., 1999, "Resistance, Sinkage and Trim, Wave Profile, and Nominal Wake and Uncertainty Assessment for DTMB Model 5512," Proceedings 25th ATTC, Iowa City, IA.

Lundgren, H. and Ahman, M., G., 1994, "Experimentell och numerisk bestamning av vagmotstand for ett tankfartyg (Dyne tankern)," Chalmers University of Technology Rept. X-94/58 (in Swedish).

Marvin, J.G., 1995, "Dryden Lectureship in Research: Perspectives on Computational Fluid Dynamics Validation," AIAA J., Vol. 33, No. 10, pp. 1778-1787.

Ogiwara, S., 1994, "Stern Flow Measurements for the Tanker 'Ryuko-Maru' in Model Scale, Intermediate Scale, and Full Scale Ships," Proceedings of CFD Workshop Tokyo 1994, Vol. 1, pp. 341-349.

Ogiwara, S. and Kajitani, H., 1994, "Pressure Distribution on the Hull Surface of Series 60 (C_B=0.60) Model," Proceedings of CFD Workshop Tokyo 1994, Vol. 1, pp. 350-358.

Olivieri, A. and Penna, R., 1999, "Uncertainty Assessment in Wave Elevation Measurements," ISOPE '99, Brest, France, June.

Ponkratov, D., (2016), The workshop in ship scale computer simulations, Proceedings, Lloyd's Register, Southampton, UK. [Online]. Available at https://info.lr.org/CFDworkshop (Accessed 5 February 2018).

Ratcliffe, T., 1998, http://www50.dt.navy.mil/5415/.

Stern, F., Longo, J., Maksoud, M., and Suzuki, T., 1998, "Evaluation of Surface-Ship Resistance and Propulsion Model-Scale Database for CFD Validation," 1st Symposium on Marine Applications of Computational Fluid Dynamics, McLean, VA, 19-21 May (also see www.iihr.uiowa.edu/gothenburg2000).

Suzuki, H., Miyazaki, S., Suzuki, T., and Matsumura, K., 1998a, "Turbulence Measurements in Stern Flow Field of Two Ship Models," Proceedings 3rd Osaka Colloquium on Advanced CFD Applications to Ship Flow and Hull Form Design, Osaka, Japan.

Suzuki, H., Suzuki, T., and Miyazaki, S., 1998b, "Turbulence Measurements in Stern Flow Field of a Ship Model–Series 60, C_B=0.60–," Journal of Kansai Society of Naval Architects, No. 227, pp. 29-40 (in Japanese).

Suzuki, H., Suzuki, T., Miyazaki, S. and Matsumura, K., 1998c, "Turbulence Measurements in Stern Flow Field of Two Ship Models–Ryuko-Maru and Hamburg Test Case–," Proceedings of the Kansai Society of Naval Architects, No. 10, pp. 1-4.

Tanaka, I., Suzuki, T., Himeno, Y., Takahei, T., Tsuda, T., Sakao, M., Yamazaki, Y., Kasahara, Y., and Takagi, M., 1984, "Investigation of Scale Effects on Wake Distribution Using Geosim Models," J. Kansai Soc. N.A., Japan, No. 192, pp. 103-120.

Toda, Y., Stern, F., Tanaka, I., and Patel, V.C., 1990, "Mean-Flow Measurements in the Boundary Layer and Wake of a Series 60 C_B=0.60 Model Ship With and Without Propeller," Journal of Ship Research, Vol. 34, No. 4, pp. 225-252.

Toda, Y., Stern, F., and Longo, J., 1992, "Mean-Flow Measurements in the Boundary Layer and Wake and Wave Field of a Series 60 C_B=0.60 Ship Model - Part 1: Froude Numbers 0.16 and 0.316," Journal of Ship Research, Vol. 36, No. 4, pp. 360-377.

Van, S.H., Yim, G.T., Kim, W.J., Kim, D.H., Yoon, H.S., and Eom, J.Y., 1997, "Measurement of Flows Around a 3600TEU Container Ship Model," Proceedings of the Annual Autumn Meeting, SNAK, Seoul, pp. 300-304 (in Korean).

Van, S.H., Kim W.J., Kim, D.H., Yim, G.T., Lee, C.J., and Eom, J.Y., 1998a, "Flow Measurement Around a 300K VLCC Model," Proceedings of the Annual Spring Meeting, SNAK, Ulsan, pp. 185-188.

Van, S.H., Kim, W.J., Yim, G.T., Kim, D.H., and Lee, C.J., 1998b, "Experimental Investigation of the Flow Characteristics Around Practical Hull Forms," Proceedings 3rd Osaka Colloquium on Advanced CFD Applications to Ship Flow and Hull Form Design, Osaka, Japan.