出國報告（出國類別：其他）

100 噸級與 300 噸級海洋基礎資料調查船統包建造採購案國外船模試驗報告

服務機關：國家海洋研究院
姓名職稱：專門委員 呂翰蒼
副研究員 卓訓杰

派赴國家/地區：韓國
出國期間：113 年 9 月 8 日起至 9 月 13 日止
報告日期：113 年 10 月 28 日

摘要

國家海洋研究院(下稱本院)「100 噸級與 300 噸級海洋基礎資料調查船建造統包採購」案發包委託台灣國際造船股份有限公司(下稱台船公司)辦理，依據該契約第 2 條第(二)款第 2 目第(5)點明定「船模試驗報告」為開工前須審定圖說之一，另依契約「船東需求規範書」第一篇第五章第五節規定，「阻力試驗」、「耐海性能試驗或模擬」、「自推試驗」及「流線觀察試驗或模擬」等屬船模試驗報告項目之一。

台船公司為辦理船模試驗，特委託韓國三星重工公司水槽試驗室執行。本次試驗除「耐海性能試驗」項目依契約規定得另採數值模擬方式外，其餘項目皆於本試驗水槽內進行。本院為確保本案調查船設計之船體線型與相關性能數據符合契約規定，且基於公共工程三級品管制度之精神，指派海洋科學及資訊研究中心專門委員呂翰蒼與副研究員卓訓杰共 2 員會同台船公司及財團法人船舶暨海洋產業研發中心 (本案專案管理廠商)人員共同參與本次試驗。

目錄

壹、 目的

國家海洋研究院「100 噸級與 300 噸級海洋基礎資料調查船建造統包採購」案於 113 年 3 月 14 日由台灣國際造船股份有限公司承攬施作，負責設計與建造兩艘小型調查船。為確認本案設計新造之調查船性能與船速可滿足未來任務需求，爰由台船公司依採購契約船東需求規範書之標準，委託韓國三星重工公司位於韓國大田市之船模試驗水槽於 113 年 9 月 4 日至 13 日進行 100 噸級與 300 噸級兩艘調查船船模試驗。其中 9 月 4 日至 7 日由台船公司會同專案管理監造廠商-財團法人財團法人船舶暨海洋產業研發中心(下稱船舶中心)人員參與。本院為善盡履約管理責任與執行公共工程三級品管，並經考量工作期程安排，指派本院海洋科學及資訊研究中心專門委員呂翰蒼與副研究員卓訓杰，於 9 月 8 日至 13 日會同台船公司設計處工程師林冠宇及船舶中心專案經理陳淑樺與工程師江佳琪共同參加本次試驗，並監督試驗內容及施作程序。

貳、 行程

日期	地點	行程
113 年 9 月 8 日	高雄-韓國仁川-大田	搭機出發抵達韓國
113 年 9 月 9 日	三星重工試驗水槽	100 噸級油墨試驗 300 噸級螺槳單獨性能試驗
113 年 9 月 10 日	三星重工試驗水槽	300 噸級艉跡流量測試驗
113 年 9 月 11 日	三星重工試驗水槽	300 噸級阻力試驗 300 噸級自推試驗
113 年 9 月 12 日	三星重工試驗水槽	300 噸級阻力試驗 300 噸級自推試驗
113 年 9 月 13 日	三星重工試驗水槽 韓國大田-首爾仁川-高雄	300 噸級油墨試驗 搭機返國

參、 過程

(一) 韓國三星重工船模試驗水槽介紹

韓國三星重工公司之船模試驗水槽(下簡稱 SSMB)具備有拖航水槽、空化水槽及船模製造工廠。其中拖航水槽長 400 公尺、寬 14 公尺、深 7 公尺，為世界上最大的商業拖曳水槽之一，該拖航水槽擁有 40 個獨立單元組成的造波機，可模擬波長 0.2~15 公尺，波高最大 0.5 公尺之規則/不規則波。空化水槽則有兩個不同測試段，第一段可透過產生高達 28 公尺/秒的流速進行高速模型試驗，第二段最大可容納 10 公尺長的整船模型，其內部葉輪能力可使槽體內 650 噸的水以 12 公尺/秒之速度進行循環。另外為滿足模型測試之需要，SSMB 擁有自己的船舶與螺旋槳模型製造工廠，採用高精度十軸數控工具機和五軸 CNC 工具機，可全自動化製造長度達 10 公尺的模型船和直徑達 0.3 公尺的模型螺旋槳，藉以掌握試驗所需。本水槽詳細介紹請參閱附錄一。

本次調查船船模試驗依據船東需求規範所需，安排於 SSMB 拖航水槽進行。

韓國三星重工船模拖航水槽

(二) 船模試驗

本院與船舶中心及台船公司人員前往 SSMB 後，先由 SSMB 專案經理 Soonho Choi 進行試驗及注意事項相關說明，確認本次試驗內容後逐項辦理試驗。

船模試驗前 SSMB 專案經理向本院、台船公司與船舶中心說明試驗流程

參與本次船模試驗人員合影

1. 船型基本資料

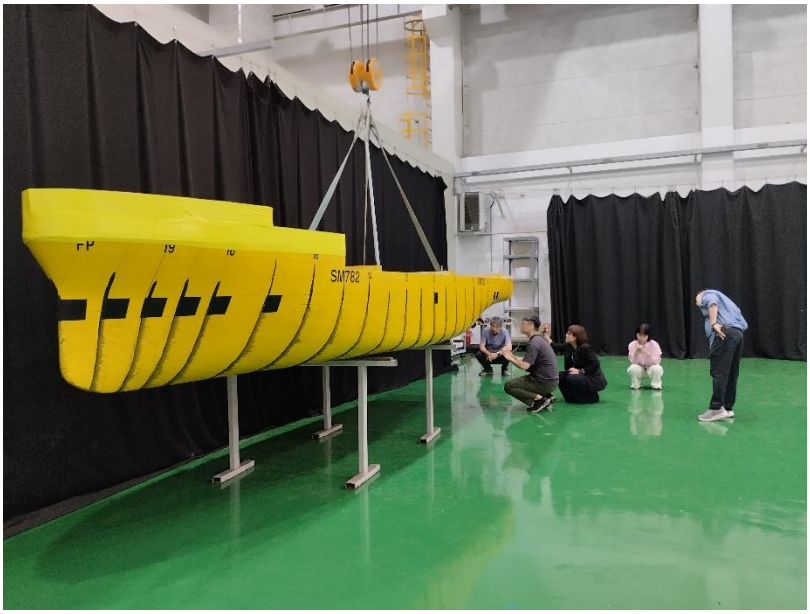
100 噸級與 300 噸級調查船之船型設計由台船公司依據統包契約規範所發展，配合 SSMB 試驗水槽尺寸，100 噸級調查船實船與船模縮尺比例為 5.2；300 噸級調查船實船與船模縮尺比例為 7.6，尺寸對照如表 3-1 與表 3-2。

表 3-1　100 噸級調查船實船與船模尺寸

100 噸級調查船			Full Scale		Model Scale (Scale 5.2)	
船況			Design	Scantling	Design	Scantling
主要尺寸	L.W.L	(m)	33.144	33.144	6.347	6.347
	L.B.P	(m)	32	32	6.154	6.154
	Breadth	(m)	7.5	7.5	1.442	1.442
	Draught (aft/fwd)	(m)	2.2/2.2	2.5/2.5	0.423/0.423	0.481/0.481
排水量	Total	(m^3)	357.058	421.192	2.539	2.996
浸水面積	Total	(m^2)	315.609	330.764	11.672	12.232
風阻面積	Trans. Projected	(m^2)	40.0	38.5	1.5	1.4
	Lateral Projected	(m^2)	138	132.1	5.1	4.9
各項船型參數	C_B		0.6762	0.7020	0.6762	0.7020
	C_P/C_W		0.7985	0.8155	0.7985	0.8155
	C_M		0.9581	0.9594	0.9581	0.9594
	Lcb (%LBP, +:fwd)		-2.49%	-3.08%	-2.49%	-3.08%
	KB	(m)	1.241	1.41	0.239	0.271
螺槳直徑	D_p	(m)	1.3		0.25	

表 3-2　300 噸級調查船實船與船模尺寸

300 噸級調查船			Full Scale		Model Scale (Scale 7.6)	
船況			Design	Scantling	Design	Scantling
主要尺寸	L.W.L	(m)	37.532	37.542	4.938	4.940
	L.B.P	(m)	35.05	35.05	4.612	4.612
	Breadth	(m)	9	9	1.184	1.184
	Draught (aft/fwd)	(m)	2.72/2.72	2.8/2.8	0.358/0.358	0.368/0.368
排水量	Total	(m^3)	543.468	566.500	1.238	1.291
浸水面積	Total	(m^2)	494.890	503.491	8.568	8.717
風阻面積	Trans. Projected	(m^2)	84.42	83.7	1.462	1.449
	Lateral Projected	(m^2)	234.8	231.8	4.065	4.013
各項船型參數	C_B		0.6334	0.6414	0.6334	0.6414
	C_P/C_W		0.7325	0.7313	0.7325	0.7313
	C_M		0.9538	0.9551	0.9538	0.9551
	Lcb (%LBP, +:fwd)		-2.09%	-2.33%	-2.09%	-2.33%
	KB	(m)	1.521	1.572	0.200	0.207
螺槳直徑	D_p	(m)	1.9		0.25	



100 噸級調查船船舶模型(編號：SM782)

300 噸級調查船船舶模型(編號：SM783)

2. 試驗項目

(1) 螺槳單獨性能試驗(Propeller Open Water Test)：螺槳單獨性能試驗目的為測試螺槳於均勻入流狀況下，不受船體影響時之單獨性能。

(2) 船艉跡流量測(Wake Measurement)：船艉跡流量測目的為測試螺槳位置處的船艉跡流分佈。利用拖曳水槽進行試驗，在螺槳未作動的狀況下，於船艉裝

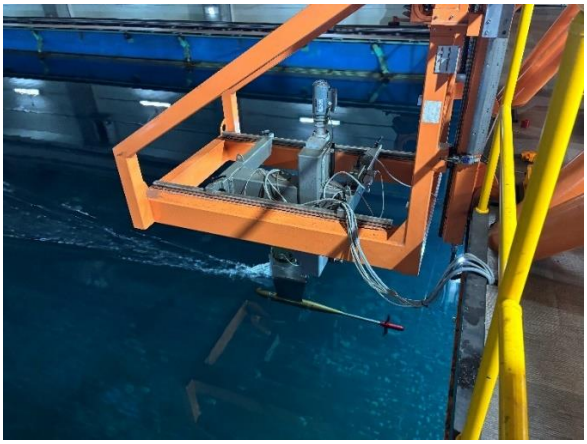
上五孔皮托管後，拖曳船模量測而得。

(3) 阻力試驗(Resistance Test)：阻力試驗目的為求得船舶於不同船速下，考慮與雷諾數有關的摩擦阻力、與福勞德數有關的剩餘阻力等影響產生之阻力。

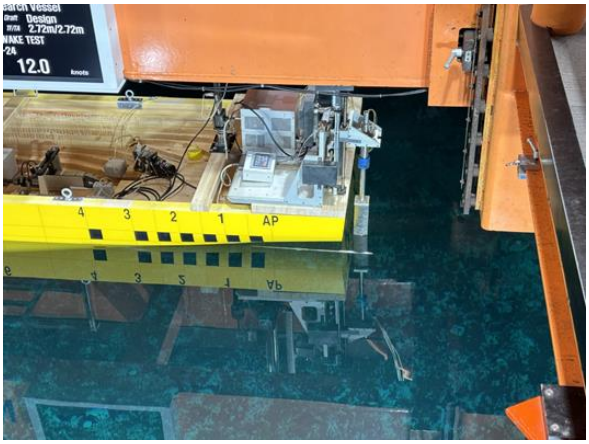
(4) 自推試驗(Self Propulsion Test)：結合船模阻力試驗與單獨螺槳性能試驗，利用模型螺槳產生的推力，以自行推著船舶克服其阻力，而達到自航的平衡點，求取跡流係數、推減係數及相對旋轉效率之推進因子。

(5) 油墨試驗：目的在於瞭解該船於設計吃水船況與設計船速時，沿船殼表面流線之流動方向與速度大小。船殼表面每隔一段距離塗黑色黏性油墨，其油墨距離依水槽實驗室經驗而定，並於所有附屬物上塗上油墨，於試驗結束後將船模吊放至觀察區，查看油墨流動方向，判斷是否有流場剝離之可能。

100 噸級調查船船模油墨試驗

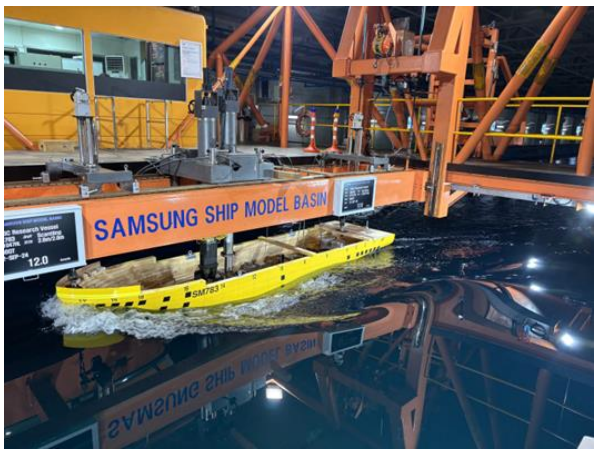


300 噸級調查船船模螺槳性能試驗

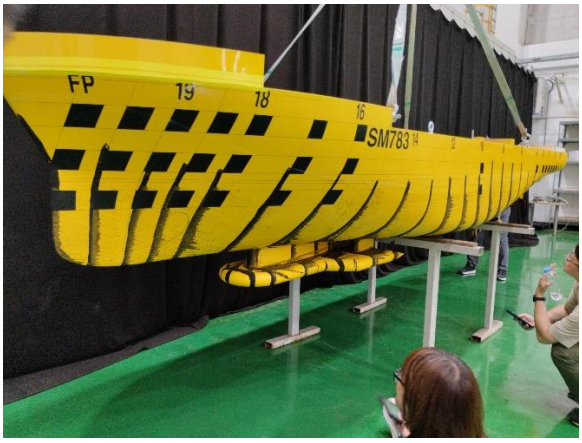


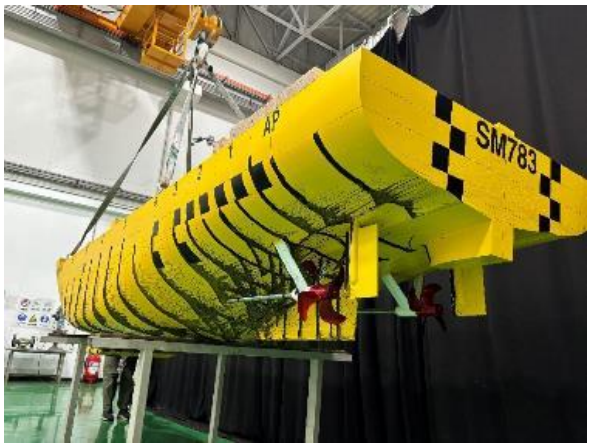
300 噸級調查船船模艉跡流量測

300 噸級調查船船模自推試驗



300 噸級調查船船模阻力試驗





300 噸級調查船船模油墨試驗

(三) 試驗結果

本次船模試驗施作項目均順利完成，船模試驗報告詳如附錄二。依據螺槳試驗、船艉跡流量測、自推試驗及阻力試驗之綜合結果，100 噸級調查船在設計吃水 2.2 公尺以及 300 噸級調查船在設計吃水 2.72 公尺船況下，推估實船之船速與馬力曲線分別如圖 3-1 與圖 3-2，本案兩型調查船最高船速皆可達 12 節，船體線型設計成果與船速符合採購規範所需。另外依據油墨試驗結果，SSMB 提供泌龍骨建議位置如圖 3-3 與圖 3-4，將作為未來建造安裝的依據。

Project Name	: Research Ves	Length BP	: 32.00 m
Ship Model ID	: SM782	Draught at FP	: 2.20 m
Prop. Model ID	: SP1045RL	Draught at AP	: 2.20 m
Test Cond.	: Design	Displacement	: 357. m^3
Scale Ratio	: 5.2000	Ca × 1000	: 0.40
		Cn	: 1.000

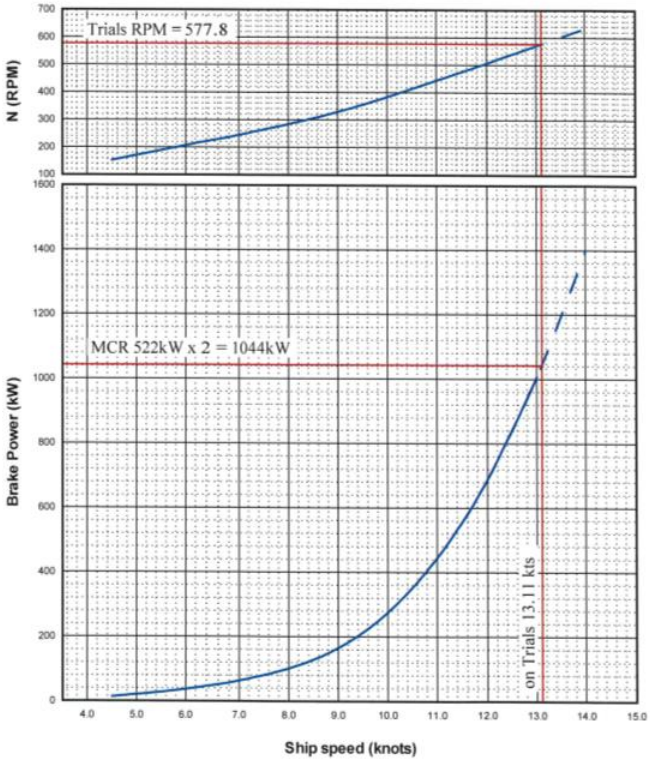


Figure 7 Full scale Prediction of Powering Performance (Design)

圖 3-1 預估 100 噸級調查船實船設計吃水船況之船速馬力曲線圖

PRELIMINARY

Project Name	: Research Ves	Length BP	: 35.05 m
Ship Model ID	: SM783	Draught at FP	: 2.72 m
Prop. Model ID	: SP1047RL	Draught at AP	: 2.72 m
Test Cond.	: Design	Displacement	: 543. m^3
Scale Ratio	: 7.6000	Ca × 1000	: 0.40
		Cn	: 1.000

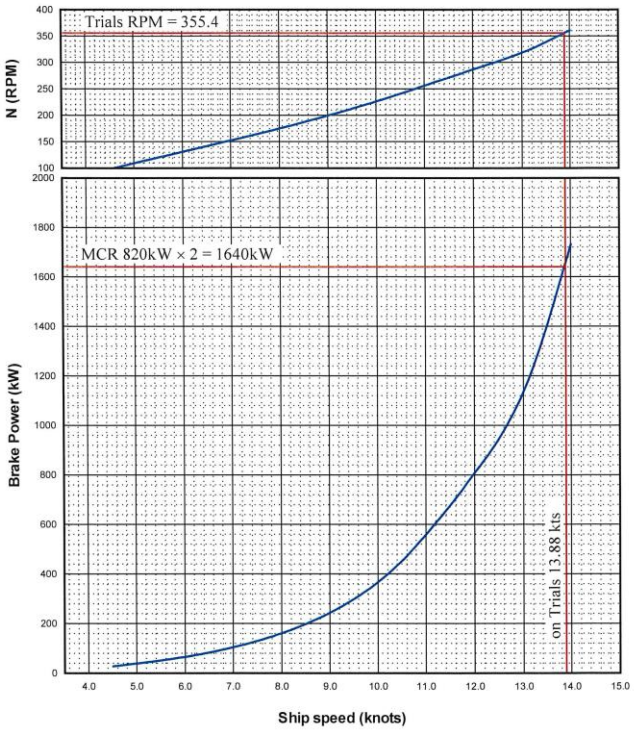


Figure 7 Full scale Prediction of Powering Performance (Design)

圖 3-2 預估 300 噸級調查船實船設計吃水船況之船速馬力曲線圖

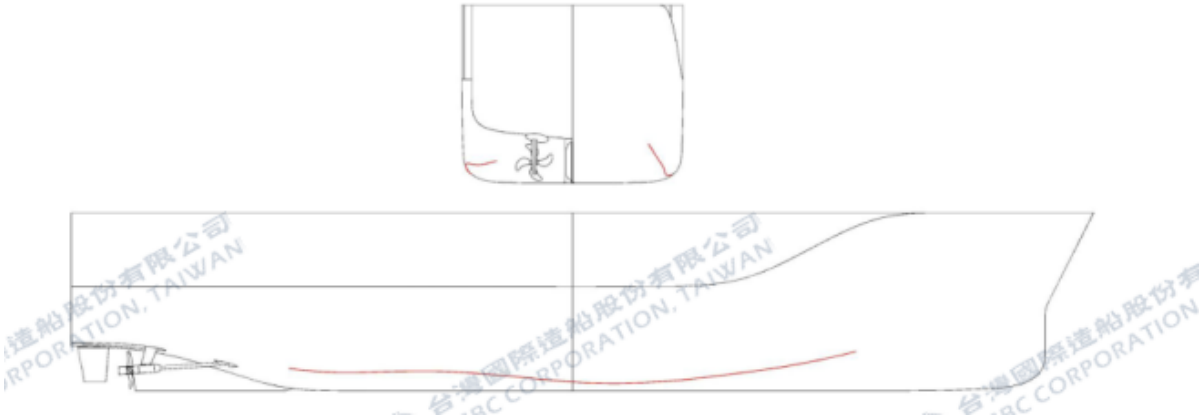


圖 3-3　100 噸級調查船 SSMB 建議泌龍骨位置

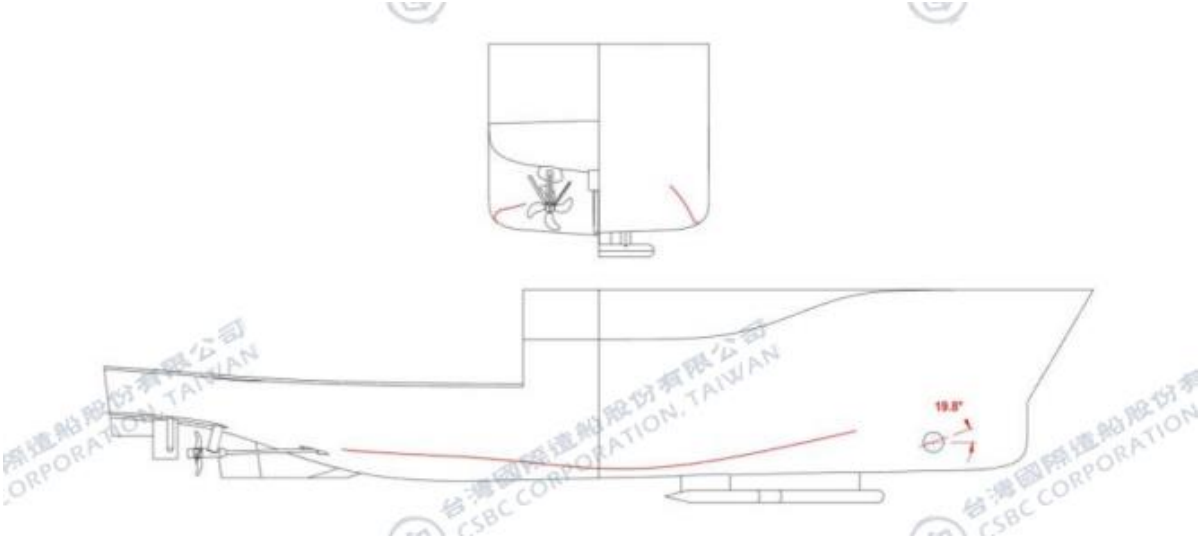


圖 3-4　300 噸級調查船 SSMB 建議泌龍骨位置

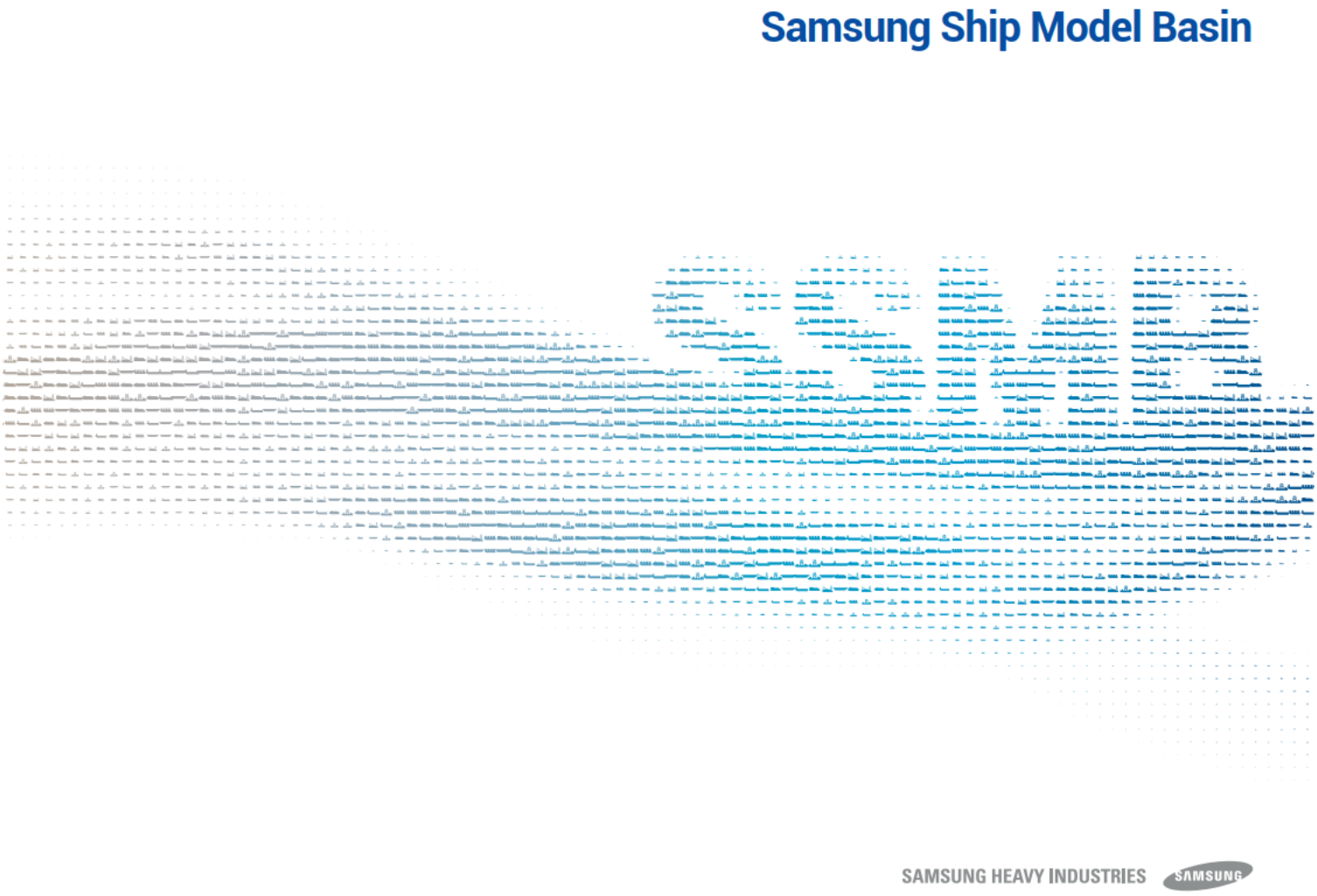
肆、心得與建議

1、 本次試驗為本院造船建案之首次船模試驗，亦為首次前往國外進行試驗。本試驗過程均依契約要求與船東需求規範辦理，試驗結果亦符合規範要求。整體過稱堪稱順利，此有賴於事前完備船模試驗作業計畫、同時委託具豐富經驗的水槽試驗室辦理，並經專案管理廠商審核確認無虞後執行。本院人員參與此次試驗除督導履約品質，亦學習瞭解船模試驗相關知識與技能，有助於本院未來更精準監督造船履約細節與品質。

2、 本院刻正推動興建「國家船模實驗室」，藉由參與本次試驗，可瞭解他國船模試驗品質及程序作業等，亦可參考借鏡國際船模廠區量能。本次於韓國 SSMB 試驗的船舶模型未來將運回交付本院，屆時併同相關試驗報告與數據，可提供「國家船模實驗室」團隊訓練測試使用，俾加速我國船模試驗的能量建立與經驗累積。

伍、附錄

附錄一、韓國三星重工水槽



SSMB AP 2 4 6 8 10 12 14 16 18 FP

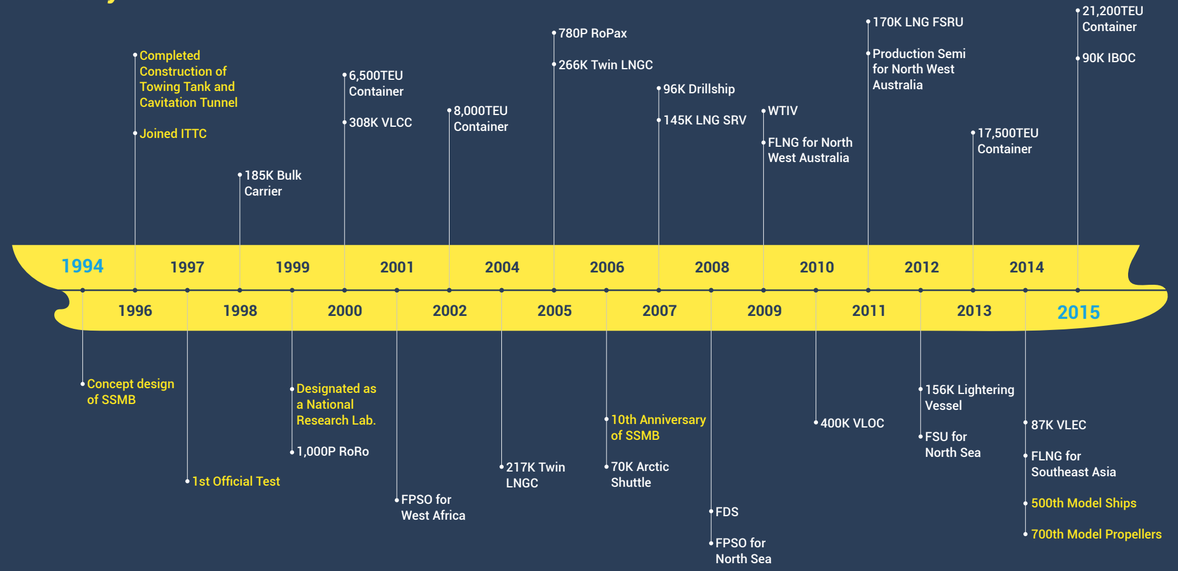
CONTENTS

Total Solution Provider in Hydrodynamics

Vision of SSMB

SSMB (Samsung Ship Model Basin) provides new and enhanced technologies, expertise and solutions in hydrodynamics of ships and offshore structures. Our vision is to develop ships and offshore structures that meet clients' expectations. SSMB has one of the world's largest commercial towing tanks and cavitation tunnels with about 150 experienced research engineers. Capability of SSMB does not only stay in analysis of model test results but extend to estimate of full scale performances with databases of model tests and sea trials. SSMB is putting its utmost effort to meet, and even exceed, the clients' expectations through the latest technologies in simulations, model tests, and sea trial measurement.

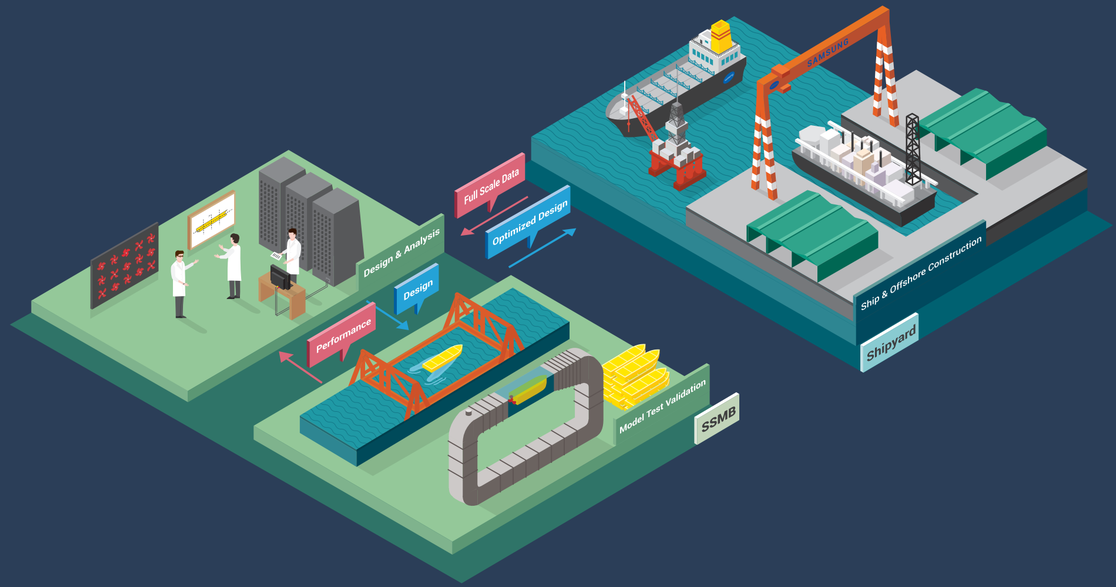
History



Role of SSMB

In rapidly changing market of ship and offshore industries, clients are to request various requirements for successful project. SSMB provides optimized solution through processes of designs based on extensive experiences, sophisticated simulations and model test validation to satisfy the clients' needs and step up as a leader in the industry.

Not limited in form of drawings, the optimized design solution is extended to actual ships and offshore structures via validation processes of production at SHI shipyard. Sea trial data of full scale ships and offshore structures returns to SSMB as valuable feedback for further improvement in simulations and model tests.



Model List

Model Type

Tanker · Container Ship · Passenger Ship · LNGC · Drillship · FLNG, FPSO · ETC.

Samsung Model No.

001 002 003 004 005 006 007 008 009 **010** 011 012 013 014 015 016 017 018 019 020 021 022 023
024 025 026 027 028 029 030 031 032 033 034 035 036 037 038 039 040 041 042 043 044 045 046 047
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528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 545 546 **547** 548 549 550

As of December 2015

308K VLCC
Samsung Model No. 010

266K Twin LNGC
Samsung Model No. 237

96K Drillship
Samsung Model No. 271

FLNG
Samsung Model No. 351

13,200TEU Container
Samsung Model No. 400

780P Ro-Pax
Samsung Model No. 206

70K Arctic Shuttle Tanker
Samsung Model No. 243

145K LNG SRV
Samsung Model No. 273

Wind Turbine Installation Vessel
Samsung Model No. 386

21,200TEU Container
Samsung Model No. 547

FACILITIES AND TEST CAPABILITIES

Towing Tank

Cavitation Tunnel

Ocean Engineering Basin (KRISO)

Towing Tank

Dimension
L x B x D : 400m x 14m x 7m
Carriages
Linear Induction Motor Driven
Maximum Speed : 18.0 m/s (carriage #1),
5.0 m/s (carriage #2)

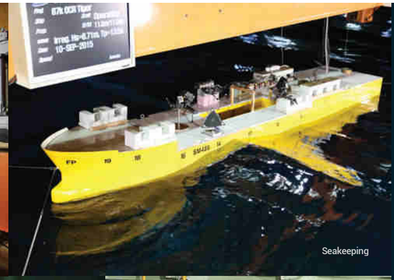
Wave Generator
Multi-plunger Type
Max.Wave Height : 0.5m

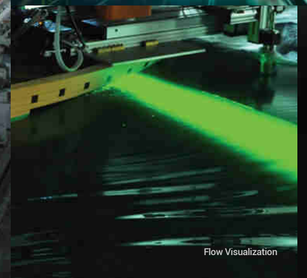
Towing Tank

SSMB has one of the world's largest commercial towing tanks to focus on improving hydrodynamic performances of ship and offshore structures, and developing new products. The tank is 400m in length, 14m in width, and 7m in depth. Two towing carriages are driven by linear induction motors with low noise and vibration; one carriage has a maximum speed of 18m/s for high-speed ships, and the other has a maximum speed of 5m/s for ordinary ships. Also, a wave generator consisting of 40 independent plungers can simulate real sea states.

The towing tank at SSMB is capable of testing various models including powering, manoeuvring, and seakeeping performance. In addition to the standard tests, flow visualizations and local flow measurements are performed for further research. Rigorous research activities thus drive development of safe and efficient ships and offshore structures with superior hydrodynamic performance in actual sea conditions. SSMB always provides the expertise in marine hydrodynamics to comply with clients' requests.


Resistance and Self-propulsion


Seakeeping


Flow Visualization


Propeller Open Water


PMM Test

Test Capabilities

Powering
- Calm Water Resistance Test
- Propeller Open Water Test
- Self Propulsion Test
- Wave Pattern Analysis
- Flow Visualization
- Local Flow Measurement

Seakeeping
- Motions and Speed Loss Test in Waves
- Green Water and Impact Load Test
- Springing and Whipping Test
- Parametric Roll Test

Manoeuvring
- PMM (Planar Motion Mechanism) Test
- Rudder Open Water Test
- Towing Stability & Load Test
- Free Sailing Test
- Crabbing Test

Cavitation Tunnel

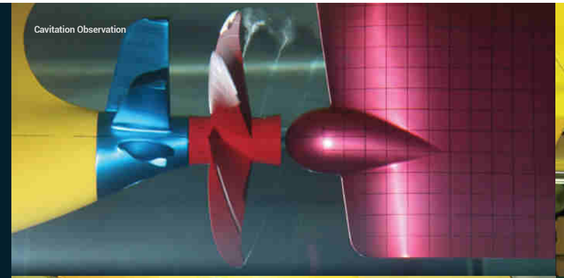
As one of the large commercial cavitation tunnels, a low-noise cavitation tunnel was constructed at SSMB in 1996. SSMB has two different test sections. No.1 section is 6m in length, 1.2m in width, and 1.2m in depth to enable high-speed model tests with a tunnel flow speed up to 28m/s. With the dimension of 12m, 3m, and 1.4m in length, width and depth, respectively, No.2 section can accommodate the entire model ship maximum length of 10m. In No.2 section, 650 tons of water inside the tunnel is circulated up to 12m/s by an impeller.

SSMB provides high quality model tests, which enables cost effective and accurate prediction of cavitation performances such as inception speed, cavitation extent, and propeller induced hull pressure fluctuation and rudder cavitation with reliable wake field as the entire model ship is installed on the tunnel. Cavitation tests are valuable tools for measuring and visualizing the flow field to design efficient propellers with low noise and vibration, and to develop energy saving devices.

Test Capabilities

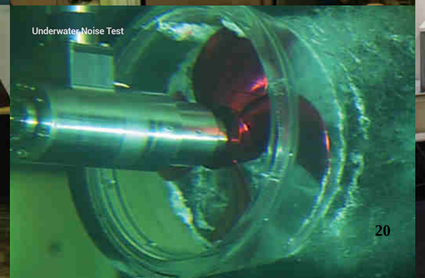
Cavitation
- Cavitation Observation (Propeller, Rudder)
- Pressure Fluctuation Measurement
- Cavitation Inception Test
- Propeller Erosion Test
- Underwater Noise Test

Visualization
- Wake Measurement by PIV / Pitot Tube
- Paint Test
- Tuft Test


Cavitation Observation


Pressure Fluctuation Measurement


Wake Measurement by PIV


Underwater Noise Test

Cavitation Tunnel

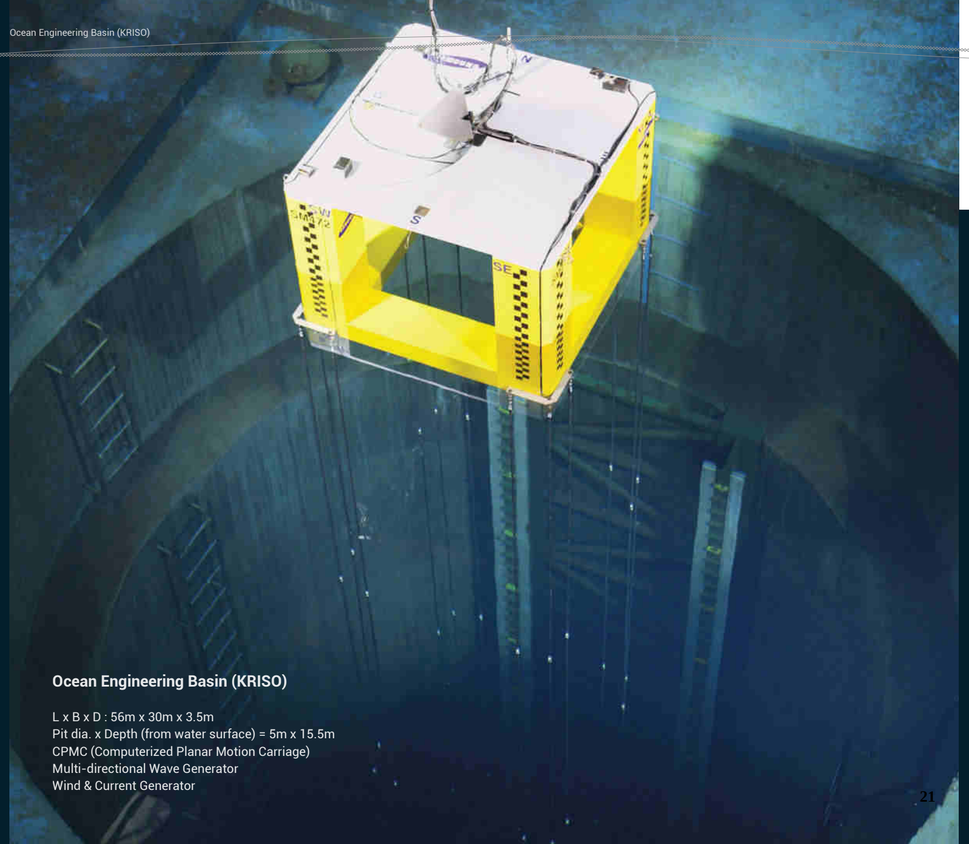
Test Section #1
L x B x D : 6m x 1.2m x 1.2m
Max. Flow Spaeed : 28 m/s
Pressure Range : 0.1 ~ 4.0 bar

Test Section #2
L x B x D : 12m x 3.0m x 1.4m
Max. Flow Speed : 12 m/s
Pressure Range : 0.1 ~ 4.0 bar

Ocean Engineering Basin (KRISO)

SSMB has a solid cooperation with KRISO (Korea Research Institute of Ships and Offshore Engineering) in ship and offshore researches. SSMB not only cooperates with KRISO in engineering projects but also leases KRISO's Ocean Engineering Basin in a long-term agreement since 2006. Realistic environments with waves, wind and current can be simulated in KRISO's Ocean Engineering Basin.

KRISO's Ocean Engineering Basin is capable of various offshore model tests such as seakeeping, mooring, ship-to-ship operability, and dynamic positioning tests. Also, a 15.5m deep pit is available for model tests on TLP which requires ultra-deep water.



Ocean Engineering Basin (KRISO)

L x B x D : 56m x 30m x 3.5m
Pit dia. x Depth (from water surface) = 5m x 15.5m
CPMC (Computerized Planar Motion Carriage)
Multi-directional Wave Generator
Wind & Current Generator

Test Capabilities

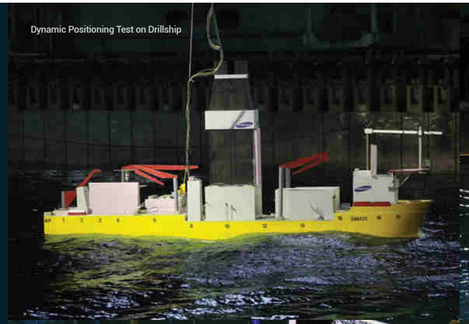
Seakeeping
- Motion Test in Waves
- Green Water and Impact Load Test
- Springing and Whipping Test
- Offloading Operability Test

Position Keeping
- DP (Dynamic Positioning) Test
- Turret / Spread Mooring Test
- DP assisted Mooring Test
- TLP (Tension Leg Platform) Test

Manoeuvring
- Computerized Motion Test
- Free Sailing Test

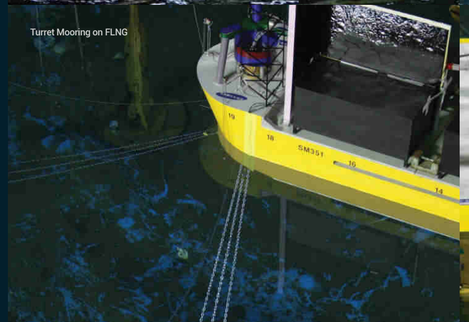
Marine Operation
- Lifting & Mating Test

Offshore Renewable Energy
- Floating Wind Turbine Test
- Wave Energy Converter Test



Dynamic Positioning Test on Drillship

Motions in Waves on Semi Rig



Turret Mooring on FLNG

Ship-to-ship Mooring Test on FLNG & LNGC

SHIP PERFORMANCE

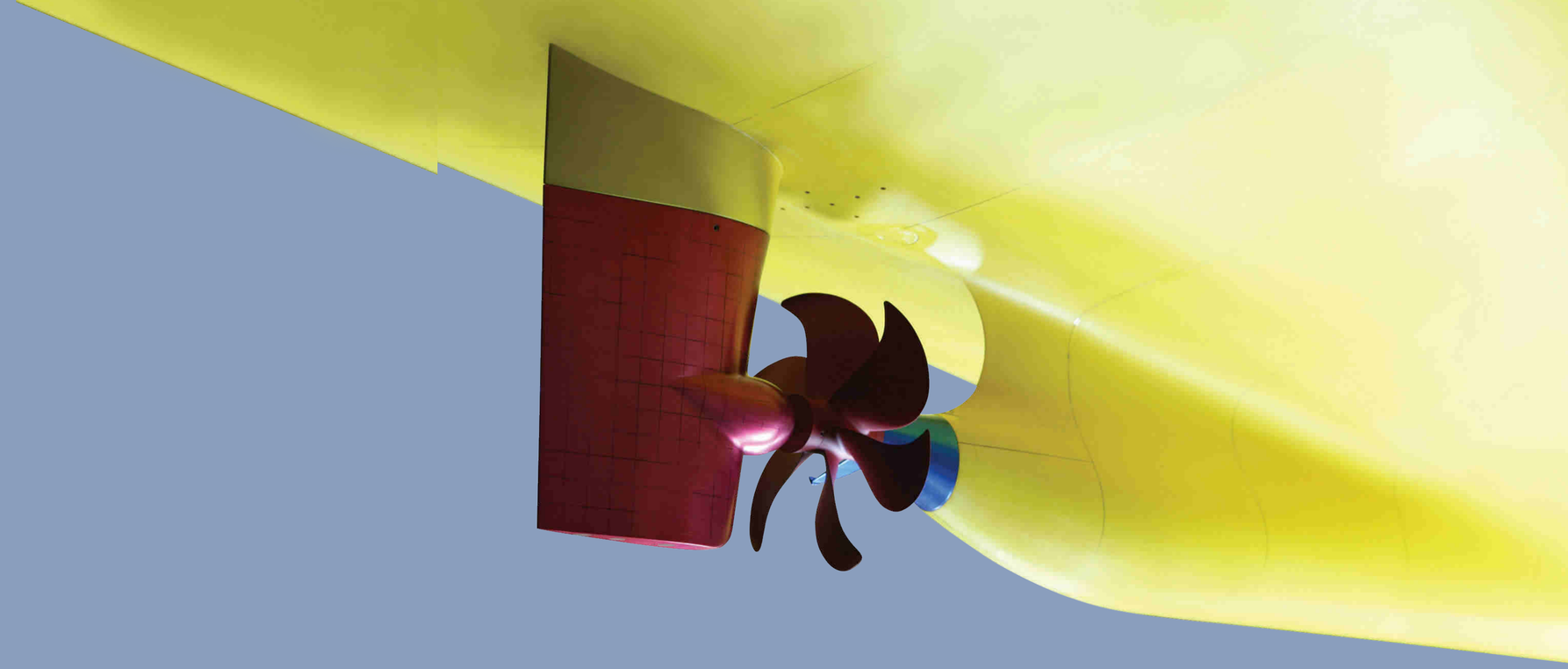
Hull Form Design

Propeller Design

Seakeeping & Manoeuvring

Energy Saving Device Development

Smart Ship Development



Hull Form Design

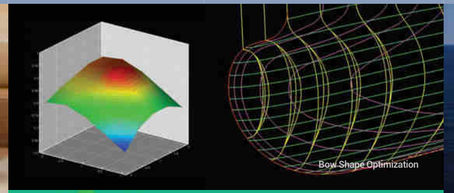
Research in hull form optimization at SSMB, covering from tankers to high-speed cruisers, has been progressed to provide the world-class ships. Hull form optimization starts with a statistical approach using in-house data-base. Then the hull forms are evaluated based on CFD calculations to pick the most probable hull form and verified its powering performance through the model tests in the towing tank.

This process to design the best hull form takes from a year to several years of continuous efforts. Results of such researches have been applied to all contracted ships, which have been highly acclaimed for their exceptional performance from the clients. SSMB continues research on further improvement in hull form performance and development of newly fashioned hull forms for future market.

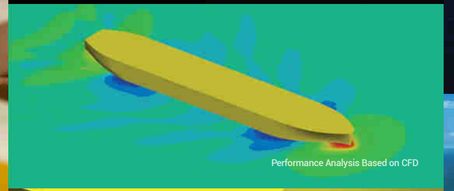
Performance Analysis Based on Model Test

R&D Activities

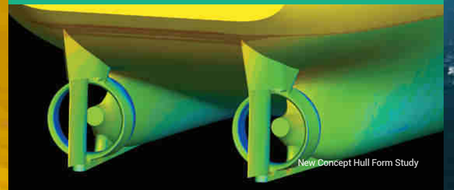
- **Initial Hull Form Speed Assessment**
- **Economical Hull Form Design**
  - Container Ship, Gas Carrier, Shuttle Tanker, Crude Oil Tanker..
  - Drillship. Arctic Vessel, RoPax, WTIV..
  - New Concept Hull Form Study
- **Customized Optimization**
  - Operation Profile
  - Minimum Added Resistance in Waves
  - Hull Form with Special Propulsor



Bow Shape Optimization



Performance Analysis Based on CFD



New Concept Hull Form Study

Container Ship

LNG Carrier

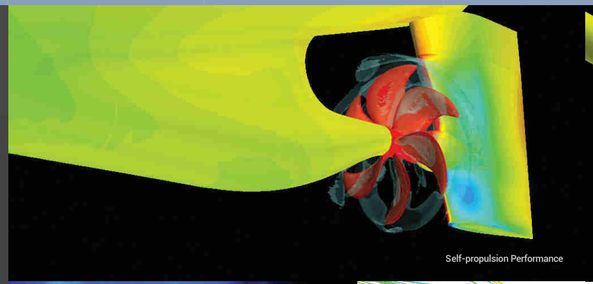
Propeller Design

Generally, propeller design is to find an optimum point to satisfy propulsive and vibratory performance. Propeller with the best performance can be designed through selection of diameter, blade area ratio, blade cross section, combination of various design parameters. Our propeller design technology is more advanced than that of any other ship-builders or competitors. STAR (Samsung Tip Advanced Rake) propeller was developed by adoption the winglet in airplane, propulsive efficiency improvement and lower propeller excitation force were achieved simultaneously.
Furthermore, optimization method such as genetic algorithm and high accurate CFD simulations are also applied to the propeller design. Based on accumulated model test and full scale data, SSMB has confidence in propeller performance and is ready to provide the world-best propeller for client.

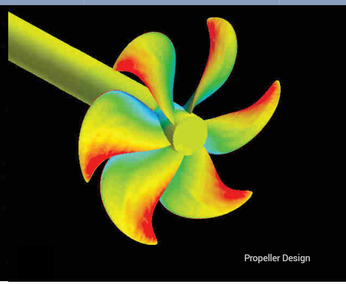
Various Propeller Designs

R&D Activities

- **Optimized Propeller Design**
- **Propeller Performance Analysis on Various Designs**
  - Propeller Efficiency and Cavitation Performance
  - Hull Surface Force / Shaft Bearing Force
  - Blade Strength by FEM / Propeller-Rudder Interaction
- **Performance Verification on Special Propulsors**
  - CPP (Controllable Pitch Propeller)
  - Podded Propulsor / Azimuth Thruster

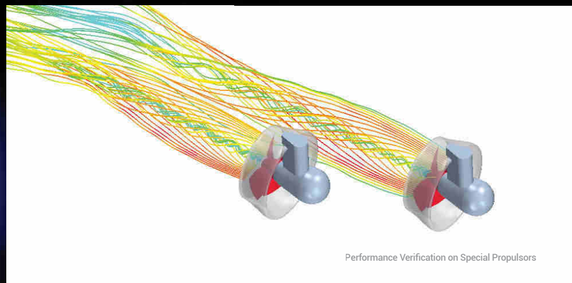


Self-propulsion Performance



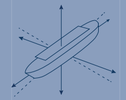
Propeller Design

Observation of Full-scale Propeller Cavitation



Performance Verification on Special Propulsors

Seakeeping & Manoeuvring



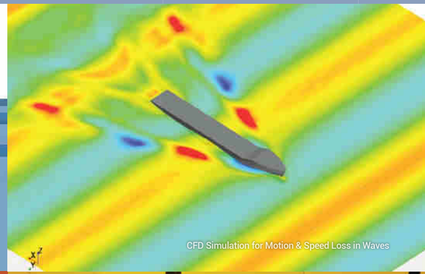
SSMB provides the service of evaluating seakeeping and manoeuvring performances of vessels. Seakeeping performance is evaluated by numerical analysis and model tests in terms of global motions and speed loss in waves, parametric roll motion, slamming, and green water loads. SSMB designs rudders for the SHI's contracted ships and the manoeuvrability is evaluated by the numerical models based on the captive model test and sea trial database. Free sailing model test and CFD analysis can be used. Recently, towing stability for large offshore structures becomes an issue in offshore projects. Towing stability and loads for large offshore structures can be fully estimated by the model test with the advantage of very long towing tank.

Seakeeping Test on Container Ship

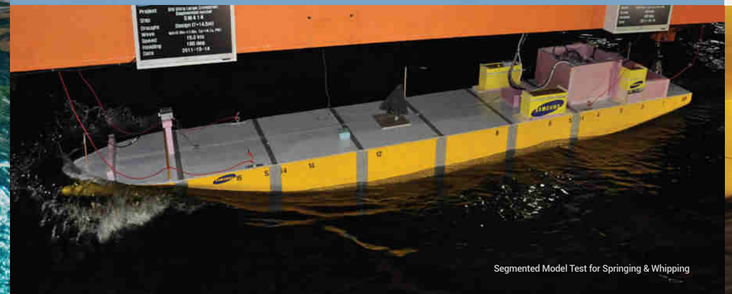
R&D Activities

- **Seakeeping Performance Evaluation**
  - Motion & Speed Loss in Waves
  - Green Water & Impact Load
  - Springing & Whipping
  - Parametric Roll
- **Manoeuvring Performance Evaluation**
  - Optimized Rudder Design
  - High Lift Rudder Section Development
  - Manoeuvring in Wind and Waves
  - Manoeuvring in Ice & Shallow Water
  - Crabbing Ability

CFD Simulation for Green Water & Impact Load



CFD Simulation for Motion & Speed Loss in Waves



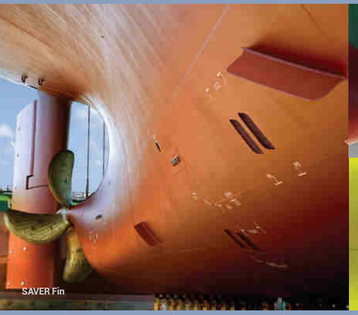
Segmented Model Test for Springing & Whipping

Rudder Design

Energy Saving Device Development

ESD (Energy Saving Device) is an effective method to reduce fuel consumption and CO_2 emissions. The strongest advantage that ESD has is that they can be designed, applied and installed on both existing and newly built ships. In order to meet the needs of the clients, SSMB has developed its own unique ESDs:

-SAVER Fin (SAmsung Vibration and Energy Reduction Fin)
-SARB (Samsung Asymmetric Rudder Bulb)
-SAVER Stator (SAmsung Vibration and Energy Reduction Stator)
-SAVER Air (SAmsung Vibration and Energy Reduction Air lubrication system)
-SPCB (Samsung Propeller Cap Blade)


SAVER Fin


SARB


SAVER Stator

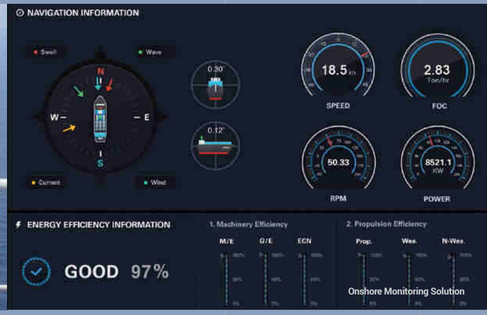

SAVER Air

R&D Activities

- Design of ESDs and Evaluation of Performance
- Assessment of Structural Safety
- Research of ESDs Installation on Ship
- Development of Innovative ESDs

Smart Ship Development

SSMB aims to enhance ship's operational efficiency and safety by merging shipbuilding technology and ICT, and to pursue unmanned ship development, that is, a ship can be operated by remote control. For this, SSMB has developed a system whose purposes are to support economic, safe and convenient operation of ship, to monitor operating state of ship from onshore office, and to optimize operational efficiency through managing and controlling the target ship. In addition, SSMB provides engineering services to optimize operational performance and to prevent machinery failure based on ship's operational data analysis.



R&D Activities

- Smart Ship & Offshore Platform Development
- Eco/Safe Navigation Solution
- Engineering Service using Big Data Analysis
- Fleet Management System

OFFSHORE ENGINEERING

Engineering & Development for Offshore Structures

Engineering & Development for Drilling Equipment

CFD Applications

Engineering & Development for Offshore Structures

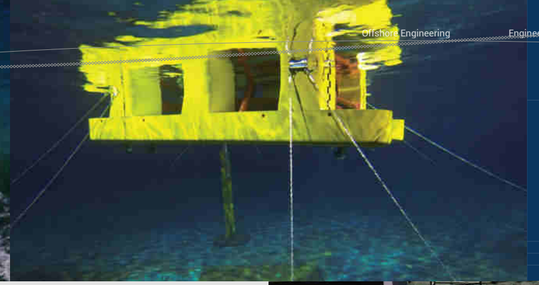
SSMB has been fully dedicated to the FEED and EPCI offshore projects of FPSOs, FLNGs, Semi-submersibles in terms of global performance analyses which include wave induced loads and motions, air gap, slamming and hydrodynamic loads, mooring & riser dynamics and dynamic positioning. Not only analytical analyses but also SSMB provides high quality model tests. Our experienced researchers also manage the model tests in co-operative model basins from preparing specifications to analyzing the results. In addition to the hydrodynamic performances, SSMB provides advanced structural engineering services for the offshore projects.
Efforts to deliver better engineering solutions are kept through the internal research projects and the cooperation with the engineering communities participating in JIPs. Based on the engineering capabilities and experiences on offshore floating structures, SSMB has tried to develop the better designs of our own drillships, semi-rigs, FLNGs, and production platforms.

R&D Activities

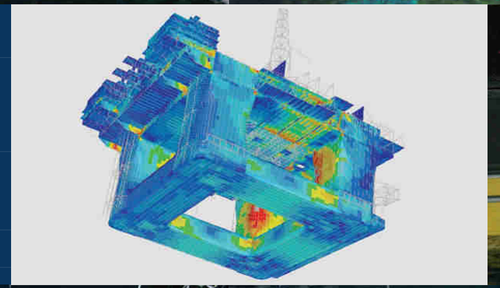
- **Global Performance Analysis**
  - Motions and Wave Load
  - Airgap, Green Water & Impact Load
  - Heading Analysis
  - DP Analysis
- **Structural Analysis**
  - Global & Local Strength
  - Fatigue Analysis
  - Dynamic Impact
  - Fluid Structure Interaction (FSI)
- **Mooring & Riser**
  - Mooring & Riser Design & Analysis
  - DP assisted Mooring
  - VIV & VIM
  - Fatigue Assessment (TT & OPB/IPB)
- **Offloading Operability**
- **Sloshing Analysis**
- **Towing Stability & Load**
- **Products Development**
  - Advanced Offshore Platform
  - Arctic Drillship
  - Offshore Renewable Energy Converter

Semi Rig

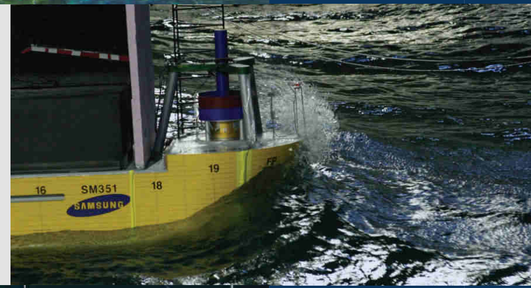
FPSO

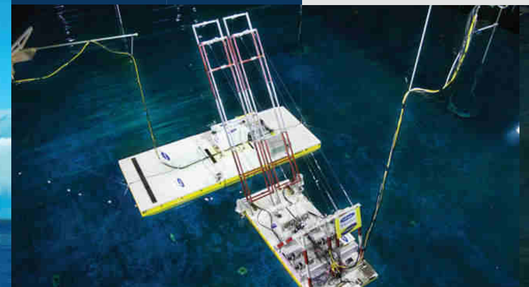


Motions and Airgap in Waves (L)
DP Assisted Mooring (R)



Structural Analysis (L)
Green Water on FLNG (R)





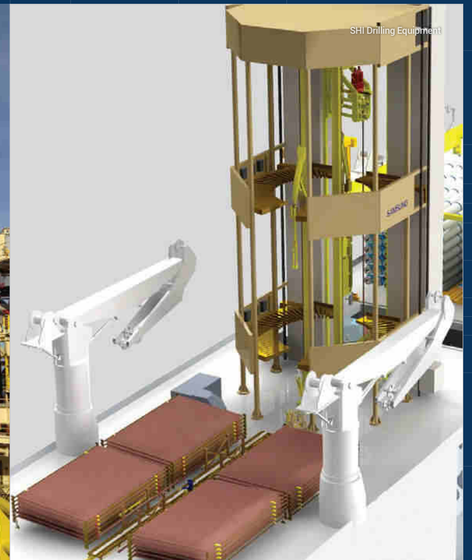
Marine Operations (L)
Ship to ship Offloading Operability (R)

Engineering & Development for Drilling Equipment

SSMB is also in progress of developing drilling automation technology to improve the efficiency and to validate the performance for next generation of drilling rig.

- -Hoisting & Rotation
- -Motion Compensation
- -Drilling Equipment Control & Interface.
- -Pipe & Material Handling
- -Fluid Circulation and Well Control


Conventional Drilling Equipment

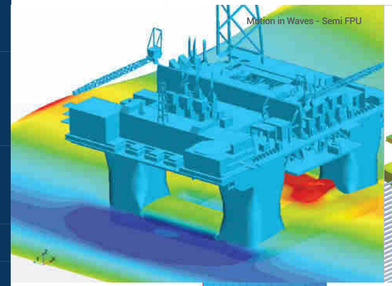

SHI Drilling Equipment

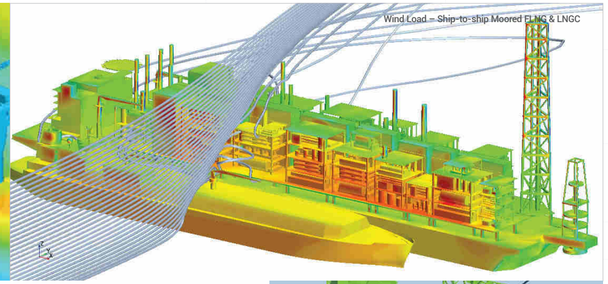
R&D Activities

- **Performance Verification of Topside Equipment for Drilling Rigs**
- **Static and Dynamic Analysis of Mechanical Systems**
- **Design and Performance Verification of Drilling Control System**
- **Development of Top side Equipment for Drilling Rigs**
  - Continuous Hoisting & Rotation System
  - High Efficiency Pipe Handling System
  - Multi Function Material Handling System
  - Drilling HIL System
  - Compact Heaving Compensation System
  - Fluid Circulation System
  - HPHT BOP (Blow Out Preventer)

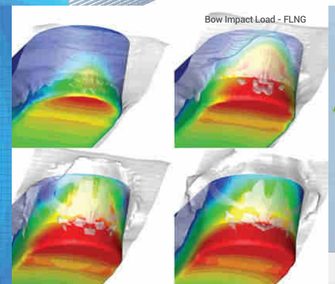
CFD Applications

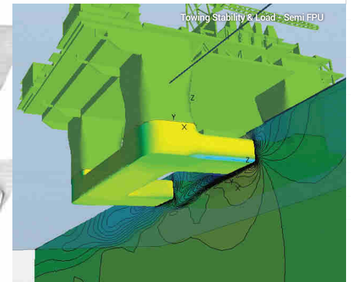
A wide variety of complicated flow problems is observed in offshore engineering; some can be investigated via model tests. Such flow problems can be investigated through CFD simulations instead of model tests. SSMB has tried to set up CFD simulations on various flow phenomena to evaluate global performance, seakeeping, wind & current loads, impact loads, VIM (Vortex Induced Motion), damping and added mass coefficients of offshore structures. Technical supports on aero & hydrodynamic performances of ships and offshore structures can be provided to the clients at the early design stage.


Motion in Waves - Semi FPU


Wind Load – Ship-to-ship Moored FLNG & LNGC


Roll Damping - FPSO


Bow Impact Load - FLNG


Towing Stability & Load - Semi FPU

R&D Activities

- **Motion in Waves**
- **Wind & Current Load**
- **Damping & Added Mass**
- **Airgap, Green Water**
- **Impact Loads (Slamming, Sloshing)**
- **VIV & VIM**
- **Time domain Simulation Coupling with Riser/Mooring**
- **Towing Stability & Load**
- **Numerical Wave Basin**
  - Nonlinear Irregular Waves
  - Short-crested Wave

CONTACT US

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http://www.samsungshi.com

附錄二、試驗結果：100 噸級與 300 噸級調查船船模試驗報告

100 噸級調查船船模試驗報告(Preliminary)

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PRELIMINARY RESULT

RS240005-P1

CALM WATER MODEL TESTS
FOR
100GT RESEARCH VESSEL

/ POWERING PERFORMANCE /

CUSTOMER
NATIONAL ACADEMY OF MARINE RESEARCH
SHIP AND OCEAN INDUSTRIES R&D CENTER

CLIENT
CSBC CORPORATION, TAIWAN

SEPTEMBER 2024

PRELIMINARY

Table 1 Open Water Characteristics of the Design Propeller (SP1045RL)

Results of Propeller Open Water Tests

Geometry of Propeller SP1045RL

Number of Propeller	: 2	Number of Blades	: 4
Diameter of Ship Prop	: 1.300 m	Model Scale Ratio	: 5.2000
Diameter of Model Prop	: 0.250 m	Section Type	: Given
Expanded Area Ratio	: 0.3984	Pitch-Dia Ratio (0.7r)	: 0.7675
Chord-Dia Ratio (0.7r)	: 0.21962	Thick-Dia Ratio (0.7r)	: 0.02439
Water Temperature	: 22.6 deg C	Propeller Revolutions	: 17.00 rps
Propeller Design J	: 0.55	Reynolds Number	: 0.5607 e6
Blade Roughness Kp	: 30.0 e-6	Test Date	: 04-SEP-24

[Remarks] All tests have been performed in SSMB.

Characteristics of Propeller SP1045RL

J	Kt	10*Kq	EtaO	Cth
0.000	0.3242	0.3277	0.0000	-
0.100	0.3009	0.3174	0.1509	76.6323
0.200	0.2713	0.3006	0.2873	17.2733
0.250	0.2550	0.2903	0.3495	10.3904
0.300	0.2380	0.2790	0.4074	6.7353
0.350	0.2206	0.2666	0.4609	4.5857
0.400	0.2028	0.2533	0.5097	3.2278
0.450	0.1847	0.2390	0.5535	2.3231
0.500	0.1664	0.2237	0.5920	1.6949
0.550	0.1477	0.2072	0.6242	1.2437
0.600	0.1287	0.1893	0.6490	0.9101
0.650	0.1090	0.1699	0.6636	0.6570
0.700	0.0885	0.1487	0.6635	0.4601
0.750	0.0670	0.1253	0.6383	0.3032
0.800	0.0440	0.0993	0.5641	0.1751
0.850	0.0192	0.0704	0.3689	0.0676
0.880	0.0032	0.0514	0.0884	0.0107

Coefficients of Propeller Characteristics

	a(0)	a(1)	a(2)	a(3)	a(4)
[Kt]	0.324212E+00	-0.189960E+00	-0.491718E+00	0.675015E+00	-0.388562E+00
[Kq]	0.327654E-01	-0.618367E-02	-0.449502E-01	0.484649E-01	-0.340198E-01

[polynomial fit] value = a(0) + a(1)*j^1 + a(2)*j^2 + a(3)*j^3 + a(4)*j^4

PRELIMINARY

Project Name	: CSBC Research \EAR		:	0.3984
Prop. Model ID	: SP1045RL	P/D (0.7R)	:	0.7675
Diameter	: 0.2500 M	C/D (0.7R)	:	0.2196
Scale Ratio	: 5.2000	T/D (0.7R)	:	0.0244
Section Type	: Given	Rn Model $\times 10^6$	:	0.5607
Date of Test	: 04-SEP-24			

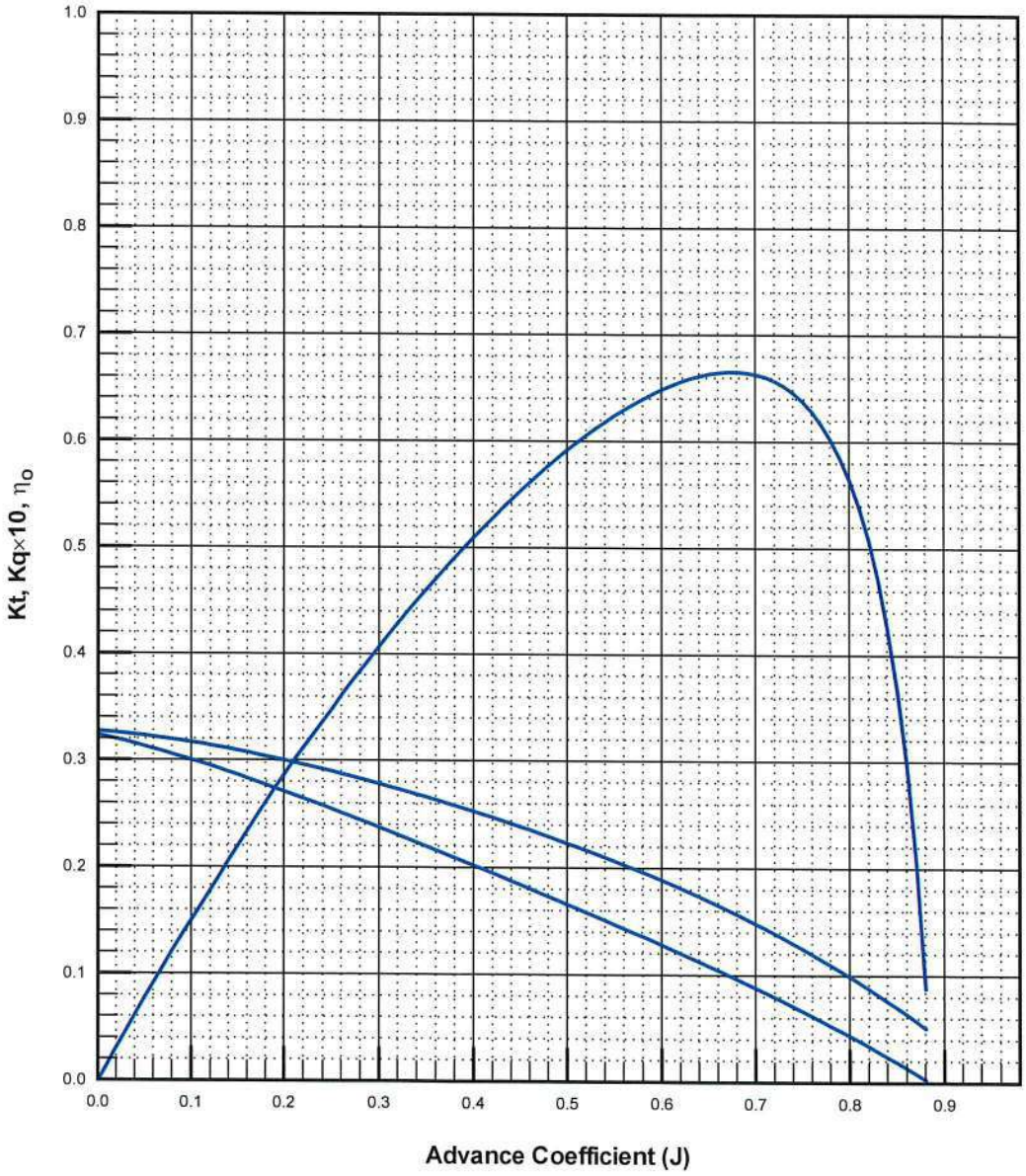


Figure 1 Open Water Characteristics of the Design Propeller (SP1045RL)

PRELIMINARY

Table 2 Result of Wake Measurement (Axial Velocity)

Project Name	: CSBC Research Ve	Length BP	:	32.00	M
Ship Model ID	: SM782	Draught FP	:	2.20	M
Test Condition	: Design	Draught AP	:	2.20	M
Scale Ratio	: 5.2000	Propeller Dia.	:	1.30	M
Water Temperature	: 22.60 deg	Density	:	997.52	kg/m3
Test Date	: 04-SEP-24	Ship Speed	:	12.00	kts
Remarks	: 100GT, PORT Side				

AXIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R)				
	0.300	0.500	0.700	0.900	1.100
0.0	0.882	0.818	0.697	0.622	0.592
5.0	0.897	0.824	0.714	0.637	0.622
10.0	0.905	0.830	0.724	0.658	0.645
20.0	0.913	0.835	0.745	0.688	0.699
30.0	0.928	0.855	0.786	0.725	0.733
45.0	0.939	0.892	0.837	0.788	0.790
60.0	0.967	0.941	0.910	0.881	0.864
75.0	0.980	0.972	0.960	0.950	0.953
90.0	0.985	0.990	0.990	0.988	0.987
105.0	0.986	0.994	0.994	0.993	0.990
120.0	0.988	0.993	0.994	0.995	0.999
135.0	0.986	0.991	0.992	0.996	0.997
150.0	0.985	0.995	1.000	0.999	0.999
165.0	0.977	0.993	0.997	0.999	0.996
180.0	0.975	0.989	0.993	0.998	0.992
195.0	0.981	0.987	0.990	0.996	0.997
210.0	0.983	0.984	0.987	0.993	0.993
225.0	0.985	0.981	0.980	0.984	0.985
240.0	0.981	0.985	0.984	0.982	0.975
255.0	0.974	0.980	0.978	0.971	0.965
270.0	0.970	0.972	0.970	0.964	0.963
285.0	0.960	0.953	0.949	0.949	0.953
300.0	0.938	0.921	0.909	0.895	0.900
315.0	0.854	0.857	0.841	0.799	0.746
330.0	0.765	0.776	0.708	0.637	0.536
340.0	0.737	0.747	0.681	0.590	0.509
350.0	0.801	0.750	0.695	0.624	0.564
355.0	0.840	0.782	0.678	0.600	0.547
360.0	0.878	0.822	0.704	0.613	0.597

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.

PRELIMINARY

Table 3 Result of Wake Measurement (Radial Velocity)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

RADIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R) 0.300	0.500	0.700	0.900	1.100
0.0	0.100	0.122	0.101	0.087	0.105
5.0	0.110	0.121	0.103	0.093	0.106
10.0	0.114	0.121	0.103	0.099	0.104
20.0	0.111	0.112	0.106	0.098	0.090
30.0	0.103	0.105	0.101	0.092	0.073
45.0	0.081	0.088	0.086	0.079	0.070
60.0	0.048	0.058	0.057	0.056	0.051
75.0	0.009	0.015	0.017	0.018	0.014
90.0	-0.023	-0.027	-0.029	-0.031	-0.034
105.0	-0.040	-0.064	-0.069	-0.072	-0.073
120.0	-0.047	-0.095	-0.104	-0.108	-0.110
135.0	-0.046	-0.120	-0.134	-0.138	-0.140
150.0	-0.044	-0.137	-0.157	-0.167	-0.164
165.0	-0.030	-0.151	-0.171	-0.183	-0.179
180.0	-0.043	-0.158	-0.176	-0.188	-0.184
195.0	-0.098	-0.157	-0.171	-0.181	-0.182
210.0	-0.114	-0.142	-0.153	-0.164	-0.166
225.0	-0.104	-0.113	-0.120	-0.130	-0.133
240.0	-0.075	-0.076	-0.078	-0.081	-0.082
255.0	-0.039	-0.028	-0.026	-0.026	-0.023
270.0	0.002	0.022	0.027	0.028	0.033
285.0	0.047	0.068	0.077	0.079	0.080
300.0	0.079	0.108	0.118	0.119	0.125
315.0	0.083	0.119	0.137	0.143	0.149
330.0	0.058	0.099	0.098	0.094	0.092
340.0	0.048	0.104	0.106	0.088	0.083
350.0	0.076	0.121	0.146	0.141	0.140
355.0	0.088	0.117	0.117	0.104	0.106
360.0	0.101	0.126	0.102	0.084	0.105

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Outward radial velocities are considered positive.

PRELIMINARY

Table 4 Result of Wake Measurement (Tangential Velocity)

Project Name	: CSBC Research Ve	Length BP	:	32.00	M
Ship Model ID	: SM782	Draught FP	:	2.20	M
Test Condition	: Design	Draught AP	:	2.20	M
Scale Ratio	: 5.2000	Propeller Dia.	:	1.30	M
Water Temperature	: 22.60 deg	Density	:	997.52	kg/m3
Test Date	: 04-SEP-24	Ship Speed	:	12.00	kts
Remarks	: 100GT, PORT Side				

TANGENTIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R)				
	0.300	0.500	0.700	0.900	1.100
0.0	-0.084	-0.062	-0.041	-0.040	-0.071
5.0	-0.098	-0.068	-0.053	-0.049	-0.096
10.0	-0.111	-0.079	-0.057	-0.064	-0.115
20.0	-0.139	-0.099	-0.082	-0.089	-0.142
30.0	-0.172	-0.126	-0.108	-0.108	-0.142
45.0	-0.211	-0.166	-0.145	-0.136	-0.151
60.0	-0.248	-0.204	-0.183	-0.170	-0.170
75.0	-0.276	-0.221	-0.202	-0.194	-0.193
90.0	-0.284	-0.220	-0.202	-0.193	-0.188
105.0	-0.279	-0.204	-0.186	-0.177	-0.173
120.0	-0.260	-0.175	-0.161	-0.154	-0.150
135.0	-0.208	-0.135	-0.122	-0.120	-0.117
150.0	-0.113	-0.085	-0.080	-0.080	-0.079
165.0	-0.011	-0.032	-0.031	-0.034	-0.034
180.0	0.074	0.026	0.022	0.016	0.014
195.0	0.151	0.084	0.075	0.071	0.065
210.0	0.206	0.136	0.125	0.122	0.116
225.0	0.234	0.176	0.167	0.167	0.164
240.0	0.246	0.206	0.198	0.198	0.199
255.0	0.247	0.219	0.213	0.211	0.212
270.0	0.237	0.216	0.211	0.209	0.207
285.0	0.210	0.197	0.195	0.195	0.194
300.0	0.169	0.160	0.161	0.161	0.168
315.0	0.117	0.111	0.113	0.112	0.104
330.0	0.049	0.055	0.051	0.060	0.040
340.0	-0.005	0.023	0.021	0.022	-0.004
350.0	-0.066	-0.032	-0.003	0.002	-0.023
355.0	-0.077	-0.053	-0.026	-0.015	-0.047
360.0	-0.089	-0.063	-0.041	-0.036	-0.078

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Clockwise tangential velocities are considered negative

PRELIMINARY

Table 5 Result of Wake Measurement (Mean Velocity)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

CIRCUMFERENCIAL MEAN VELOCITY COMPONENTS

RADIUS (r/R)	AXIAL (VA/V)	RADIAL (VR/V)	TANGENTIAL (VT/V)
0.200	0.795	0.006	-0.015
0.300	0.943	0.003	-0.015
0.400	0.942	-0.003	-0.011
0.500	0.933	-0.010	-0.006
0.600	0.922	-0.013	-0.002
0.700	0.911	-0.014	0.001
0.800	0.901	-0.016	0.002
0.900	0.891	-0.019	0.002
1.000	0.884	-0.020	0.000

VOLUMETRIC MEAN OF VA (HUB RATIO : 0.20)	= 0.9093
NOMINAL WAKE FRACTION (WN)	= 0.0907

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Outward radial velocities are considered positive.
-Clockwise tangential velocities are considered negative.

PRELIMINARY

Table 6 Harmonic Analysis of Velocity Components (0.3r/R)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.300

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.943	0.000	0.943	0.
	1	-0.065	0.022	0.068	162.
	2	-0.037	0.027	0.046	144.
	3	-0.008	0.024	0.025	108.
	4	0.004	0.020	0.021	80.
	5	0.012	0.013	0.017	47.
	6	0.009	0.006	0.011	35.
	7	0.006	0.002	0.007	16.
	8	0.004	0.000	0.004	5.
RADIAL COMPONENT	**K**	**A(K)**	**B(K)**	**C(K)**	**PHI(K)**
	0	0.003	0.000	0.003	0.
	1	0.091	0.005	0.091	3.
	2	0.011	-0.013	0.017	-49.
	3	-0.017	0.025	0.030	125.
	4	0.003	0.004	0.005	57.
	5	-0.002	0.009	0.009	100.
	6	0.007	0.001	0.007	7.
	7	0.001	0.003	0.003	72.
	8	0.003	-0.001	0.003	-15.
TANGENTIAL COMPONENT	**K**	**A(K)**	**B(K)**	**C(K)**	**PHI(K)**
	0	-0.015	0.000	-0.015	180.
	1	-0.064	-0.265	0.272	-104.
	2	0.011	0.028	0.030	69.
	3	-0.017	-0.002	0.017	-174.
	4	0.001	0.003	0.003	78.
	5	-0.003	0.004	0.005	125.
	6	-0.003	0.000	0.003	177.
	7	0.001	0.003	0.003	67.
	8	-0.001	0.002	0.002	113.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K))]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 7 Harmonic Analysis of Velocity Components (0.5r/R)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.500

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.933	0.000	0.933	0.
	1	-0.092	0.015	0.093	171.
	2	-0.048	0.011	0.050	167.
	3	-0.013	0.012	0.018	137.
	4	0.003	0.010	0.010	71.
	5	0.006	0.009	0.011	57.
	6	0.005	0.005	0.007	43.
	7	0.005	0.003	0.005	29.
	8	0.002	0.002	0.003	36.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.010	0.000	-0.010	180.
	1	0.145	-0.018	0.146	-7.
	2	-0.011	-0.005	0.012	-154.
	3	-0.009	0.009	0.013	137.
	4	-0.002	0.003	0.004	114.
	5	0.002	0.002	0.003	47.
	6	0.003	0.000	0.003	9.
	7	0.003	0.000	0.003	-7.
	8	0.001	-0.001	0.002	-39.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.006	0.000	-0.006	180.
	1	-0.037	-0.213	0.217	-100.
	2	-0.005	0.008	0.010	121.
	3	-0.002	0.006	0.006	105.
	4	-0.003	0.003	0.004	129.
	5	-0.002	0.001	0.003	156.
	6	-0.002	0.000	0.002	176.
	7	-0.001	0.000	0.001	-174.
	8	-0.001	0.001	0.001	153.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K))]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 8 Harmonic Analysis of Velocity Components (0.7r/R)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.700

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.911	0.000	0.911	0.
	1	-0.131	0.010	0.131	176.
	2	-0.070	0.004	0.070	177.
	3	-0.024	0.008	0.025	162.
	4	0.000	0.009	0.009	87.
	5	0.004	0.009	0.010	63.
	6	0.004	0.004	0.006	45.
	7	0.004	0.000	0.004	0.
	8	0.002	-0.002	0.003	-48.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.014	0.000	-0.014	180.
	1	0.154	-0.024	0.156	-9.
	2	-0.018	-0.007	0.019	-159.
	3	-0.011	0.005	0.012	155.
	4	-0.003	0.003	0.004	137.
	5	0.002	0.001	0.002	40.
	6	0.004	0.000	0.004	-6.
	7	0.002	-0.002	0.003	-40.
	8	0.001	-0.004	0.004	-69.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.001	0.000	0.001	0.
	1	-0.029	-0.201	0.203	-98.
	2	-0.006	0.008	0.010	126.
	3	0.000	0.008	0.008	88.
	4	-0.002	0.004	0.005	116.
	5	-0.001	0.001	0.002	117.
	6	0.000	0.000	0.000	-89.
	7	0.000	-0.001	0.001	-73.
	8	0.000	0.000	0.000	-84.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K)]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 9 Harmonic Analysis of Velocity Components (0.9r/R)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.900

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.891	0.000	0.891	0.
	1	-0.168	0.009	0.168	177.
	2	-0.087	0.004	0.087	177.
	3	-0.030	0.009	0.031	163.
	4	0.002	0.014	0.014	83.
	5	0.008	0.012	0.015	56.
	6	0.006	0.006	0.008	46.
	7	0.004	0.000	0.004	2.
	8	0.002	-0.002	0.003	-44.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.019	0.000	-0.019	180.
	1	0.156	-0.025	0.158	-9.
	2	-0.023	-0.008	0.025	-161.
	3	-0.013	0.006	0.014	156.
	4	-0.003	0.003	0.004	142.
	5	0.001	0.002	0.002	60.
	6	0.004	0.002	0.004	27.
	7	0.003	-0.001	0.003	-19.
	8	0.002	-0.003	0.003	-58.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.002	0.000	0.002	0.
	1	-0.026	-0.196	0.198	-98.
	2	-0.009	0.008	0.012	139.
	3	0.001	0.006	0.006	85.
	4	-0.003	0.002	0.004	143.
	5	0.000	0.000	0.001	-130.
	6	0.001	-0.002	0.002	-65.
	7	0.001	-0.001	0.002	-56.
	8	0.000	0.000	0.000	10.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K))]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 10 Harmonic Analysis of Velocity Components (1.1r/R)

Project Name	: CSBC Research Ve	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Condition	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Water Temperature	: 22.60 deg	Density	: 997.52 kg/m3
Test Date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 1.100

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.879	0.000	0.879	0.
	1	-0.185	0.018	0.186	174.
	2	-0.098	0.017	0.100	170.
	3	-0.033	0.025	0.042	143.
	4	0.004	0.030	0.030	83.
	5	0.015	0.020	0.025	53.
	6	0.009	0.007	0.011	38.
	7	0.004	-0.003	0.005	-31.
	8	0.002	-0.006	0.006	-75.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.019	0.000	-0.019	180.
	1	0.154	-0.028	0.157	-10.
	2	-0.023	-0.012	0.026	-152.
	3	-0.013	0.005	0.014	156.
	4	0.000	0.002	0.002	102.
	5	0.003	0.003	0.004	44.
	6	0.006	0.003	0.007	27.
	7	0.006	0.001	0.006	5.
	8	0.003	-0.002	0.004	-32.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.006	0.000	-0.006	180.
	1	-0.040	-0.197	0.201	-101.
	2	-0.022	0.003	0.022	172.
	3	-0.005	0.003	0.006	153.
	4	-0.005	-0.001	0.006	-169.
	5	0.000	-0.002	0.002	-102.
	6	0.003	-0.004	0.005	-51.
	7	0.003	-0.004	0.004	-55.
	8	0.001	-0.001	0.002	-52.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K)]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Project Name	: CSBC Research Ves	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Cond.	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Test date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

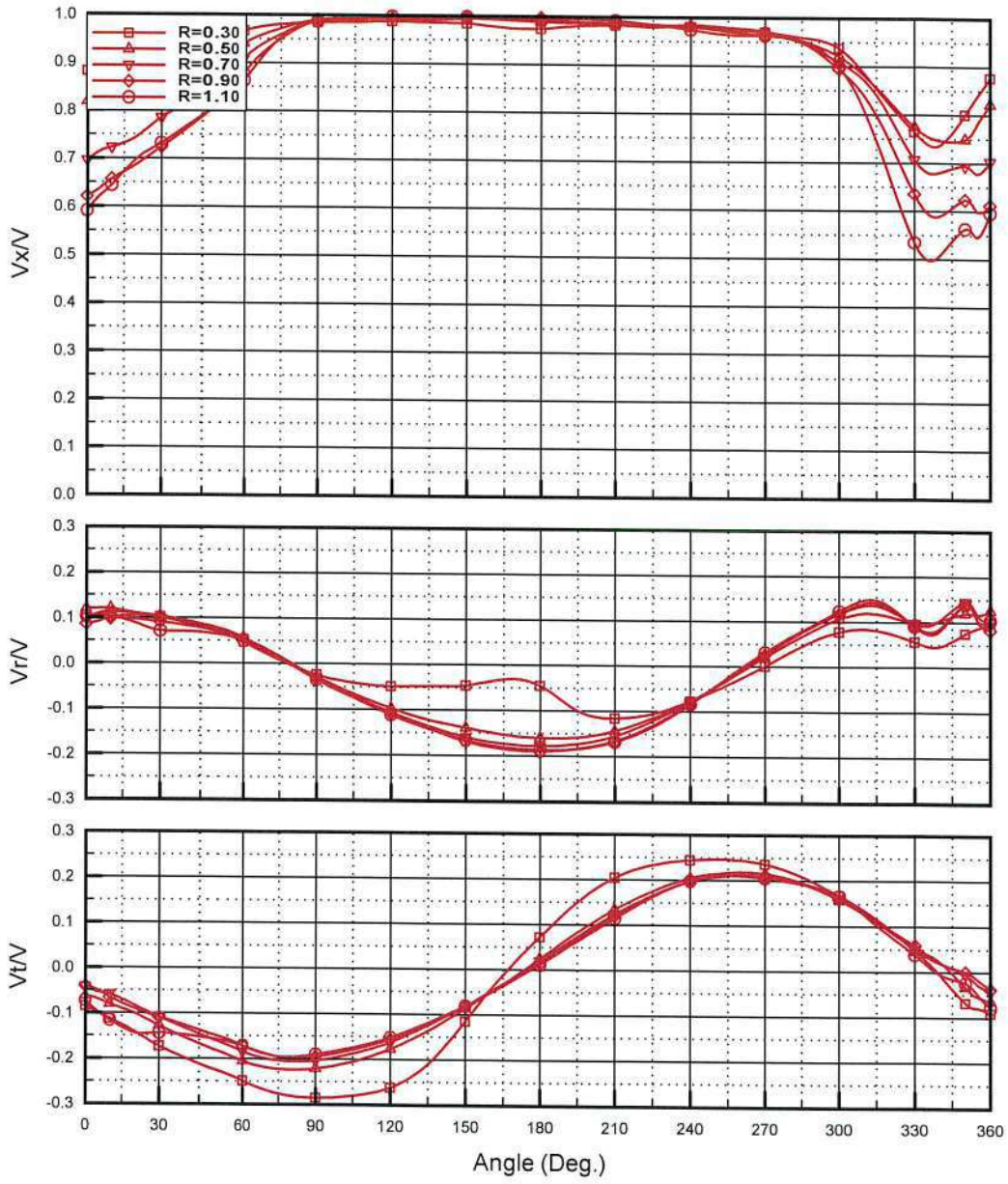


Figure 2 Circumferential Distributions of Velocity Components

PRELIMINARY

Project Name	: CSBC Research Ves	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Cond.	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Test date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

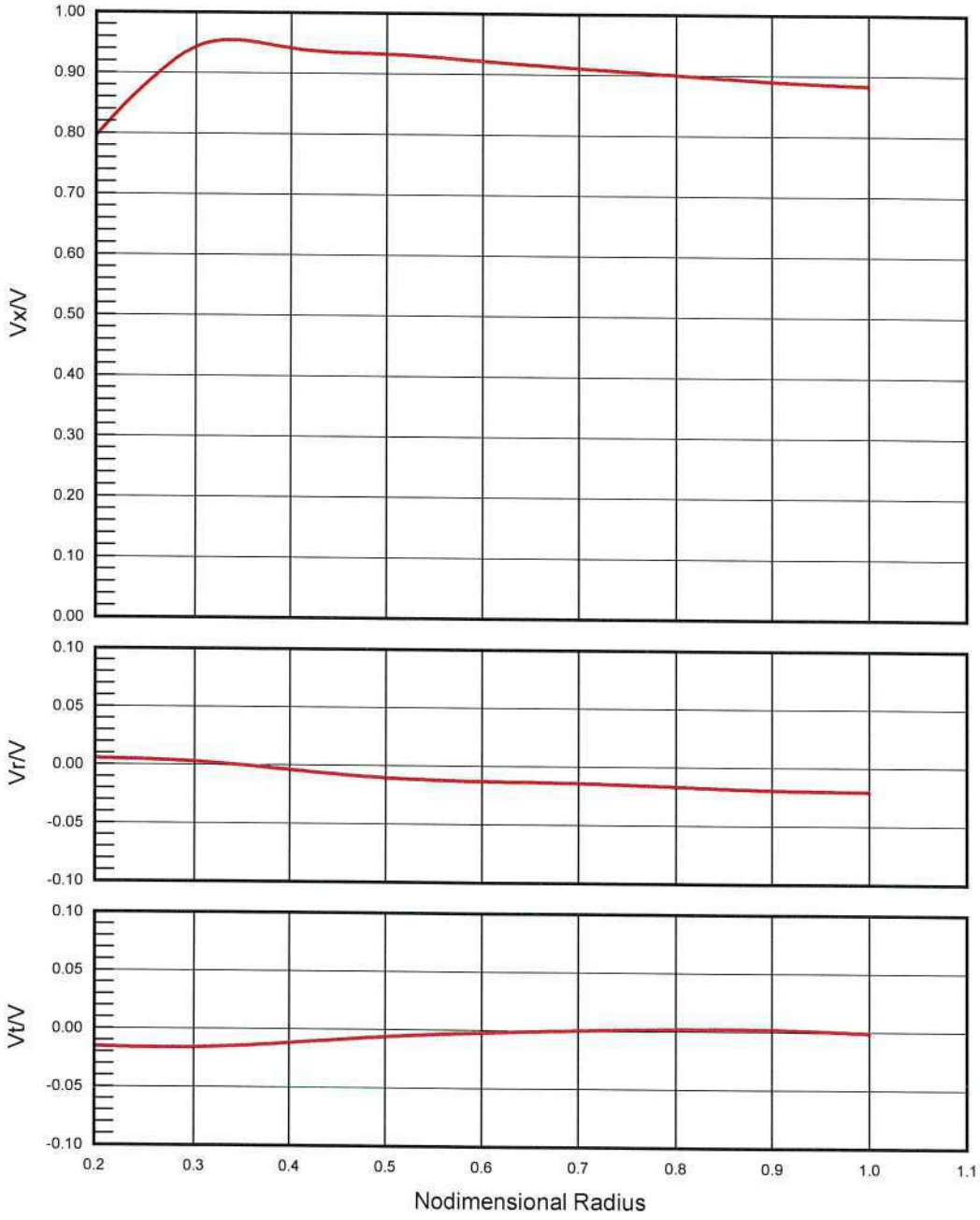
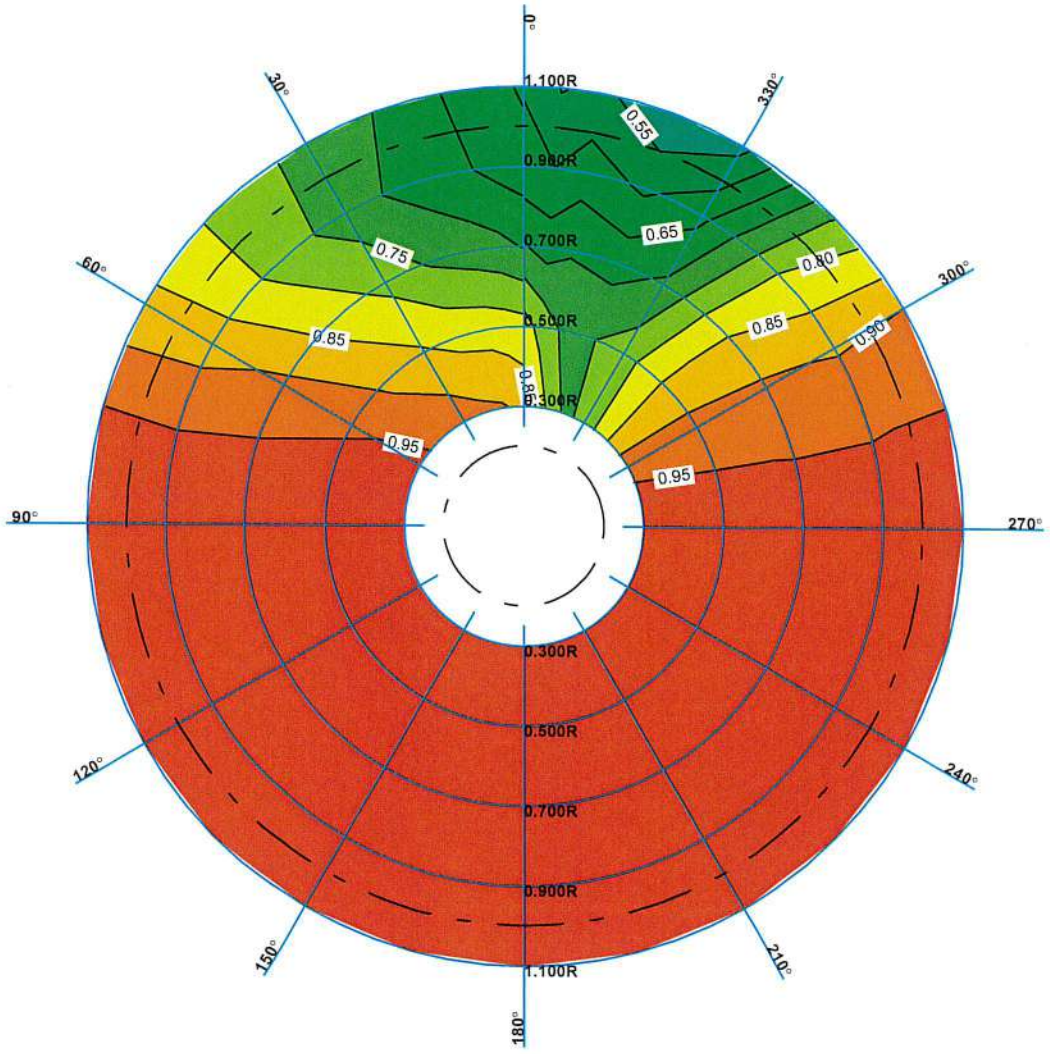


Figure 3 Radial Distribution of Circumferential Mean Velocity

PRELIMINARY

Project Name	: CSBC Research Ves	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Cond.	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Test date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		



Propeller Diameter

Volumetric Mean of 1-Vx = .091

Figure 4 Iso-axial Velocity Contours

PRELIMINARY

Project Name	: CSBC Research Ves	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Cond.	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Test date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

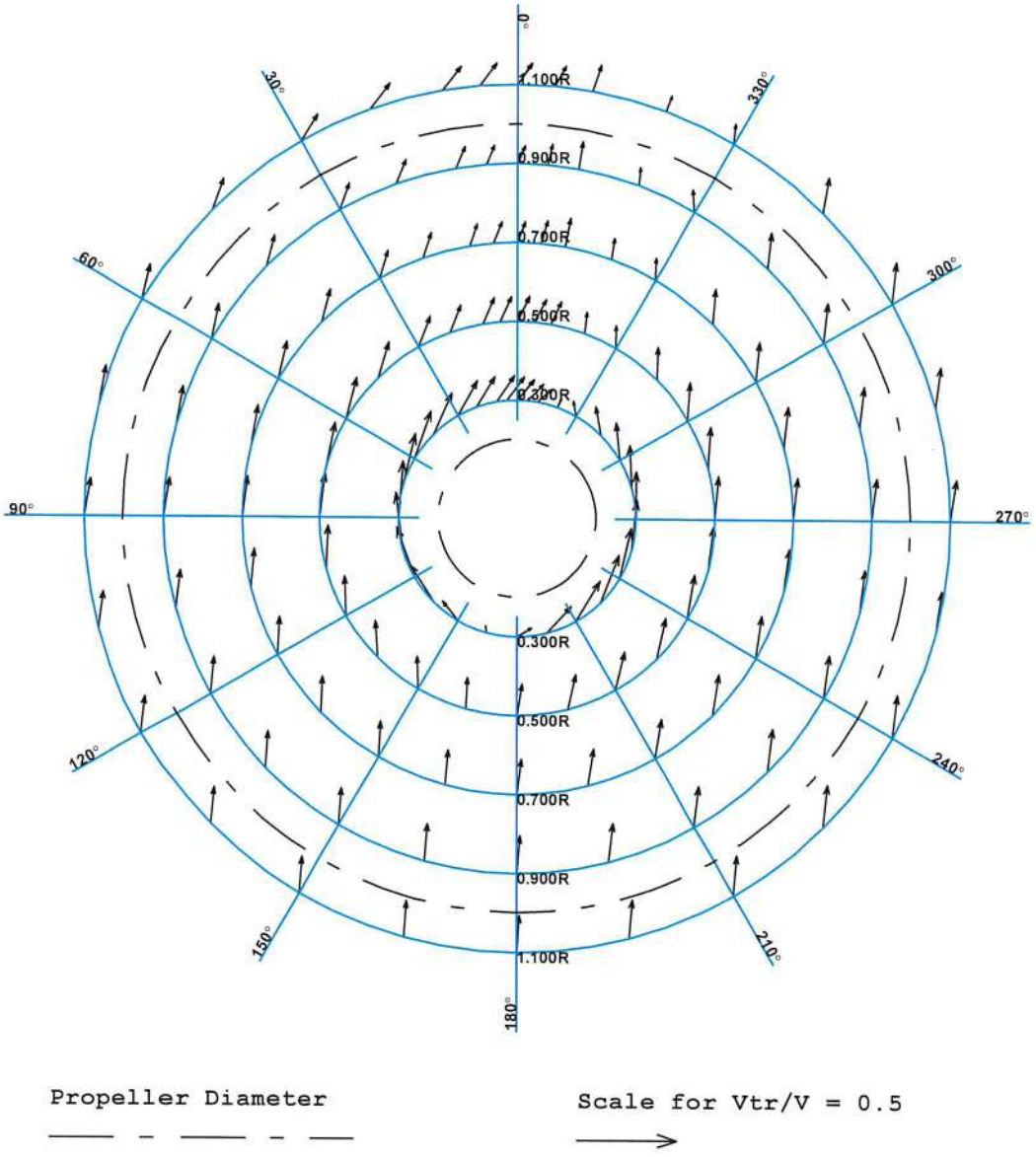


Figure 5 Transverse Velocity Vectors

PRELIMINARY

Project Name	: CSBC Research Ves	Length BP	: 32.00 M
Ship Model ID	: SM782	Draught FP	: 2.20 M
Test Cond.	: Design	Draught AP	: 2.20 M
Scale Ratio	: 5.2000	Propeller Dia.	: 1.30 M
Test date	: 04-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 100GT, PORT Side		

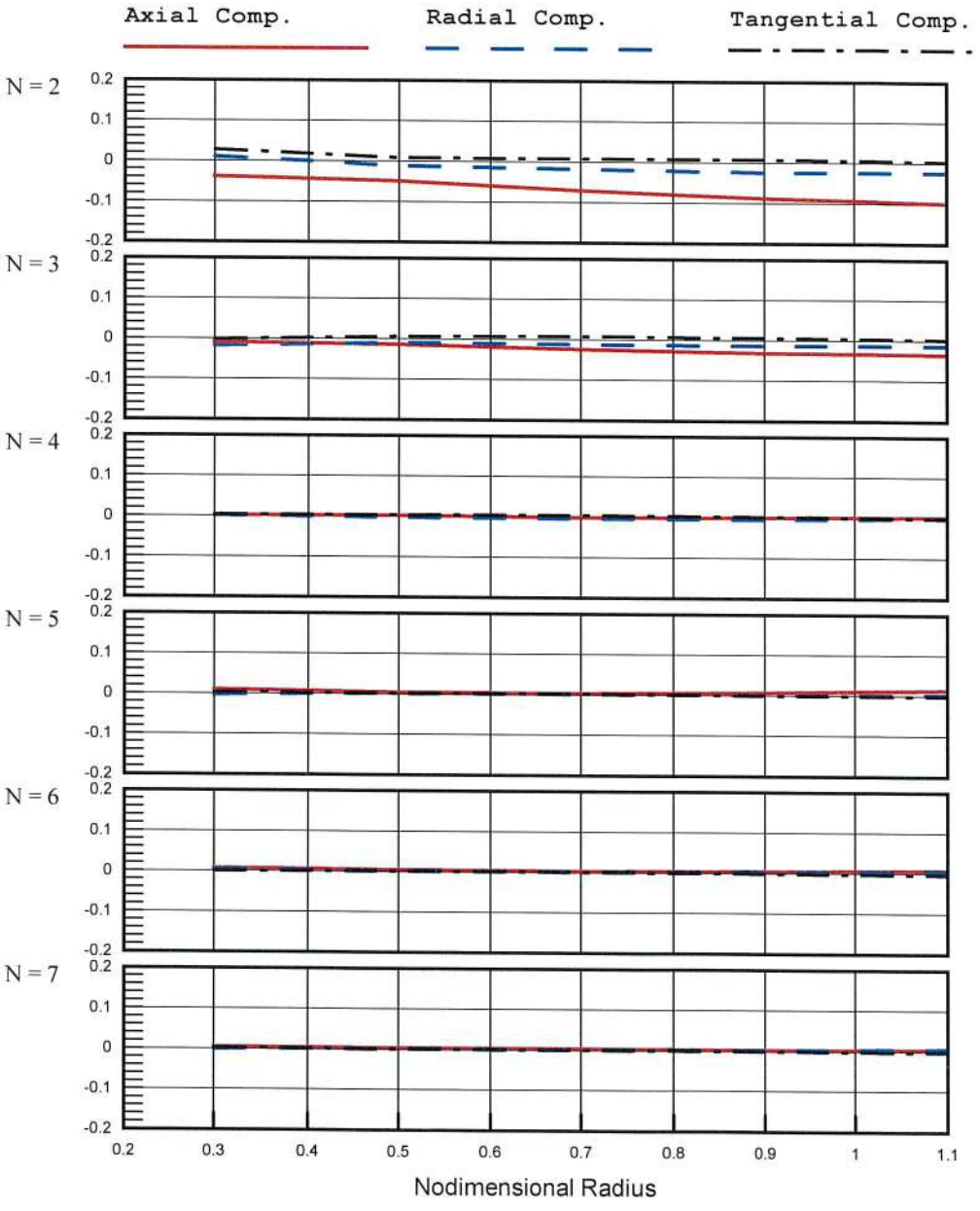


Figure 6 Radial Distributions of Harmonic Amplitudes of Velocity

PRELIMINARY

Table 11 Results of Resistance Test (Design)

Results of Resistance Tests

Project Name : Research Vessel
Ship Model ID : SM782
Test Date : 05-SEP-24
Test Option : 100GT
Test Draught : Design
Scale Ratio : 5.200

Water Temperature = 22.60 Deg C
Standard Temp = 15.00 Deg C
Density (Fresh) = 997.52 kg/m3
Density (Sea) = 1025.90 kg/m3
Viscosity (Fresh) = 0.94345e-6 m2/s
Viscosity (Sea) = 1.18829e-6 m2/s

Ship Particulars

Length BP	=	32.00 m
Length WL	=	33.14 m
Draught at FP	=	2.20 m
Draught at AP	=	2.20 m
Breadth	=	7.50 m
Wetted Surface Area	=	316. m2
Displacement Volume	=	357. m3
Bilge Keel Area	=	0.00 m2
T.Proj Area abv WL	=	40.00 m2
Hull Roughness(e6)	=	150. m
Ca*1000	=	0.4000
Cas*1000	=	0.0000
Cair*1000	=	0.1267

Vs (kts)	Vm (m/s)	Fn	Rnm (e-6)	Rtm (N)	Ctm (e+3)	Cfm (e+3)	Cr (e+3)	Trim (deg)
4.50	1.015	0.128	6.858	29.43	4.906	3.207	1.699	0.063
6.00	1.354	0.171	9.145	56.18	5.267	3.047	2.220	0.112
7.50	1.692	0.214	11.431	96.07	5.765	2.932	2.833	0.194
9.00	2.030	0.257	13.717	159.35	6.640	2.842	3.798	0.296
10.50	2.369	0.300	16.003	274.52	8.404	2.769	5.635	0.374
12.00	2.707	0.342	18.289	439.68	10.305	2.708	7.597	0.434
13.00	2.933	0.371	19.813	569.56	11.375	2.673	8.702	0.551

Vs (kts)	Rns (e-9)	Cfs (e+3)	Cts (e+3)	Rts (kN)	PE (kW)	PE (PS)	Sinkage FP (m)	Sinkage AP
4.50	0.065	2.222	4.448	4	9	12	0.040	0.005
6.00	0.086	2.129	4.876	8	23	32	0.076	0.014
7.50	0.108	2.061	5.421	13	50	69	0.125	0.017
9.00	0.129	2.008	6.333	22	102	138	0.187	0.022
10.50	0.151	1.965	8.127	38	207	282	0.258	0.049
12.00	0.172	1.929	10.052	62	383	521	0.326	0.084
13.00	0.187	1.907	11.136	81	539	733	0.396	0.088

Trim by bow is defined to be positive.

PRELIMINARY

Table 12 Results of Self Propulsion Test (Design)

Results of Self Propulsion Tests

Project Name : Research Vessel
Ship Model ID : SM782
Propeller ID : SP1045RL
Test Date : 05-SEP-24
Test Option : 100GT
Test Draught : Design
Scale Ratio : 5.200

Ship Particulars

Length BP	=	32.00 m
Length WL	=	33.14 m
Draught at FP	=	2.20 m
Draught at AP	=	2.20 m
Breadth	=	7.50 m
Wetted Surface Area	=	316. m2
Displacement Volume	=	357. m3
Bilge Keel Area	=	0.00 m2
T.Proj Area abv WL	=	40.00 m2

	Temp (DegC)	Density (kg/m3)	Viscosity (m2/s)
Res	22.6	997.5	0.94345e-6
S-P	22.6	997.5	0.94345e-6
Sea	15.0	1025.9	1.18829e-6

Model-Ship Correlation

Prop Roughness = 30.e-6 m
Hull Roughness = 150.e-6 m

Propeller Particulars

Number of Propeller	=	2
Number of Blades	=	4
Propeller Diameter	=	1.300 m
Pitch/Dia at 0.7r	=	0.767
Chord Length at 0.7r	=	0.286 m
Blade thickness 0.7r	=	0.032 m
Rn(model) at 0.7r	=	5.61e+5
Expanded Area Ratio	=	0.398
Section Type	:	Given
Test Date	:	04-SEP-24

Ship Speed (kts)	Model Speed (m/s)	Rtm S-P (N)	SFC (N)	S-P Adv (J)	Rate Revs (rps)	Thrust (N)	Torque (N-m)	Model Propeller Open Water Charact (J)	(10kt)	(100kq)
4.50	1.015	29.43	3.51	0.656	5.78	13.88	0.577	0.000	3.242	3.277
6.00	1.354	56.18	5.52	0.634	7.81	27.44	1.085	0.100	3.009	3.174
7.50	1.692	96.07	7.84	0.610	9.98	48.37	1.830	0.200	2.713	3.006
9.00	2.030	159.35	10.40	0.578	12.46	82.84	2.997	0.300	2.380	2.790
10.50	2.369	274.52	13.20	0.532	15.65	147.47	5.084	0.400	2.028	2.533
12.00	2.707	439.68	16.21	0.493	19.19	242.82	8.104	0.450	1.847	2.390
13.00	2.933	569.56	18.31	0.474	21.59	319.75	10.508	0.500	1.664	2.237
								0.550	1.477	2.072
								0.600	1.287	1.893
								0.650	1.090	1.699
								0.700	0.885	1.487
								0.750	0.670	1.253
								0.800	0.440	0.993

PRELIMINARY

Table 13 Propulsion Performance of Full Scale Ship (Design)

Propulsion Performance of Full Scale Ship

Project Name	: Research Vessel	Ship Particulars	
Ship Model ID	: SM782		
Propeller ID	: SP1045RL	Length BP	= 32.00 m
Test Date	: 05-SEP-24	Length WL	= 33.14 m
Test Option	: 100GT	Draught at FP	= 2.20 m
Test Draught	: Design	Draught at AP	= 2.20 m
Scale Ratio	: 5.200	Breadth	= 7.50 m
		Wetted Surface Area	= 316. m2
		Displacement Volume	= 357. m3
		Bilge Keel Area	= 0.00 m2
		T.Proj Area abv WL	= 40.00 m2

ITTC Standard Prediction

Ship Speed (kts)	Fn	PE (kW)	PD (kW)	S-P Adv (J)	Rate Revs (rpm)	Thrust (kN)	Torque (kN-m)	Model Wake (Wtm)	Ship Wake (Wts)
4.50	0.128	9	14	0.652	153.14	2	0	0.066	0.066
6.00	0.171	23	36	0.629	207.11	4	1	0.085	0.085
7.50	0.214	50	78	0.606	264.35	7	1	0.100	0.100
9.00	0.257	102	159	0.575	329.92	12	2	0.113	0.113
10.50	0.300	207	337	0.529	414.17	22	4	0.121	0.121
12.00	0.342	383	656	0.490	507.34	36	6	0.127	0.127
13.00	0.371	539	956	0.472	570.78	47	8	0.128	0.128

Ship Speed (kts)	Thrust Deduct (Thdf)	Hull Effi (EtaH)	Relative Rotative Effi (EtaR)	Prop Effi (EtaO)	Behind Effi (EtaB)	Total Effi (EtaD)	Full Scale Propeller Open (J)	Water (10Kt)	Charact (100Kq)
4.50	0.066	1.000	0.944	0.663	0.626	0.626	0.000	3.242	3.277
6.00	0.077	1.009	0.966	0.656	0.634	0.639	0.100	3.009	3.174
7.50	0.088	1.013	0.983	0.650	0.639	0.647	0.200	2.713	3.006
9.00	0.101	1.014	0.995	0.635	0.632	0.641	0.300	2.380	2.790
10.50	0.114	1.008	1.001	0.610	0.611	0.615	0.400	2.028	2.533
12.00	0.128	0.999	1.001	0.584	0.585	0.584	0.450	1.847	2.390
13.00	0.138	0.989	1.002	0.569	0.570	0.564	0.500	1.664	2.237
							0.550	1.477	2.072
							0.600	1.287	1.893
							0.650	1.090	1.699
							0.700	0.885	1.487
							0.750	0.670	1.253
							0.800	0.440	0.993

PRELIMINARY

Table 14 Prediction of Powering Performance (Design)

Prediction of Powering Performance

Project Name	: Research Vessel	Ship Particulars	
Ship Model ID	: SM782		
Propeller ID	: SP1045RL	Length BP	= 32.00 m
Test Date	: 05-SEP-24	Length WL	= 33.14 m
Test Option	: 100GT	Draught at FP	= 2.20 m
Test Draught	: Design	Draught at AP	= 2.20 m
Scale Ratio	: 5.200	Breadth	= 7.50 m
		Wetted Surface Area	= 316. m2
		Displacement Volume	= 357. m3
		Bilge Keel Area	= 0.00 m2
		T.Proj Area abv WL	= 40.00 m2

Ship Trial Prediction with
Ca*1000 = 0.400, Cn = 1.000, EtaT =0.950

Ship Speed (kts)	Brake Power (kW)	Brake Power (PS)	Rate of Revs. (rps)	Rate of Revs. (rpm)
4.50	15	20	2.552	153.14
6.00	38	52	3.452	207.11
7.50	82	111	4.406	264.35
9.00	167	227	5.499	329.92
10.50	355	482	6.903	414.17
12.00	690	938	8.456	507.34
13.00	1007	1369	9.513	570.78

[Trials] Vs = 13.11 kts, Ns = 577.8 rpm
at Pb = 1044 kW

[Notes]
- For explanations of abbreviations see list of symbols.
- Reynolds and Froude number based on Lwl= 33.14.
- Frictional resistance determined according to the ITTC-1957 formula.
- A model-ship correlation allowance Ca=0.00040.
- A extra resistance due to steering Cas= 0.00000.
- A resistance of above water part through the air, Cair=.0001267.
- The results have been obtained by Froude scaling from self-propulsion point of ship corresponding to a scale effect correction on resistance determined by means of the ITTC-1957 formula.
- The propulsion factors are based on thrust identity.
- Self propulsion points are faired by variation of speed.
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.
- Remarks: All tests performed in deep water towing tank of SSMB.

PRELIMINARY

Project Name	: Research Ves	Length BP	: 32.00 m
Ship Model ID	: SM782	Draught at FP	: 2.20 m
Prop. Model ID	: SP1045RL	Draught at AP	: 2.20 m
Test Cond.	: Design	Displacement	: 357. m^3
Scale Ratio	: 5.2000	Ca × 1000	: 0.40
		Cn	: 1.000

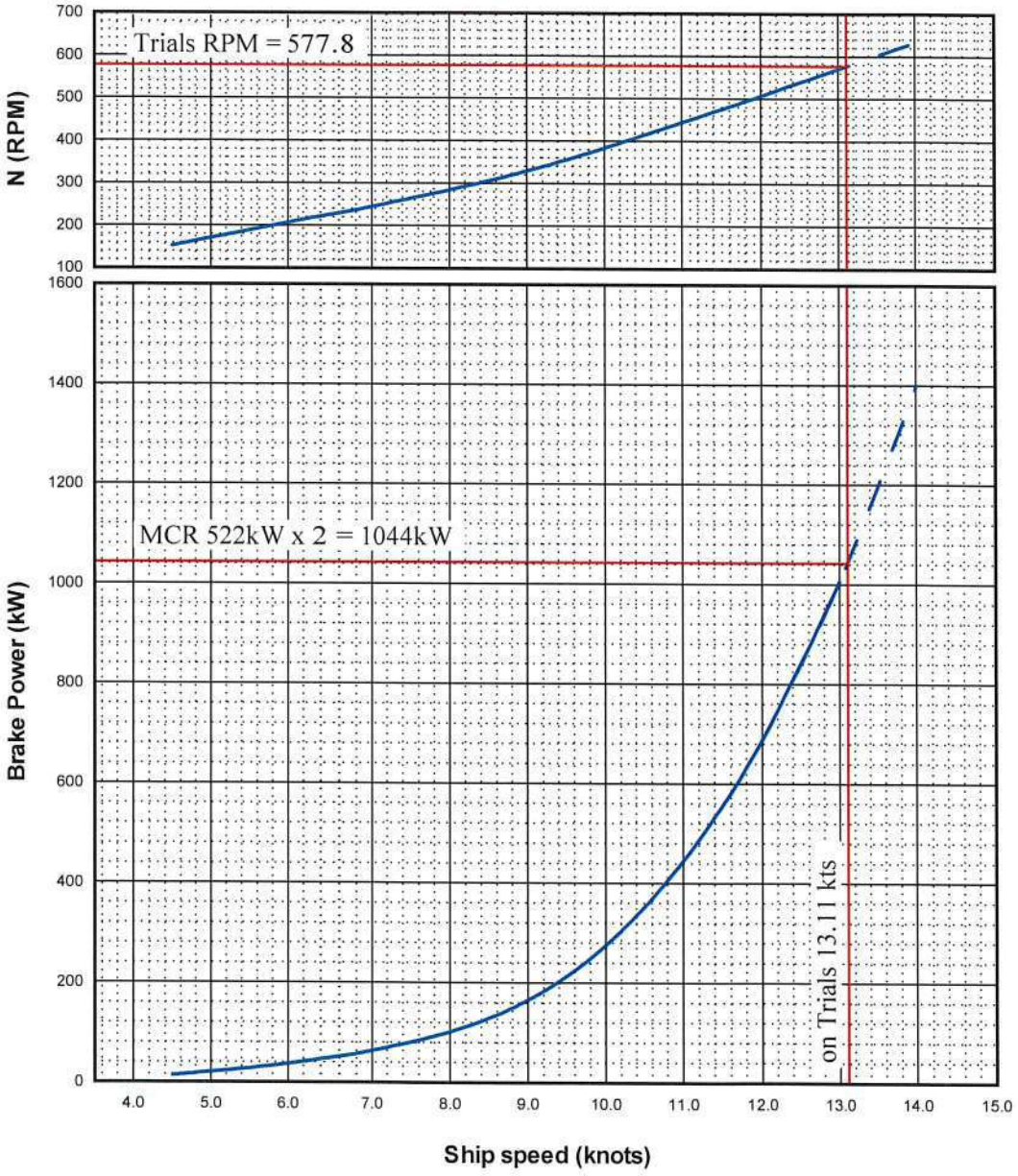


Figure 7 Full scale Prediction of Powering Performance (Design)

PRELIMINARY

Photo 1 Wave Profiles of Running Model Ship (Design, 4.5 knots)

PRELIMINARY

Photo 2 Wave Profiles of Running Model Ship (Design, 6.0 knots)

PRELIMINARY

Photo 3 Wave Profiles of Running Model Ship (Design, 7.5 knots)

PRELIMINARY

Photo 4 Wave Profiles of Running Model Ship (Design, 9.0 knots)

PRELIMINARY

Photo 5 Wave Profiles of Running Model Ship (Design, 10.5 knots)

PRELIMINARY

Photo 6 Wave Profiles of Running Model Ship (Design, 12.0 knots)

PRELIMINARY

Photo 7 Wave Profiles of Running Model Ship (Design, 13.0 knots)

PRELIMINARY

Table 15 Results of Resistance Test (Scantling)

Results of Resistance Tests

Project Name	: Reaearch Vessel	Ship Particulars	
Ship Model ID	: SM782	Length BP	= 32.00 m
Test Date	: 06-SEP-24	Length WL	= 33.14 m
Test Option	: 100GT	Draught at FP	= 2.50 m
Test Draught	: Scantling	Draught at AP	= 2.50 m
Scale Ratio	: 5.200	Breadth	= 7.50 m
		Wetted Surface Area	= 331. m2
Water Temperature	= 22.60 Deg C	Displacement Volume	= 421. m3
Standard Temp	= 15.00 Deg C	Bilge Keel Area	= 0.00 m2
Density (Fresh)	= 997.52 kg/m3	T.Proj Area abv WL	= 38.50 m2
Density (Sea)	= 1025.90 kg/m3	Hull Roughness(e6)	= 150. m
Viscosity (Fresh)	= 0.94345e-6 m2/s	Ca*1000	= 0.4000
Viscosity (Sea)	= 1.18829e-6 m2/s	Cas*1000	= 0.0000
		Cair*1000	= 0.1164

Vs (kts)	Vm (m/s)	Fn	Rnm (e-6)	Rtm (N)	Ctm (e+3)	Cfm (e+3)	Cr (e+3)	Trim (deg)
4.50	1.015	0.128	6.858	35.27	5.609	3.207	2.402	0.060
6.00	1.354	0.171	9.145	65.43	5.853	3.047	2.806	0.111
7.50	1.692	0.214	11.431	113.78	6.515	2.932	3.583	0.185
9.00	2.030	0.257	13.717	189.81	7.547	2.842	4.705	0.266
10.50	2.369	0.300	16.003	313.31	9.152	2.769	6.383	0.321
12.00	2.707	0.342	18.289	516.86	11.559	2.708	8.851	0.372
12.50	2.820	0.357	19.051	591.34	12.188	2.690	9.498	0.434

Vs (kts)	Rns (e-9)	Cfs (e+3)	Cts (e+3)	Rts (kN)	PE (kW)	PE (PS)	Sinkage FP (m)	Sinkage AP
4.50	0.065	2.222	5.140	5	11	15	0.042	0.009
6.00	0.086	2.129	5.452	9	27	37	0.078	0.016
7.50	0.108	2.061	6.161	16	60	82	0.126	0.023
9.00	0.129	2.008	7.230	26	122	166	0.187	0.039
10.50	0.151	1.965	8.864	44	237	322	0.251	0.072
12.00	0.172	1.929	11.296	73	451	613	0.317	0.109
12.50	0.179	1.918	11.932	84	538	732	0.353	0.111

Trim by bow is defined to be positive.

PRELIMINARY

Table 16 Results of Self Propulsion Test (Scantling)

Results of Self Propulsion Tests

Project Name : Reaearch Vessel
Ship Model ID : SM782
Propeller ID : SP1045RL
Test Date : 06-SEP-24
Test Option : 100GT
Test Draught : Scantling
Scale Ratio : 5.200

Ship Particulars

Length BP	=	32.00 m
Length WL	=	33.14 m
Draught at FP	=	2.50 m
Draught at AP	=	2.50 m
Breadth	=	7.50 m
Wetted Surface Area	=	331. m2
Displacement Volume	=	421. m3
Bilge Keel Area	=	0.00 m2
T.Proj Area abv WL	=	38.50 m2

	Temp (DegC)	Density (kg/m3)	Viscosity (m2/s)
Res	22.6	997.5	0.94345e-6
S-P	22.6	997.5	0.94345e-6
Sea	15.0	1025.9	1.18829e-6

Model-Ship Correlation

Prop Roughness = 30.e-6 m
Hull Roughness = 150.e-6 m

Propeller Particulars

Number of Propeller	=	2
Number of Blades	=	4
Propeller Diameter	=	1.300 m
Pitch/Dia at 0.7r	=	0.767
Chord Length at 0.7r	=	0.286 m
Blade thickness 0.7r	=	0.032 m
Rn(model) at 0.7r	=	5.61e+5
Expanded Area Ratio	=	0.398
Section Type	:	Given
Test Date	:	04-SEP-24

Ship Speed (kts)	Model Speed (m/s)	Rtm S-P (N)	SFC (N)	S-P Adv (J)	Rate Revs (rps)	Thrust (N)	Torque (N-m)	Model Propeller Open Water Charact (J)	(10kt)	(100kq)
4.50	1.015	35.27	3.68	0.615	6.04	17.47	0.672	0.000	3.242	3.277
6.00	1.354	65.43	5.79	0.598	8.15	33.47	1.272	0.100	3.009	3.174
7.50	1.692	113.78	8.21	0.575	10.53	59.64	2.173	0.200	2.713	3.006
9.00	2.030	189.81	10.90	0.545	13.21	101.88	3.573	0.300	2.380	2.790
10.50	2.369	313.31	13.84	0.508	16.42	171.72	5.833	0.400	2.028	2.533
12.00	2.707	516.86	16.98	0.467	20.36	288.28	9.463	0.450	1.847	2.390
12.50	2.820	591.34	18.08	0.457	21.59	330.98	10.751	0.500	1.664	2.237
								0.550	1.477	2.072
								0.600	1.287	1.893
								0.650	1.090	1.699
								0.700	0.885	1.487
								0.750	0.670	1.253
								0.800	0.440	0.993

PRELIMINARY

Table 17 Propulsion Performance of Full Scale Ship (Scantling)

Propulsion Performance of Full Scale Ship

Project Name	: Reaearch Vessel	Ship Particulars	
Ship Model ID	: SM782	Length BP	= 32.00 m
Propeller ID	: SP1045RL	Length WL	= 33.14 m
Test Date	: 06-SEP-24	Draught at FP	= 2.50 m
Test Option	: 100GT	Draught at AP	= 2.50 m
Test Draught	: Scantling	Breadth	= 7.50 m
Scale Ratio	: 5.200	Wetted Surface Area	= 331. m2
		Displacement Volume	= 421. m3
		Bilge Keel Area	= 0.00 m2
		T.Proj Area abv WL	= 38.50 m2

ITTC Standard Prediction

Ship Speed (kts)	Fn	PE (kW)	PD (kW)	S-P Adv (J)	Rate Revs (rpm)	Thrust (kN)	Torque (kN-m)	Model Wake (Wtm)	Ship Wake (Wts)
4.50	0.128	11	17	0.611	160.12	3	1	0.084	0.084
6.00	0.171	27	44	0.595	215.77	5	1	0.099	0.099
7.50	0.214	60	97	0.572	278.75	9	2	0.105	0.105
9.00	0.257	122	200	0.542	349.47	15	3	0.114	0.114
10.50	0.300	237	404	0.506	434.18	25	4	0.119	0.119
12.00	0.342	451	811	0.465	537.97	42	7	0.122	0.122
12.50	0.357	538	975	0.455	570.33	48	8	0.125	0.125

Ship Speed (kts)	Thrust Deduct (Thdf)	Hull Effi (EtaH)	Relative Rotative Effi (EtaR)	Prop Effi (EtaO)	Behind Effi (EtaB)	Total Effi (EtaD)	Full Scale Propeller Open Water Charact (J)	(10Kt)	(100Kq)
4.50	0.096	0.987	0.973	0.651	0.633	0.625	0.000	3.242	3.277
6.00	0.109	0.989	0.966	0.646	0.624	0.617	0.100	3.009	3.174
7.50	0.115	0.989	0.985	0.634	0.624	0.617	0.200	2.713	3.006
9.00	0.122	0.991	0.995	0.619	0.615	0.610	0.300	2.380	2.790
10.50	0.128	0.990	0.996	0.595	0.593	0.587	0.400	2.028	2.533
12.00	0.133	0.987	0.998	0.564	0.563	0.556	0.450	1.847	2.390
12.50	0.134	0.990	1.001	0.557	0.558	0.552	0.500	1.664	2.237
							0.550	1.477	2.072
							0.600	1.287	1.893
							0.650	1.090	1.699
							0.700	0.885	1.487
							0.750	0.670	1.253
							0.800	0.440	0.993

PRELIMINARY

Table 18 Prediction of Powering Performance (Scantling)

Prediction of Powering Performance

Project Name	: Reaearch Vessel	Ship Particulars		
Ship Model ID	: SM782	Length BP	=	32.00 m
Propeller ID	: SP1045RL	Length WL	=	33.14 m
Test Date	: 06-SEP-24	Draught at FP	=	2.50 m
Test Option	: 100GT	Draught at AP	=	2.50 m
Test Draught	: Scantling	Breadth	=	7.50 m
Scale Ratio	: 5.200	Wetted Surface Area	=	331. m2
		Displacement Volume	=	421. m3
		Bilge Keel Area	=	0.00 m2
		T.Proj Area abv WL	=	38.50 m2

Ship Trial Prediction with
Ca*1000 = 0.400, Cn = 1.000, EtaT =0.950

Ship Speed (kts)	Brake Power (kW)	Brake Power (PS)	Rate of Revs. (rps)	Rate of Revs. (rpm)
4.50	18	25	2.669	160.12
6.00	46	63	3.596	215.77
7.50	102	139	4.646	278.75
9.00	210	286	5.825	349.47
10.50	425	578	7.236	434.18
12.00	854	1160	8.966	537.97
12.50	1026	1396	9.506	570.33

[Trials] Vs = 12.55 kts, Ns = 573.4 rpm
at Pb = 1044 kW

[Notes]
- For explanations of abbreviations see list of symbols.
- Reynolds and Froude number based on Lwl= 33.14.
- Frictional resistance determined according to the ITTC-1957 formula.
- A model-ship correlation allowance Ca=0.00040.
- A extra resistance due to steering Cas= 0.00000.
- A resistance of above water part through the air, Cair=.0001164.
- The results have been obtained by Froude scaling from self-propulsion point of ship corresponding to a scale effect correction on resistance determined by means of the ITTC-1957 formula.
- The propulsion factors are based on thrust identity.
- Self propulsion points are faired by variation of speed.
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.
- Remarks: All tests performed in deep water towing tank of SSMB.

PRELIMINARY

Project Name	: Reaearch Ves	Length BP	: 32.00 m
Ship Model ID	: SM782	Draught at FP	: 2.50 m
Prop. Model ID	: SP1045RL	Draught at AP	: 2.50 m
Test Cond.	: Scantling	Displacement	: 421. m^3
Scale Ratio	: 5.2000	Ca × 1000	: 0.40
Test Date	: 06-SEP-24	Cn	: 1.000

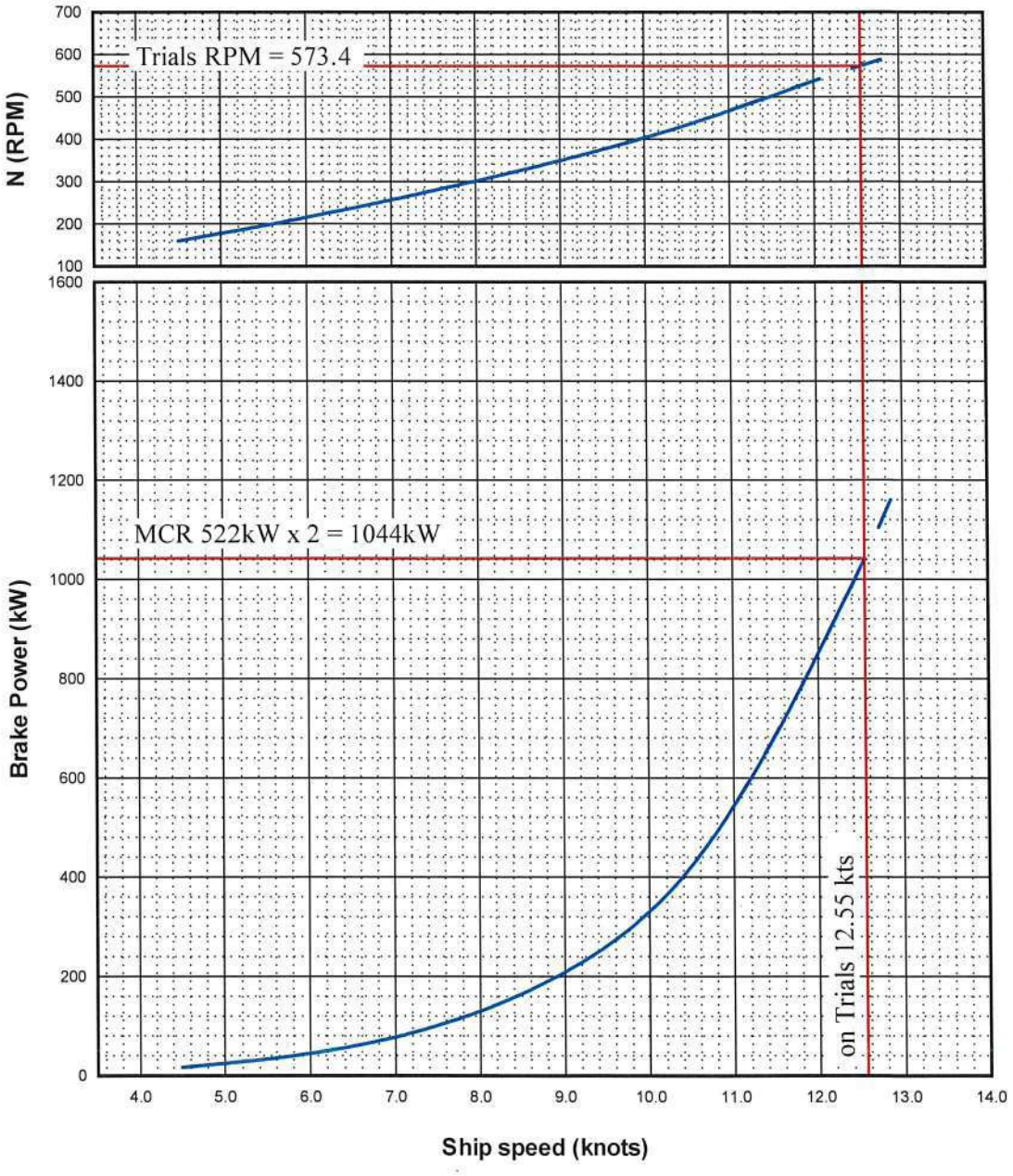


Figure 8 Full scale Prediction of Powering Performance (Scantling)

PRELIMINARY

Photo 8 Wave Profiles of Running Model Ship (Scantling, 4.5 knots)

PRELIMINARY

Photo 9 Wave Profiles of Running Model Ship (Scantling, 6.0 knots)

PRELIMINARY

Photo 10 Wave Profiles of Running Model Ship (Scantling, 7.5 knots)

PRELIMINARY

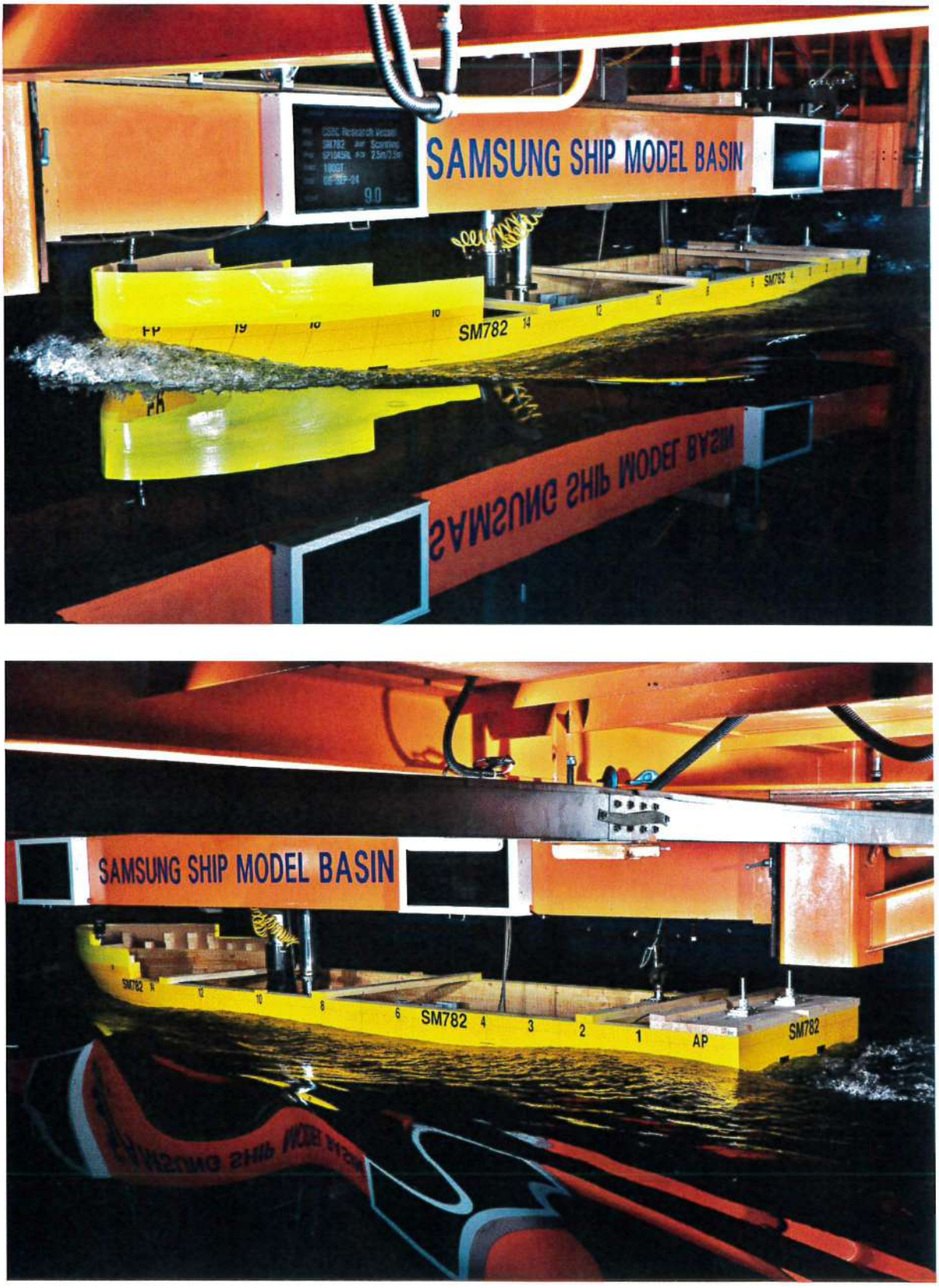


Photo 11 Wave Profiles of Running Model Ship (Scantling, 9.0 knots)

PRELIMINARY

Photo 12 Wave Profiles of Running Model Ship (Scantling, 10.5 knots)

PRELIMINARY

Photo 13 Wave Profiles of Running Model Ship (Scantling, 12.0 knots)

PRELIMINARY

Photo 14 Wave Profiles of Running Model Ship (Scantling, 13.0 knots)

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PRELIMINARY

Photo 15 Paint Test (SM782)

PRELIMINARY

Photo 18 Paint Test (SM782)

PRELIMINARY

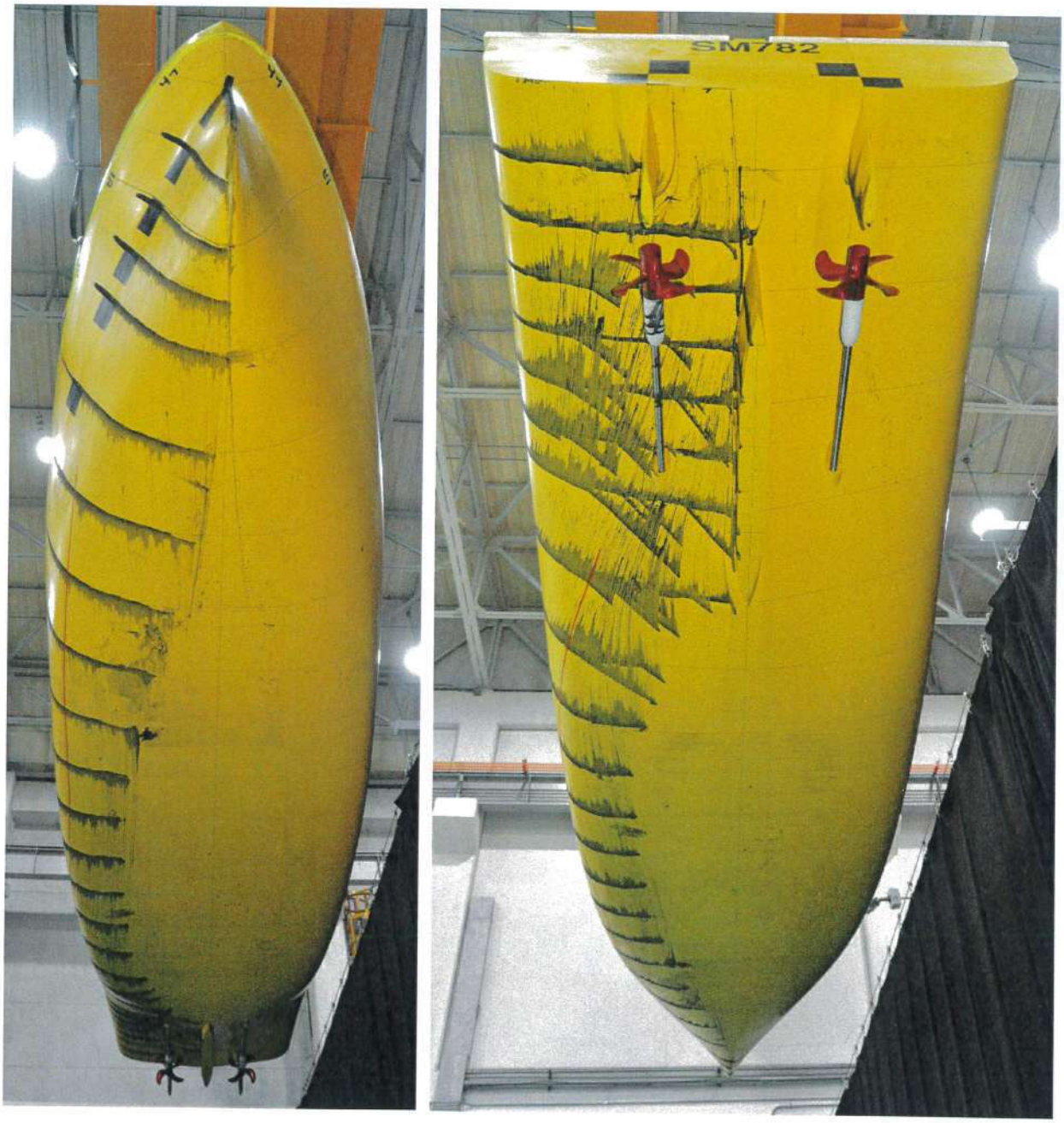

Photo 19 Paint Test (SM782)

PRELIMINARY

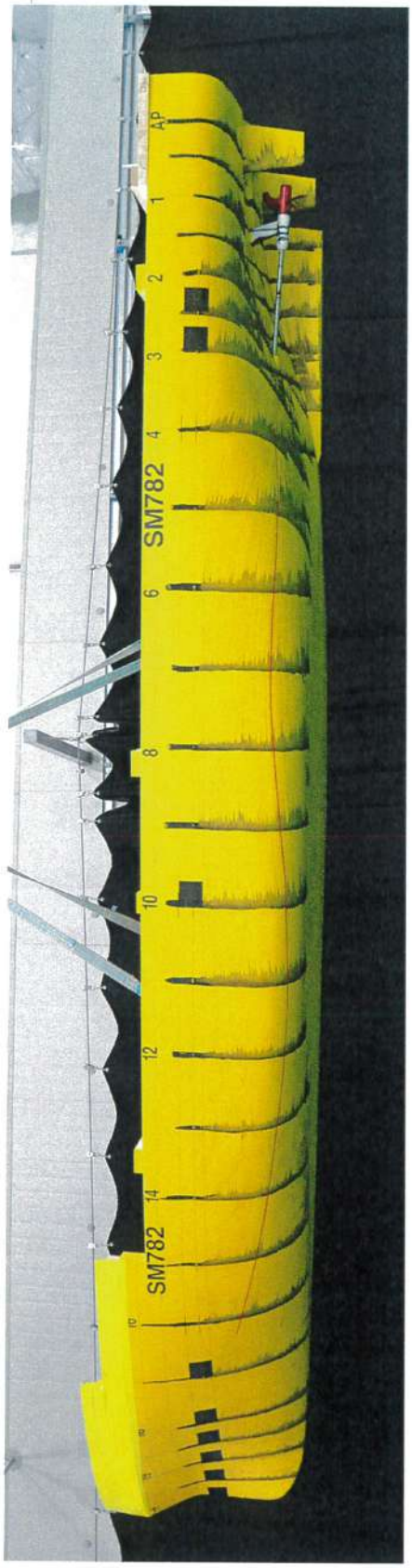

Photo 20 Paint Test (SM782)

Table 19 Streamlines in the bilge region (Design, 12.0 knots)

ST.No.	X(m)	Y(m)	Z(m)
4.00	6.400	2.559	0.752
4.25	6.800	2.711	0.706
4.50	7.200	2.854	0.667
4.75	7.600	2.986	0.638
5.00	8.000	3.104	0.622
5.25	8.400	3.208	0.618
5.50	8.800	3.294	0.621
5.75	9.200	3.365	0.630
6.00	9.600	3.423	0.641
6.25	10.000	3.472	0.653
6.50	10.400	3.512	0.663
6.75	10.800	3.543	0.667
7.00	11.200	3.567	0.664
7.25	11.600	3.583	0.654
7.50	12.000	3.595	0.636
7.75	12.400	3.602	0.613
8.00	12.800	3.604	0.586
8.25	13.200	3.603	0.555
8.50	13.600	3.596	0.521
8.75	14.000	3.583	0.484
9.00	14.400	3.564	0.445
9.25	14.800	3.537	0.405
9.50	15.200	3.503	0.366
9.75	15.600	3.461	0.331
10.00	16.000	3.415	0.301
10.25	16.400	3.365	0.277
10.50	16.800	3.317	0.261
10.75	17.200	3.273	0.254
11.00	17.600	3.236	0.255
11.25	18.000	3.204	0.263
11.50	18.400	3.178	0.277
11.75	18.800	3.156	0.297
12.00	19.200	3.139	0.323
12.25	19.600	3.126	0.356
12.50	20.000	3.117	0.396
12.75	20.400	3.108	0.441
13.00	20.800	3.095	0.490
13.25	21.200	3.075	0.540
13.50	21.600	3.048	0.590
13.75	22.000	3.015	0.642
14.00	22.400	2.977	0.696
14.25	22.800	2.937	0.755
14.50	23.200	2.893	0.820
14.75	23.600	2.847	0.890
15.00	24.000	2.798	0.966

[Note]
X(m): Distance from A.P.
Y(m): Half Breadth from Center Line
Z(m): Height from Base Line

PRELIMINARY

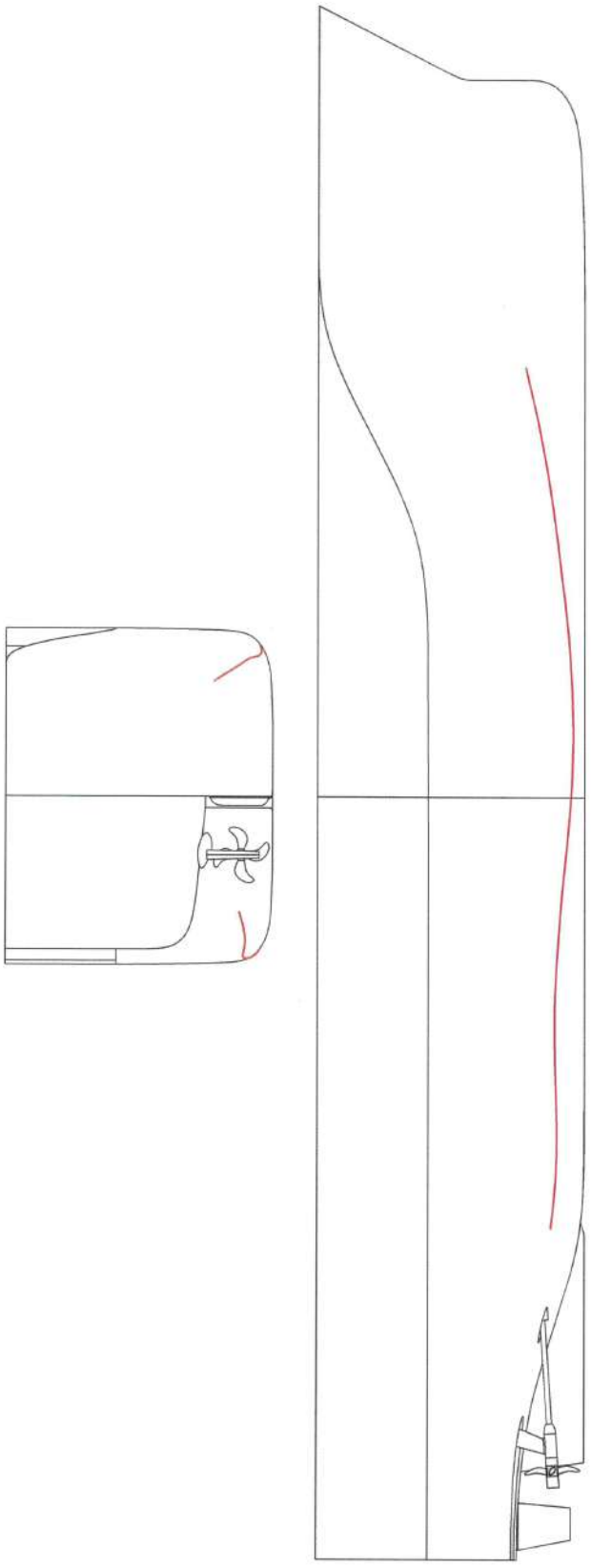

Figure 9 Streamline

300 噸級調查船船模試驗報告(Preliminary)

SAMSUNG SHIP MODEL BASIN
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PRELIMINARY RESULT

RS240005-P2

CALM WATER MODEL TESTS
FOR
300GT RESEARCH VESSEL

/ POWERING PERFORMANCE /

CUSTOMER
NATIONAL ACADEMY OF MARINE RESEARCH
SHIP AND OCEAN INDUSTRIES R&D CENTER

CLIENT
CSBC CORPORATION, TAIWAN

SEPTEMBER 2024

PRELIMINARY

Table 1 Open Water Characteristics of the Design Propeller (SP1047RL)

Results of Propeller Open Water Tests

Geometry of Propeller SP1047RL

Number of Propeller :	1	Number of Blades :	4
Diameter of Ship Prop :	1.900 m	Model Scale Ratio :	7.6000
Diameter of Model Prop:	0.250 m	Section Type :	Given
Expanded Area Ratio :	0.4124	Pitch-Dia Ratio (0.7r):	0.7951
Chord-Dia Ratio (0.7r):	0.22525	Thick-Dia Ratio (0.7r):	0.01162
Water Temperature :	22.6 deg C	Propeller Revolutions :	16.00 rps
Propeller Design J :	0.60	Reynolds Number :	0.5442 e6
Blade Roughness Kp :	30.0 e-6	Test Date :	09-SEP-24

[Remarks] All tests have been performed in SSMB.

Characteristics of Propeller SP1047RL

J	Kt	10*Kq	EtaO	Cth
0.000	0.3501	0.3704	0.0000	-
0.100	0.3223	0.3519	0.1458	82.0829
0.200	0.2910	0.3299	0.2809	18.5286
0.300	0.2574	0.3049	0.4031	7.2843
0.350	0.2400	0.2914	0.4588	4.9889
0.400	0.2221	0.2772	0.5102	3.5356
0.450	0.2039	0.2621	0.5571	2.5639
0.500	0.1852	0.2461	0.5987	1.8860
0.550	0.1659	0.2290	0.6342	1.3964
0.600	0.1459	0.2105	0.6620	1.0321
0.650	0.1251	0.1904	0.6797	0.7540
0.700	0.1032	0.1685	0.6827	0.5366
0.750	0.0801	0.1444	0.6625	0.3627
0.800	0.0554	0.1176	0.5999	0.2205
0.850	0.0289	0.0880	0.4442	0.1018
0.900	0.0001	0.0548	0.0030	0.0004
0.900	0.0001	0.0548	0.0030	0.0004

Coefficients of Propeller Characteristics

	a(0)	a(1)	a(2)	a(3)	a(4)
[Kt]	0.350135E+00	-0.255046E+00	-0.261190E+00	0.345003E+00	-0.244508E+00
[Kq]	0.370355E-01	-0.162190E-01	-0.247368E-01	0.283376E-01	-0.267898E-01

[polynomial fit] value = a(0) + a(1)*j^1 + a(2)*j^2 + a(3)*j^3 + a(4)*j^4

PRELIMINARY

Project Name	: Research Vessel	EAR	:	0.4124
Prop. Model ID	: SP1047RL	P/D (0.7R)	:	0.7951
Diameter	: 0.2500 M	C/D (0.7R)	:	0.2253
Scale Ratio	: 7.6000	T/D (0.7R)	:	0.0116
Section Type	: Given	Rn Model $\times 10^6$	:	0.5442
Date of Test	: 09-SEP-24			

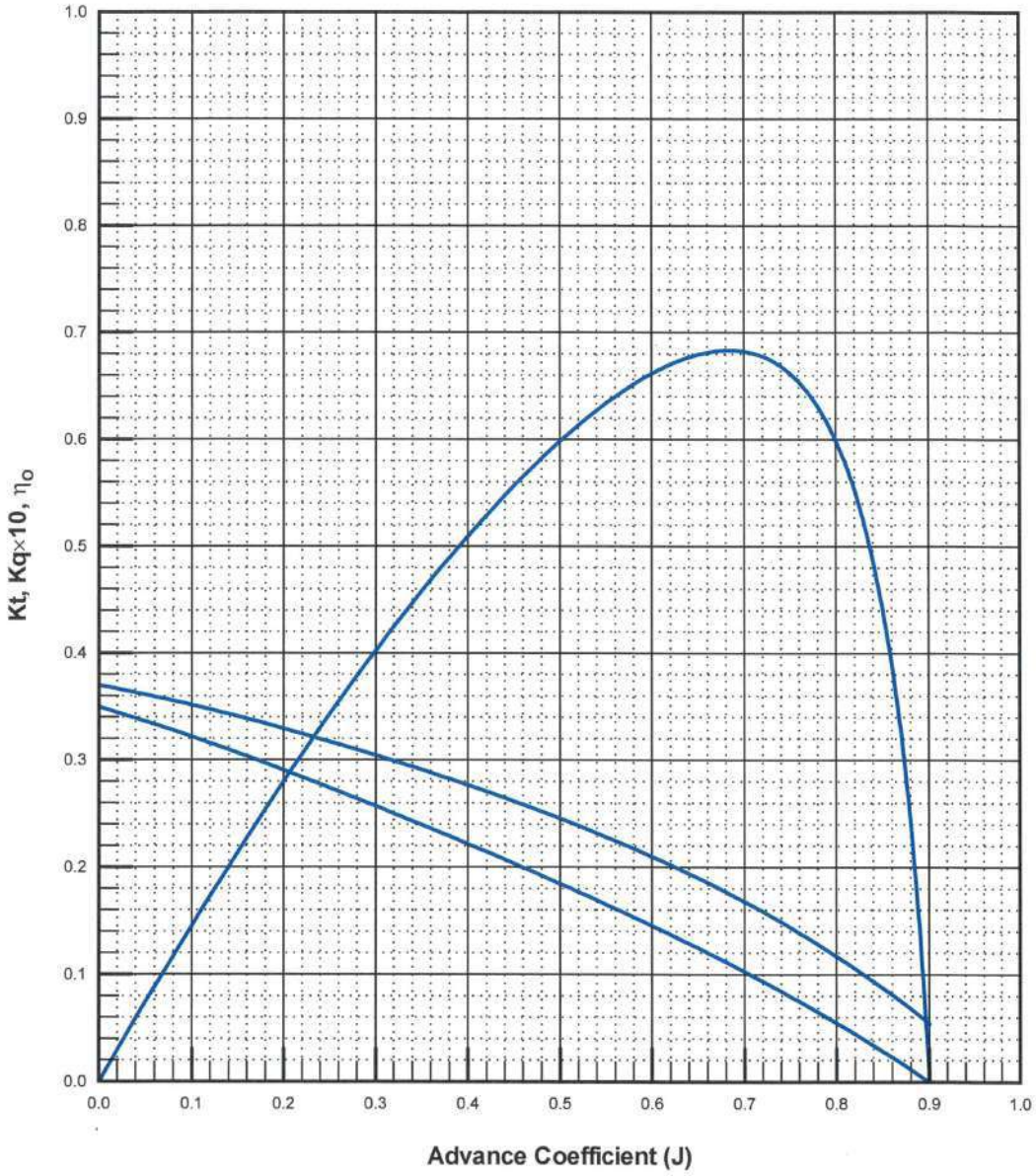


Figure 1 Open Water Characteristics of the Design Propeller (SP1047RL)

PRELIMINARY

Table 2 Result of Wake Measurement (Axial Velocity)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

AXIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R) 0.300	0.500	0.700	0.900	1.100
0.0	0.773	0.741	0.659	0.574	0.578
10.0	0.808	0.743	0.664	0.614	0.640
20.0	0.791	0.739	0.695	0.678	0.712
25.0	0.767	0.707	0.667	0.673	0.703
30.0	0.814	0.765	0.735	0.757	0.791
35.0	0.842	0.785	0.776	0.793	0.826
45.0	0.848	0.821	0.831	0.859	0.882
60.0	0.867	0.863	0.896	0.923	0.930
75.0	0.894	0.906	0.936	0.943	0.944
90.0	0.907	0.924	0.947	0.950	0.949
105.0	0.920	0.938	0.950	0.952	0.954
120.0	0.929	0.944	0.951	0.951	0.954
135.0	0.934	0.944	0.951	0.952	0.953
150.0	0.931	0.944	0.951	0.951	0.952
165.0	0.928	0.937	0.946	0.948	0.950
180.0	0.922	0.916	0.920	0.927	0.935
195.0	0.911	0.894	0.905	0.900	0.922
210.0	0.898	0.884	0.908	0.902	0.916
225.0	0.885	0.880	0.905	0.909	0.912
240.0	0.878	0.868	0.878	0.865	0.858
255.0	0.866	0.853	0.857	0.848	0.836
270.0	0.861	0.838	0.845	0.841	0.830
285.0	0.859	0.833	0.835	0.827	0.822
300.0	0.864	0.834	0.825	0.803	0.792
310.0	0.793	0.840	0.820	0.788	0.733
320.0	0.758	0.777	0.761	0.745	0.692
325.0	0.744	0.790	0.767	0.723	0.636
330.0	0.736	0.767	0.737	0.669	0.559
340.0	0.723	0.748	0.676	0.564	0.469
350.0	0.742	0.731	0.645	0.539	0.497
360.0	0.773	0.741	0.659	0.574	0.578

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.

PRELIMINARY

Table 3 Result of Wake Measurement (Radial Velocity)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

RADIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R) 0.300	0.500	0.700	0.900	1.100
0.0	0.032	0.072	0.090	0.096	0.091
10.0	0.033	0.079	0.097	0.098	0.105
20.0	0.035	0.072	0.091	0.109	0.116
25.0	0.059	0.074	0.073	0.079	0.087
30.0	0.086	0.089	0.066	0.064	0.062
35.0	0.090	0.083	0.065	0.060	0.057
45.0	0.075	0.066	0.051	0.045	0.036
60.0	0.042	0.028	0.010	0.003	-0.004
75.0	0.010	-0.011	-0.027	-0.031	-0.034
90.0	-0.023	-0.041	-0.054	-0.057	-0.058
105.0	-0.043	-0.063	-0.074	-0.077	-0.079
120.0	-0.057	-0.080	-0.088	-0.089	-0.090
135.0	-0.064	-0.086	-0.095	-0.097	-0.098
150.0	-0.064	-0.088	-0.097	-0.099	-0.101
165.0	-0.059	-0.086	-0.091	-0.093	-0.097
180.0	-0.054	-0.083	-0.085	-0.082	-0.084
195.0	-0.049	-0.081	-0.089	-0.083	-0.079
210.0	-0.047	-0.083	-0.098	-0.105	-0.111
225.0	-0.036	-0.071	-0.081	-0.084	-0.082
240.0	-0.020	-0.047	-0.044	-0.040	-0.036
255.0	0.002	-0.017	-0.013	-0.009	-0.002
270.0	0.029	0.012	0.016	0.017	0.015
285.0	0.054	0.045	0.045	0.041	0.038
300.0	0.066	0.077	0.075	0.073	0.065
310.0	0.051	0.085	0.091	0.092	0.083
320.0	0.016	0.078	0.104	0.120	0.127
325.0	0.005	0.075	0.108	0.123	0.139
330.0	0.000	0.069	0.094	0.111	0.113
340.0	-0.002	0.054	0.067	0.065	0.060
350.0	0.014	0.056	0.070	0.071	0.060
360.0	0.032	0.072	0.090	0.096	0.091

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Outward radial velocities are considered positive.

PRELIMINARY

Table 4 Result of Wake Measurement (Tangential Velocity)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

TANGENTIAL VELOCITY COMPONENT

POSITION ANGLE (DEG)	NONDIMENSIONAL RADIUS (r/R) 0.300	0.500	0.700	0.900	1.100
0.0	-0.056	-0.043	-0.029	-0.019	-0.064
10.0	-0.071	-0.069	-0.058	-0.056	-0.091
20.0	-0.085	-0.081	-0.091	-0.098	-0.124
25.0	-0.120	-0.114	-0.109	-0.112	-0.130
30.0	-0.147	-0.141	-0.136	-0.141	-0.152
35.0	-0.156	-0.138	-0.143	-0.145	-0.155
45.0	-0.178	-0.154	-0.160	-0.161	-0.161
60.0	-0.200	-0.169	-0.166	-0.156	-0.147
75.0	-0.207	-0.165	-0.149	-0.138	-0.133
90.0	-0.197	-0.149	-0.130	-0.121	-0.113
105.0	-0.175	-0.125	-0.105	-0.098	-0.092
120.0	-0.143	-0.097	-0.079	-0.070	-0.065
135.0	-0.106	-0.067	-0.052	-0.043	-0.040
150.0	-0.060	-0.037	-0.022	-0.015	-0.012
165.0	-0.016	-0.005	0.007	0.014	0.019
180.0	0.024	0.023	0.032	0.043	0.053
195.0	0.061	0.049	0.051	0.057	0.078
210.0	0.096	0.078	0.082	0.087	0.106
225.0	0.126	0.109	0.120	0.127	0.135
240.0	0.147	0.132	0.135	0.134	0.145
255.0	0.155	0.142	0.138	0.131	0.139
270.0	0.155	0.141	0.132	0.129	0.141
285.0	0.141	0.130	0.127	0.127	0.137
300.0	0.124	0.112	0.112	0.111	0.123
310.0	0.108	0.101	0.102	0.102	0.108
320.0	0.053	0.059	0.084	0.087	0.090
325.0	0.040	0.048	0.059	0.059	0.064
330.0	0.027	0.035	0.050	0.052	0.052
340.0	-0.004	0.007	0.015	0.028	0.020
350.0	-0.030	-0.023	-0.008	0.003	-0.023
360.0	-0.056	-0.043	-0.029	-0.019	-0.064

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Clockwise tangential velocities are considered negative

PRELIMINARY

Table 5 Result of Wake Measurement (Mean Velocity)

RESULT OF WAKE MEASUREMENT

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

CIRCUMFERENCIAL MEAN VELOCITY COMPONENTS

RADIUS (r/R)	AXIAL (VA/V)	RADIAL (VR/V)	TANGENTIAL (VT/V)
0.200	0.867	0.001	-0.024
0.300	0.863	-0.002	-0.018
0.400	0.860	-0.005	-0.013
0.500	0.857	-0.007	-0.008
0.600	0.856	-0.009	-0.004
0.700	0.853	-0.010	-0.001
0.800	0.848	-0.009	0.002
0.900	0.841	-0.009	0.004
1.000	0.838	-0.010	0.005

VOLUMETRIC MEAN OF VA = 0.8508
(HUB RATIO : 0.19)

NOMINAL WAKE FRACTION (WN) = 0.1492

Note: -Results are given as a fraction of the speed.
-The position angle is measured in degrees in counter-clockwise direction from top position.
-Outward radial velocities are considered positive.
-Clockwise tangential velocities are considered negative.

PRELIMINARY

Table 6 Harmonic Analysis of Velocity Components (0.3r/R)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.300

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.863	0.000	0.863	0.
	1	-0.073	0.029	0.079	159.
	2	-0.025	0.004	0.025	172.
	3	-0.010	0.012	0.016	129.
	4	0.002	0.011	0.012	78.
	5	0.008	0.005	0.009	35.
	6	0.008	0.000	0.008	0.
	7	0.003	-0.003	0.004	-43.
	8	0.001	0.000	0.001	-30.

RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.002	0.000	-0.002	180.
	1	0.055	-0.012	0.056	-12.
	2	-0.012	0.015	0.019	128.
	3	-0.018	0.017	0.025	137.
	4	-0.004	0.008	0.009	116.
	5	0.000	0.001	0.001	77.
	6	0.003	-0.003	0.004	-44.
	7	0.002	-0.004	0.005	-66.
	8	0.002	-0.004	0.004	-65.

TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.018	0.000	-0.018	180.
	1	-0.040	-0.174	0.178	-103.
	2	0.003	-0.005	0.006	-59.
	3	0.002	0.006	0.006	74.
	4	0.001	0.005	0.005	78.
	5	0.001	0.005	0.005	77.
	6	0.002	0.002	0.003	51.
	7	0.001	0.001	0.002	59.
	8	-0.001	0.000	0.001	159.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta-PHI(K)]$

where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 7 Harmonic Analysis of Velocity Components (0.5r/R)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.500

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.857	0.000	0.857	0.
	1	-0.083	0.034	0.089	157.
	2	-0.032	-0.016	0.036	-154.
	3	-0.012	-0.006	0.013	-155.
	4	-0.005	-0.004	0.006	-138.
	5	0.002	0.004	0.005	62.
	6	0.005	0.000	0.005	-5.
	7	0.004	0.000	0.004	5.
	8	0.003	-0.001	0.003	-21.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.007	0.000	-0.007	180.
	1	0.090	-0.020	0.092	-12.
	2	0.002	0.001	0.002	22.
	3	-0.014	0.010	0.017	143.
	4	-0.005	0.005	0.007	131.
	5	-0.003	0.003	0.004	137.
	6	0.002	0.002	0.002	44.
	7	0.002	-0.001	0.002	-21.
	8	0.001	0.000	0.002	5.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.008	0.000	-0.008	180.
	1	-0.037	-0.145	0.149	-105.
	2	-0.004	-0.014	0.015	-107.
	3	0.004	0.003	0.005	33.
	4	0.001	0.002	0.002	70.
	5	0.000	0.004	0.004	89.
	6	0.002	0.002	0.002	45.
	7	0.000	0.001	0.001	69.
	8	0.000	0.000	0.001	68.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K)]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 8 Harmonic Analysis of Velocity Components (0.7r/R)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.700

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.853	0.000	0.853	0.
	1	-0.111	0.042	0.119	159.
	2	-0.056	-0.005	0.057	-175.
	3	-0.028	-0.008	0.029	-164.
	4	-0.015	-0.005	0.015	-159.
	5	0.001	0.004	0.004	72.
	6	0.001	0.000	0.001	-28.
	7	0.003	0.004	0.005	53.
	8	0.003	0.001	0.003	15.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.010	0.000	-0.010	180.
	1	0.098	-0.028	0.102	-16.
	2	0.008	-0.005	0.009	-35.
	3	-0.009	0.010	0.013	133.
	4	-0.001	0.003	0.003	111.
	5	-0.006	0.004	0.007	144.
	6	0.002	0.005	0.005	66.
	7	0.001	0.002	0.002	61.
	8	0.002	0.004	0.004	61.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.001	0.000	-0.001	180.
	1	-0.040	-0.139	0.144	-106.
	2	-0.003	-0.020	0.020	-98.
	3	0.008	-0.003	0.008	-23.
	4	0.001	-0.001	0.001	-41.
	5	0.001	0.006	0.006	79.
	6	0.002	0.001	0.002	34.
	7	0.000	0.002	0.002	95.
	8	0.001	0.001	0.001	25.

Note: $V(\theta) = A(0) + \sum[A(K)\cos(K\theta)+B(K)\sin(K\theta)]$
$= C(0) + \sum[C(K)\cos(K\theta - PHI(K)]$

where, $K = 1 \sim 8$

$C(K) = \sqrt{A(K)^2 + B(K)^2}$

$PHI(K) = \arctan(B(K)/A(K))$

PRELIMINARY

Table 9 Harmonic Analysis of Velocity Components (0.9r/R)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 0.900

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.841	0.000	0.841	0.
	1	-0.133	0.058	0.145	157.
	2	-0.075	0.011	0.076	172.
	3	-0.046	0.005	0.046	174.
	4	-0.026	0.003	0.026	174.
	5	-0.005	0.009	0.010	120.
	6	-0.001	0.002	0.002	124.
	7	0.002	0.009	0.010	78.
	8	0.007	0.003	0.008	28.

RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.009	0.000	-0.009	180.
	1	0.100	-0.031	0.105	-17.
	2	0.010	-0.007	0.012	-33.
	3	-0.008	0.009	0.012	130.
	4	0.000	0.002	0.002	99.
	5	-0.009	0.005	0.010	150.
	6	0.002	0.008	0.009	78.
	7	0.000	0.003	0.003	92.
	8	0.002	0.006	0.006	72.

TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.004	0.000	0.004	0.
	1	-0.041	-0.135	0.141	-107.
	2	-0.001	-0.021	0.021	-93.
	3	0.007	-0.007	0.010	-44.
	4	0.002	-0.002	0.003	-53.
	5	0.004	0.005	0.006	53.
	6	0.003	0.000	0.003	1.
	7	-0.001	0.002	0.002	118.
	8	0.002	0.000	0.002	9.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta - PHI(K)]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Table 10 Harmonic Analysis of Velocity Components (1.1r/R)

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Condition	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Water Temperature	: 22.90 deg	Density	: 997.45 kg/m3
Test Date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

HARMONIC ANALYSIS OF VELOCITY COMPONENTS

NONDIMENSIONAL RADIUS : 1.100

AXIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.836	0.000	0.836	0.
	1	-0.147	0.074	0.164	153.
	2	-0.075	0.034	0.082	156.
	3	-0.048	0.023	0.053	155.
	4	-0.022	0.022	0.031	135.
	5	0.002	0.015	0.015	82.
	6	0.004	0.005	0.006	47.
	7	0.006	0.009	0.011	55.
	8	0.009	0.003	0.009	22.
RADIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	-0.011	0.000	-0.011	180.
	1	0.099	-0.033	0.104	-18.
	2	0.010	-0.006	0.012	-31.
	3	-0.005	0.009	0.011	118.
	4	0.000	0.002	0.002	91.
	5	-0.011	0.007	0.013	150.
	6	0.001	0.011	0.011	87.
	7	-0.002	0.004	0.005	114.
	8	0.001	0.008	0.008	83.
TANGENTIAL COMPONENT	K	A(K)	B(K)	C(K)	PHI(K)
	0	0.006	0.000	0.006	0.
	1	-0.054	-0.138	0.149	-111.
	2	-0.010	-0.021	0.023	-115.
	3	-0.001	-0.011	0.011	-97.
	4	-0.002	-0.002	0.003	-130.
	5	0.001	0.002	0.002	55.
	6	0.002	0.000	0.002	-11.
	7	-0.002	0.001	0.002	146.
	8	0.000	0.001	0.001	74.

Note: $V(\theta) = A(0) + SUM[A(K)*COS(K*\theta)+B(K)*SIN(K*\theta)]$
$= C(0) + SUM[C(K)*COS(K*\theta-PHI(K)]$
where, $K = 1 \sim 8$
$C(K) = SQRT(A(K)^2 + B(K)^2)$
$PHI(K) = ARCTAN(B(K)/(A(K))$

PRELIMINARY

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Cond.	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Test date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

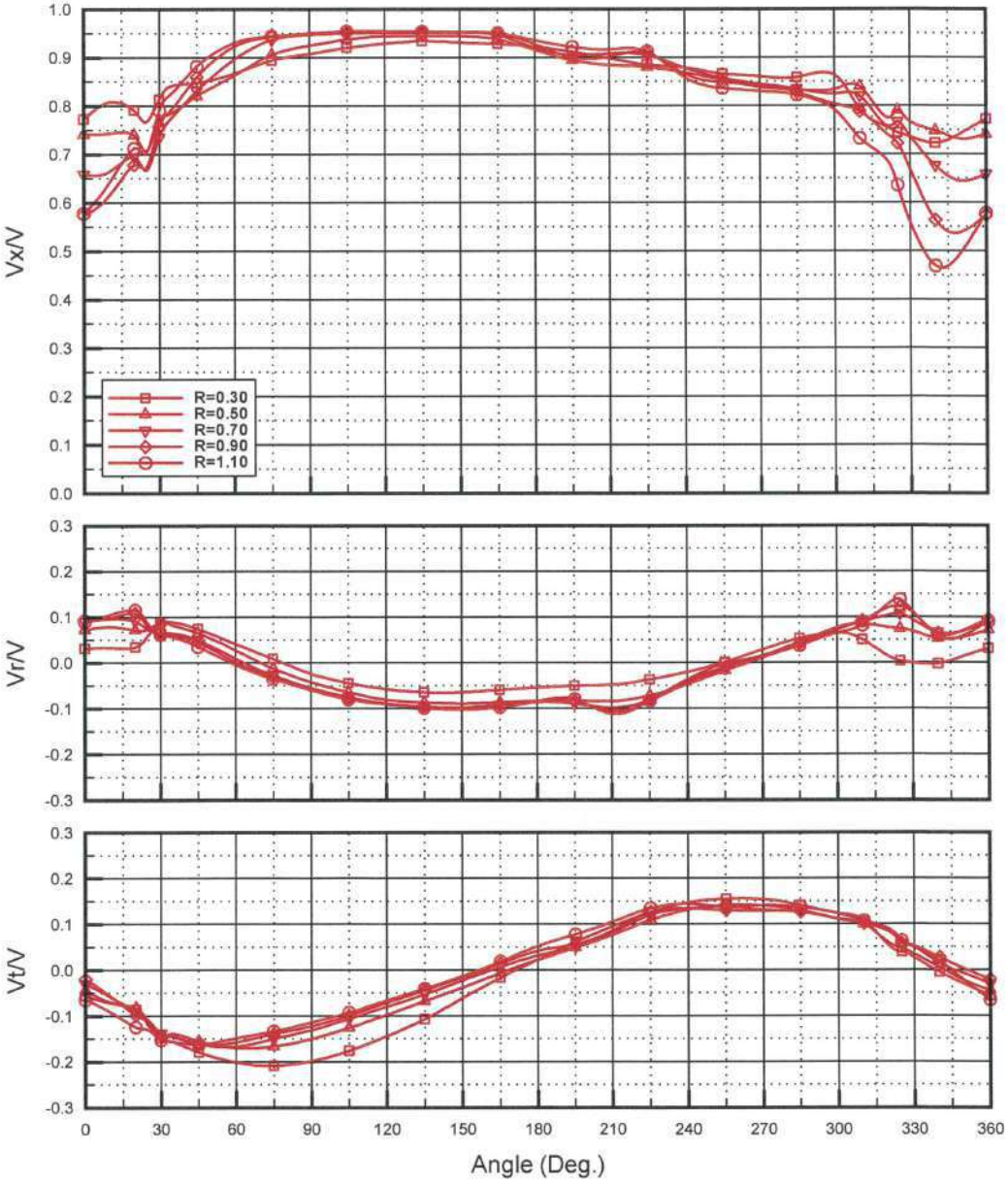


Figure 2 Circumferential Distributions of Velocity Components

PRELIMINARY

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Cond.	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Test date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

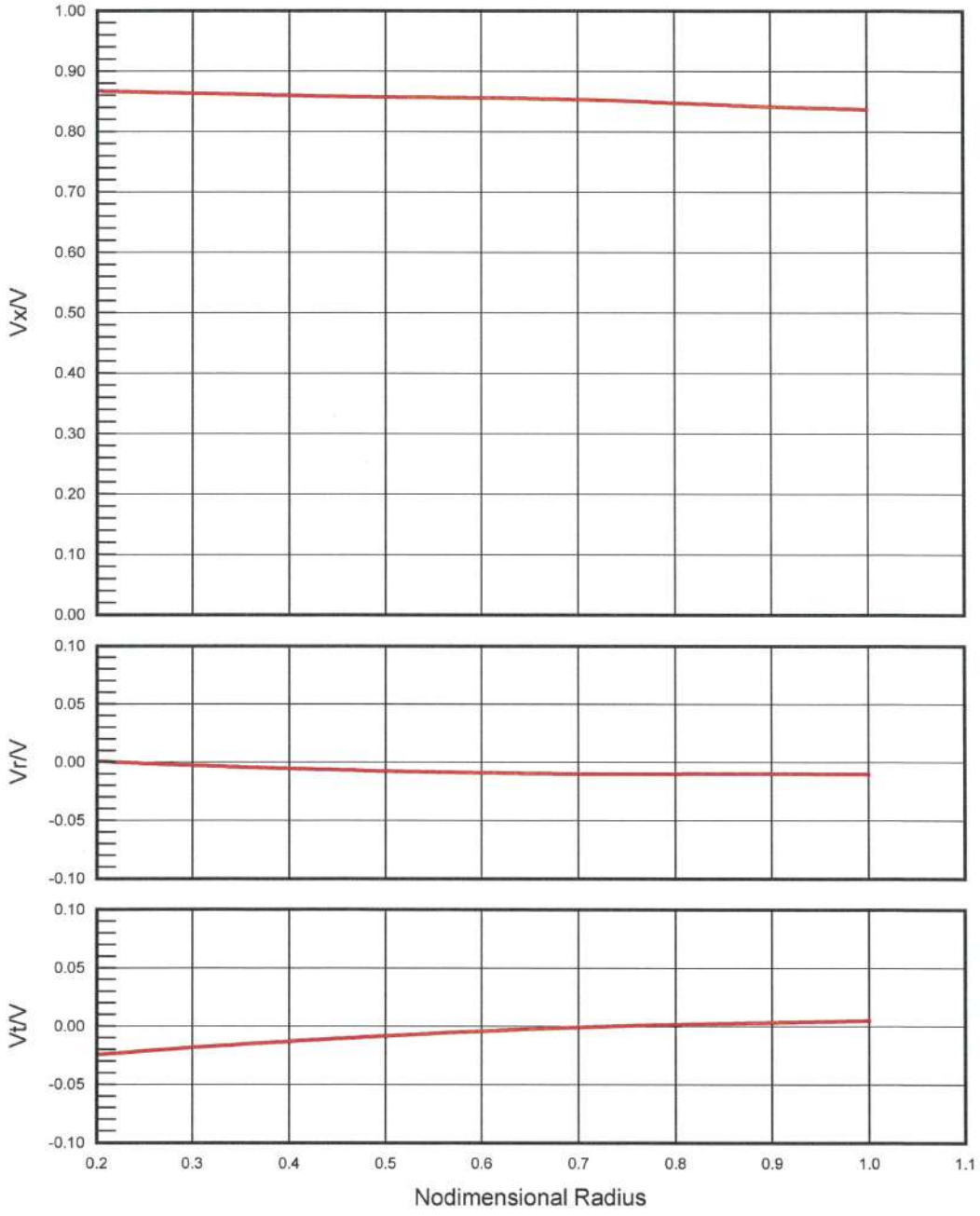
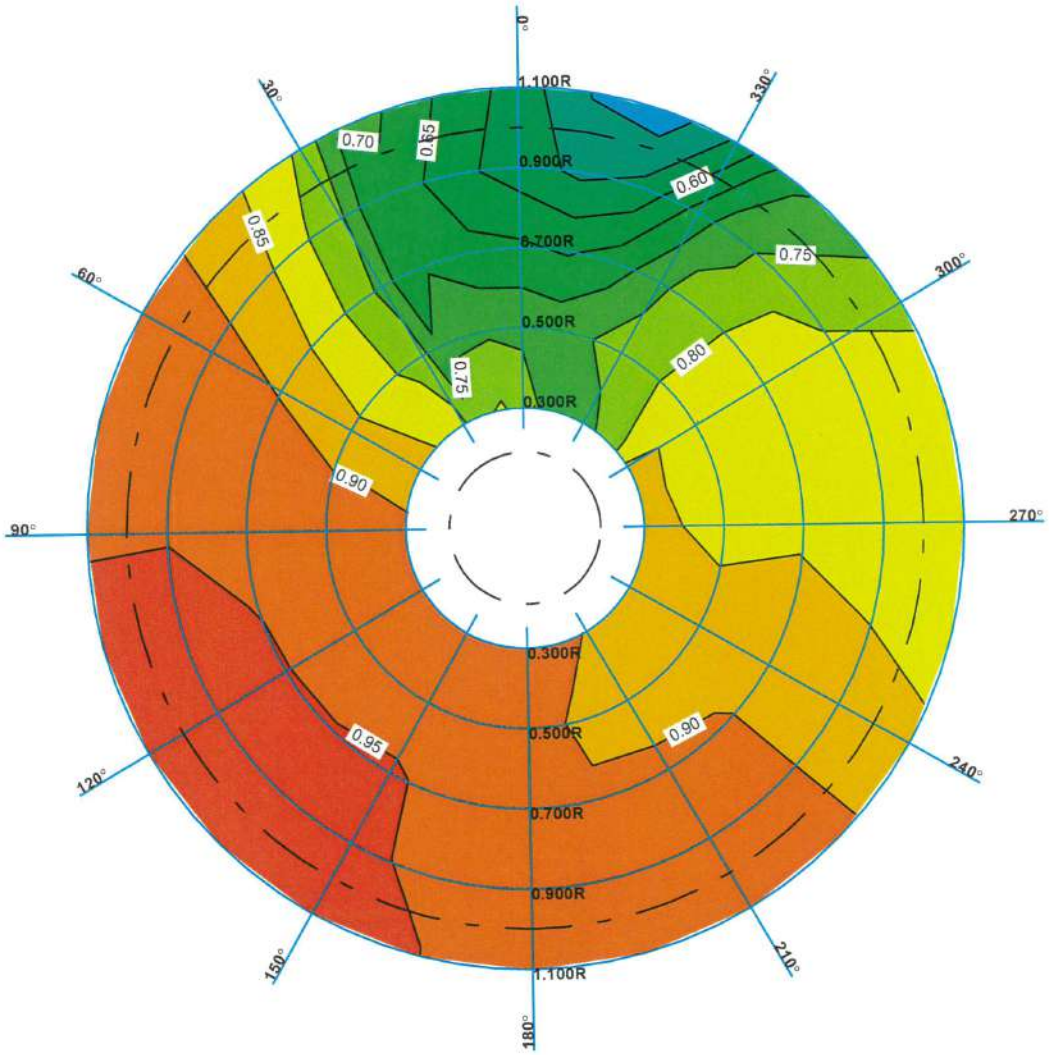


Figure 3 Radial Distribution of Circumferential Mean Velocity

PRELIMINARY

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Cond.	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Test date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		



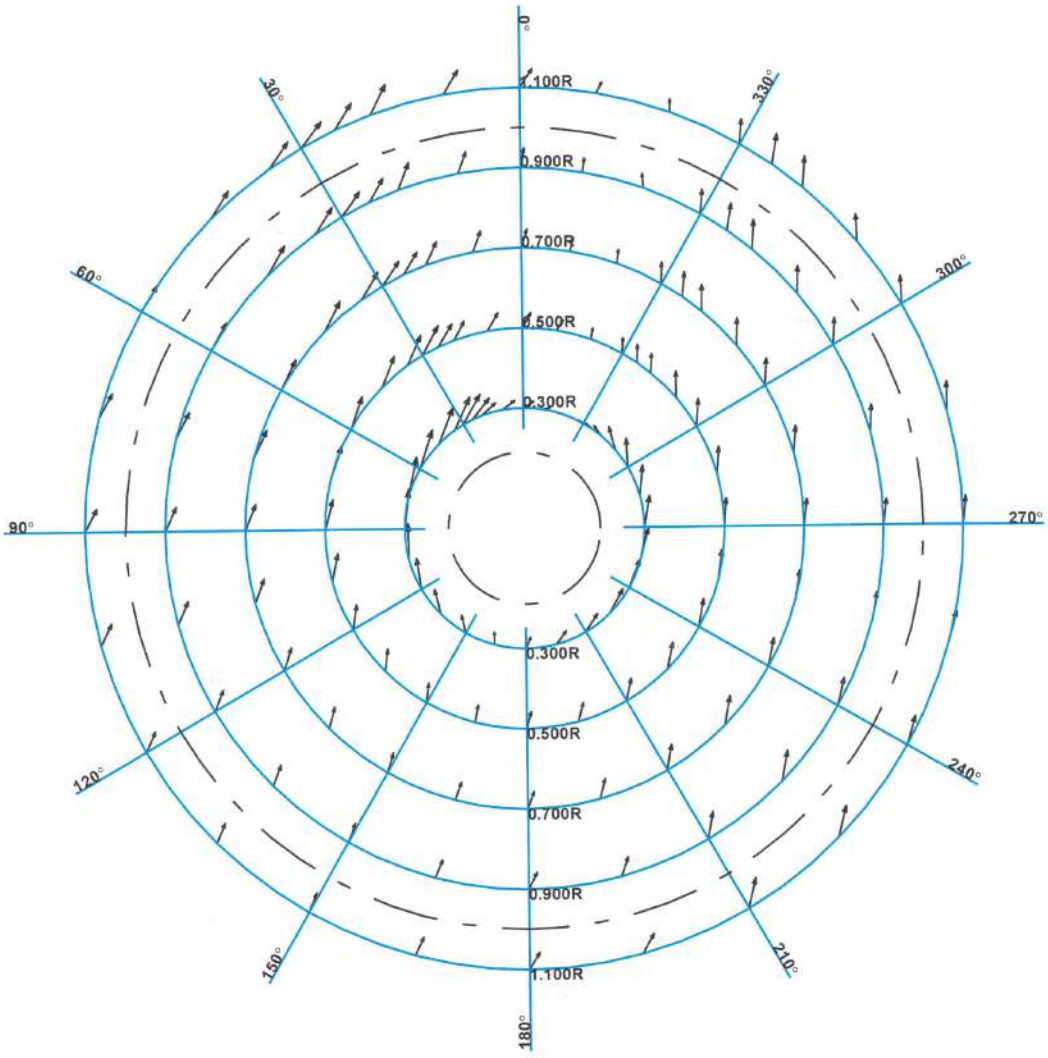
Propeller Diameter

Volumetric Mean of 1-Vx = 0.149

Figure 4 Iso-axial Velocity Contours

PRELIMINARY

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Cond.	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Test date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		



Propeller Diameter

Scale for Vtr/V = 0.5

Figure 5 Transverse Velocity Vectors

PRELIMINARY

Project Name	: Research Vessel	Length BP	: 35.05 M
Ship Model ID	: SM783	Draught FP	: 2.72 M
Test Cond.	: Design	Draught AP	: 2.72 M
Scale Ratio	: 7.6000	Propeller Dia.	: 1.90 M
Test date	: 10-SEP-24	Ship Speed	: 12.00 kts
Remarks	: 300GT, PORT Side		

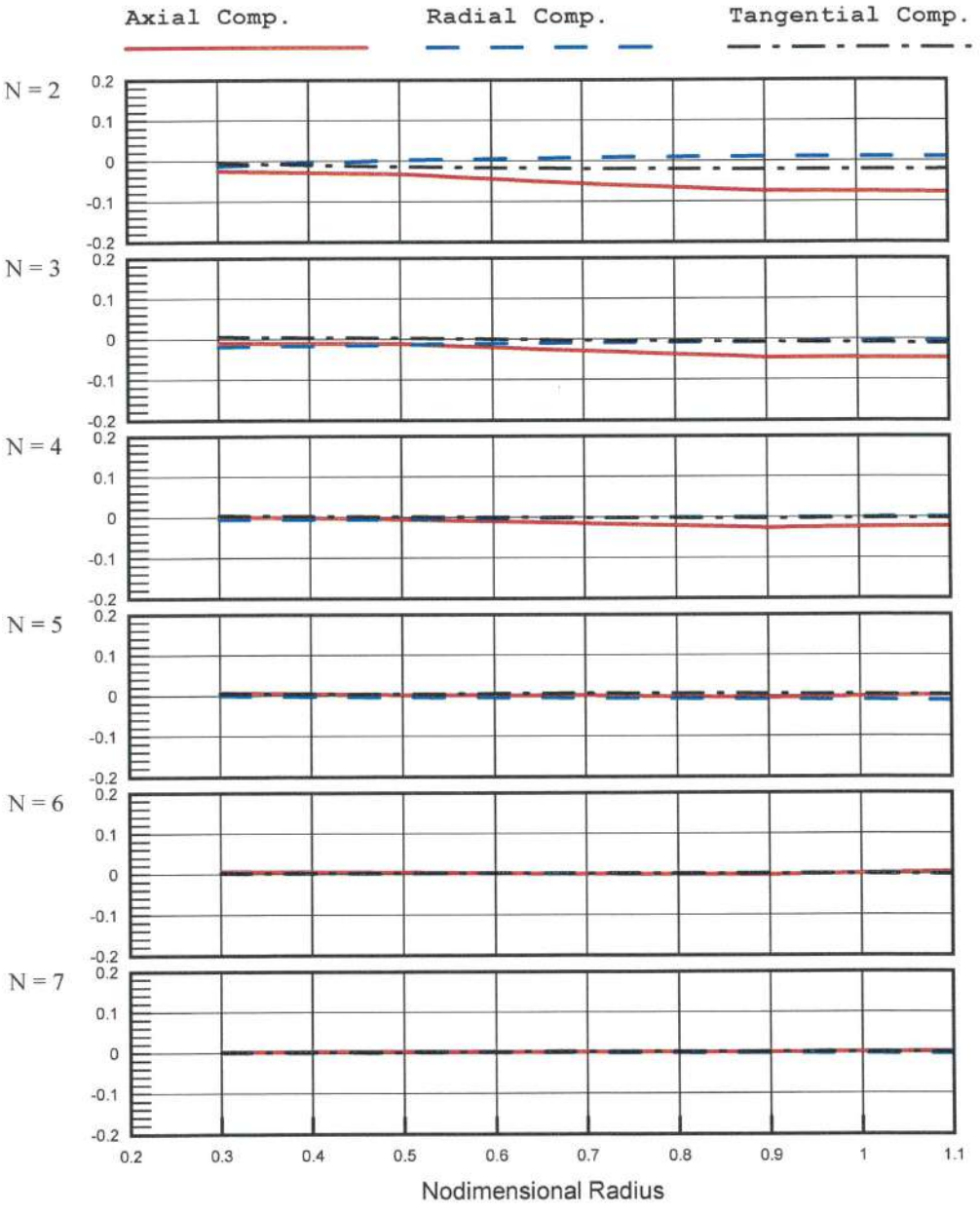


Figure 6 Radial Distributions of Harmonic Amplitudes of Velocity

PRELIMINARY

Table 11 Results of Resistance Test (Design)

Results of Resistance Tests

Project Name	: Research Vessel	Ship Particulars	
Ship Model ID	: SM783		
Test Date	: 11-SEP-24	Length BP	= 35.05 m
Test Option	: 300GT	Length WL	= 37.53 m
Test Draught	: Design	Draught at FP	= 2.72 m
Scale Ratio	: 7.600	Draught at AP	= 2.72 m
		Breadth	= 9.00 m
		Wetted Surface Area	= 495. m2
Water Temperature	= 22.90 Deg C	Displacement Volume	= 543. m3
Standard Temp	= 15.00 Deg C	Bilge Keel Area	= 0.00 m2
Density (Fresh)	= 997.45 kg/m3	T.Proj Area abv WL	= 84.42 m2
Density (Sea)	= 1025.90 kg/m3	Hull Roughness(e6)	= 150. m
Viscosity (Fresh)	= 0.93688e-6 m2/s	Ca*1000	= 0.4000
Viscosity (Sea)	= 1.18829e-6 m2/s	Cas*1000	= 0.5000
		Cair*1000	= 0.1706

Vs (kts)	Vm (m/s)	Fn	Rnm (e-6)	Rtm (N)	Ctm (e+3)	Cfm (e+3)	Cr (e+3)	Trim (deg)
4.50	0.840	0.121	4.426	17.39	5.770	3.475	2.295	0.087
6.00	1.120	0.161	5.902	30.42	5.680	3.295	2.385	0.138
7.50	1.400	0.201	7.377	47.53	5.679	3.165	2.514	0.240
9.00	1.679	0.241	8.853	72.79	6.039	3.065	2.974	0.353
10.50	1.959	0.282	10.328	113.92	6.944	2.983	3.961	0.435
12.00	2.239	0.322	11.804	173.52	8.098	2.915	5.183	0.526
13.00	2.426	0.349	12.787	222.50	8.848	2.876	5.972	0.634
14.00	2.612	0.375	13.771	305.47	10.474	2.840	7.634	0.719

Vs (kts)	Rns (e-9)	Cfs (e+3)	Cts (e+3)	Rts (kN)	PE (kW)	PE (PS)	Sinkage FP (m)	Sinkage AP
4.50	0.073	2.181	5.547	8	17	24	0.053	0.000
6.00	0.097	2.091	5.546	13	41	56	0.089	0.005
7.50	0.122	2.025	5.610	21	82	111	0.147	0.000
9.00	0.146	1.973	6.018	33	152	206	0.218	0.002
10.50	0.171	1.931	6.963	52	279	379	0.287	0.021
12.00	0.195	1.896	8.149	79	487	662	0.364	0.043
13.00	0.211	1.875	8.918	101	677	921	0.431	0.044
14.00	0.227	1.856	10.561	139	1002	1362	0.494	0.054

Trim by bow is defined to be positive.

PRELIMINARY

Table 12 Results of Self Propulsion Test (Design)

Results of Self Propulsion Tests

Project Name : Research Vessel
Ship Model ID : SM783
Propeller ID : SP1047RL
Test Date : 11-SEP-24
Test Option : 300GT
Test Draught : Design
Scale Ratio : 7.600

Ship Particulars

Length BP	=	35.05 m
Length WL	=	37.53 m
Draught at FP	=	2.72 m
Draught at AP	=	2.72 m
Breadth	=	9.00 m
Wetted Surface Area	=	495. m2
Displacement Volume	=	543. m3
Bilge Keel Area	=	0.00 m2
T.Proj Area abv WL	=	84.42 m2

	Temp (DegC)	Density (kg/m3)	Viscosity (m2/s)
Res	22.9	997.4	0.93688e-6
S-P	22.9	997.4	0.93688e-6
Sea	15.0	1025.9	1.18829e-6

Model-Ship Correlation

Prop Roughness = 30.e-6 m
Hull Roughness = 150.e-6 m

Propeller Particulars

Number of Propeller	=	2
Number of Blades	=	4
Propeller Diameter	=	1.900 m
Pitch/Dia at 0.7r	=	0.795
Chord Length at 0.7r	=	0.428 m
Blade thickness 0.7r	=	0.022 m
Rn(model) at 0.7r	=	5.44e+5
Expanded Area Ratio	=	0.412
Section Type	:	Given
Test Date	:	09-SEP-24

Ship Speed (kts)	Model Speed (m/s)	Rtm S-P (N)	SFC (N)	S-P Adv (J)	Rate Revs (rps)	Thrust (N)	Torque (N-m)	Model Propeller Open Water Charact (J)	(10kt)	(100kq)
4.50	0.840	17.39	2.69	0.675	4.39	8.57	0.339	0.000	3.501	3.704
6.00	1.120	30.42	4.31	0.672	5.84	15.36	0.605	0.100	3.223	3.519
7.50	1.400	47.53	6.19	0.667	7.29	24.40	0.955	0.200	2.910	3.299
9.00	1.679	72.79	8.33	0.651	8.88	38.27	1.469	0.300	2.574	3.049
10.50	1.959	113.92	10.70	0.622	10.76	61.73	2.290	0.400	2.221	2.772
12.00	2.239	173.52	13.28	0.591	12.85	96.18	3.460	0.450	2.039	2.621
13.00	2.426	222.50	15.11	0.573	14.29	124.78	4.412	0.500	1.852	2.461
14.00	2.612	305.47	17.03	0.541	16.23	173.97	5.983	0.550	1.659	2.290
								0.600	1.459	2.105
								0.650	1.251	1.904
								0.700	1.032	1.685
								0.750	0.801	1.444
								0.800	0.554	1.176
								0.900	0.001	0.548

PRELIMINARY

Table 13 Propulsion Performance of Full Scale Ship (Design)

Propulsion Performance of Full Scale Ship

Project Name	: Research Vessel	Ship Particulars	
Ship Model ID	: SM783	Length BP	= 35.05 m
Propeller ID	: SP1047RL	Length WL	= 37.53 m
Test Date	: 11-SEP-24	Draught at FP	= 2.72 m
Test Option	: 300GT	Draught at AP	= 2.72 m
Test Draught	: Design	Breadth	= 9.00 m
Scale Ratio	: 7.600	Wetted Surface Area	= 495. m2
		Displacement Volume	= 543. m3
		Bilge Keel Area	= 0.00 m2
		T.Proj Area abv WL	= 84.42 m2

ITTC Standard Prediction

Ship Speed (kts)	Fn	PE (kW)	PD (kW)	S-P Adv (J)	Rate Revs (rpm)	Thrust (kN)	Torque (kN-m)	Model Wake (Wtm)	Ship Wake (Wts)
4.50	0.121	17	27	0.655	98.38	4	1	0.118	0.118
6.00	0.161	41	63	0.652	130.82	8	2	0.125	0.125
7.50	0.201	82	124	0.647	163.40	13	4	0.132	0.132
9.00	0.241	152	232	0.632	199.09	19	6	0.139	0.139
10.50	0.282	279	432	0.605	240.62	31	9	0.146	0.146
12.00	0.322	487	769	0.576	286.77	47	13	0.152	0.152
13.00	0.349	677	1082	0.560	318.48	61	16	0.156	0.156
14.00	0.375	1002	1646	0.529	360.83	84	22	0.160	0.160

Ship Speed (kts)	Thrust Deduct (Thdf)	Hull Effi (EtaH)	Relative Rotative Effi (EtaR)	Prop Effi (EtaO)	Behind Effi (EtaB)	Total Effi (EtaD)	Full Scale Propeller Open Water Charact (J)	(10Kt)	(100Kq)
4.50	0.143	0.972	0.993	0.679	0.674	0.655	0.000	3.501	3.704
6.00	0.150	0.971	0.993	0.679	0.675	0.655	0.100	3.223	3.519
7.50	0.153	0.976	0.993	0.679	0.674	0.657	0.200	2.910	3.299
9.00	0.158	0.978	0.993	0.672	0.668	0.653	0.300	2.574	3.049
10.50	0.164	0.979	0.994	0.663	0.659	0.645	0.400	2.221	2.772
12.00	0.167	0.982	0.994	0.648	0.644	0.633	0.450	2.039	2.621
13.00	0.169	0.985	0.995	0.639	0.636	0.626	0.500	1.852	2.461
14.00	0.171	0.987	0.996	0.619	0.616	0.608	0.550	1.659	2.290
							0.600	1.459	2.105
							0.650	1.251	1.904
							0.700	1.032	1.685
							0.750	0.801	1.444
							0.800	0.554	1.176
							0.900	0.001	0.548

PRELIMINARY

Table 14 Prediction of Powering Performance (Design)

Prediction of Powering Performance

Project Name	: Research Vessel	Ship Particulars	
Ship Model ID	: SM783		
Propeller ID	: SP1047RL	Length BP	= 35.05 m
Test Date	: 11-SEP-24	Length WL	= 37.53 m
Test Option	: 300GT	Draught at FP	= 2.72 m
Test Draught	: Design	Draught at AP	= 2.72 m
Scale Ratio	: 7.600	Breadth	= 9.00 m
		Wetted Surface Area	= 495. m2
		Displacement Volume	= 543. m3
		Bilge Keel Area	= 0.00 m2
		T.Proj Area abv WL	= 84.42 m2

Ship Trial Prediction with
Ca*1000 = 0.400, Cn = 1.000, EtaT =0.950

Ship Speed (kts)	Brake Power (kW)	Brake Power (PS)	Rate of Revs. (rps)	Rate of Revs. (rpm)
4.50	28	38	1.640	98.38
6.00	67	90	2.180	130.82
7.50	131	178	2.723	163.40
9.00	244	332	3.318	199.09
10.50	454	618	4.010	240.62
12.00	810	1101	4.780	286.77
13.00	1139	1548	5.308	318.48
14.00	1733	2356	6.014	360.83

[Trials] Vs = 13.88 kts, Ns = 355.4 rpm
at Pb = 1640 kW

[Notes]
- For explanations of abbreviations see list of symbols.
- Reynolds and Froude number based on Lwl= 37.53.
- Frictional resistance determined according to the ITTC-1957 formula.
- A model-ship correlation allowance Ca=0.00040.
- A extra resistance due to steering Cas= 0.00050.
- A resistance of above water part through the air, Cair=.0001706.
- The results have been obtained by Froude scaling from self-propulsion point of ship corresponding to a scale effect correction on resistance determined by means of the ITTC-1957 formula.
- The propulsion factors are based on thrust identity.
- Self propulsion points are faired by variation of speed.
- The results are valid for unrestricted deep water of 15.0 deg C and a mass density of 1025.9 kg/m3, clean surfaces of hull and propeller blades and no effects of wind and waves.
- Remarks: All tests performed in deep water towing tank of SSMB.

PRELIMINARY

Project Name	: Research Ves	Length BP	: 35.05 m
Ship Model ID	: SM783	Draught at FP	: 2.72 m
Prop. Model ID	: SP1047RL	Draught at AP	: 2.72 m
Test Cond.	: Design	Displacement	: 543. m^3
Scale Ratio	: 7.6000	Ca × 1000	: 0.40
		Cn	: 1.000

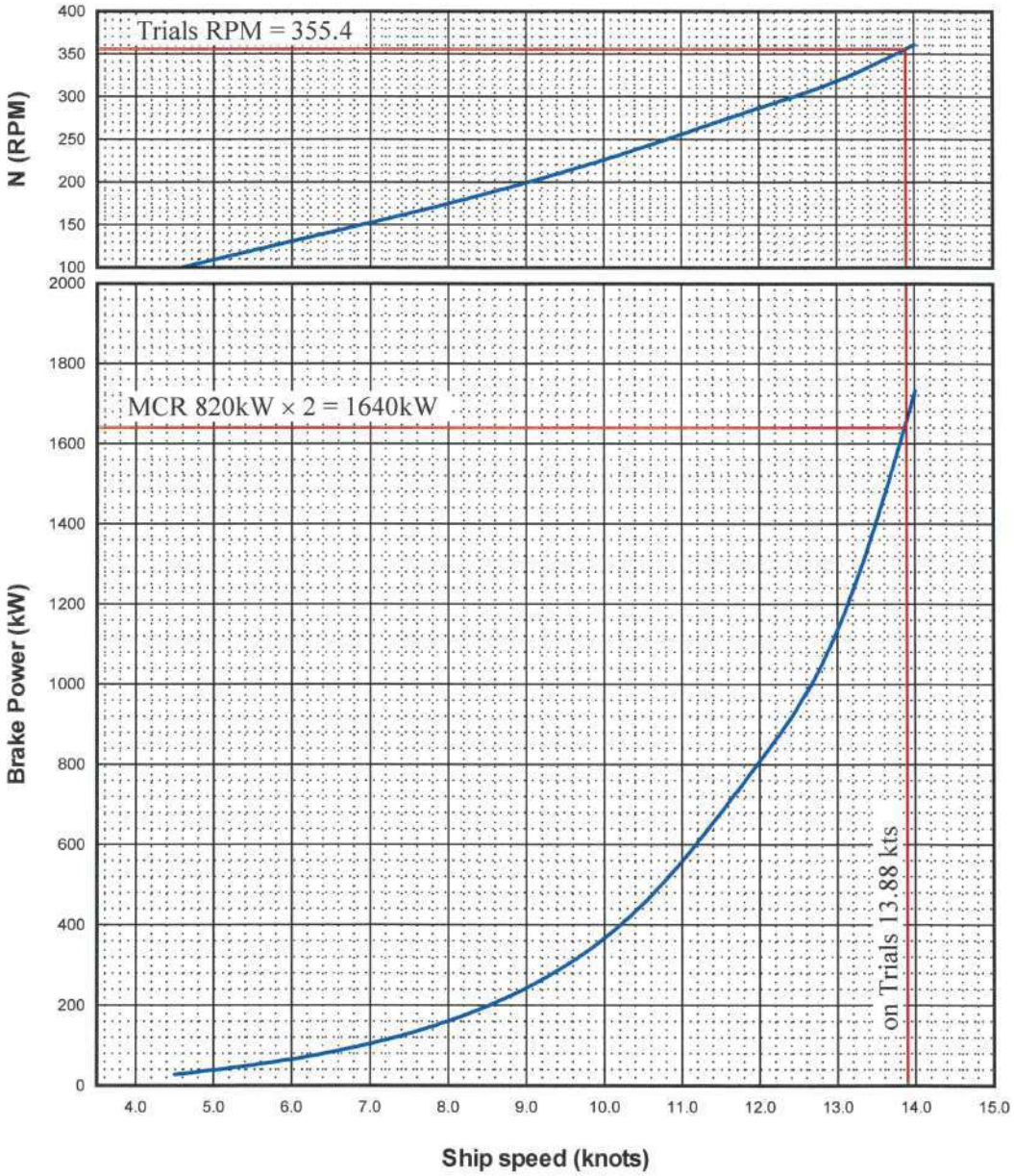


Figure 7 Full scale Prediction of Powering Performance (Design)

PRELIMINARY

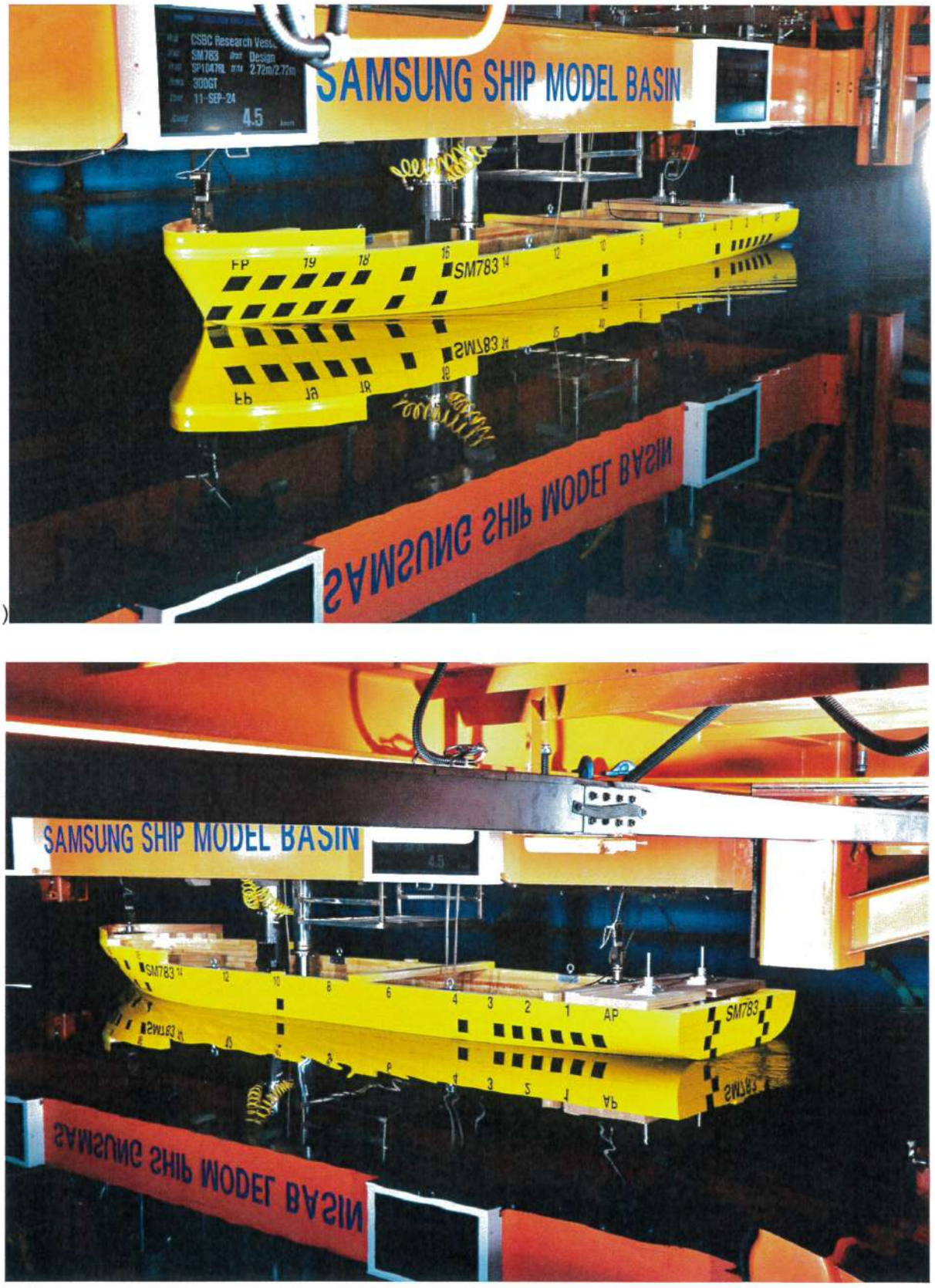


Photo 1 Wave Profiles of Running Model Ship (Design, 4.5 knots)

PRELIMINARY

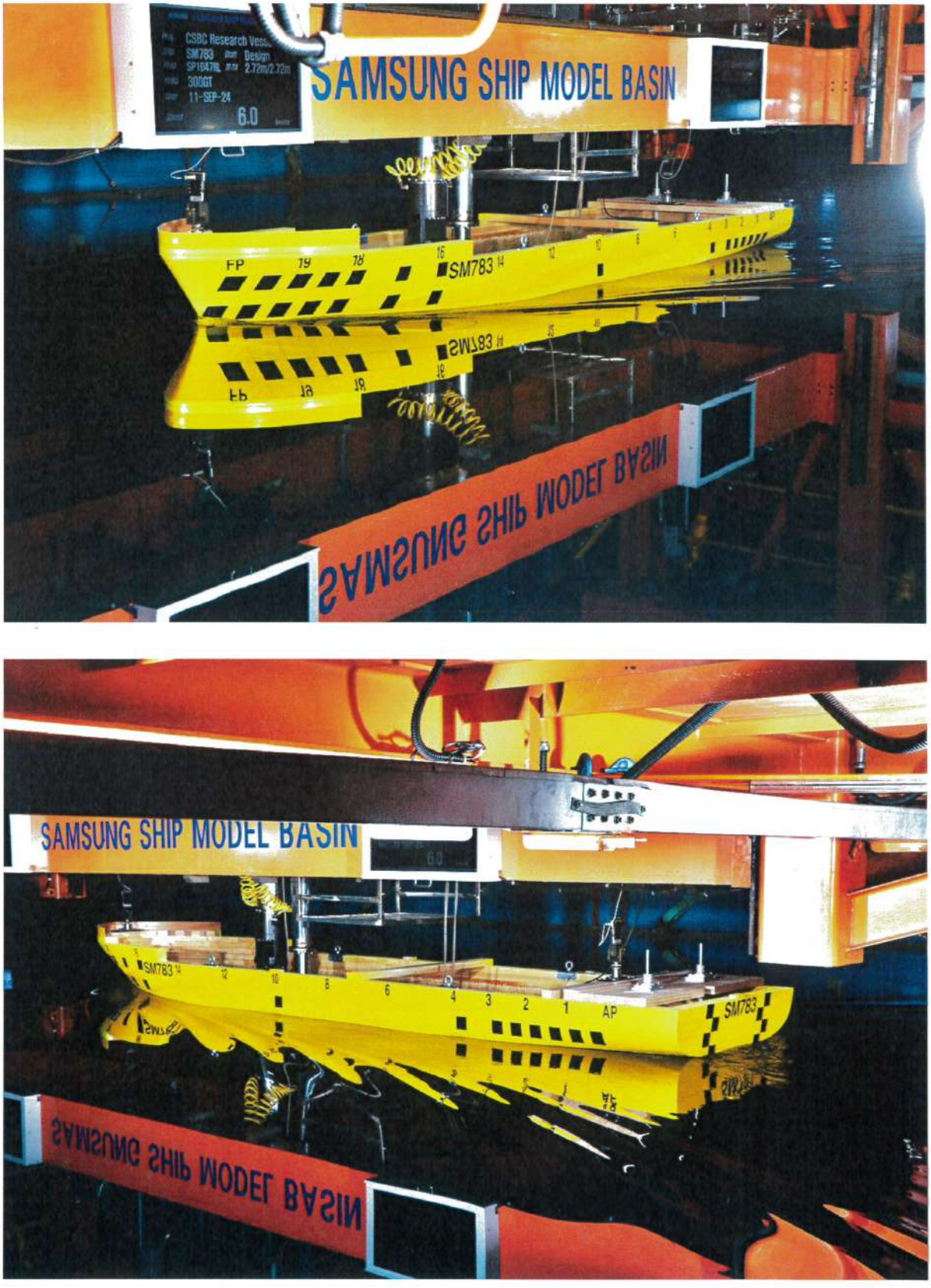


Photo 2 Wave Profiles of Running Model Ship (Design, 6.0 knots)

PRELIMINARY

Photo 3 Wave Profiles of Running Model Ship (Design, 7.5 knots)

PRELIMINARY

Photo 4 Wave Profiles of Running Model Ship (Design, 9.0 knots)

PRELIMINARY

Photo 5 Wave Profiles of Running Model Ship (Design, 10.5 knots)

PRELIMINARY

Photo 6 Wave Profiles of Running Model Ship (Design, 12.0 knots)

PRELIMINARY

Photo 7 Wave Profiles of Running Model Ship (Design, 13.0 knots)

PRELIMINARY

Photo 8 Wave Profiles of Running Model Ship (Design, 14.0 knots)

APPENDIX B Descriptions of analysis

The resistance tests are performed by towing the model ship with a towing carriage through the calm water. The towing force as the total resistance of the model ship is measured at corresponding speeds giving the same Froude numbers as the full scale ship.

1. Resistance test

The total resistance of the model ship, R_{TM} measured in the bare hull resistance tests is expressed in the non-dimensional form as,

$$C_{TM} = \frac{R_{TM}}{\frac{1}{2}\rho_M S_M V_M^2}$$

This is reduced to the residual resistance coefficient C_R by following relation.

$$C_R = C_{TM} - C_{FM}$$

, where the frictional resistance coefficient C_F for the model or ship is calculated by formula as,

$$C_F = \frac{0.075}{(\log_{10} Rn - 2)^2}$$

The total resistance coefficient C_{TS} of a ship is defined as,

$$C_{TS} = \frac{S_S + S_{BK}}{S_S}(C_{FS} + C_A) + C_R + C_{AA} + C_{AS}$$

, where the air resistance coefficient C_{AA} can be calculated by,

$$C_{AA} = 0.001\frac{A_T}{S_S}$$

In the above equation, C_A is a model-ship correlation allowance coefficient and C_{AS} is an additional model-ship correlation allowance coefficient to consider the effect of appendages, openings, etc. which are not fitted to the model ship. The model-ship correlation allowances are determined by SSMB's DB of model tests and sea trial data.

Total resistance of the ship is,

$$R_{TS} = \frac{1}{2}\rho_S C_{TS} S_S V_S^2$$

Effective power can be obtained as,

$$P_E = R_{TS} V_S$$

2. Propeller Open Water Test

A propeller model is installed on a horizontal driving shaft of a propeller open water test equipment and the immersion depth of the shaft should be more than 1.5 times as large as the propeller diameter. The thrust and the torque are measured in the test. The measured thrust values are corrected with respect to the drag of the hub and cap, and the torque values are corrected with respect to the shaft friction. This correction is determined experimentally in idling tests with a dummy hub and cap only. The propeller loading is normally varied by changing the speed of advance and keeping the rate of revolution constant so that the local Reynolds number at 0.7R must not be lower than at least 3×105. The local Reynolds number is calculated as follows;

$$Rn_{c_{0.7R}} = c_{0.7RM} \cdot n_M \cdot D_M \cdot \frac{\sqrt{J_M^2 + (0.7\pi)^2}}{\nu_M}$$

The propeller thrust, T_M and torque, Q_M measured with the rate of propeller revolution, n_M in the open water test can be expressed in non-dimensional forms as follows;

$$K_{TM} = \frac{T_M}{\rho_M n_M^2 D_M^4}, \qquad K_{QM} = \frac{Q_M}{\rho_M n_M^2 D_M^5}$$

These non-dimensional thrust and torque coefficients are presented as a function of the advance ratio, J together with the open water efficiency of model propeller, η_{OM}.

The open water efficiency of the model propeller and advance ratio are defined as,

$$\eta_{OM} = \frac{J \cdot K_{TM}}{2\pi \cdot K_{QM}}, \qquad J = \frac{V_A}{n_M \cdot D_M}$$

3. Self Propulsion Test

Thrust, T_M torque, Q_M and rate of revolutions, n_M of each propeller have been measured at the self-propulsion and can be expressed in non-dimensional form as,

$$K_{TM} = \frac{T_M}{\rho_M n_M^2 D_M^4}, \qquad K_{QM} = \frac{Q_M}{\rho_M n_M^2 D_M^5}$$

With K_{TM} as input data, the advance ratio, J_{TM} and the torque coefficient, K_{QTM} are read off from the open water characteristics of the model propeller and the wake fraction,

$$w_{TM} = 1 - \frac{J_{TM} n_M D_M}{V_M}$$

and the relative rotative efficiency

$$\eta_R = \frac{K_{QTM}}{K_{QM}}$$

are calculated.

The thrust deduction is obtained from

$$t = \frac{T_M + F_D - R_{TMC}}{T_M}$$

The towing force, F_D to compensate for the difference of propeller loading by surface friction between model and ship is derived as follows;

$$F_D = \tfrac{1}{2}\rho_M S_M V_M^2 (C_{FM} - C_{FS} - C_A)$$

And R_{TMC} is the resistance corrected for differences in temperature between resistance and self-propulsion tests.

$$R_{TMC} = R_{TM} \times \frac{C_{FMC} + C_R}{C_{FM} + C_R}$$

, where C_{FMC} is the frictional resistance coefficient at the water temperature of the self-propulsion test.

4. Full Scale Prediction

4-1. Scale Effect Corrections for Propeller Open Water Characteristics

The open water characteristics of the full scale propeller are calculated from the model propeller open water characteristics as follows;

$$K_{TS} = K_{TM} - \Delta K_T$$

$$K_{QS} = K_{QM} - \Delta K_Q$$

, where

$$\Delta K_T = -\Delta C_D \cdot 0.3 \cdot \frac{P_{0.7R}}{D} \cdot \frac{c_{0.7R} \cdot Z}{D}$$

$$\Delta K_Q = \Delta C_D \cdot 0.25 \cdot \frac{c_{0.7R} \cdot Z}{D}$$

ΔC_D is the difference in blade drag coefficient as follows;

$$\Delta C_D = C_{DM} - C_{DS}$$

, where

$$C_{DM} = 2 \cdot \left(1 + 2\frac{t_{0.7R}}{c_{0.7R}}\right) \cdot \left(\frac{0.044}{(Rn_{c_{0.7R}})^{1/6}} - \frac{5}{(Rn_{c_{0.7R}})^{2/3}}\right)$$

and

$$C_{DS} = 2 \cdot \left(1 + 2\frac{t_{0.7R}}{c_{0.7R}}\right) \cdot \left(1.89 + 1.62 \cdot \log\frac{c_{0.7R}}{k_p}\right)^{-2.5}$$

If ΔC_D is less than zero, $\Delta C_D = 0$ is used.

The blade roughness k_p is set to 30㎛. Local Reynolds number , $Rn_{c_{0.7R}}$ must not be lower than at least 3×10^5 in the open water test.

4-2. Full Scale Wake Method

The full scale wake is calculated from the model wake fraction with rudder bulb and model wake and thrust deduction fraction without rudder bulb as follows;

$$w_{TS} = (t_o + 0.04) + (w_{TMo} - t_o - 0.04)\frac{C_{FS} + C_A}{C_{FM}} + (w_{TM} - w_{TMo})$$

, where 0.04 is used to take account of rudder effect.

4-3. Full Scale Prediction based on ITTC 1978 method

The load of the full scale propeller is obtained from

$$\frac{K_T}{J^2} = \frac{S_S}{2D_S^2} \cdot \frac{C_{TS}}{(1-t)\cdot(1-w_{TS})^2}$$

With this K_{TS} / J^2 as input value, the full scale advance coefficient, J_{TS} and the torque coefficient, K_{QTS} are read off from the full scale propeller characteristics and the following quantities are calculated.

the rate of revolutions :

$$n_S = \frac{(1-w_{TS})\cdot V_S}{J_{TS}\cdot D_S}\cdot C_N \qquad (rps)$$

the delivered power :

$$P_{DS} = 2\pi\cdot\rho_S\cdot D_S^5\cdot n_S^3\cdot\frac{K_{QTS}}{\eta_R}\cdot 10^{-3} \qquad (kW)$$

the thrust of the propeller :

$$T_S = \frac{K_T}{J^2}\cdot J_{TS}^2\cdot\rho_S\cdot D_S^4\cdot n_S^2 \qquad (N)$$

the torque of the propeller :

$$Q_S = \frac{K_{QTS}}{\eta_R}\cdot\rho_S\cdot D_S^5\cdot n_S^2 \qquad (N-m)$$

the effective power :

$$P_E = C_{TS}\cdot\frac{1}{2}\cdot\rho_S\cdot V_S^3\cdot S_S\cdot 10^{-3} \qquad (kW)$$

$$= C_{TS}\cdot\frac{1}{2}\cdot\rho_S\cdot V_S^3\cdot S_S\cdot\frac{1}{75\cdot g} \qquad (PS)$$

the total efficiency :
(Quasi-Propulsion Efficiency)

$$\eta_D = \frac{P_E}{P_D}$$

the hull efficiency:

$$\eta_H = \frac{1-t}{1-w_{TS}}$$