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Report on the Cooperative Experimental Study Program

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Abstract

The present paper describes the results of the cooperative experimental study organized by the Resistance Committee of the Korea Towing Tank Conference, which aims to improve model testing technique and accuracy and to self-evaluate their own capabilities.

A Series 60, $C_b=0.60$ model was tested at the towing tanks of Korea Institute of Machinery & Metals, Hyundai Maritime Research Institute, Seoul National University, and Inha University.

Results for total resistance, wave pattern analysis, wave profile, trim & sinkage and wake measure ments are presented.

1. Introduction

The Resistance Committee of the Korea Towing Tank Conference organized a program for cooperative experimental study at the meeting on May 24, 1985.

All the member organizations in Korea spontaneously joined the program to motivate cooperations between them, to improve model testing technique and accuracy and to self-evaluate their own capabilities.

A Series 60, $C_b=0.60$ model was selected for the object of the cooperative program in line with the international cooperative experimental program organized by the Resistance Committee of the ITTC in 1978 and reported at the 17th ITTC meeting in 1984.

The organizations prepared 5 models with different scale ratios based on the lines drawing from Hyundai Maritime Research Institute. The models were carefully checked by the measuring device at KIMM and it was found that deviations were within $\pm0.2\%$ of given offsets.

Tank tests were conducted in accordance with the test scope of Japanese cooperative experimental study program which was basically identical with the ITTC cooperative study.

The test results obtained by KIMM, HMRI, SNU and IU are summarized in the present report. A separate report from BNU will be available after successfully fixing troubles in its towing carriage.

The cooperative study will be extended to the geosim tests by exchanging the models between the towing tanks. The results also will be summarized by the end of this year.

2. Total Resistance

Dimensions of towing tanks and model sizes of the

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Table 1 Towing tank dimensions and model sizes

Organizations	Tank Dimension (m)			Model		Symbol
	L	B	D	Scale	L_{pp}(m)	
KIMM	223	16	7	25	4.877	□
HMRI	232	14	6	17.5	6.967	⬡
SNU	117	8	3.5	36	3.387	△
IU	79	5	3	48.77	2.5	◇
BNU	87	5	3	60.96	2.0	+

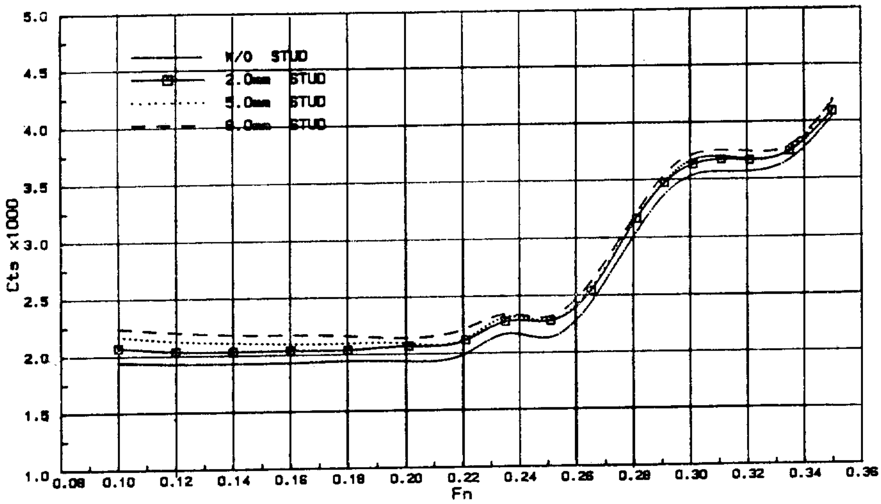

Fig. 1 Effects of stud height on resistance (KIMM)

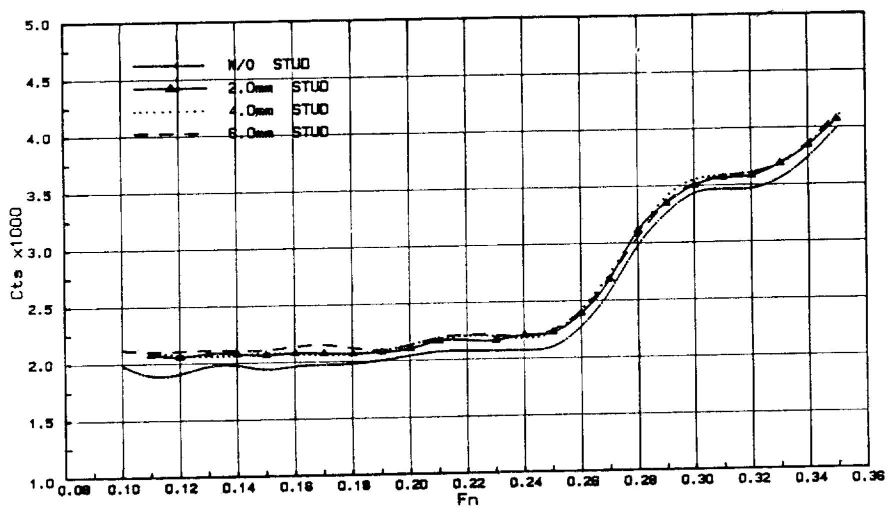

Fig. 2 Effects of stud height on resistance (SNU)

organizations are given in Table 1. Types of the measurements are listed in Table 2 along with Froude number ranges and hull attitudes.

Trapezoidal studs proposed by Tagori are used as a turbulence stimulator and fitted at $9\frac{1}{2}$ station with 10mm pitch. These arrangements are identical with

Table 2 Overview of the measurements

Organizations	C_t		C_{wp}		C_v		Wave Profile	
	F_n	ATT	F_n	ATT	F_n	ATT	F_n	ATT
KIMM	0.10~0.35	FR, FX	0.20~0.35	FR, FX	0.30	FX	0.20~0.34	FR, FX
HMRI	0.10~0.31	FR, FX	—	—	0.28	FR	0.20~0.35	FR, FX
SNU	0.10~0.35	FR, FX	0.20~0.35	FR, FX	0.25, 0.30	FR, FX	0.20~0.35	FR, FX
IU	0.10~0.35	FR	—	—	—	—	0.20~0.34	FR

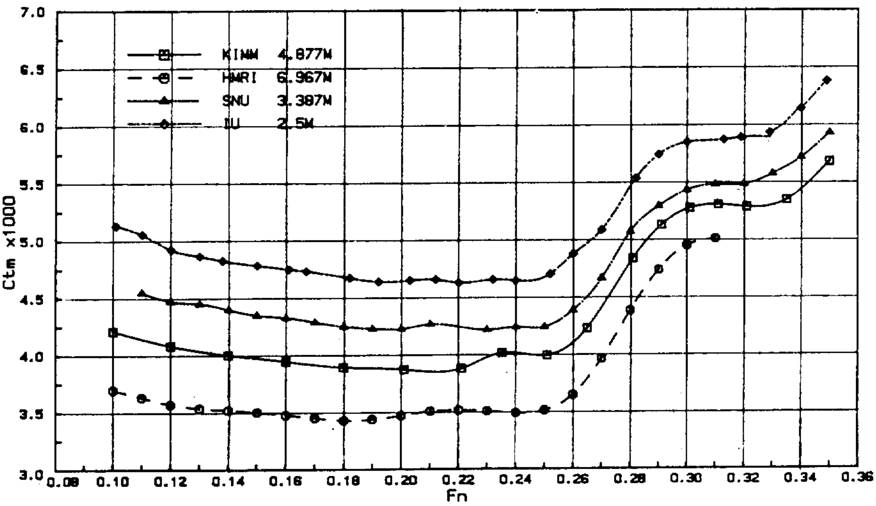

Fig. 3 C_{tm} Curves at free condition

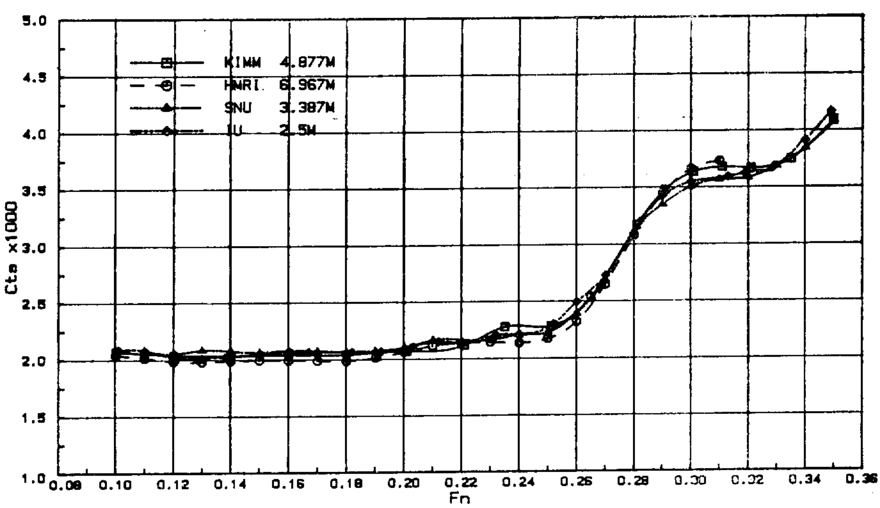

Fig. 4 C_{ts} Curves at free condition

the Japanese cooperative experimental study. Towing point is fixed at LCB and VCB. The resistance test result of KIMM, HMRI, SNU and IU are summarized in Fig. 1~Fig. 4.

SNU measured resistances with studs of 2, 4, 6mm heights and without stud while KIMM tested with studs of 2, 5, 8mm heights and without stud. Figures 1 and 2 show that the resistance grows with increasing

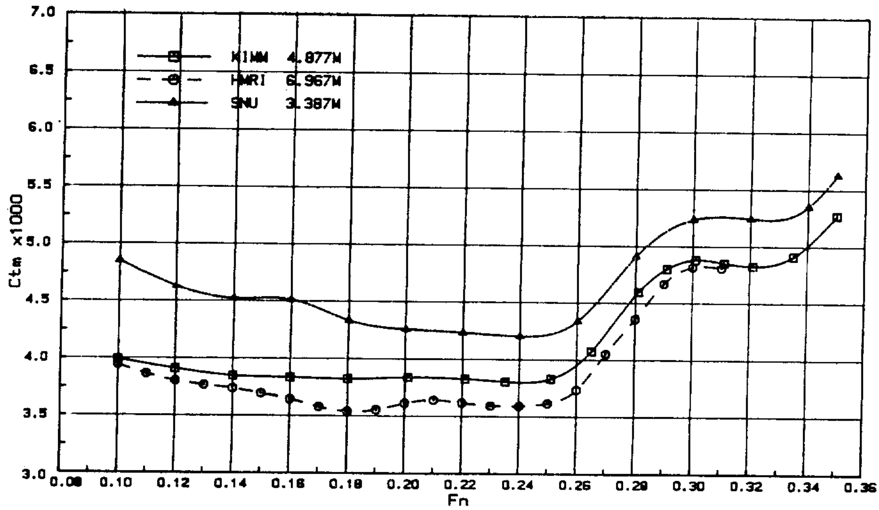

Fig. 5 C_{tm} Curves at fixed condition

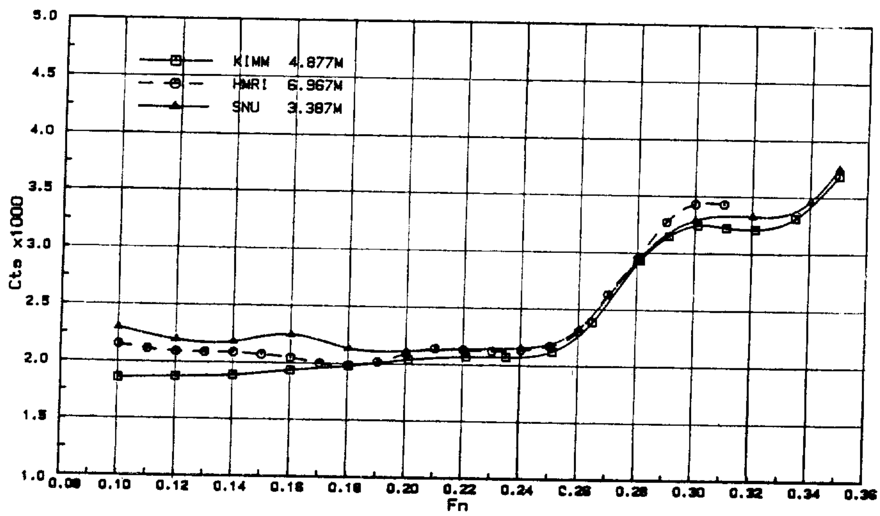

Fig. 6 C_{ts} Curves at fixed condition

stud heights in the F_n range tested. The results of both organizations for 2mm stud are almost identical in the test range and the curves show good parallelity with the resistance curve without stud. It was tentatively decided that 2mm is sufficient for the stud height in the present cooperative experimental study.

The total resistance coefficients of the models at the free condition measured by the participating organizations are summarized in Fig. 3.

The results are brought to a standard temperature of 15°C and a predesignated length of 121.92m using the "ITTC 1957 Model—Ship Correlation Line". The total resistances so predicted at the free condition are plotted in Fig. 4 and show no significant discrepancies.

Also the total resistance coefficients of each model and predesignated ship at the fixed condition are plotted in Fig. 5 and Fig. 6 respectively. The discrepancies appeared in the range of $F_n < 0.22$ have been caused by difficulties and differencies of fixing models.

From the comparison of Fig. 4 and Fig. 6, it is apparent that the total resistance coefficients at the free condition are slightly higher than those at the fixed condition. The trend becomes more profound if F_n increases.

3. Wave Pattern Resistance

KIMM and SNU measured wave patterns at different longitudinal cuts. SNU used cuts located at $Y/L_{pp}=$ 0. 179, 0. 35, 0. 50, while KIMM selected a single cut at $Y/L_{pp}=0.70$.

The organizations have analyzed the measured wave data with their own computer programs as shown in Table 3. The mean values of C_{wp} analyzed by SNU at the three different cuts are compared with those obtained by KIMM in Fig. 7. The figure shows that the results of both organizations agree well in the test range except $F_n=0.28$.

The influences of hull attitudes to the values of C_{wp} can be found in the figure which are already noticed in the case of the total resistance coefficients. The amounts, however, are not identical each other. It might be concluded that hull attitudes affect frictional resistances as well as wave resistances.

Table 3 Wave pattern resistance coefficients ($C_{wp}\times 10^3$)

Organizations	KIMM		SNU	
Att. / F_n	FR	FX	FR	FX
0. 20	0. 102	0. 096	0. 150	0. 145
0. 22	0. 159	0. 150	0. 206	0. 200
0. 24	—	—	0. 199	0. 209
0. 25	0. 197	0. 180	0. 240	0. 256
0. 26	—	—	0. 384	0. 370
0. 28	0. 945	0. 843	1. 026	0. 949
0. 30	1. 480	1. 322	1. 477	1. 335
0. 32	1. 593	1. 409	1. 592	1. 403
0. 34	1. 635	—	1. 698	1. 502
0. 35	—	1. 639	—	—

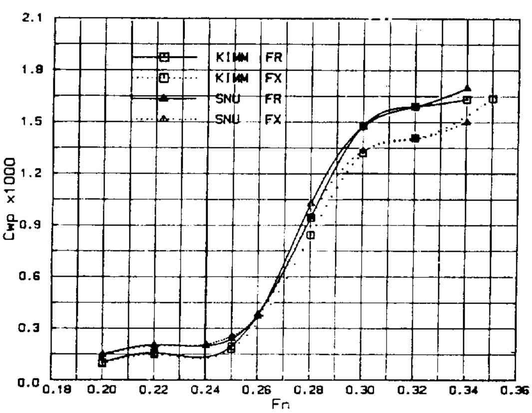

Fig. 7 Comparison of wave pattern resistance coefficients

4. Trim and Sinkage

The relative displacements of bow and stern were measured by pentagraph type trim guiders. From these displacements, trim and sinkage are derived. The results of the organizations were plotted in Fig. 8.

Sinkage curves show a fairly good agreement except SNU's results in low F_n ranges. Trim curves show some deviations between organizations but trends are nearly same.

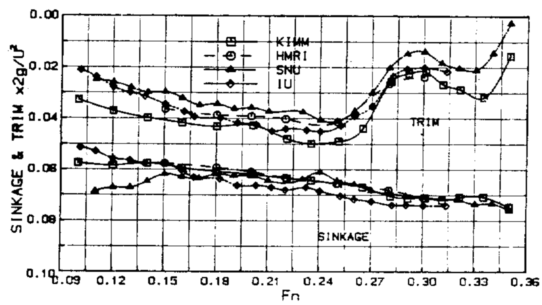

Fig. 8 Nondimensionalized trim and sinkage curves

5. Wave Profiles

The wave profiles along the hull surfaces were obtained from the photographs taken during the tests.

The wave profiles along the hull obtained at the free condition are summarized in Fig. 9 ~ Fig. 11 with sinkage and trim corrections. In general, the profiles show good agreements with each other, but at low Froude number, the profiles show some deviations caused by the difficulties in reading out the small quantity of wave heights. Furthermore significant deviations are presented at the vicinity of the bow because of the strong local wave effects.

The measured wave profiles at the fixed condition are summarized in Fig. 12 ~ Fig. 14 which show same tendency as free condition.

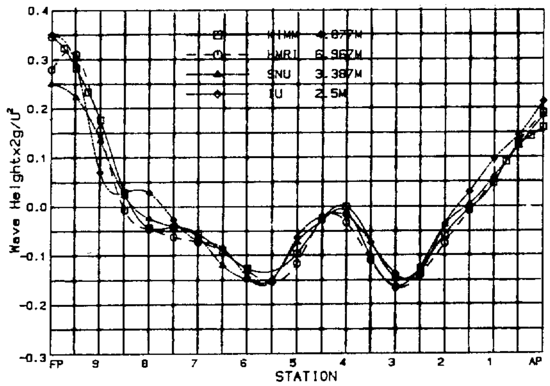

Fig. 9 Wave profiles at free condition (F_n=0.22)

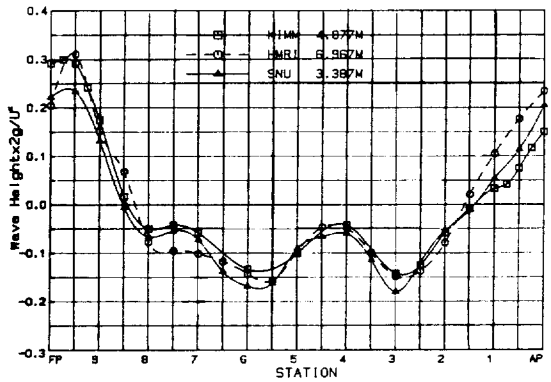

Fig. 12 Wave profiles at fixed condition (F_n=0.22)

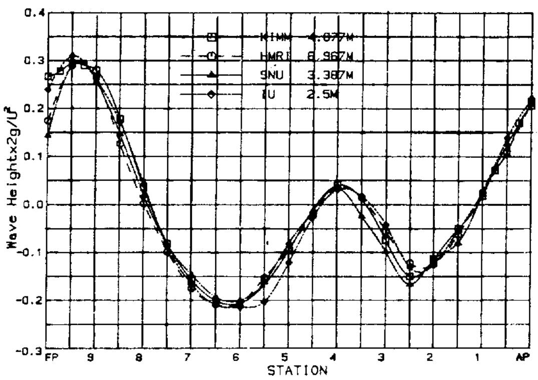

Fig. 10 Wave profiles at free condition (F_n=0.28)

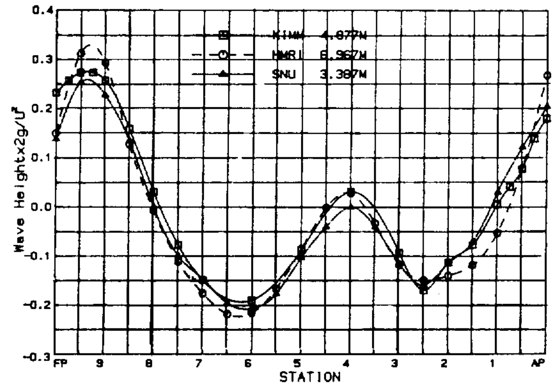

Fig. 13 Wave profiles at fixed condition (F_n=0.28)

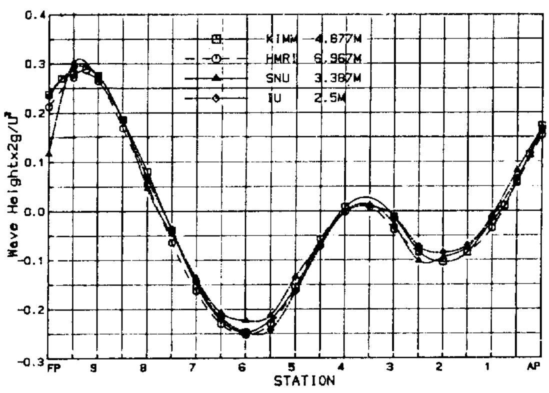

Fig. 11 Wave profiles at free condition (F_n=0.30)

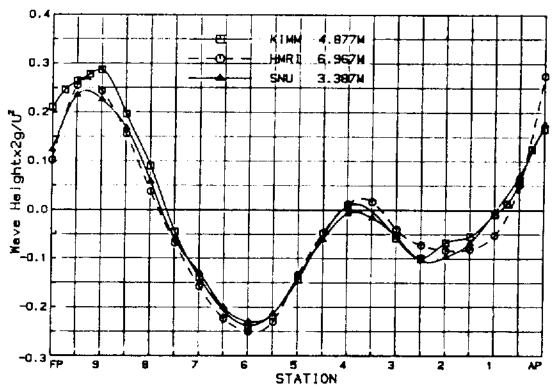

Fig. 14 Wave profiles at fixed condition (F_n=0.30)

6. Wake Survey

KIMM, SNU and HMRI measured model wakes. But as shown in Table 4 only a small amount of results is obtained because of time limitations.

It is not adequate to make quantitative comparisons of the wake survey results because the model sizes are different. The values of total head losses are integrated over the transverse direction Y at the fixed depth by the relation of $\int_w \frac{(H_0-H)}{L} d\left(\frac{Y}{B}\right)$. They are compared in Fig. 15 and Fig. 16 at the free and

Table 4 Viscous resistance coefficients ($C_v \times 10^3$)

Organization		KIMM	HMRI	SNU
FR	F_n=0.25	—	—	3.937
	0.28	—	3.14	—
	0.30	—	—	3.912
FX	F_n=0.25	—	—	3.823
	0.30	3.61	—	3.647
X/L_{pp}		0.9	0.9	0.9
$Z, \Delta Z$(cm)		2.5～27.5, 2.5	2.5～12.5, 2.5 17.5～52.5, 5.0	8.0～48.0, 8.0
$Y, \Delta Y$(cm)		0.0～12.5, 2.5 17.5～32.5, 5.0	0.0～50.0, 5.0	0.0～44.0, 4.0
Z/D		1.523	2.018	1.400
Y/B		1.440	1.538	0.947

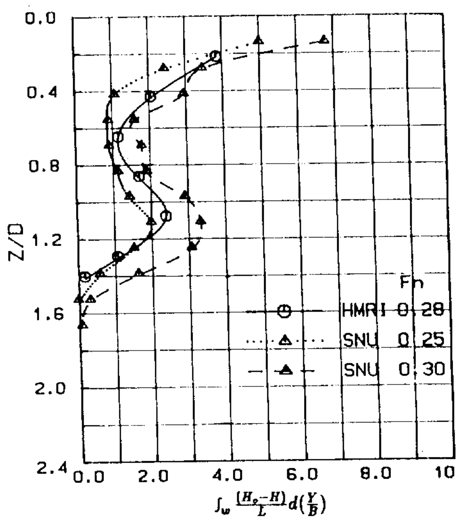

Fig. 15 Comparison of $\int_w \frac{(H_0-H)}{L} d\left(\frac{Y}{B}\right)$ at free condition

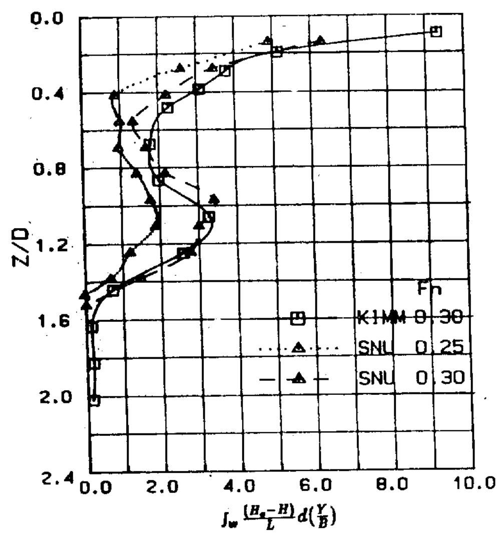

Fig. 16 Comparison of $\int_w \frac{(H_0-H)}{L} d\left(\frac{Y}{B}\right)$ at fixed condition

fixed conditions, repectively, and the results show same qualitative tendencies.

The viscous resistance coefficients in Table 4 are calculated by each organization with their own methods. The values are plotted in Fig. 17 and give reasonable estimations for viscous resistance, as clearly seen by comparing to the "ITTC 1957 Model—Ship Correlation Line" and "Schoenherr (ATTC) Line".

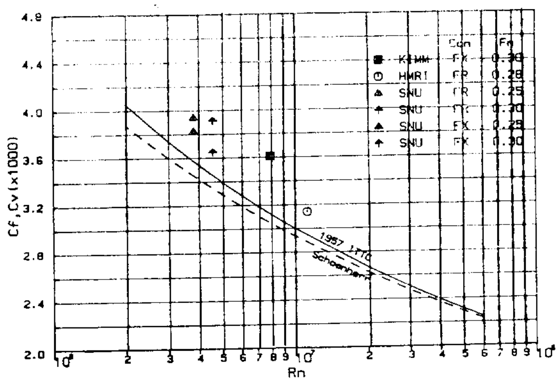

Fig. 17 Comparison of viscous resistance coefficients

Conclusions

Based on the recommendation of ITTC Resistance Committee, the member organizations of KTTC have carried out a series of tests on the Series 60 model.

The results of organizations are compared each other and, in general, show reasonably good agreements in spite of the fact that the various equipments, instruments, and people are involved. They were reported to the ITTC Resistance Committee and also will be found in the Proceedings of 18th ITTC.

The member organizations, especially, SNU and IU considering that their tank sizes are relatively small, have successfully demonstrated their experimental research capabilities, at least within the test scope of the present program.

The authors wish to thank all the member organizations of KTTC for their significant contributions to the present Cooperative Experimental Study Program.