Application of Rankine Source Method for Improving Hull Form of Fishing Vessels

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SUMMARY: The Rankine source method is applied for improving hull form of a fisheries research vessel. The vessel should be enlarged lengthwise. Furthermore, a bulge and a bulbous bow will be added. Effects due to these subjects on the wave making resistance are highlighted. The bulge decreases hull resistance and a physical reason is discussed. The method of optimizing bulge form is proposed and finally an improved hull form with optimized bulge is shown.

KEYWORDS **: flow simulation, improvement of hull form, bulge designing**

INTRODUCTION

A fisheries research vessel, the Ushio Maru of Hokkaido University is now in reconstruction. The vessel should be enlarged lengthwise. Furthermore, bulge and bulbous bow will be added. But the speed loss due to these reconstructions is one of problems. Because the possibility of increasing resistance due to increased ship volume and added bulge resistance is existed. In this plan, exchanging of the main engine for a larger power one is not included.

The Dawson's Rankine source method[1)] which is a kind of the boundary element methods to calculate wave flow around a ship hull is applied for evaluating the effects of these reconstructions on wave making resistance. Firstly, a flow field around original hull is discussed. Secondly, the effects of enlarging lengthwise, bulbous bow and bulge are examined. The fact that the bulge decreases the wave making resistance is found out in this process. The physical reason is also explained. Thirdly, a method to optimize bulge form is proposed and an improved hull form with an optimized bulge is shown. Finally, the results of model experiments in the circulating water channel are shown.

An application for a fisheries research vessel

This calculation method is applied for the Usio Maru. Fig.1 and Fig.2 show wave contour and hull pressure respectively. As common and typical characteristics on fishing vessels, the degree of changing of wave and pressure for hull length direction through whole ship area are larger than fine merchant ships. The height of wave at fore end part is distinguished. Resistance area at both fore end part and aft part are very clear, another thrust area at fore part is little recognized.

In the plan of reconstruction, ship length Lpp is enlarged from 27.5m to 33.7m and the original main engine is not exchanged for large size one. The voyage speed Vs is planned under the condition of that from original Vs=11.0kt (Fn=0.345) to modified Vs=10.0kt (Fn=0.283). Here, Fn is Froude number.

Comparative calculations are tried under the conditions of Case-1(original), Case-2(enlarged),Case-3(enlarged+bulge) and Case-4(enlarged+bulge+bulb). Fig.3 shows coefficient of wave making resistance Cw. Fig.4 expresses hull side wave. From view point to get indications for improving hull form, analyzing to the hull side wave is essential, because hull side wave depends on hull pressure distribution directly.

As effect due to bulbous bow, distinguished decreasing is got from Case3-Case4. But from hull side wave, bulbous bow influences on flow field of oneself limitedly, not necessarily wildly over ship hull. This result indicates limitation to improving under the

Fig.10 shows Cw correspondingly to results by calculations (Fig3). Effects due to enlarging, bulbous bow and bulge are qualitatively same as in calculations. The existence of bulge effect for decrease of Cw is clear and Cw decreases 14% at Fn=0.283. Fig.11 shows hull side wave. Results of experiments agree with calculations, specially the bulge effect for hull side wave is nearly same as calculations(Fig.4). Synthetically throughout above mentioned improvement, the coefficient of residual resistance Cr is possible to decrease about 25% to original one under 10.0 kt. The problem on speed loss according to the reconstruction in planning is neglected through calculations and experiments.

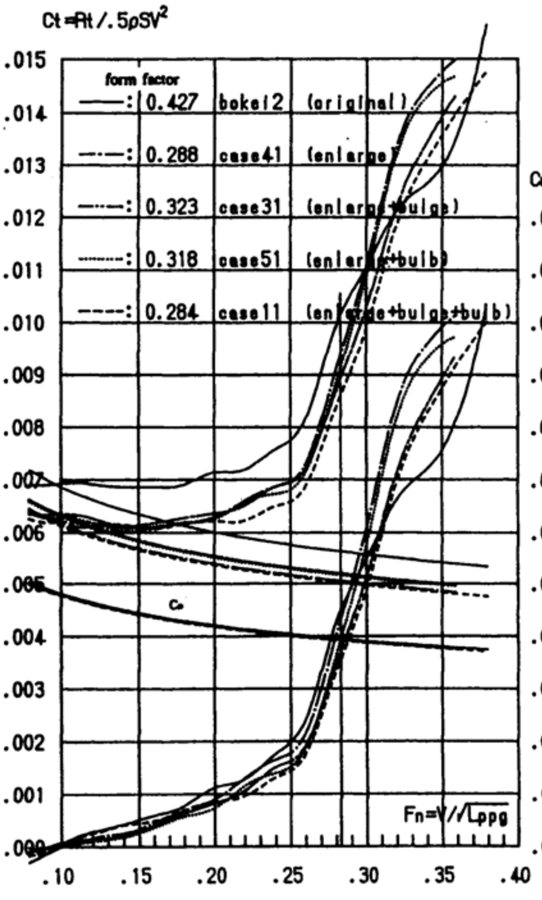

Fig.10 Results of model experiments in CWC

Conclusion

1) Rankine source method is applied to facilitate the planning of several modifications on a fisheries research vessel. The vessel should be enlarged lengthwise. Furthermore, a bulge and a bulbous bow

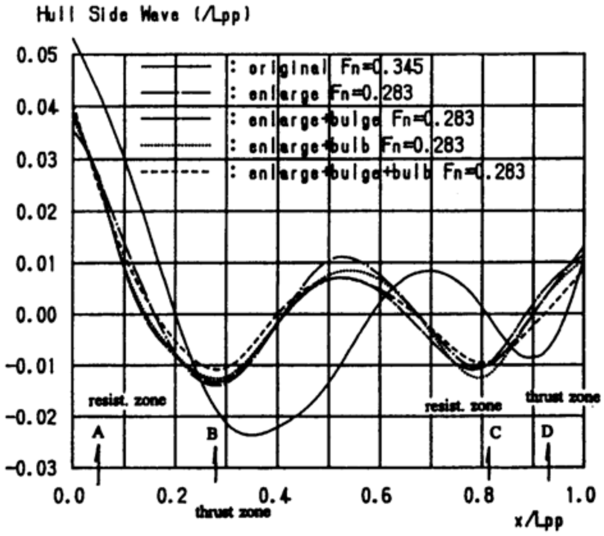

Fig.11 Results of measured hull side wave in CWC

will be added. Results of calculations for Cw and hull side wave are qualitatively in agreement with results of CWC experiments.

2) Bulge is not necessarily increasing the wave making resistance. Because bulge protects the pressure drop near aft shoulder part of ship. But the effects of bulge on the flow field is limited locally.

3) Various modifications of the bulge forms are examined and finally a ship with an optimized bulge is proposed.

4) Gain of effects due to sectional area curve and water line curve of bulge are first order, one due to frame line is second order.

5) The speed loss due to the longer length and bulge is neglected through the present calculations and experiments

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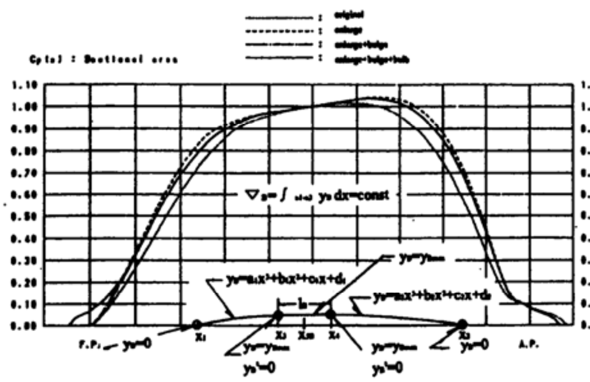

Fig.5 Modified prismatic curves of hull and bulge

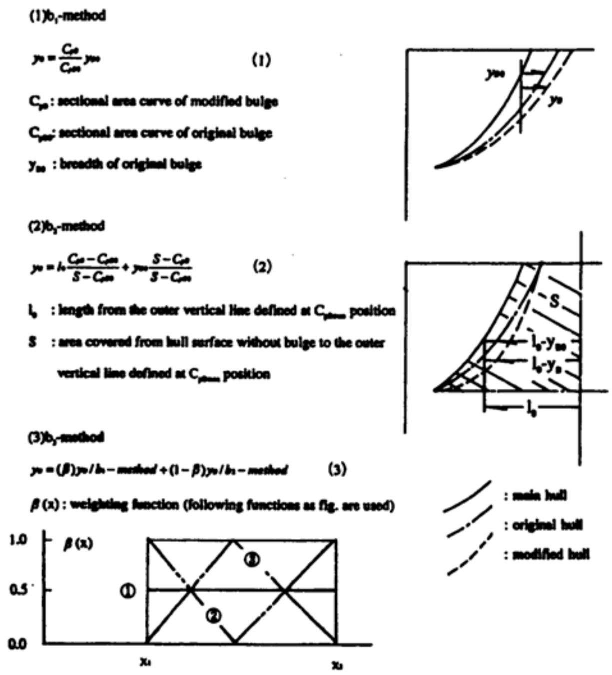

Fig.6 Modified frame line of bulge

β is weighting function.

Calculations to series ships with systematical modified bulge form are tried under Fn=0.283. As in Fig.7, an optimized bulge decreases 9% Cw to original. Fig.8 shows an improved ship with an optimized bulge. Curvature of bulge form is stronger than original form and center position of bulge buoyancy is near SS5. Fig.9 is hull side wave. The difference between modified wave and original one is very little. But improving of pressure near aft part is distinguished.

CWC Experiments for Inspection

Model experiments are tried to check the inspection for results of calculations by using circulating water

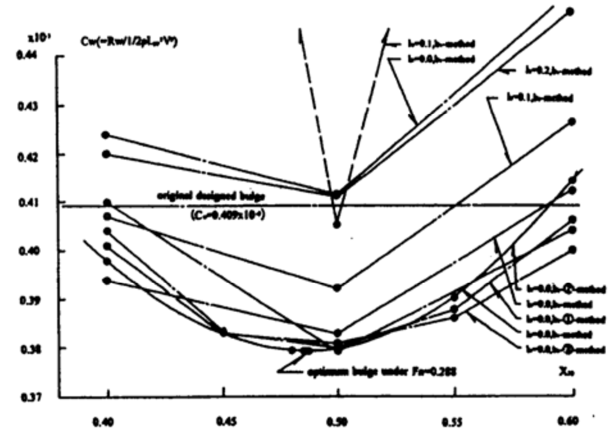

Fig.7 Calculated Cw of various modified bulges

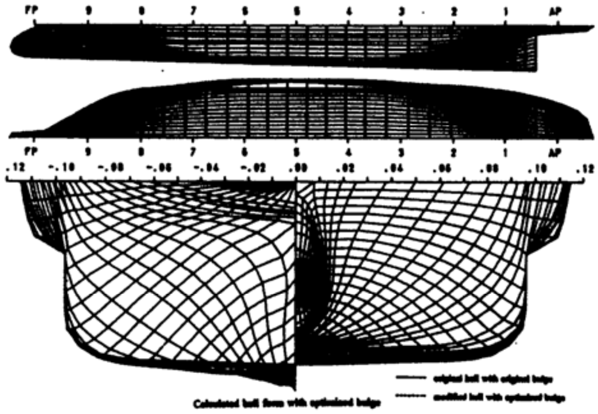

Fig.8 Calculated hull form with optimized bulge

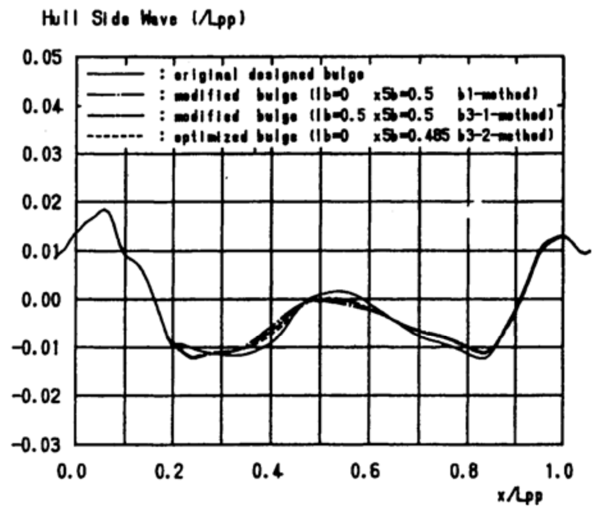

Fig.9 Calculated hull side wave of modified hull

channel of NRIFE. Through basic and continual researches[3], the higher qualitative and quantitative experiments are possible under the condition of non steady wave, non inclination and perfect uniform velocity distribution.

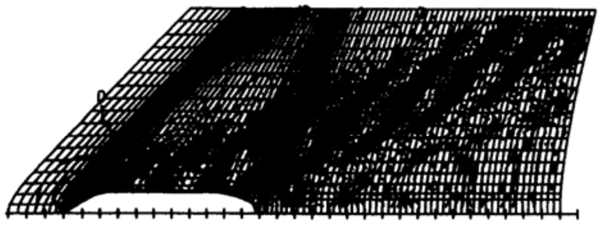

Fig.1 Wave of original hull (Fn=0.345)

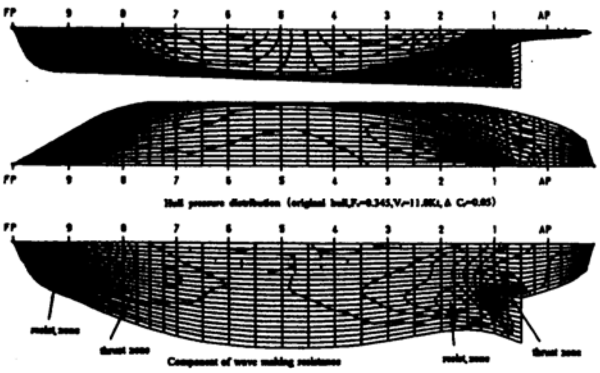

Fig.2 Pressure of original hull (Fn=0.345)

condition only to quip bulbous bow without improving of main hull form.

Cw is not necessarily increasing by bulge compared from Case2-Case3. In this case, it is possible to decrease over whole zone without designing point Fn=0.283. The gain of effect due to bulge is as same as one due to bulbous bow. The bulge effect for hull side wave is not existed at fore part, but distinct differences are recognized at shoulder area of fore part (B in Fig.4), mid ship area and shoulder area of aft part (C in one). As area B is thrust zone due to pressure, bulge increases Cw. But bulge introduces to decrease Cw at area C that is resistance zone due to pressure. As result by integrating hull pressure, to decrease Cw is possible.It is considered that Cw is increased according to the increasing of Δ/L^3, L/B, Cb and so on by added bulge volume. On the other hand as in Fig.5, shoulder part of prismatic curve is cut due to increase of transverse area of mid ship by bulge. This modification of prismatic curve gives definitive decreasing of Cw.

A designing on bulge form

The bulge form is separated into sectional area and frame lines as same as in treating on aft hull form of fine ships by Miyata et al.[2]. Sectional area curve of

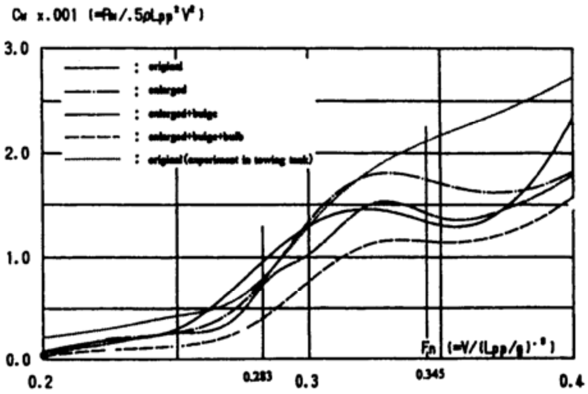

Fig.3 Calculated wave making resistance

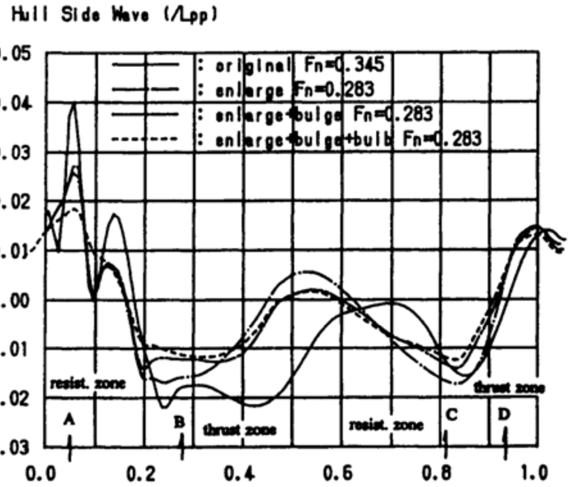

Fig.4 Calculated hull side wave (Fn=0.283)

bulge, Cpb is expressed analytically as in Fig.5. Here Cpb is consisted of linear part and shoulder parts. The shoulder parts are expressed by a cubic curve with conditions of the smooth connection at edges and shoulder points. Furthermore the condition of constant volume is added. Unknown parameters are length of parallel part lb and the center position of area x_{5B}. Positions at fore and aft edges is fixed. Through changing these parameters, the original Cpb is possible to be produced systematically.

On the other hand, methods of changing of bulge frame line by Eq.(1), Eq.(2) and Eq.(3) as in Fig.6 respectively are adapted under using of Cpb defined as above mentioned. The b1-method gives deformation for the zone of frame mainly near the free surface, the b2-method effects emphatically for the zone near the bottom of bulge and the b3-method induced the changing combined with b1and b2-method, here