MARITIME

SHOPERA Workshop WP2&4:
Simple Semi-Empirical Models for Calm-Water Forces X_s, Y_s and Moment N_s
Duisburg, 2015-03-16&17

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[5 min]

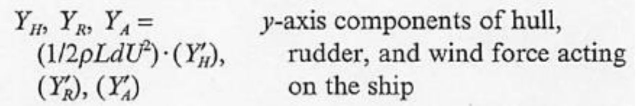
Confidential

Kang & Hasegawa (2007)

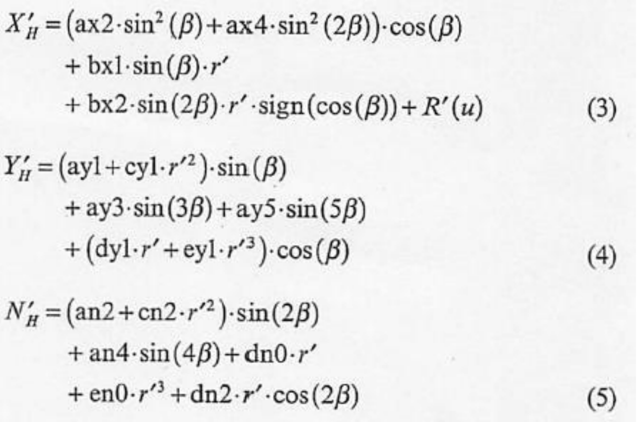
D. Kang & K. Hasegawa (2007) Prediction method of hydrodynamic forces acting on the hull of a blunt-body in the even keel condition, J. Mar. Sci. Technol. **12,** 1-14

- Extension of two well-known methods: *Kijima (2002)* and *Karasuno (2003)*
- Regression formulae to match both *Kijima* and *Karasuno* models for VLCC *Esso Osaka*
- Resulting method should be suitable for *blunt-body ships* in very broad region of drift angle and rotation rate: $-90^\circ < \beta < 90^\circ$ and $-1.6 \le r' \le 1.6$
- Broad region of drift angles is relevant for course-keeping; broad range of rotation rates is not necessary

Kang & Hasegawa (2007): Method Description



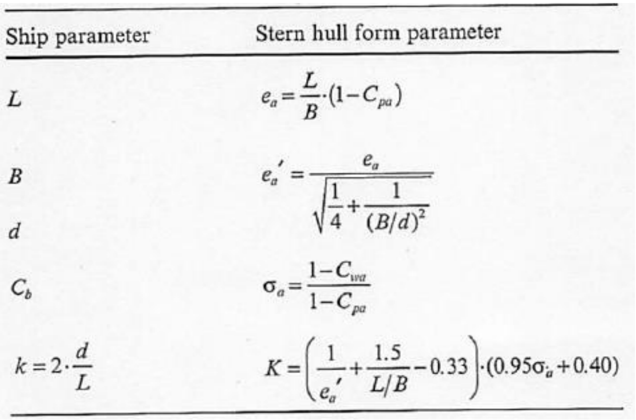
$Y_H, Y_R, Y_A = (1/2\rho L d U^2)\cdot(Y_H'), (Y_R'), (Y_A')$ — y-axis components of hull, rudder, and wind force acting on the ship



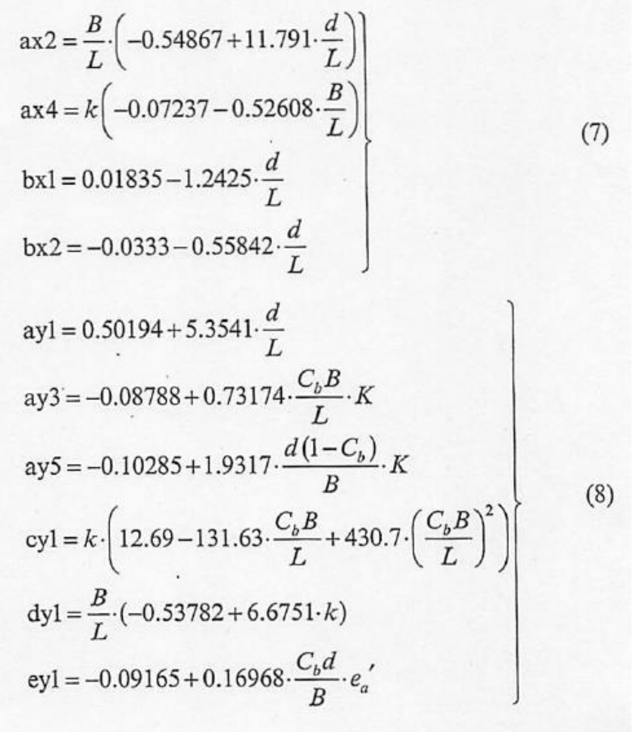
$$X_H' = (\mathrm{ax2}\cdot\sin^2(\beta) + \mathrm{ax4}\cdot\sin^2(2\beta))\cdot\cos(\beta) + \mathrm{bx1}\cdot\sin(\beta)\cdot r' + \mathrm{bx2}\cdot\sin(2\beta)\cdot r'\cdot\mathrm{sign}(\cos(\beta)) + R'(u) \quad (3)$$

$$Y_H' = (\mathrm{ay1} + \mathrm{cy1}\cdot r'^2)\cdot\sin(\beta) + \mathrm{ay3}\cdot\sin(3\beta) + \mathrm{ay5}\cdot\sin(5\beta) + (\mathrm{dy1}\cdot r' + \mathrm{ey1}\cdot r'^3)\cdot\cos(\beta) \quad (4)$$

$$N_H' = (\mathrm{an2} + \mathrm{cn2}\cdot r'^2)\cdot\sin(2\beta) + \mathrm{an4}\cdot\sin(4\beta) + \mathrm{dn0}\cdot r' + \mathrm{en0}\cdot r'^3 + \mathrm{dn2}\cdot r'\cdot\cos(2\beta) \quad (5)$$

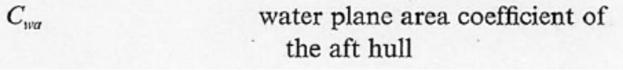


Ship parameter	Stern hull form parameter
L	$e_a = \frac{L}{B}\cdot(1-C_{pa})$
B	$e_a' = \frac{e_a}{\sqrt{\frac{1}{4}+\frac{1}{(B/d)^2}}}$
d	
C_b	$\sigma_a = \frac{1-C_{wa}}{1-C_{pa}}$
$k = 2\cdot\frac{d}{L}$	$K = \left(\frac{1}{e_a'}+\frac{1.5}{L/B}-0.33\right)\cdot(0.95\sigma_a+0.40)$

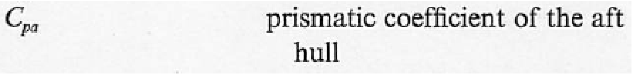


$$\left.\begin{aligned}
\mathrm{ax2} &= \frac{B}{L}\cdot\left(-0.54867+11.791\cdot\frac{d}{L}\right)\\
\mathrm{ax4} &= k\left(-0.07237-0.52608\cdot\frac{B}{L}\right)\\
\mathrm{bx1} &= 0.01835-1.2425\cdot\frac{d}{L}\\
\mathrm{bx2} &= -0.0333-0.55842\cdot\frac{d}{L}
\end{aligned}\right\} \quad (7)$$

$$\left.\begin{aligned}
\mathrm{ay1} &= 0.50194+5.3541\cdot\frac{d}{L}\\
\mathrm{ay3} &= -0.08788+0.73174\cdot\frac{C_bB}{L}\cdot K\\
\mathrm{ay5} &= -0.10285+1.9317\cdot\frac{d(1-C_b)}{B}\cdot K\\
\mathrm{cy1} &= k\cdot\left(12.69-131.63\cdot\frac{C_bB}{L}+430.7\cdot\left(\frac{C_bB}{L}\right)^2\right)\\
\mathrm{dy1} &= \frac{B}{L}\cdot(-0.53782+6.6751\cdot k)\\
\mathrm{ey1} &= -0.09165+0.16968\cdot\frac{C_bd}{B}\cdot e_a'
\end{aligned}\right\} \quad (8)$$



C_{wa} water plane area coefficient of the aft hull



C_{pa} prismatic coefficient of the aft hull

L/B, d/L, C_b

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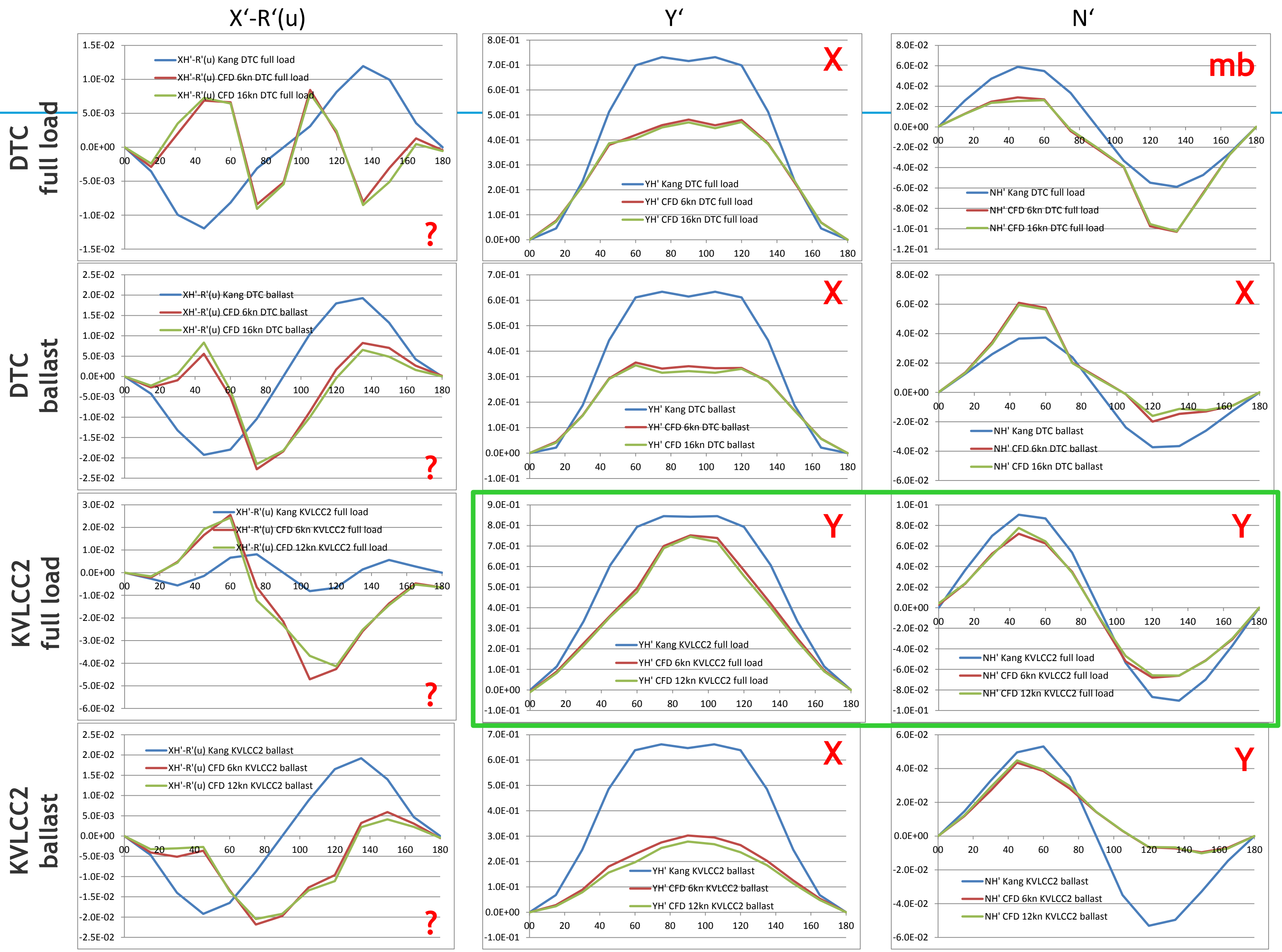
⇒ Looks rather as Level 2 method:

- Full geometry is required
- Calculations were done with *MS Excel*

Kang & Hasegawa (2007): Validation



Conclusions

- Method of *Kang & Hagesawa* can be used for full ships in full load
- However, is rather Level 2 than Level 1 method => a simpler method is desirable
- Empirical method is required anyway for slenderer ships in full load
- Ballast/heavy ballast loading conditions will not likely be relevant

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