Program for appended hull PMM tests in deep water

US Navy Combatant 5415

The following describes the tests carried out at FORCE Technology in 2000 (see Molgaard, A., 2000, "PMM-tests with a model of a frigate class DDG-51," FORCE-DMI 2000071, Report No. 1.).

Scope

PMM tests have been conducted in deep water (i.e. $h/T > 10$) with an appended model i.e. equipped with (stock) propeller, rudder and bilge keels. Model size was **L_{pp} = 4.0 m**, i.e. a scale of **1:35.48**. The model was free in heave and pitch, and the tests included heel (4 DOF). Approach speeds (U_0) are **18 kn** and **30 kn**. The nominal rates of revolutions (N_0) at these speeds are **73 rpm** and **136 rpm**, respectively. The scope of the tests covered the parameters given in Tables 1 and 2 in the stated combinations.

Note about propeller revolutions

In order to model the full-scale condition as closely as possible, the following two conditions were fulfilled:

1) The rate of revolutions was adjusted to the model scale self-propulsion point by applying a <u>tow rope force</u> to account for the theoretical friction force correction.

2) At speed fractions below the nominal approach speed, corresponding to a certain point in the manoeuvre (e.g. a turning circle), the rate of revolutions was reduced to maintain the correct loading on the propeller(s). This reduction follows a <u>constant torque</u> strategy for the fixed pitch propellers. Initial speed tests (at zero rudder and drift angles) were conducted to determine these rates of revolutions.

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Table 1: Scope of appended hull PMM tests in deep water for $U_0 = 18$ kn, DTMB 5415

	Speed U/U_0 (non-dim.)	Prop. Revs. (non-dim.)	Rudder Angle δ (deg)	Drift Angle β (deg)	Heel Angle ϕ (deg)	Sway Vel. v' (nondim)	Yaw Vel. r' (nondim)
STATIC TESTS							
static rudder	1.00	1.00	± 0, 10, 20, 30, 40	0	0	-	-
	0.80	0.89	± 0, 10, 20, 30, 40	0	0	-	-
	0.60	0.79	± 0, 10, 20, 30, 40	0	0	-	-
	0.40	0.67	± 0, 10, 20, 30, 40	0	0	-	-
static drift	1.00	1.00	0	± 0, 0.5, 1, 2, 4	0	-	-
	0.80	0.89	0	± 0, 2, 4, 6, 8, 10, 12	0	-	-
	0.60	0.79	0	± 0, 4, 8, 10, 12, 16	0	-	-
	0.40	0.67	0	± 0, 6, 10, 16	0	-	-
drift & rudder	0.80	0.89	± 0, 10, 20, 30, 40	± 8	0	-	-
	0.80	0.89	± 0, 10, 20, 30, 40	12	0	-	-
	0.60	0.79	± 0, 10, 20, 30, 40	± 16	0	-	-
static heel	0.60	0.79	0	0	± 8, 10	-	-
	0.40	0.67	0	0	-10	-	-
heel & drift	0.80	0.89	0	4, 6, 8, 10	-4	-	-
	0.60	0.79	0	-6, -10, -14, -16	8	-	-
	0.60	0.79	0	6, 10, 12, 16	-8	-	-
	0.60	0.79	0	-6, -10, -14, -16	10	-	-
	0.40	0.67	0	6, 10, 14, 16	-10	-	-
DYNAMIC TESTS							
pure sway	1.00	1.00	0	0	0	0.04, 0.07	0
	0.80	0.89	0	0	0	0.11	0
	0.60	0.79	0	0	0	0.14, 0.17	0
pure yaw	1.00	1.00	0	0	0	0	0.05, 0.10, 0.15, 0.20
	0.60	0.79	0	0	0	0	0.30
	0.60	0.79	0	0	0	0	0.60
yaw & drift	0.60	0.79	0	± 8	0	0	0.30
	0.60	0.79	0	± 16	0	0	0.60
yaw & rudder	0.60	0.79	± 10	0	0	0	0.30
	0.60	0.79	± 20	0	0	0	0.60
yaw & drift & rudder	0.60	0.79	± 10	± 8	0	0	0.30
	0.60	0.79	± 20	± 16	0	0	0.60

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Table 2: Scope of appended hull PMM tests in deep water for U_0 = 30 kn, DTMB 5415

	Speed U/U_0 (non-dim.)	Prop. Revs. (non-dim.)	Rudder Angle δ (deg)	Drift Angle β (deg)	Heel Angle ϕ (deg)	Sway Vel. v' (nondim)	Yaw Vel. r' (nondim)
STATIC TESTS							
static rudder	1.00	1.00	± 0, 10, 20, 30, 40	0	0	-	-
	0.80	0.88	± 0, 10, 20, 30, 40	0	0	-	-
	0.60	0.78	± 0, 10, 20, 30, 40	0	0	-	-
static drift	1.00	1.00	0	± 0, 0.5, 1, 2, 4	0	-	-
	0.80	0.88	0	± 0, 2, 4, 6, 8, 10	0	-	-
	0.60	0.78	0	± 0, 6, 10, 14, 16	0	-	-
drift & rudder	0.60	0.78	± 0, 10, 20, 30, 40	± 8	0	-	-
	0.60	0.78	± 0, 10, 20, 30, 40	12	0	-	-
static heel	1.00	1.00	0	0	-4,-8,-10	-	-
	0.80	0.88	0	0	-4,-8,-10		
	0.60	0.78	0	0	-4,-8,-10	-	-
heel & drift	0.80	0.88	0	-8,-10,-12	4	-	-
	0.80	0.88	0	4, 6, 8, 10	-4		
	0.60	0.78	0	-6,-12,-16	8	-	-
	0.60	0.78	0	6, 10, 12, 16	-8	-	-
DYNAMIC TESTS							
pure sway	1.00	1.00	0	0	0	0.04, 0.07	0
	0.80	0.89	0	0	0	0.11	0
	0.60	0.79	0	0	0	0.14, 0.17	0
pure yaw	1.00	1.00	0	0	0	0	0.05, 0.10, 0.15, 0.20
	0.50	0.74	0	0	0	0	0.40
	0.50	0.74	0	0	0	0	0.60
yaw & drift	0.50	0.74	0	10	0	0	0.40
	0.50	0.74	0	-16	0	0	0.60
yaw & rudder	0.50	0.74	-10	0	0	0	0.40
	0.50	0.74	20	0	0	0	0.60
yaw & drift & rudder	0.50	0.74	-10	10	0	0	0.40
	0.50	0.74	20	-16	0	0	0.60