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Calculation of Added Water Mass for 300t Fishery Administration Vessel

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Abstract. To avoid resonance and make the 300t fishery administration vessel meet the requirements of low vibration and noise, vibration characteristics must be predicted during the process of design. In order to more accurately predict the vibration characteristics, it is necessary to calculate the added water mass. Three-dimensional modeling of the 300t fishery administration vessel is constructed accurately to calculate added water mass. Lewis formula is employed to obtain the added water mass. The added water mass of first three order vertical and horizontal vibration are calculated in this paper. Under the condition of no load, the added mass of vertical vibration is greater than horizontal vibration. Under the condition of full load, the added mass of horizontal vibration is greater.

1. Introduction

As a ship of marine fishery law enforcement and marine accident relief, fishery administration vessel need a better mobility and reliability characteristics. Because the fishery administration vessel need to work in different sea conditions, especially the extreme harsh sea conditions, and to ensure the reliability and comfort of the ship operation, it is necessary to suppress the hull vibration and reduce the noise at the beginning of the design. Because the ship added water mass and ship structure weight in an order of magnitude, the added water mass affects the natural frequency of the ship under various operating conditions. The inertia of ship added water mass has a greater impact on the hull vibration. In order to more accurately predict the vibration characteristics of the newly designed 300-ton fishery administration vessel, the calculation of the added water mass is carried out under no load and full load condition in this paper.

2. Theoretical Analysis and Modeling

2.1 Calculation method of the added water mass.

The empirical formula method, the fluid finite element method and boundary element method are the mainly calculation method of ship added water mass. Based on the actual ship test, F. M. Lewis, F. H. Todd etc. puts forward the empirical formula used to calculate added water mass. To calculate the added water mass, the empirical formula method of Lewis is adopted. To calculate the vertical vibration of the ship, the formula of added water mass on the unit length is:

$$m_{av} = \frac{1}{2}\pi a_v C_v K_{vi} \rho b^2 \tag{1}$$

Where α_v, C_v, K_{vi}, ρ and b are shallow water correction factor, the correction factors of vertical vibration for added mass, three-dimensional flow correction factors of vertical vibration for added water, water density (t/m^3) and the half width of the waterline in rated section (m).

In calculating the horizontal vibration of the ship, the formula of added water mass on the unit length is:

$$m_{ah} = \frac{1}{2}\pi a_h C_h K_{hi} \rho d^2 \tag{2}$$

Where α_h, C_h, K_{hi}, ρ and *d*are marrow water correction factor, the correction factors of horizontal vibration for added mass, three-dimensional flow correction factors of horizontal vibration for added water, water density (t/m^3) and the sea gauge in rated section (m).

Table 1. Three-dimensional flow correction coefficient Kvi and Khi

L/B or L/d	1st order (i=1)	2nd order (i=2)	3st order (i=3)	4th order (i=4)	5th order (i=5)
5.0	0.700	0.624	0.551	0.494	0.477
6.0	0.748	0.678	0.614	0.560	0.515
7.0	0.786	0.719	0.661	0.611	0.568
8.0	0.815	0.756	0.698	0.653	0.611
9.0	0.839	0.784	0.733	0.687	0.647
10.0	0.858	0.808	0.759	0.716	0.677
11.0	0.874	0.828	0.782	0.742	0.706
12.0	0.888	0.845	0.802	0.763	0.730
13.0	0.890	0.859	0.820	0.783	0.751
14.0	0.909	0.870	0.835	0.803	0.770
15.0	0.917	0.883	0.848	0.818	0.788
20.0	0.947	0.920	0.895	0.876	0.857
25.0	0.968	0.944	0.925	0.909	0.894
30.0	0.980	0.958	0.940	0.924	0.910
35.0	0.987	0.967	0.950	0.934	0.922

Table 2. Added water mass coefficient Cv of vertical vibration

b/d β	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
0.0	1.510	1.100	0.935	0.860	0.815	0.785	0.760	0.755	0.750	0.750
0.1	1.250	0.975	0.860	0.800	0.775	0.765	0.755	0.752	0.753	0.753
0.2	1.060	0.880	0.805	0.764	0.750	0.750	0.750	0.750	0.750	0.752
0.3	0.815	0.815	0.760	0.750	0.750	0.755	0.760	0.770	0.775	0.790
0.4	0.800	0.740	0.750	0.750	0.765	0.770	0.775	0.780	0.800	0.801
0.5	0.740	0.760	0.765	0.774	0.785	0.790	0.800	0.816	0.825	0.831
0.6	0.700	0.788	0.802	0.815	0.830	0.842	0.852	0.865	0.875	0.880
0.7	0.860	0.880	0.895	0.905	0.915	0.920	0.925	0.933	0.940	0.942
0.8	1.035	1.035	1.032	1.030	1.025	1.020	1.020	1.018	1.015	1.010
0.9	1.320	1.270	1.240	1.200	1.185	1.162	1.150	1.130	1.120	1.115
1.0	1.980	1.760	1.640	1.570	1.518	1.472	1.434	1.400	1.375	1.355

Table 3. Added water mass coefficient Ch of horizontal vibration

b/d β	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
0.0	1.108	1.271	1.406	1.554	1.707	1.863	2.011	2.152	2.295	2.430
0.1	1.083	1.197	1.327	1.440	1.554	1.678	1.791	1.912	2.036	2.134
0.2	1.061	1.160	1.270	1.352	1.431	1.530	1.606	1.683	1.764	1.851
0.3	1.049	1.123	1.184	1.263	1.308	1.387	1.436	1.505	1.554	1.616
0.4	1.024	1.073	1.123	1.172	1.209	1.263	1.295	1.332	1.382	1.419
0.5	1.017	1.049	1.061	1.091	1.123	1.147	1.172	1.191	1.221	1.246
0.6	1.012	1.024	1.036	1.061	1.061	1.073	1.086	1.086	1.098	1.110
0.7	1.007	1.012	1.012	1.036	1.036	1.036	1.036	1.036	1.036	1.036
0.8	0.997	0.997	1.004	1.009	1.009	1.012	1.012	1.012	1.024	1.026
0.9	1.002	1.002	1.012	1.036	1.049	1.049	1.049	1.061	1.061	1.061
1.0	1.049	1.073	1.098	1.110	1.123	1.140	1.160	1.165	1.184	1.197

2.2 3D Modeling of the 300t fishery administration vessel.

Three-dimensional modeling is constructed accurately to calculate added water mass of the 300t fishery administration vessel. The main technical parameters are showed in table 4. As the structure is complex, three-dimensional model of the hull structure is established in Pro/E according to the design paper. 3D geometric model of the 300t fishery administration vessel is showed in Fig.1

Table 4 Main parameters of the 300t fishery administration vessel

Parameter	Size	Unit
Ship length	49.9	metre
Length between perpendiculars	47.0	metre
Molded breadth	7.6	metre
Moulded depth	4.3	metre
Frame space	0.5	metre
Mean draught of no-load condition	2.1	metre
Ligth displacement	269.2	ton
Full load displacement	340.1	ton

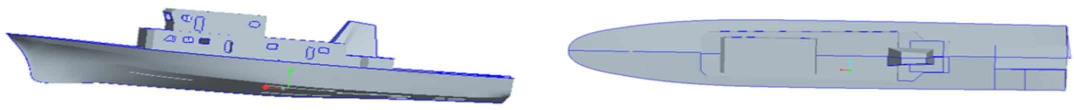

Fig. 1 Three-dimensional geometric model of the 300t fishery administration vessel

3. Calculation of the added water mass

Formula 1 and formula 2 are used to calculate the added water mass per unit length of each section. After calculating the added water mass of 21 segments, the average value of the added mass of the adjacent section is calculated. Finally, the added water mass of vertical and horizontal vibration are calculated. Reference ship vibration control guide of CCS, detailed calculation process of the added water mass of 1^{st} vertical vibration is showed in Table 5

Table 5. Calculation of added water mass of 1st vertical vibration

The vessel segmented number	Ratio of half width of waterline and sea gauge (b/d)	Area coefficient of rated section(β)	Added mass coefficient of vertical vibration (Cv)	3D flow correction factors (Kv1)	Added water mass in rated section(t/m)	Added water mass of vessel segmented (t)
0	1.096	0.176	0.750		4.373	—
1	1.612	0.257	0.760		9.584	16.399
2	1.641	0.310	0.770		10.061	23.084
3	1.668	0.356	0.781		10.542	24.209
4	1.695	0.405	0.790		11.011	25.325
5	1.719	0.452	0.805		11.545	26.503
6	1.742	0.501	0.821		12.090	27.772
7	1.760	0.549	0.825		12.408	28.785
8	1.771	0.593	0.875		13.324	30.235
9	1.767	0.617	0.875		13.264	31.241
10	1.729	0.615	0.870	0.748	12.622	30.416
11	1.653	0.599	0.865		11.475	28.314
12	1.547	0.584	0.859		9.980	25.210
13	1.411	0.569	0.826		7.979	21.102
14	1.239	0.557	0.816		6.079	16.518
15	1.042	0.500	0.785		4.139	12.006
16	0.828	0.500	0.774		2.576	7.890
17	0.622	0.552	0.783		1.468	4.752
18	0.409	0.575	0.788		0.639	2.476
19	0.193	0.551	0.720		0.130	0.904
20	0.000	0.00	0.000		0.000	0.152
∑Mv1						383.292

Table 6. Added water mass for no load

Order	Added water mass of vertical vibration(ton)	Added water mass of horizontal vibration(ton)
1	383.3	340.1
2	347.4	330.8
3	314.6	323.1

Based on the above method, the added water mass for no load of first three order vertical and horizontal vibration are calculated and showed in Table 6. The added water mass for full load of first three order vertical and horizontal vibration are showed in Table 7.

Table 7. Added water mass for full load

Order	Added water mass of vertical vibration(ton)	Added water mass of horizontal vibration(ton)
1	412.1	421.8
2	373.5	410.4
3	338.3	400.7

4. Summary

The main conclusions drawn from the results of this study are listed as follows:

(1)The added water mass of full load is greater than the no-load condition.

(2) Under the condition of no load, the added mass of vertical vibration is greater than horizontal vibration. Under the condition of full load, the added mass of horizontal vibration is greater.

(3)The added water mass for no-load is greater than light displacement; the added water mass for full load is greater than Full load displacement

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