STUDY ON DIFFERENT ESTIMATION METHODS OF PROPULSION POWER FOR 60 mts OFFSHORE SUPPLY VESSEL

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Abstract - *The ever increasing demand from oil and natural gas industries to construct offshore supply vessel. Propulsion power estimation plays keel roll while selecting main engine and its axillaries. So that it was considered an offshore supply vessel has their basic hull geometrical dimensions which was obtained by parent ship analysis and first approximation of displacement. There are several methods to obtain hull form resistance and powering requirement to propel the hull. In each estimation method, hull resistance and effective power calculated at various speeds of ship (i.e 10 to 19 kts) and compared among the various estimation methods.*

Key words: resistance, power, speed, offshore supply vessel

1. INTRODUCTION

One of the most important considerations for a naval architect is the powering requirement for a ship. Once the hull form has been decided upon, it is necessary to determine the amount of engine power that will enable the ship to meet its operational requirements. Knowing the power required to propel a ship enables the naval architect to select a propulsion plant, determine the amount of fuel storage required, and refine the ship's center of gravity estimate.

Throughout history, naval architects have endeavored to increase the speed of ships. Increased speed would enable a warship to close with its opponent, or conversely, to escape from an attack. Increased speed enables merchant vessels to reach port sooner and maximize profit for its owner.

Until the early 1800's, wind was the force used to propel ships through the water and ships could only go as fast as the wind would propel them. Additionally, because ships were constructed of wood, the structural limitations of wooden hull configurations drove hull designs to primarily meet the structural needs while hydrodynamics was only a secondary concern. With the advent of steam propulsion in the early 1800's, naval architects realized that ship speeds were no longer constrained by the wind and research began into the power required to propel a hull through the water using this new propulsion medium.

The three methods that are used to analyze the resistance of this offshore supply vessel are:

1. Resistance calculation by Guldhammer & Harvald
2. Resistance prediction by Holtrop method using Nav-cad
3. Resistance calculation by Oortmerssen using Nav-cad

2. CALCULATION OF RESISTANCE BY GULDHAMMER AND HARVALD METHOD

The resistance calculation is done by method described in "Resistance and Propulsion of Ships" by SV. AA . Harvald. [9]. Following parameters are used to calculate the resistance.

Length on Waterline Lwl	= 60.9 m
Breath on waterline	= 14.9 m
Draft	= 5.5 m
C_B (for L=Lwl)	= 0.69

C_P (for L=Lwl) = 0.705

Displacement = 3447.45 m^3

Wetted Surface Area = 1205.98 m^2

LCB = 2.8% aft of midship

The calculations are done for speeds of 10,11,12,13,14,15,16,17 and 18 knots. The values of 10^3 C_R is calculated for $L/\nabla^{1/3}$ = 4.03 which is obtained from Guldhammer and Harvald charts by extrapolating the values for $L/\nabla^{1/3}$ = 4 and

$L/\nabla^{1/3}$ = 4.5 .

To calculate the coefficient of frictional resistance, ITTC 1957 formula is used. $C_F = 0.075/(\log Rn - 2)^2$

Table-1a: various parameters calculated at various speeds of offshore supply vessel.

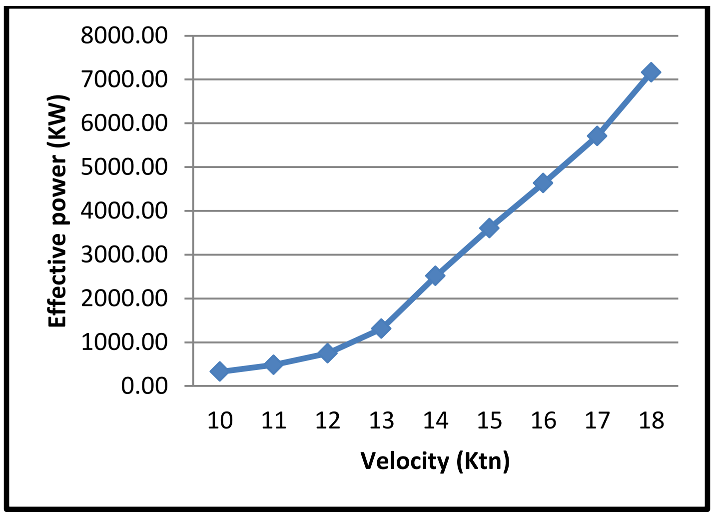
V(kts)	V (m/s)	Fn	0.5 * 1.025 *S*V²	10^3 Cr(4.03)	B/T corr	%LCB
10	5.14	0.21	16471.40	1.48	0.03	0.28
11	5.66	0.23	19930.39	1.93	0.03	-0.50
12	6.17	0.25	23718.82	2.77	0.03	-1.55
13	6.69	0.27	27836.67	4.72	0.03	-2.50
14	7.20	0.30	32283.94	**8.14**	0.03	-3.35
15	7.72	0.32	37060.65	9.40	0.03	-4.10
16	8.23	0.34	42166.78	9.36	0.03	-5.12
17	8.75	0.36	47602.34	8.68	0.03	-6.05
18	9.26	0.38	53367.33	8.39	0.03	-7.00

Table-1b: various parameters calculated at various speeds of offshore supply vessel.

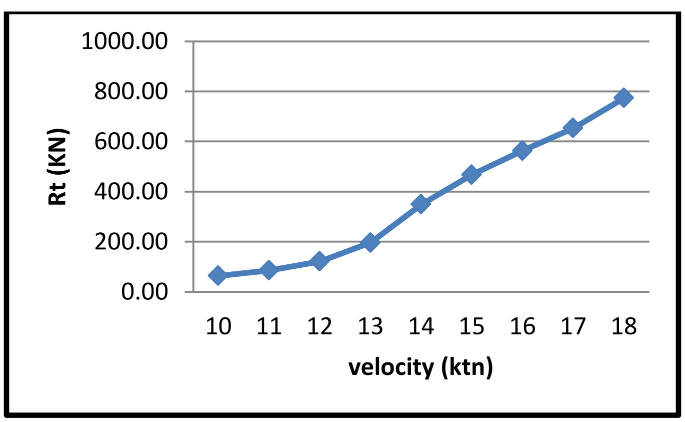
LCB std.	Cr/LCB	LCB Corr	Cr	Rn	Cf	S'/S
0.10	0.12	0.00	0.0015	2.6E+08	0.0018	1.01
-0.70	0.23	0.00	0.002	2.9E+08	0.0018	1.01
-1.70	0.31	0.00	0.0028	3.2E+08	0.0018	1.01
-2.70	0.42	0.00	0.0048	3.4E+08	0.0018	1.01
-3.50	**0.52**	**0.36**	0.0085	3.7E+08	0.0017	1.01
-4.30	0.62	**0.93**	0.0104	4E+08	0.0017	1.01
-5.20	0.72	**1.73**	0.0111	4.2E+08	0.0017	1.01
-6.20	0.82	**2.79**	0.0115	4.5E+08	0.0017	1.01
-7.20	0.88	**3.87**	0.0123	4.7E+08	0.0017	1.01

Table-1c: various parameters calculated at various speeds of offshore supply vessel.

Cf'	Ca correl	Ca air	Ca steer	C total	Rt (kN)	PE (kW)
0.0018	0.0004	0.00007	0.00004	0.004	63.54	326.85
0.0018	0.0004	0.00007	0.00004	0.004	85.33	482.81
0.0018	0.0004	0.00007	0.00004	0.005	120.9	746.88
0.0018	0.0004	0.00007	0.00004	0.007	195.8	1309.4
0.0018	0.0004	0.00007	0.00004	0.011	348.6	2510.4
0.0017	0.0004	0.00007	0.00004	0.013	467.2	3605.1
0.0017	0.0004	0.00007	0.00004	0.013	562.9	4633.2
0.0017	0.0004	0.00007	0.00004	0.014	652.8	5709.1
0.0017	0.0004	0.00007	0.00004	0.014	773.5	7162.6



Graph 1a: velocity (knots) vs effective power (KW)



Graph 1b: velocity(knots) vs Total resistance(KN)

Corrections:

a) B/T correction

= 0.16(B/T – 2.5)

= 0.0334

b) LCB correction

The value of LCBstd is read from the graph of LCBstd v/s Froude number. Also, the value of ə10^3 Cr/ə LCB is read from the graph of □10^3 Cr/ə LCB v/s Froude number.

The correction is = ə10^3 Cr/ə LCB * |əLCB| where |əLCB| is the distance between the LBCstd and the LCB of the ship.

Note: This correction is not applied when LBB of the ship is aft of LCBstd.

c) Bulbous bow correction

No bulb correction as no bulb is incorporated.

d) Correction for rudder

Area of rudder by DNV formula

$A_R = (T*LBP/100)* (1 + 25 (B/LBP)^2)$

$= 8.624 m^2$

The correction of C_F for appendages is made by increasing C_F proportional to the wetted surface area of the appendages. Thus $C_{F1} = S^1/S * C_F$ where S^1 is the wetted surface area of hull and appendages and S is the wetted surface area of bare hull.

e) Correction for roughness

For vessels with L< 100 m , $10^3 C_A = 0.4$

f) Correction for air resistance

In absence of the knowledge of the windage of the ship design, correction for air resistance is given by $10^3 C_{AA} = 0.07$

g) Correction for steering resistance

The correction for steering resistance is $10^3 C_{AS} = 0.04$

Thus the total resistance R_T is obtained by

$R_T = C_T * 0.5*ə*S*V^2$

And the effective power is obtained by $P_E = R_T * V$

Thus for the service speed of 14 knots, the total resistance and effective power are 383.46kN and 2761.526KW respectively.

3. RESISTANCE PREDICTION BY HOLTROP METHOD (1988) USING NAV-CAD

Analysis parameters

Bare-hull: Holtrop-1984 method, Appendage: Holtrop-1988 method

Technique: Prediction

C_F type: ITTC

Correlation allow (C_A): 0.00043

3-D correction: Form factor (1+k): 1.3193

Water type: Standard salt

Mass density: 1025.86 kg/m^3

Kinematic viscosity: 1.1883e-06 m^2/s

Hull data

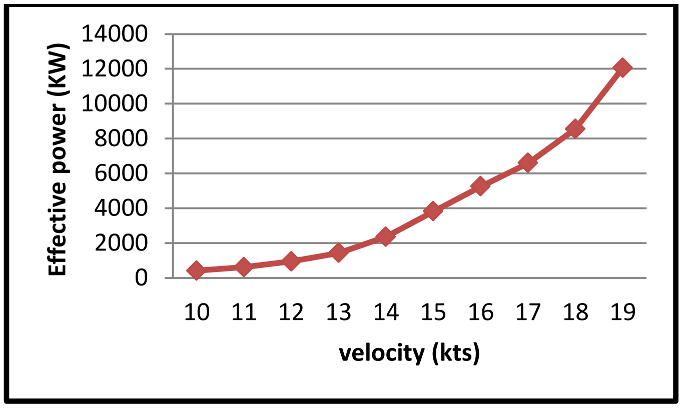
Length between PP:	58.6 m
Length on WL:	60.9 m
Max beam on WL:	14.9 m
Draft at mid WL:	5.5 m
Displacement bare:	3840.89 t
Mid ship area coef(Cx):	0.984
Waterplane coef:	0.89
Wetted surface:	1205.98m^2
LCB aft of FP:	30.96 m
Half ent angle:	34 deg
Bow shape:	V shaped
Stern shape:	U shaped
Loading:	Load draft
Rudders:	8.624 m^2 ,
Drag coefficient:	1.35
Wind speed:	Free stream
Arrangement:	Cargo ship

Table-2a: various parameters calculated at various speeds of offshore supply vessel by holtrop.

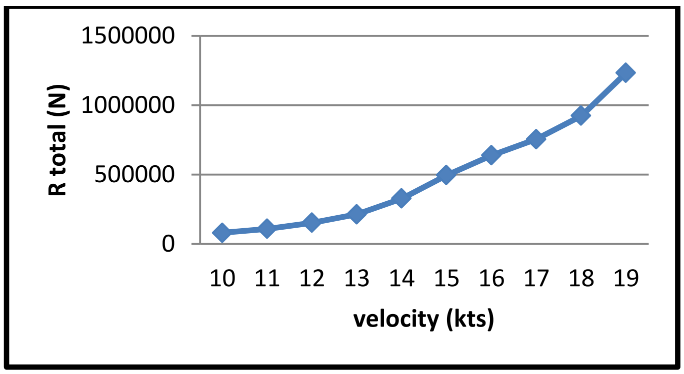
V(kts)	Fn	Rn	Cf	Cr	Ct
10	0.211	2.64E+08	0.001819	0.0016	0.0048
11	0.232	2.90E+08	0.001796	0.0023	0.0054
12	0.253	3.16E+08	0.001775	0.0033	0.0064
13	0.274	3.43E+08	0.001756	0.0046	0.0077
14	0.295	3.69E+08	0.001739	0.0071	0.0102
15	0.316	3.95E+08	0.001723	0.0103	0.0134
16	0.337	4.22E+08	0.001709	0.0121	0.0152
17	0.358	4.48E+08	0.001695	0.0129	0.0159
18	0.379	4.75E+08	0.001683	0.0144	0.0174
19	0.4	5.01E+08	0.001671	0.0178	0.0208

Table-2b: various parameters calculated at various speeds of offshore supply vessel by holtrop.

R bare(N)	Rwind (N)	R total(N)	R bare/W	PE bare (kW)	PE total (kW)
78865	0	78865	0.0023	405.7	405.7
107997	0	107997	0.0031	611.1	611.1
151992	0	151992	0.0044	938.3	938.3
213341	0	213341	0.0061	1426.8	1426.8
327197	0	327197	0.0094	2356.5	2356.5
494773	0	494773	0.0142	3818	3818
638125	0	638125	0.0183	5252.5	5252.5
753710	0	753710	0.0216	6591.6	6591.6
923375	0	923375	0.0265	8550.5	8550.5
1233503	0	1233503	0.0354	12057	12056.8



Graph 2a: velocity (knots) vs effective power (KW)



Graph 2b: velocity (knots) vs Total resistance (KN)

The total resistance and effective power for service speed of 14knots as predicted by this method are 327.197kN and 2356.5 KW respectively.

4. RESISTANCE PREDICTION BY OORTMERSSEN METHOD USING NAV-CAD

Analysis parameters

Bare-hull: Oortmerssen method

Appendage: Holtrop-1988 method

Technique: Prediction

C_F type: ITTC

Correlation allow (C_A): 0.00040

3-D corr: Form factor (1+k): 1.3193

Water type: Standard salt

Mass density: 1025.86 kg/m^3

Kinematic viscosity: 1.1883e-06 m^2/s

Hull data

Length between PP:	58.6 m
Length on WL:	60.9 m
Max beam on WL:	14.9 m
Draft at mid WL:	5.5 m
Displacement bare:	3840.89 t
Mid ship area coef(Cx):	0.984
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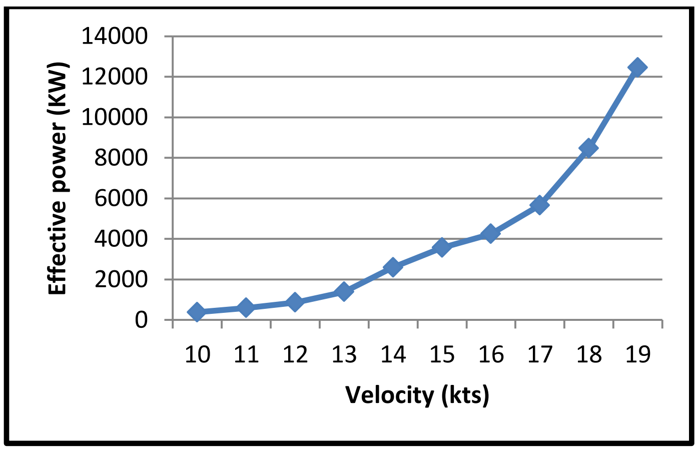
Wetted surface:	1205.98m^2
LCB aft of FP:	30.96 m
Half ent angle:	34 deg
Bow shape:	V shaped
Stern shape:	U shaped
Loading:	Load draft
Rudders:	8.624 m^2 ,
Drag coefficient:	1.35
Wind speed:	Free stream
Arrangement:	Cargo ship

Table-3a: various parameters calculated at various speeds of offshore supply vessel by oortmerssen.

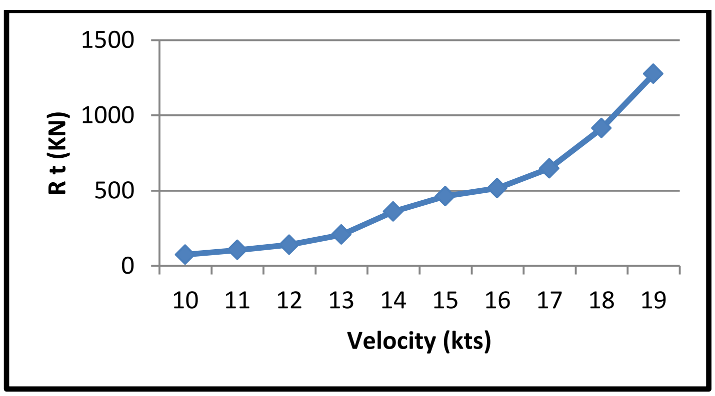
V(kts)	Fn	Rn	Cf	Cr	Ct
10	0.211	2.64E+08	0.0018	0.0019	0.0045
11	0.232	2.90E+08	0.0018	0.0027	0.0053
12	0.253	3.16E+08	0.0018	0.0034	0.0059
13	0.274	3.43E+08	0.0018	0.0049	0.0075
14	0.295	3.69E+08	0.0017	0.0087	0.0112
15	0.316	3.95E+08	0.0017	0.0100	0.0125
16	0.337	4.22E+08	0.0017	0.0098	0.0123
17	0.358	4.48E+08	0.0017	0.0112	0.0137
18	0.379	4.75E+08	0.0017	0.0148	0.0172
19	0.4	5.01E+08	0.0017	0.0191	0.0216

Table-3b: various parameters calculated at various speeds of offshore supply vessel by oortmerssen.

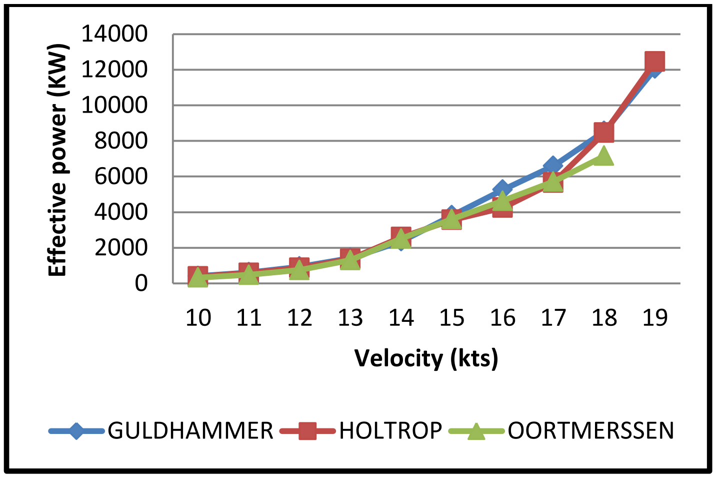
Rbare(N)	R wind (kN)	Rtotal (KN)	Rbare/W	PEbare(kW)	Petotal(kW)
73804	0	73.804	0.0022	379.7	379.7
104314	0	104.314	0.0031	590.3	590.3
140152	0	140.152	0.0042	865.2	865.2
206550	0	206.550	0.0061	1381.4	1381.4
360274	0	360.274	0.0107	2594.8	2594.8
462198	0	462.198	0.0137	3566.6	3566.6
515917	0	515.917	0.0153	4246.6	4246.6
647499	0	647.499	0.0192	5662.7	5662.7
913932	0	913.932	0.027	8463	8463
1274259	0	1274.25	0.0377	12455	12455.2



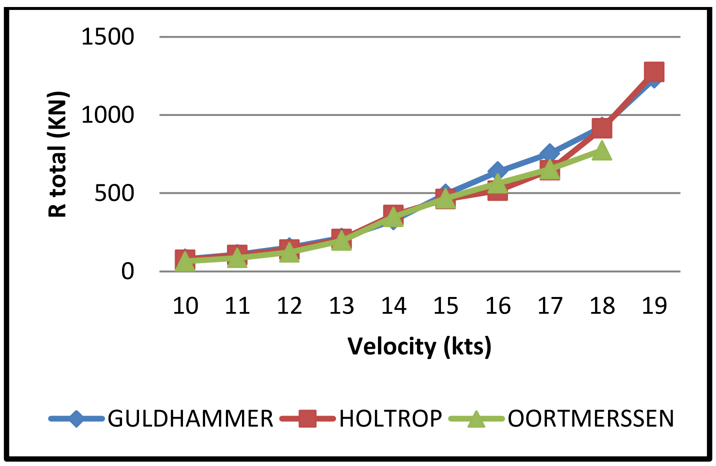
Graph 3a: velocity(knots) vs effective power(KW)



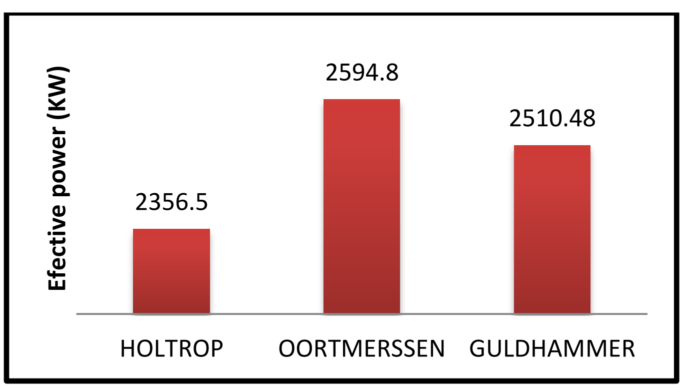
Graph3b: velocity(knots) vs Total resistance(KN)



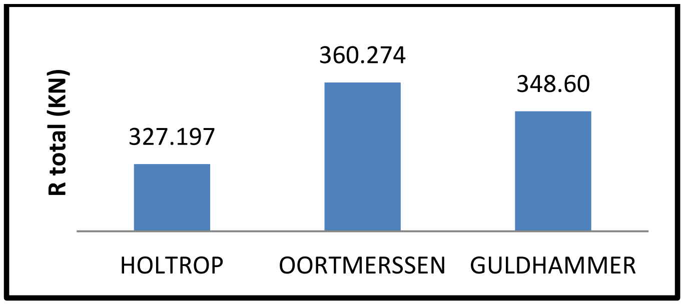
Graph 4a: Effective power vs speed (comparison among various methods)



Graph 4b: Resistance vs speed(comparison among various methods)



Graph 4c: Effective power vs speed at 14 knots (comparison among various methods)



Graph 4d: Resistance vs speed at 14 knots (comparison among various methods)

5. CONCLUSIONS

- The resistance and effective power is calculated by three methods at various speeds.
- From above graphs 4a and 4b found that the curve of guldhammer is higher at certain speed.
- Offshore supply vessel speed is restricted to 14 knots only.
- The resistance predicted by Oortmerssen method is more than that predicted by method Guldhammer and Harvald and holtrop method.
- Resistance calculated by all three method is almost similar ie 360.274kN, 327.197kN, and 348.6 kN.
- However selecting higher resistance value will reduce the risk.
- Hence, the resistance calculated by Oortmerssen method is used for further powering calculations.