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Effect of Whisker Spray on Power of High Speed Planing Hull

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Abstract: ***Total resistance comprises bare hull resistance, aerodynamic resistance and whisker spray resistance in planing hull. In this thesis, total resistance has been calculated by using C++ computer programming language according to method published by Savitsky in the October 1964. Data have been collected from the paper of Inclusion of Whisker SprayDrag in Performance Prediction method for High Speed Planing Hulls published in January 2007. Empirical formulas have been used as different functions of the code. Giving suitable condition for every function. Different variables are assigned and make it ready to be executed. Finally, all the instructions of the program are executed loaded in the memory. Thereof graphs have been generated automatically between Resistance Vs Speed by using Python computer programming language. Afterwards, results are validated with the values taken from the paper of Inclusion of Whisker Spray Drag in Performance Prediction method for High Speed Planing Hulls published in January 2007. After the validation of present program, required power for service planing vessel have been calculated and from which the effect of whisker spray on power of planing hull has been determined.***

Keywords: Planing Hull, Whisker Spray Resistance, Power Prediction

1. Introduction

The Savitsky method for predicting the performance of planing hulls was originally published in SNAME's Marine Technology, volume 1, number 1, dated October 1964[1].

This method continues to be used by naval architects even to this date (2006). Briefly, the method combines the elemental hydrodynamic characteristics of prismatic planning surface (lift, drag, wetted area and center of pressure) to determine the equilibrium running condition (trim, draft, wetted keel and chine length and resistance) and proposing tendencies of the hull as a function of hull dimension, loading, dead rise angle, LCG position and speed. The hydrodynamic equations are applicable only to the bottom pressure area aft of the leading edge stagnation line. The wetted bottom area forward of the stagnation line is called whisker spray area. Although it is identified in Savitsky (1964), its contribution to the total resistance was not completely developed or verified at that time. However, as the maximum speeds of planning craft continue to increase, it has been found that the whisker spray contribution to total resistance cannot be ignored.

In 2007, Savitsky, Michael F. DeLorme and Raju Datla found that the whisker spray resistance increased approximately as 4.3 power of the speed and was nearly 12% of the barehull resistance at a maximum speed of 46 knots. This is due mainly to the fact that the trimangle decreases from 9.2 degree at 20 knots to 3.58 degree at 46 knots. However, the whiskerspray resistance can be as large as 50% of the bare hull resistance and must be included when estimating the total resistance of high speed hull. [2].

The present paper identifies the whisker spray, quantifiesits contribution to the total drag as a function of trim angle, dead rise angle and speed. Since the performance speed effective method must include bare hull resistance, aerodynamic resistance and whisker spray resistance. In this paper C++ computer programming language is used to calculate the total resistance by adopting iteration process for solving nonlinear equation. After getting the output of the program, Python computer programming language is used to generate Resistance Vs Speed graph automatically.

However, the main focus is to carry out the effect of whisker spray resistance on power of high speed planing hull.

2. Methodology

Total resistance R_T, includes bare hull resistance, aerodynamic resistance and whisker spray resistance in planing hull. R_T has been calculated by using C++ computer programming code according to[1]. Data have been collected from the paper [2].

Empirical formulas [3] have been used as different functions of the code. Giving suitable condition for every function. Different variables are assigned and make it ready to be executed. Finally, all the instructions of the program are executed loaded in the memory.

Thereof graphs have been generated automatically between Resistance Vs Speed by using Python computer programming language. Afterwards, results are validated. After the validation of present program, required power for service planing vessel have been calculated and from which the effect of whisker spray on power of planing hull has been determined.

3. Results & Validation

3.1 Input Parameters [2]

- Weight of the boat, $\Delta = 115000\ ft$
- Deadrise angle, $\beta = 18.5^{o}$
- Beam at LCG, b = 16:2 ft
- Model scale, n = 12

- LCG = 27.5 ft
- Density, ρ = 1.937lb/ft^3
- Kinematic viscosity, ν = 0:00001078ft^2/sec
- Shaft angle, ε = 10º
- Roughness allowance = 0.0004
- Frontal area of hull, A_h = 164ft^2
- Air density, ρ_{Air} = 0.00234$lbsec^2/ft^4$

3.2 Summary of the Output

Table 1: Resistances at different speed

V (kts)	τ (deg)	R_{BH} (lbs)	R_{Air} (lbs)	R_s (lbs)	R_T (lbs)	% of R_s of R_T
30	4.74	14238.6	344.3	283.5	14866.4	1.906
32	4.71	14628.1	391.8	314.2	15334.1	2.049
34	4.63	14946.4	442.3	350.2	15738.9	2.225
36	4.52	15221	495.8	391.6	16108.4	2.43
38	4.38	15474	552.5	438.4	16464.9	2.66
40	4.22	16333	612.2	490.5	17435.7	2.813

3.3 Effect of Whisker spray on Total Resistance

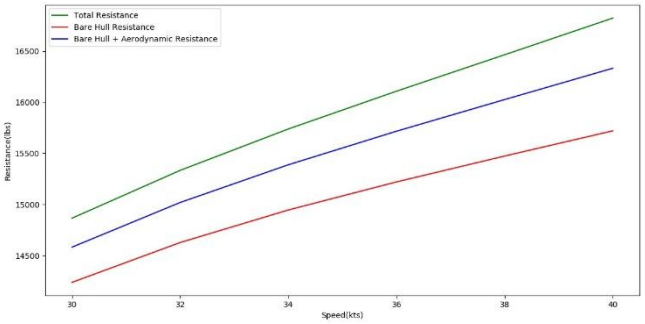

Figure 1: Resistance Vs Speed.

As the speed increases, trim angle τ gradually decrease and all component of resistance such as Bare hull resistance, Aerodynamic resistance, Whisker spray resistance increases simultaneously. It is shown that the magnitude of resistance component is dependent on the trim angle. It is largest operating at relatively low trim angle. The effect of whisker spray on total resistance gradually increases with the increase of speed. It has been seen from the Table 1 that the highest effect of whisker spray resistance on total resistance is 2.813% at speed 40 knot.

3.4 Validation

Table 2: Validation of Results

V (kts)	R'_{BH} (lbs)	R'_T (lbs)	R_{BH} (lbs)	R_T (lbs)	$D1$	$D2$
30	14230	14850	14238.6	14866.4	0.06	0.11
32	14580	15280	14628.1	15334.1	0.33	0.35
34	14860	15650	14846.4	15738.9	0.58	0.57
36	15120	16010	15221	16108.5	0.67	0.62
38	15360	16340	15474	16465	0.74	0.76
40	15620	16720	15720.8	16823.5	0.65	0.62

R'_{BH}= Bare Hull Resistance according to Savitsky method.
R'_T= Total Resistance according to Savitsky method.
R_{BH}= Bare Hull Resistance according to Present Program.
R_T= Total Resistance according to Present Program.

D1 = % of difference between Bare Hull Resistance according to Savitsky method and BareHull Resistance according to Present Program.
D2 = % of difference between Total Resistance according to Savitsky method and Total Resistance according to Present Program.

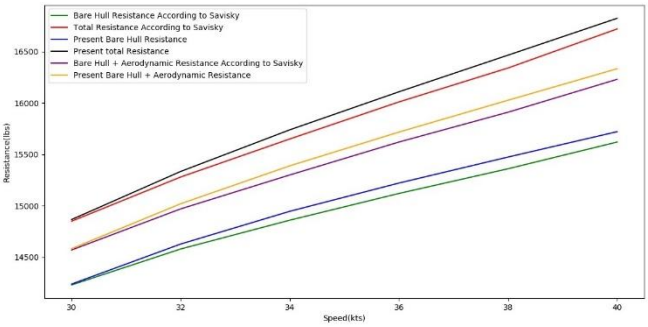

Figure 2: Validation of results

Figure 2 shows that Blue and Green curve indicates Bare Hull resistance calculated by present program and Bare Hull resistance according to Savitsky method respectively. Both the curves are very much close to each other. Similarly, Black and Red curves show that Total resistance calculated by present program and by Savitsky method respectively. They are also very much close to each other.

Table 2 shows that the minimum percentage of difference between Total resistance by present program and according to Savitsky method is 0.11% and the maximum percentage of difference between these two is 0.764%. For both maximum and minimum cases percentage of difference is less than 1% which is very much acceptable. There is a slight difference between these two because in the present program, iteration process has been used in present C++ program to solve several nonlinear equations and in Savisky method values have been determined from several graphs.

There is also a notable thing is that as the speed of the vessel increases, the percentage of differences is increases. As it has been already said that iteration process has been used to determine several parameters such as C_{LO}, λ, V_M which has direct or indirect relation with speed of the vessel.

3.5 Validation of Present Program with Excel Program

Current program which is developed by C++ computer programming language is validated by an excel program which was developed by Brian Trenhaile [4]. Input Parameters for the program are taken from [1].

Table 3: Validation of Results with Excel Program

V (kts)	$R_{BH-Excel}$ (deg)	R_{BH} (lbs)	% of difference
31	7332.07	7144.67	2.55
35.75	8310.89	8128.25	2.195
40.5	9284.14	9114.47	1.827
45.25	10347.18	10148.3	1.922
50	11480.21	11267.62	1.852

From the Table 3 it has been seen that the minimum and % of difference between the BareHull resistance calculated by Excel program and by C++ program are 1.852% and 2.55%.

There is a slight difference because in the Excel program nonlinear equations are solved by parabolic interpolation and in the present C++ program Newton - Raphson method is used to find the root and optimization. For both cases the % of difference is much less than 5%. This slight difference can be neglected. So, present program is validated successfully.

4. Effect of Whisker Spray on Power

4.1 Catalog Specification

- Length, L_{OA} : $310' - 6''$
- Beam : $8' - 6''$
- Depth : $3' - 6''$
- Power Recommended
  (a) Speed: 18 to 20 knots = 75 HP × 2
  (b) Speed: 25 to 28 knots = 115 HP ×2
- Capacity: 14 persons

Figure 3: MFG 33 XLC CABIN BOAT

4.2 MFG 33 XLC CABIN BOAT's Parameters

- Displacement, Δ=4.804 tonnes =10591.007 lb
- Deadrise angle, β= 20º
- Density, ρ = 1:937lb/ft^3
- LCG = 14.02364 ft
- VCG = 3.385 ft
- Air density, ρ_{Air} = 0:00234$lbsec^2/ft^4$
- Kinematic viscosity = 0.00001078 ft^2/sec
- Roughness allowance = 0.0004
- Propeller efficiency =0.55
- Selected Percentage for Continuous Operational RPM = 70% [4]

4.3 Calculation of Power

Table 4: Summary of Power Calculation

V (kt)	R_S (lb)	R_T (lb)	P'_E (HP)	P_E (HP)	P'_B (HP)	P_B (HP)	D'
25	84.27	1581.1	68	72	177	189	6.3
26	92.73	1625.7	73	77	189	200	5.5
27	102.1	1671.4	77	82	200	213	6.1
28	112.3	1718.5	82	88	213	227	6.2

- P'_E= Effective power without whisker spray
- P_E= Effective power with Whisker spray
- P'_B= Brake Horsepower for continuous operation without whisker spray
- P_B= Brake Horsepower for continuous operation with whisker spray
- D' = % of difference between P'_B&P_B

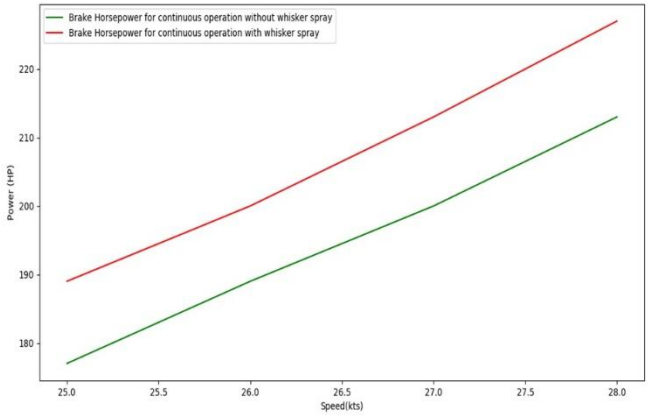

Figure 4: Power Vs Speed

From the Figure 4 it has been seen that red graph and the green graph indicates Brake Horsepower for continuous operation with whisker spray and Brake Horsepower for continuous operation without whisker spray respectively. As the speed of the vessel increases, for both cases the required horsepower increases gradually. For maximum speed 28 knot Brake horse power required after the consideration of whisker spray is 227 HP & without the consideration of whisker spray is 213 HP. There is sufficient gap between the red curve and the green curve. This indicates the effect of whisker spray on power. The gap between these 2 curves is more than 5%. So this amount cannot be negligible. This % of difference is the effect of whisker spray on power. So, for proper power prediction effect of whisker spray should be needed consideration.

4.4 Comparison between Present result& Catalog specification

Table 5: Comparison between Present result & Catalog specification

V(kts)	P_B(HP)	P_{BC}(HP)	% of difference
28	227	230	1.3

where,

- P_B =Present result Brake Horsepower for continuous operation with whisker spray
- P_{BCS} = Power required according to catalog specification

From Table 5it has been clearly seen that the percentage of difference between the Brake Horsepower which is calculated by Present program by considering the effect of whisker spray resistance and Power required according to catalog specification is 1.3% which is much less than 5%. So it can be said that both these values are matched with each other. Though there is a slight difference, it is negligible. For the calculation of Brake Horsepower, if whisker spray is not considered that it's value will be 213 HP. Then percentage of difference between these twos will become 7.39% which is greater than 5%. This magnitude cannot be neglected. So for the prediction of power of High Speed Planing Hull the effect of whisker spray has to be considered.

5 Conclusion

From the above study mentioned, the following conclusions can be drawn-

- The present computational method gives satisfactory results of equilibrium trim angle, Several coefficients, Bare Hull Resistance, Aerodynamic Resistance, Whisker Spray Resistance, Effective and Brake Horsepower and so on.
- Comparison of the present computed method results with the ref. [2] and the ref. [4] has shown good agreement. For all cases the percentage of difference between the results obtained by present computed method and the values in the following references is much less than 5% which is very much neglected. This present method is validated successfully.
- By the output obtained from the current C++ computer program, Graphs of Resistance Vs Speed have been generated automatically by Python computer program.
- As the developed program is giving satisfactory results compared with [2] and the ref. [4], the program can be used as design tool for prediction of power of planning hull.
- After the calculation of brake horsepower of planning hull, it has been observed that the effect of whisker spray on power is greater than 5%. In some cases, it will become even larger. So for proper power prediction the effect of whisker spray resistance on power cannot be ignored.

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