Chapter 7

Effect of Basis Hull Form on Design

7.1 Basis Hull Forms

The hull geometry manipulation is carried out as a weighted average of user defined basis hull forms [15] (as explained in section 4.2).

In this chapter the effect of the choice of basis hull forms on the design is studied. The cases used for the purpose involve two and three basis hull forms. Table 7.1 gives information on the three basis hull forms used in this study. The comparison of the three basis hull forms is based on the common principal dimensions and draft as mentioned in the table. This is necessary because a comparison of the hull forms is possible only if we use these common properties. The symbols used in the table are explained in the list of symbols. They are mentioned here again for convenient reference.

Table 7.1 Basis Ship Information

Loa (m)	B (m)	D (m)	T (m)
300	43	15	10

Ship [15]	Disp (m^3)	Cb	Cp	Cm	Cwp	Lcb (%L)	A_BT	H_B
Basis 14	80908	0.6272	0.7114	0.8779	0.8233	1.09	32.4	3.4
Basis 11	89010	0.6900	0.6953	0.9924	0.8303	1.59	33.4	3.4
Basis 22	92299	0.7155	0.7426	0.9635	0.8625	2.81	33.6	3.4

where

Loa	=	Length, overall in meters.
B	=	Beam, maximum in meters.
D	=	Depth, at side in meters.
T	=	Draft, design in meters.
Disp.	=	Displacement, volume in meters.
Cb	=	Block coefficient.
Cp	=	Prismatic coefficient.
Cm	=	Midship section coefficient.
Cwp	=	Waterplane coefficient.
Lcb	=	Longitudinal center of buoyancy forward of 0.5 L expressed as percentage of length.
A_BT	=	Transverse area of bulbous bow at the position where the still-water Surface intersects the stem expressed in $meters^2$.

H_B = Position of the area of bulbous bow above base expressed in meters.

7.2 Use of Different Hull Forms in Design

The purpose of Table 7.2 is to study the use of different hull forms on the design and to identify the best combination, in other words, the combination that gives the optimum ship. In this table, for each combination of hull forms case 1 shows the best point identified by starting from the lower bounds, upper bounds and the middle of the design space. Cases 2, 3 and 4 show the results starting from the point identified in case 1 and continuing until the results converge. The symbols used in the table are explained in section 4.4. They are mentioned here again for convenient reference.

M: Method used in DOT
1. MMFD: Modified Method of Feasible Directions
2. SLP: Sequential Linear Programming
3. SQP: Sequential Quadratic Programming

IT: Number of iterations

TC: Termination Criteria
- A: Relative convergence criteria (0.001) met for 2 consecutive iterations
- B: Absolute convergence criteria (0.0001) met for 2 consecutive iterations
- C: Search vector is less than the specified tolerance (0.0001)

AC: Constraints active at the optimum, in addition to the displacement-weight equality constraint:
- Fb: Freeboard Constraint (2.68)
- Troll: Rolling period constraint (2.70)
- GM: Constraint on metacentric height (2.67)
- L/D: Geometric constraint on the Loa /Depth ratio (2.65)

Table 7.2 Use of Different Hull Forms in Design: (a)

M	Loa	B	D	T	Vk	C14	C11	C22	Obj: RFR	IT	TC	AC
Basis Ships Used: 14 and 11												
Case 1. Best optimum point identified by starting from LB, UB and Middle of design space.												
1	299.8	43	14.7	10.0	17.19	0.00	1.00	-	.001029	14	A,B	Fb,Troll
2	300	43	14.7	10.0	17.94	0.02	0.98	-	.001031	11	A,B	Fb,Troll
3	300	43	14.9	10.2	17.56	0.31	0.69	-	.001034	5	C	Fb,Troll
Case 2. Starting from best point identified by MMFD												
1	300	43	14.7	10.0	17.19	0.00	1.00	-	.001029	2	A,B	Fb,Troll
2	300	43	14.7	10.0	17.39	0.03	0.97	-	.001029	14	A,B	Fb,Troll
Case 3. Starting from best point identified by SLP												
1	300	43	14.7	10.0	17.28	0.0	1.0	-	.001028	3	A	Fb,Troll
2	300	43	14.7	10.0	17.42	0.03	0.97	-	.001029	9	A	Fb,Troll

Table 7.2 Use of Different Hull Forms in Design: (b)

Case 4. Starting from best point identified by SQP												
2	300	43	14.7	10.0	17.56	0.00	1.00	-	.001029	7	A	**Fb,Troll**
3	300	43	14.9	10.2	17.45	0.30	0.70	-	.001034	2	C	Fb,Troll
Basis Ships Used: 11 and 22												
Case 1. Best optimum point identified by starting from LB, UB and Middle of design space.												
1	300	43	14.7	10.0	17.28	-	0.97	0.03	.001029	11	D,E	Fb,Troll
2	300	43	14.7	10.0	17.30	-	1.0	0.00	.001029	9	A	Fb,Troll
3	300	43	14.7	10.0	17.62	-	1.00	0.00	.001029	7	C	Fb,Troll
Case 2. Starting from best point identified by MMFD												
1	300	43	14.7	10.0	17.28	-	0.97	0.03	.001029	1	D,E	Fb,Troll
2	300	43	14.7	10.0	17.28	-	0.97	0.03	.001029	2	A	Fb,Troll
Case 3. Starting from best point identified by SLP												
1	300	43	14.7	10.0	17.3	-	1.00	0.00	.001029	2	ABCDE	Fb
2	300	43	14.7	10.0	17.22	-	1.00	0.00	.001029	5	A	Fb,Troll
Case 4. Starting from best point identified by SQP												
2	299.9	43	14.7	10.0	17.58	-	0.98	0.02	.001029	7	A,B	Fb,Troll
3	300	43	14.7	10.0	17.28	-	1.00	0.00	.001029	2	A,C	Fb,Troll
Basis Ships Used: 14 and 22												
Case 1. Best optimum point identified by starting from LB, UB and Middle of design space.												
1	300	43	15.6	10.2	17.06	0.16	-	0.84	.001045	12	A,B	Troll
2	300	43	15.7	10.1	17.21	0.00	-	1.00	.001044	10	A	Troll
3	300	43	15.6	10.2	16.75	0.20	-	0.80	.001047	14	A,C	Troll
Case 2. Starting from best point identified by MMFD												
1	300	43	15.6	10.2	17.09	0.14	-	0.86	.001045	2	A	Troll
2	300	43	15.6	10.1	17.15	0.05	-	0.95	.001044	6	A	Troll
Case 3. Starting from best point identified by SLP												
1	300	43	15.7	10.1	17.2	0.01	-	0.99	.001044	2	A,B	Troll
2	300	43	15.7	10.1	17.04	0.00	-	1.00	.001044	12	A	Troll
Case 4. Starting from best point identified by SQP												
2	300	43	15.7	10.1	17.04	0.00	-	1.00	.001044	8	A	Troll
3	300	43	15.6	10.2	17.18	0.18	-	0.82	.001046	4	A,B,C	Troll
Basis Ships Used: 14, 11 and 22												
Case 1. Best optimum point identified by starting from LB, UB and Middle of design space.												
1	300	43	14.7	10.0	17.3	0.00	1.00	0.00	.001029	10	A,B	Fb,Troll
2	300	43	14.7	10.0	17.2	0.0	0.99	0.01	.001029	8	A,B	Fb,Troll
3	300	43	14.9	10.2	17.4	0.34	0.58	0.08	.001036	8	A,C	Fb,Troll
Case 2. Starting from best point identified by MMFD												
1	300	43	14.7	10.0	17.3	0.00	1.00	0.00	.001029	2	A,B	Fb,Troll
2	299.9	43	14.7	10.0	17.6	0.00	1.00	0.00	.001029	13	A	**Fb,Troll**

Table 7.2 Use of Different Hull Forms in Design: (c)

Case 3. Starting from best point identified by SLP												
1	300	43	14.7	10.0	17.2	0.0	0.99	0.01	.001029	2	A,B	Fb
2	300	43	14.7	10.0	17.4	0.03	0.97	0.01	.001029	5	A	Fb,Troll
Case 4. Starting from best point identified by SQP												
2	299.9	43	14.7	10.0	16.9	0.04	0.95	0.01	.001030	20	A,B	Fb,Troll
3	300	43	14.9	10.1	17.2	0.26	0.68	0.06	.001034	4	A,C	Fb,Troll

Observations

The results in decreasing order of goodness are as follows:

- Using basis hulls 11 and 22; Optimum hull: 11.
  Using basis hulls 14, 11 and 22; Optimum hull: 11
  Using basis hulls 14 and 11; Optimum hull: 11.
  Note: These three cases give the same result.
- Using basis hulls 14 and 22. Optimum hull: 22

We see that the optimizer favors basis hull 11, the intermediate hull, over basis hull 22, the full hull. The hydrostatic properties of the resultant hull forms in the decreasing order of the goodness of the results are shown in Table 7.3.

Table 7.3 Hydrostatic properties of resultant hull forms

Basis Ships/ Case	Cb	Cp	Cm	Cwp	A_BT	H_B
14 and 11/ 4.2	.6860	.6914	.9922	.8190	36.6	3.8
11 and 22/ 3.2	.6814	.6907	.9865	.8176	36.7	3.8
14 and 22/ 4.2	.6817	.6913	.9861	.8195	36.6	3.8
14, 11 and 22/ 3.2	.6948	.7314	.9499	.8334	39.2	4.0

7.3 Conclusions

Using three basis hulls, for the above-mentioned combination of basis hull forms and for the formulation of the problem as explained in section 4.1,gives as good a result as the best combination of two basis hulls. But the additional degree of freedom does not show an improvement in the objective function.

The flatness of the objective function, as seen from the insensitivity of the objective function to the blending coefficient (Figure 5.2: f), in the vicinity of the optimum could be the cause. Also this is not an anomaly because we can perceive the problem as trying to maximize the cargo carrying capacity, in other words, maximize the volume available for container stowage. Changing the shape of the hull using the added degree of freedom need not result in a significant or even noticeable change in the volume.

SLP is the method to use to converge to a local optimum once a good point is identified in the design space. This can be seen from the results of the optimization process provided in Table 7.2 for any given combination of basis hulls. SQP used for the purpose does not give good convergence.