Chapter 8

Detection of Numerical Errors

The objective function is found to be a non-smooth function of the design variables. The cause of the non-smoothness was tracked down to an error in the calculation of the sectional area coefficient and corrections were made to make the objective function smooth.

8.1 Alpha Plots

The alpha plot is a diagnostic tool used to detect noise in a response by plotting the response along a straight line in the design space. The line is obtained by joining two points (X_1 and X_2) identified in the design space that show non-smooth behavior:

$$X = \alpha X_1 + (1-\alpha) X_2$$

where
X is the vector of design variables.

Table 8.1 shows results obtained starting from two different points in the design space. The abbreviations used in this table are explained in section 4.1. The basis hull forms (discussed in section 7.1) used are 14 and 22 and the method used is Sequential Quadratic Programming. An alpha plot between the resultant vector of design variables, as in Figure 8.1, shows the non-smooth behavior of the objective functions: the return on investment (2.63) as well as the required freight rate (2.62).

Table 8.1 Results indicating lack of convergence

Design Variable	Loa	B	D	T	Vk	C14
Starting Pt. 1	225.8	30.5	16.5	8.4	23	0.2
Starting Pt. 2	225.8	35.5	16.5	8.4	23	0.2

Loa	B	D	T	Vk	C14	C22	Obj: ROI	IT	TC	Disp.
Optimum point starting from Pt.1										
300	42.1	18.2	11.0	21.43	0.00	1.00	94.68	12	B	98386
Optimum point starting from Pt.2										
290.8	41.5	18.0	11.0	21.88	0.17	0.83	92.66	7	B	90610

8.2 Elimination of Numerical Error

To find out the cause of this jump in the objective function, the design corresponding to point 6 in Figure 8.1 was checked for feasibility. Note that the twenty-one points on the x-axes in Figures 8.1 and 8.2 correspond to values of α from 0.0 to 1.0 at intervals of 0.05. It was found that the constraint that displacement be equal to weight was violated.

The displacement and weight are plotted along with the objective functions in Fig. 8.1. It can be seen that a drop in weight is the cause of the displacement- weight constraint violation.

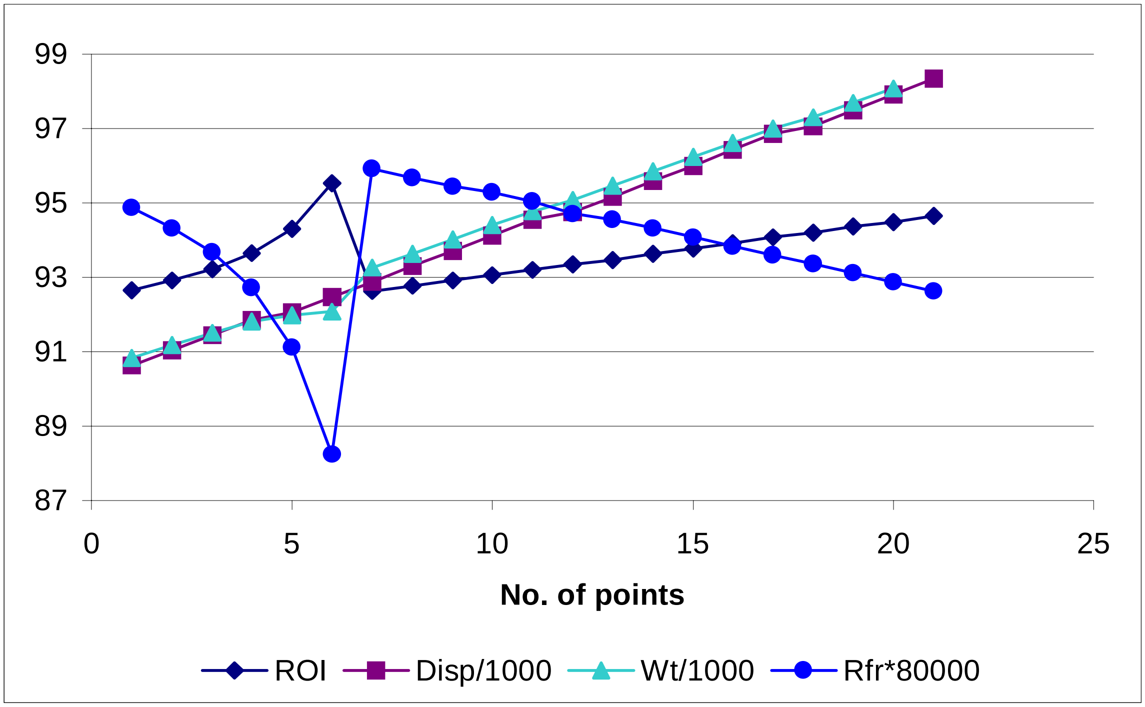

Figure 8.1: Representation of design space between two optima showing non-smoothness

A comparison of the parameters leading to the weight at points 6 and 7, as in Table 8.2, revealed that the drop in the total weight at point 6 was caused by a drop in the fuel weight which in turn was due to a drop in SHP. Since the propulsion module assumes a constant overall propulsive efficiency, this drop is caused by the resistance.

Table 8.2: Comparison of parameters at points 6 and 7 in figure 8.1

Parameter	**Point 6**	**Point 7**	**% Diff.**
Total weight	92075	93259	1.27
Lightship	24924	25342	1.65
Cargo	65094	65397	0.463
Fuel weight	1685	2148	21.55
SHP	39,700	50,543	21.45
Resistance	17,19,053	21,91,572	21.56

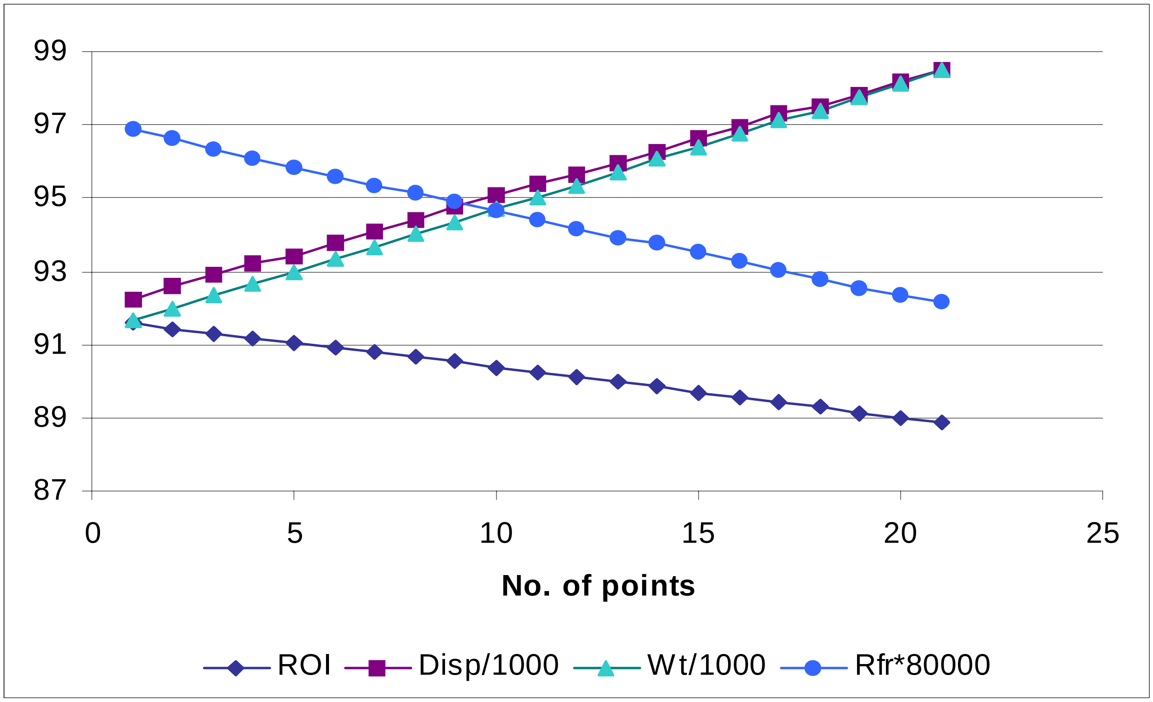

Figure 8.2: Representation of design space between two optima, non-smoothness eliminated

From an examination of the resistance module the problem was tracked down to a numerical error in the calculation of the mid-ship section coefficient. Figure 8.2 shows the same parameters as in Fig. 8.1 plotted in the same range after correction of the error. It can be seen that the non-smoothness has been eliminated.