Algorithm for Preliminary Design Optimization of Modern Fishing Vessels.

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Abstract— The making of a Software for optimization design procedure for fishing vessels parameters depend on adequate flow chart and computer program. This work present the flow chat, the formulas and result of a developing QBASIC program based on the presented flow chart for the optimization algorithm for fishing vessels design. This work aim at putting together some of the methods of fishing vessels design presented by the author as well as other authorities concerning obtaining the optimum preliminary design of fishing vessels.

Index Terms— Fishing, vessels, design, logical, lateral, thinking, flowchart, formulas, QBASIC, optimization, program.

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1 Introduction

Methods of preliminary design of fishing vessels are based on owner requirements mainly fish hold capacity, trial speed, endurance, main power amongst others. These methods include the following:

The substitution method basing on empirically derived formulas from which the design vessel parameters are derived by systematic substituting the owner requirements in the formulas [1]. This process yields one design option- the statistical Regression Best Fit (RBF) according to regression analysis for which the formulas were derived. Typically exemplified by references [1],[2][3] and others.

The iterative method where conflicting owner requirement variables limited by constraints serve as input. This is the case when deadweight range, length range or engine power range are given by the owner [4],[5]. In this case a discrete stepwise range of these parameters are substituted in the empirical equations iteratively so as to get the projected design which satisfy the bounds stipulated by the owners. This method could yield one or more results of the projected vessel parameters. In some cases one or more of the bounds may be modified in other to get some rational results.

The optimization method which involves the two methods above mentioned including a stepwise increment in the optimized ship parameter objective function and recalculation processes in the other ship constraint functions to obtain the optimum (maximized or minimized) set of ship dimensions [6], [7], [8],[9]. The model of optimization could be linear (Simplex), non-linear, based on single or multiple objective functions, and bounded by equality or inequality defined functions. These functions are defined by the formulas that characterize the design process. The projected vessel parameters from this process will be the optimum option provided all the boundary constraints are well formulated. This method can yield the optimum alternative projected design that satisfied the objective function, the equality and inequality constraints.

The flow chat presented here involves iterative substitution optimization methods. The empirical formulas or rational equations that are derived mainly by regression analysis and by ship design principles are utilised as the system expressions. The constraints are the parametric limits of the formulas used and vessel performance constraints like vessel stability criteria, and freeboard limits.

A developing QBASIC computer program is written based on the presented flow chat. Detailed listing of the QBASIC program is presented. A validation result from the program is presented in Table 1. The major empirical formulas used in the program are clearly presented inside the program. Apart from References listed above, other publications where these and many more empirical formulas related fishing vessels design are [10], [11], amongst others.

Output from the program must meet with the criteria for required minimum stability, freeboard and deck wetting [12], stipulated by International Maritime Organization or others [13]

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2. MATERIALS AND BACKGROUNDS.

2.1 Background Material for the Boat Design Flowchart

The fishing vessel design procedures are presented by the authorities cited above. In this work a new methods involving lateral thinking approach following Edward de Bono's work [14] is applied. This is coupled with the well-known optimization approach. The author used QBASIC program language in other to express the method in an easy to understand way. The main input expressions are some of the empirical formulas presented by the relevant references already mentioned above.

The algorithm adopts a categorization of decision making procedure classified as:

Logical or vertical thinking decision guided by the logical-truth table yielding "true" or "false", "1"or "0"result and well adopted by all computer programming languages and,

Lateral thinking decision making method which is associated with the new word "po" coined by Edward de Bono. Po means neither yes or no, true or false, 1 or 0, go or stop.

Po means, create, search and generate all possible alternative design, features or characteristics which satisfy the goals and constraints using all possible and conceivable methods. The conceivable methods could be structural, non-structural, random, hierarchical or otherwise, linear, or none linear, discrete, continuous, arbitrary, intuitive, sequential or otherwise provided it predict all alternative design parameters of the designed ship which can safely satisfy the required demands.

Where the vertical (logical) thinking could yields "no" or "yes" results, lateral thinking can yield more acceptable results (basing on any method, any other knowhow or anywhere), from which the optimal result may emerge. In both thinking the desired optimal result is the parameters which best satisfy all the essential design constraints in consideration of the alternative trade-offs or trade-ins necessary to achieve the best option.

The resulting flow chat for the fishing vessels design presented below utilise both lateral thinking and logical thinking in its methodology. The conventional flow chart and even the computer programming languages are design very much on the bases of logical thinking, but the lateral thinking method is introduced here in this work as well. However, we indicate that modern developments in computer programming such as the Object Oriented Programming methods try to adopt some aspects of the lateral thinking philosophy

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2.2 The Boat Design Flowchart.

The author created the flow chart on the bases of the creative or lateral as well as logical thinking and optimization method. This is shown in Fig 1. below. The lateral thinking "po" is introduced as the fourth arm after the logical "yes" or "no" branches of the decision test box. The designer experience data are values taken from existing vessels and are explained in the program at the input in line 2010 to 2200 below. In the main process box are the expressions comprising of:

- The substitution of owner requirement input to the empirical regression formulas for the regression best fit RBF design vessel dimensions.

- The iterative stepwise calculation basing on the RBF prediction and on the objective function of the optimization process.

- The checking of the predicted vessel dimensions for conformity with constraints such as safety, freeboard. **X** is the equality and inequality regression functions of the dimension of fishing vessels. Where L, B, D, d and F are the vessels length Breadth, depth, draft, and freeboard respectively then

X = (L,B,D,d, F ….) the vector of design vessel dimension variables clearly defined in the program below in section 2.3. The results emanating from the algorithm are the dimensions of all possible alternative vessels which can satisfy the owner requirements, the safety and other design criteria which are also included in the program. The developing computer program has an input and output result shown below in section2.3. The choice of QBASIC is to achieve universal easy understanding of the program pedagogically and otherwise. The input variables, mathematical and logical expressions, as well as the output procedures are presented in the program. A basic knowledge of BASIC programming language is required.

2.3 The Computer Program

The listing of the actual computer program written by the author basing on the flow chart shown in fig 1 is shown below. The program runs on Microsoft DOS QBASIC environment which is the easiest interpreter to be understood by the widest populace in arts, science and engineering.. The program will be re-written in any other computer language as it develops further.

The input variables to the program are explained and listed in the program line 3960 to 4084 for the owner requirement and lines 2350 to 3630 for the vessel operational and masses data. In line 650 the stepwise iteration process started and loops at line 3620 . A maximum of 50 iterations is allowed for this iterative loop by the program for a particular input variables set. Actual number of iterations can be varied by the user, but the program displays result of authentic feasible results which could be any number less than 50 results. The program is for the design of fish vessels limited between 15 to 50m in length. Owner requirement inputs which predict lengths or parameters outside this range cannot be designed by this program.

The program prints the feasible result on the monitor screen and saves the result on files names SFVESS and SVALT –see line 2830 named SUBROUTINE PRIVES.

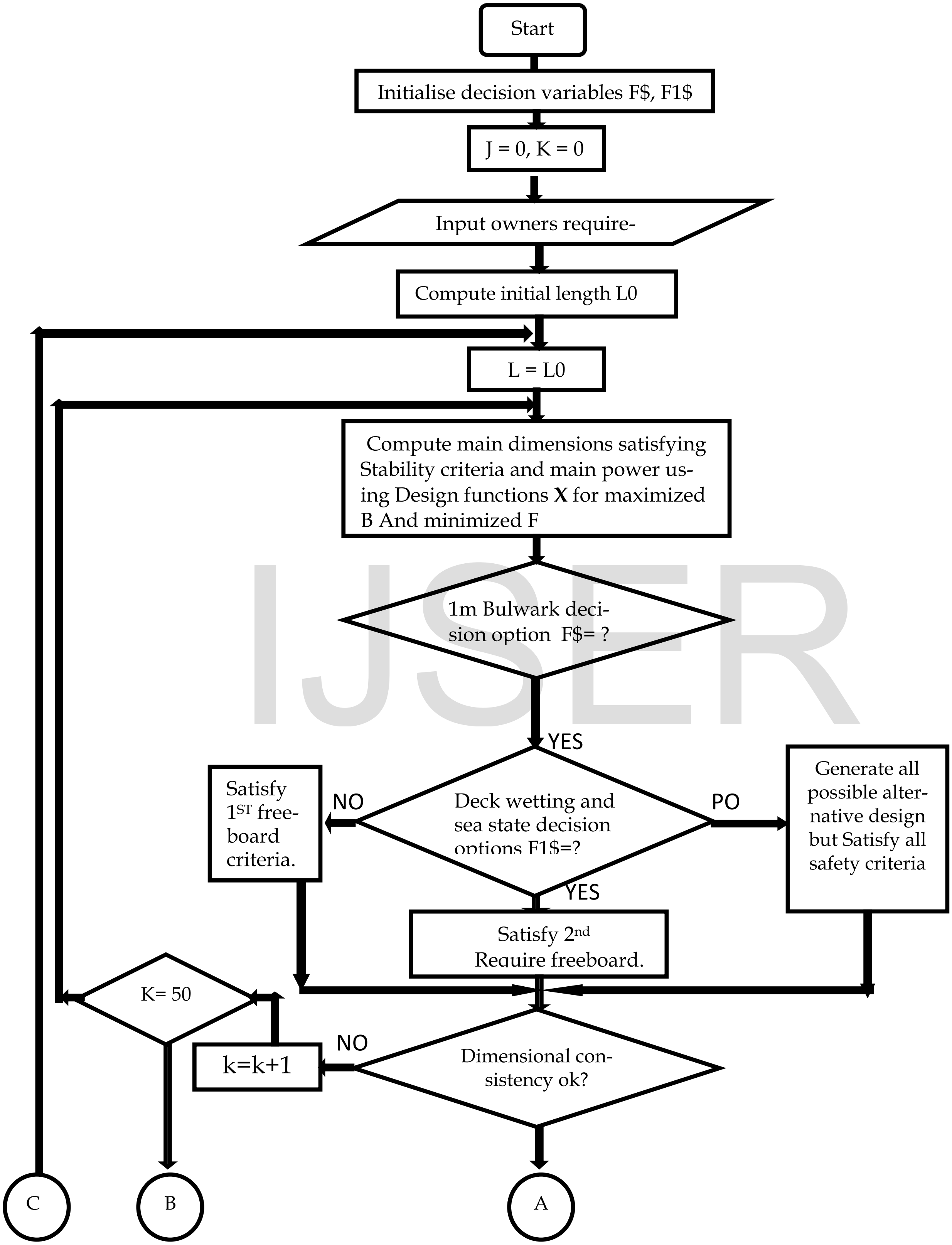

FIG 1. VESSEL DESIGN OPTIMIZATION FLOW CHART

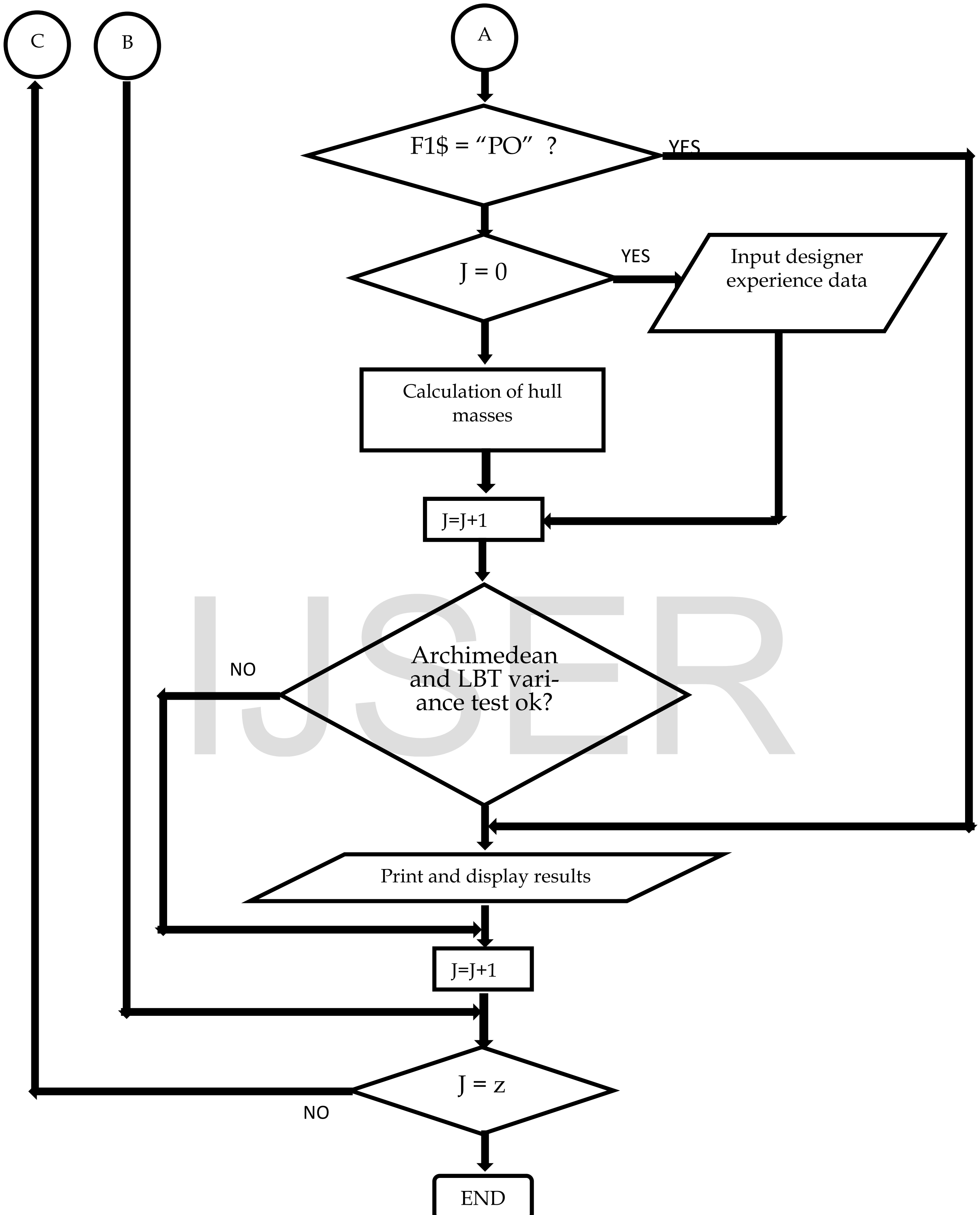

FIG.1 CONTINUED

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90 REM PROG 06 MAY 2016
100 REM SAFE FISHING VESSELS RESEARCH
110 REM PROGRAMME SFVES BY DR. ENGR. S.C.DURU
120 PRINT "PROGRAM SFVES1 IS VALID FOR VESSELS"
130 PRINT " OF LENGTH BETWEEN PERPENDICULARS LPP= 15M TO 540M"
140 OPEN "SVALT" FOR OUTPUT AS #10
150 OPEN "SFVESS" FOR OUTPUT AS #20
160 PRINT #20, "PROGRAMME SFVES1 IS VALID FOR VESSEL "
170 PRINT #20, "OF LENGHT BETWEEN PERPENDICULARS LPP=15M TO 50M"
180 P0 = (-1)
190 Q = 0
200 X = 0
210 U1 = 0
220 F0$ = "F"
230 F$ = "I"
240 F1$ = "S"
250 F2$ = "H"
252
260 PRINT #20, "****************************************************** DESIGN(MOULDED) PARTICULARS ************************************************"
270 PRINT #20, "Q   N  L     B    d    D   CB   DISP   LPP/B B/d   LBd    LBD  B/D    F/B    P    P/V   GRT   F    F1    F2   GM "
280 PRINT #20, "      (M)    (M)   (M)   (M)        (T)    (M^3)    (M^3)              (KW) (KW/Kn)        (M)   (M)   (M)  (M)   "
290 PRINT
300 REM INPUT OWNERS REQUIREMENT
310 PRINT "INPUT FISH HOLD CAPACITY (METRIC TONNES)"
320 INPUT V1
330 PRINT "INPUT STOWAGE FACTOR IN (T/M^3)'"
340 INPUT S1
350 V0 = V1
360 V1 = V1 / S1
370 PRINT "INPUT ENDURANCE (HOURS IN OPERATION AT SEA)"
380 INPUT H
390 PRINT "INPUT NUMBER OF CREW AND OFFICERS"
400 INPUT N1
410 PRINT "INPUT NUMBER OF OFFICERS ALONE"
420 INPUT N2
430 PRINT "TRIAL SPEED (KNOTS) OTHERWISE INPUT ZERO"
440 INPUT V
450 PRINT
460 REM
470 REM DESIGN PROCESS COMMENSES
480 REM
490 PRINT "INPUT MAX NUMBER OF ALTERNATIVE DESIGN OF VESSELS"
500 PRINT "YOU ITIRATIVELY LIKE TO HAVE"
510 INPUT Z
520 Z1 = INT(Z / 2)
530 Z2 = Z / 2
540 IF Z1 = Z2 GOTO 570
550 Z = INT(Z / 2)
560 GOTO 580
570 Z = Z / 2 - .5
580 PRINT "INPUT REVIEW OPTION (YES=0;NO=1)"
590 INPUT U
600 U0 = U
601 IF U <> 0 OR U <> 1 GOTO 580
615 REM C1 = L*B*T(M^3) [1]
618 REM BASIC PREDICTED VESSEL'S LENGTH (m)
610 IF V1 <= 10 GOTO 3900
620 C1 = 4.816 * V1 - 44.297
630 L = .015 * C1 + 17.381
640 F$ = "NYN"
650 FOR J = 0 TO Z STEP .5
655 FF = -2
660 IF U1 = 1 GOTO 690
670 L = L + J
680 GOTO 710
690 L = L - J
700 IF L <= 0 GOTO 3560
710 L4 = L
720 X = X + 1
730 Q = Q + 1
740 IF V > 0 GOTO 760
745 REM V = VESSELS SPEED [KNOTS]
746 REM C2=BLOCK COEFFICIENT
747 REM L1 = L/B [2]
748 REM L2 = L*B*D [1]
749 REM B1 = VESSELS BREADTH B(m)
750 V = .002 * C1 + 9.323
760 C2 = .92 - .35 * V / (L / .305) ^ .5
770 IF C2 < .445 GOTO 3560
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780 IF C2 > .715 GOTO 3560
790 L1 = 2 + .055 * L
800 IF L < 15 GOTO 3560
810 IF L <= 40 GOTO 840
820 IF L <= 50 GOTO 860
830 GOTO 3560
840 B = L / L1
850 GOTO 870
860 B = L / (L1 - .5)
870 L2 = 61.496 * L - 852.124
880 D = L2 / (L * B)
890 B1 = 2.041 * D - .008
900 IF B1 < B GOTO 920
910 B = B1
920 IF B > 2.45 * D GOTO 940
930 GOTO 950
940 D = B / 2.04
950 IF B >= 1.65 * D GOTO 970
960 D = B / 1.65
970 T = C1 / (L * B)
980 IF B > 2.75 * T GOTO 1000
990 GOTO 1010
1000 T = B / 2.6
1010 IF B >= 2.1 * T GOTO 1030
1020 T = B / 2.1
1022 REM F = FREEBOARD(m)
1025 IF F$ = "PO" GOTO 1040
1027 IF F$ = "NO" GOTO 1040
1030 F = .02 * L + .1
1040 IF F <= D - T GOTO 1070
1050 T = D - F
1060 GOTO 1080
1070 F = D - T
1080
1090 F6 = F
1095 REM  IMO TOREMOLINOS CONSTRAINTS FOR FREEBOARD
1096 REM  ARE APPLIED - LINE 1100 TO 1280
1097 REM G1 = METACENTRIC RADUIS (m) RE-QUIRED
1098 REM F1 = MIN. FREEBOARD FOR SIG. WAVE HEIGHT<=2.9m
1099 REM F2 = MIN. FREEBOARD FOR SIG. WAVE HEIGHT<=1.4m
1100 IF F6 > .2 * B GOTO 1130
1110 IF F6 < .04 * B GOTO 1150
1120 GOTO 1190
1130 F6 = .2 * B
1140 GOTO 1190
1150 F6 = .04 * B
1160 IF F6 <= F GOTO 1190
1170 F = F6
1180 GOTO 1040
1190 G1 = (.6 + .05 * B) - .25 * F6
1200 F6 = 0
1210 IF B > 3.1 * T GOTO 3560
1220 IF G1 < .42 GOTO 1240
1230 GOTO 1250
1240 G1 = .42
1250 F1 = .53 + .11 * B + .32 * (2.6 - B / T) + .85 * (C2 - .6) + .61 * (G1 - .7)
1260 F2 = .85 + .23 * (2.6 - B / T) + .52 * (C2 - .6) + .62 * (G1 - .7)
1262 IF FF = FF1 OR FF = FF5 GOTO 1640
1270 GOTO 1320
1280 PRINT "IF BULWARK HEIGHT < 1meter OR"
1290 PRINT "FOR GUIDE RAILINGS ONLY please input /YES/"
1300 PRINT "OTHERWISE input /NO/"
1310 INPUT F1$
1320 IF F1$ = "YES" GOTO 1350
1330 IF F1$ = "NO" GOTO 1640
1340 GOTO 1280
1350 IF F >= F1 GOTO 1380
1360 IF F >= F2 GOTO 1430
1370 GOTO 1620
1380 PRINT
1390
1400
1410 IF Q < 50 GOTO 730
1420 GOTO 1850
1430 PRINT "THE PREDICTED VESSEL CAN FISH IN SEA STATE UPTO"
1440 PRINT "SIGNIFICANT WAVE HEIGHT OF 1.4meter AT PROBABILITY"
1450 PRINT " OF WETNESS NOT LESS THAN 5% (FREEBOARD = F1)"
1460 PRINT
1470 GOTO 1580
1480 PRINT "IF YOU WOULD BE FISHING IN SEAS OF SIGNIFICANT"
1490 PRINT " WAVE HIEGHT UPTO 2.9meter input /YES/"
1500 PRINT "OTHERWISE input /NO/"
1510 PRINT
1520 PRINT "IF YOU INPUT /PO/ YOU WILL HAVE A CHANCE TO CHOOSE A"
1530 PRINT "DESIGN WITH CAPABILITY OF FISH-ING IN 2.9M SINIFICANT"
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1540 PRINT "WAVE HEIGHT[WITH GUARD RAILS (NO BULWARK) ONLY"
1550 INPUT F$
1560 IF F$ = "YES" GOTO 1600
1570 IF F$ = "NO" GOTO 1640
1580 IF F$ = "PO" GOTO 1620
1590 GOTO 1480
1600 F = F1
1602 FF = F1
1604 FF1 = F1
1610 GOTO 1390
1620 F5 = .2294 * L ^ .5 - .057 * L / B + .0285 * L / D - .1084 * B / D + .017 * C2
1625 F = F5
1626 FF = F5
1627 FF5 = F5
1630 GOTO 1390
1632 REM H1 = BOW HEIGHT AT FP [4]
1633 REM P = MAIN POWER OF VESSEL(m)
1634 REM G2 = GROSS REGISTER TONNAGE(GRT)
1635 REM X0 = L*B*T[1]
1636 REM D1 = SEA WATER DISPLACEMENT (M^3)
1640 H1 = .117 * L * (1 + L / 220)
1650 P = V * (3.172 * L - 34.764)
1660 G2 = 10.526 * L - 134.158
1670 Y1 = B / T
1680 Y2 = B / D
1690 Y3 = P / V
1700 Y4 = F / B
1710 Y5 = V / L ^ .5
1720 Y6 = L * B * T
1730 X0 = 90 * L - 2500
1740 Y7 = L * B * D
1750 Y9 = L / B
1760 D1 = C2 * Y6 * 1.025
1761 IF FFF2 > 0 GOTO 1826
1762 IF F < F2 GOTO 1821
1770 IF F >= F1 GOTO 1820
1780 IF F >= F2 GOTO 1800
1790 GOTO 1830
1792 REM P1$ = "~" SYMBOL FOR F1 PREDICTED VESSELS
1794 REM P1$ = "^" SYMBOL FOR F2 PREDICTED VESSELS
1796 REM P1$ = "*" SYMBOL FOR RAISED DECK PREDICTED VESSELS
1800 P1$ = "~"
1810 GOTO 1830
1820 P1$ = "^"
1821 FFF2 = F
1822 F = F2
1823 D = T + F
1824 P1$ = "*"
1825 GOTO 1680
1826 IF Y6 >= L2 - 5 OR Y7 <= L2 + 5 GOTO 1829
1827 GOTO 3560
1829 FFF2 = 0
1830 IF F$ = "PO" GOTO 2790
1840 GOTO 1920
1850 PRINT "Q=50"
1860 PRINT
1870 PRINT "A T T E N T I O N !! 50 VESSEL HAVE BEEN PREDICTED"
1880 PRINT
1890 PRINT
1900 PRINT "PLEASE CHECK YOUR OWNERS RE-QUIREMENT"
1910 PRINT "INPUT FOR MODIFICATION"
1920 PRINT
1930 REM
1940 REM WEIGHT CALCULATION COMMENCES
1950 REM
1960 F2$ = "PO"
1970 IF F0$ = "F" GOTO 2010
1980 IF J > 0 GOTO 2130
1990 IF U1 = 1 GOTO 2130
2000 IF U = U + 1 GOTO 2130
2010 PRINT "INPUT RATIO OF LENGHT OF FULL BREADTH ERECTION"
2020 PRINT "TO SHIPS LENGHT (l1/LPP)"
2030 INPUT A
2040 PRINT "INPUT RATIO OF HEIGHT OF FULL BREADTH DECK"
2050 PRINT "TO SHIPS DEPTH (h1/D)"
2060 INPUT B2
2070 PRINT "INPUT RATIO OF LENGHT OF FULL BREADTH DECK"
2080 PRINT "HOUSING TO SHIPS LENGHT (l2/LPP)"
2090 INPUT C
2100 PRINT "INPUT RATIO OF HEIGHT OF FULL BREADTH DECK"
2110 PRINT "HOUSING TO SHIPS DEPTH (h2/D)"
2120 INPUT D2
2130 IF P0 = 0 GOTO 2220
2140 PRINT
2150 PRINT "NOTE THAT PREDICTED MAIN POWER [KW] ="; P
2160 PRINT
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2170 PRINT "INPUT CHOSEN MAIN ENGINE REVOLUTION PER MINUTE"
2180 INPUT R1
2190 PRINT "INPUT MAIN ENGINE POWER (KW) OR ZERO"
2200 INPUT P0
2210 IF P0 > 0 THEN LET P = P0
2212 REM M7 = MASS OF STEEL(TONNES)
2213 REM M8 = MASS OF OUTFIT(TONNES)
2214 REM M9 = MASS OF MACHINERY(TONNES)
2220 M7 = L * (B + T) + .85 * (D - T) + (.85 * A * B2 + .75 * C * D2) * L * D
2230 M7 = .037 * M7 ^ 1.36
2240 M8 = .00417 * L + .16667
2250 M8 = M8 * L * B
2260 M9 = 20 * (1.341 * P / R1) ^ .75
2270 D3 = M7 + M8 + M9
2280 PRINT
2290 PRINT "N/B LIGHTSHIP WEIGHT WITHOUT RESERVE WL(T)="; D3
2300 PRINT
2310 IF F0$ = "F" GOTO 2350
2320 IF J > 0 GOTO 2640
2330 IF U1 = 1 GOTO 2640
2340 IF U = U + 1 GOTO 2640
2350 PRINT "INPUT RATIO OF WEIGHT RESERVE TO LIGHTSHIP WL"
2360 INPUT E1
2370 D4 = (1 + E1) * D3
2380 PRINT "INPUT MAIN ENGINE FUEL CON-SUMPTION T/KW/HR)'"
2390 INPUT F3
2400 M1 = F3 * P * H
2410 PRINT
2420 PRINT "N/B MAIN POWER FUEL CONSUMP-TION WITHOUT"
2430 PRINT "RESERVE WF(T)="; M1
2440 PRINT
2450 PRINT "INPUT RATIO OF FUEL RESERVE TO WF"
2460 INPUT C3
2470 PRINT "INPUT AUX. ENGINE FUEL CON-SUMPTION (T/MAIN POWER[KW]/HR)"
2480 PRINT "{IF INCLUDED IN FUEL RESERVE ABOVE INPUT ZERO"
2490 INPUT F4
2500 PRINT "INPUT NUMBER OF AUXILLIARY ENGINES"
2510 INPUT N3
2520 PRINT "INPUT LUBRICATING OIL CON-SUMPTION (T/KW/HR)"
2530 INPUT O1
2540 PRINT "INPUT FRESH WATER CONSUMP-TION(T/HR/MAN)"
2550 INPUT W1
2560 PRINT "INPUT MASS PER OFFICER AND BAGGAGE (T)"
2570 INPUT G
2580 PRINT "INPUT MASS PER CREW AND BAG-GAGE (T)"
2590 INPUT M
2600 PRINT "INPUT MASS OF PROVISIONS PER MAN(T/HR)"
2610 INPUT P1
2620 PRINT "INPUT MASS OF SANITARY WATER PER MAN (T/HR)"
2630 INPUT N
2640 M1 = (C3 + 1) * M1 + N3 * F4 * P * H
2650 M2 = O1 * P * H
2660 M3 = W1 * N1 * (H + 96)
2670 M4 = G * N2 + M * (N1 - N2)
2680 M5 = P1 * N1 * H
2690 M6 = N * N1 * H
2700 D5 = V1 + M1 + M2 + M3 + M4 + M5 + M6
2710 D6 = D4 + D5
2720 Y8 = (D1 - D4) / D5
2730 IF Y8 < .8 THEN LET F2$ = "NO"
2740 IF Y8 > 1.2 THEN LET F2$ = "NO"
2750 IF Y6 < X0 THEN LET F2$ = "NO"
2760 IF Y6 > 2 * Y6 - X0 THEN LET F2$ = "NO"
2770 IF F2$ = "PO" THEN LET F2$ = "YES"
2780 F0$ = "O"
2790 GOSUB 2830
2800 IF Y >= X + 1 GOTO 3560
2810 IF F$ = "PO" GOTO 1480
2820 GOTO 3560
2830 REM SUBROUTINE PRIVES
2840 REM
2850 REM
2860 PRINT "NUMBER OF ITERATIONS   Q="; Q
2870 PRINT "N-TH ALTERNATIVE DESIGN      N="; X
2880 PRINT
2890 PRINT "***** OWNERS REQUIREMENT ******************"
2900 PRINT "FISH HOLD CAPACITY VH(M^3)      ="; V1
2910 PRINT "ENDURANCE AT SEA H(HRS)         ="; H
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2920 PRINT "NUMBER OF CREW+OFFICERS        ="; N1
2930 PRINT "SHIPS TRIAL SPEED (KNOTS)      ="; V
2940 PRINT "*******************************************"
2950 PRINT
2960 PRINT "****** SHIP DESIGN(MOULDED) PARTICULARS ***********"
2970 PRINT "LENGHT      LPP(M)          ="; L
2980 PRINT "BREADTH        B(M)          ="; B
2990 PRINT "DRAUGHT        d(M)          ="; T
3000 PRINT "DEPTH          D(M)          ="; D
3010 PRINT "BLOCK COEFFICIENT CB          ="; C2
3020 PRINT "DISPLACEMENT DISP(T)          ="; D1
3030 PRINT "LPP/B="; Y9; "B/d="; Y1; "LBd(M^3)="; Y6; "LBD(M^3)="; Y7
3040 PRINT "GRT="; G2; "B/D="; Y2; "F/B="; Y4; "P(KW)="; P
3050 PRINT "P/V(KW/KN)="; Y3; "V/L^.5(KN/M)="; Y5
3060 PRINT "LEAST SQUARE FIT LBd (M^3)="; C1
3070 PRINT "**************************************************"
3075 PRINT "PRESS "; 0; (ZERO); " TO CONTINUE"
3076 INPUT NS1
3080 PRINT #20, USING "## ###  ##.## ##.## ##.## ##.## .### ####.## ##.## ##.## ####.## ####.## ##.## ##.## ####.## ###.## ####.## ##.## ##.## ##.## ##.## # "; Q; X; L; B; T; D; C2; D1; Y9; Y1; Y6; Y7; Y2; Y4; P; Y3; G2; F; F2; F1; G1;
3090 PRINT #20, P1$
3110
3120 PRINT
3130 PRINT "***DECKWETNESS (PROB. OF OCCURENCE=5%) & STABILITY DATA***"
3140 PRINT "FREEBOARD FOR POSITIVE STABILITY          F(M)="; F
3150 PRINT "PFREEBOARD FOR SEA STATE <= 1.4M"
3160 PRINT "(SIGNIFICANT WAVE HEIEGHT) F1(M)="; F2
3170 PRINT "PFREEBOARD FOR SEA STATES <=2.9M"
3180 PRINT "(SIGNIFICANT WAVE HEIGHT) F2(M)="; F1
3190 PRINT " MINIMUM BOW    HEIGHT HBMIN(M)="; H1
3200 PRINT "METACENTRIC HEIGHT GM(M)="; G1
3210 PRINT "**************************************************************"
3220 PRINT
3230 IF F1$ = "NO" GOTO 3270
3240 Y = Y + 1
3250 IF F2$ = "YES" GOTO 3270
3260 GOTO 3550
3270 PRINT "************* HULL MASSES DATA *********************"
3280 PRINT "MASS OF STEEL                    MS(T)="; M7
3290 PRINT "MASS OF OUTFIT MO(T)="; M8
3300 PRINT "MASS OF MACHINERY MM(T)="; M9
3310 PRINT "MASS OF FUEL                     MF(T)="; M1
3320 PRINT "MASS OF LUBRICATING OIL ML(T)="; M2
3330 PRINT "MASS OF FRESH WATER MW(T)="; M3
3340 PRINT "MASS OF SANITARY WATER MSA(T)="; M6
3350 PRINT "MASS OF PROVISION MP(T)="; M5
3360 PRINT "MASS OF CREW,OFFICERS+BAGGAGE      MCOB(T)="; M4
3370 PRINT "DEADWEIGHT DWT(T)="; D5
3380 PRINT "LIGHTSHIP DISPLACEMENT DISP2(T)="; D4
3390 PRINT "FULLY LOADED DISPLACEMENT DISP3(T)="; D6
3400 PRINT "NOTE!! (DISP-DISP2)/DWT ="; Y8
3410 PRINT "******************************************************"
3412 PRINT "PRESS "; 0; (ZERO); " TO CONTINUE"
3413 INPUT NS1
3420 PRINT #10, "================================================================ SHIP MAIN PARAMETERS ========================================================"
3430 PRINT #10, "Q   N    L     B     d     D    CB    DISP    LPP/B  B/d    LBd     LBD     B/D     F/B    P    P/V     GRT   "
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```
3440 PRINT #10, "        (M)    (M)    (M)    (M)
(T)              (M^3)    (M^3)              (KW)
(KW/KN)              "
3450 PRINT #10, USING "## ###  ##.###  ##.###  ##.###
##.###  .###  ####.###  ##.##  ##.##  ####.###  ####.###
##.###  ##.###  ####.### ###.###  ####.###"; Q; X; L; B; T;
D; C2; D1; Y9; Y1; Y6; Y7; Y2; Y4; P; Y3; G2
3470 PRINT #10,
"++++++++++++++++++++++++++++++++++++++++++++++++
+ HALL MASSES AND DEADWIEGHT IN TONNES
++++++++++++++++++++++++++++++++++++++ PFREE-
BOARD & STABILITY (M) ++++"
3480 PRINT #10, "Q  N     MS     MO     MM    MF
ML     MW     MSA    MP    MCOB DWT     DISP2
DISP3  DWT-BALANCE     F    F1    F2   HBMIN
GM  "
3490 PRINT #10, USING "## ###  ###.### ###.###
###.### ###.### ###.### ###.### ##.### ###.### ###.###
###.### ####.### ####.###   ##.##     ##.## ##.## ##.##
##.## ##.##"; G; X; M7; M8; M9; M1; M2; M3; M6; M5;
M4; D5; D4; D6; Y8; F; F2; F1; H1; G1
3510 PRINT #10,
"=============================================
=============================================
=============================================
========="
3520 PRINT #10, "
"
3530 Y = Y + 1
3540 PRINT
3550 RETURN
3560 L = L4
3570 IF U1 = 1 GOTO 3600
3580 L = L - J
3590 GOTO 3610
3600 L = L + J
3610 Q = Q + 1
3620 NEXT J
3630 U = U + 1
3640 IF U >= 2 GOTO 3720
3650 IF U1 = 1 GOTO 3690
3660 X = 0
3670 Y = 0
3680 GOTO 620
3690 X = X / 2
3700 Y = X
3710 GOTO 620
3720 IF U1 = 1 GOTO 3780
3730 PRINT "[[ END OF PART ONE ]]"
3740 PRINT
3750 U1 = 1
3760 Y = X
3770 GOTO 580
3780 PRINT #20,
"************************************************************
************************************************************
*************"
3790 PRINT #20, "
"
3800 PRINT #20, "***** OWNERS REQUIREMENT
*****************"
3810 PRINT #20, "FISH HOLD CAPACITY VH(M^3)
="; V1
3820 PRINT #20, "ENDURANCE AT SEA H(HRS)
="; H
3830 PRINT #20, "NUMBER OF CREW+OFFICERS
="; N1
3840 PRINT #20, "SHIPS TRIAL SPEED (KNOTS)
="; V
3850 PRINT #20,
"******************************************"
3860 PRINT #20, "
"
3870 PRINT #20, "LEAST SQUARE FIT LBd(M^3)
="; C1
3880 PRINT #20,
"=========================================="
3890 PRINT #20, "
"
3900 PRINT "LIST FILES /SVALT AND /SFVESS/ FOR
HARD COPIES"
3910 IF F$ = "PO" GOTO 3940
3920 PRINT #10, "KEY: S=STEEL, O=OUTFIT,
M=MACHINERY, F=FUEL, L=LUB.OIL, W= WATER,
SA= SANITARY, P= PROVISIONS,
COB=CREW+OFFICERS+BAGGAGE,
DWT=DEADWEIGHT"
3930 PRINT #10, "DISP(_,2,3) = DISPLACE-
MENT(DESIGNED, LIGHTSHIP, FULLY LOADED),
F(_,1,2) = FREEBOARD FOR (+VE STABILITY, SIGN.
WAVE<=1.4m, SIGN. WAVE<=2.9m), HB=BOW
HEIGHT"
3940 PRINT #10, "
"
3950 PRINT #10, " "
3960 PRINT #10, "RECORD OF YOUR INPUT DATA"
3970 PRINT #10,
"^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
^^^"
```

```
3980 PRINT #10, "V1 = FISH HOLD CAPACITY (MT)
=  "; V0
3882 PRINT #10, "S1 = STOWAGE FACTOR (T/M^2)
=  "; S1
3884 PRINT #10, " H = ENDURANCE (OPS RUN-
NING HRS)      =  "; H
3990 PRINT #10, "N1 = NUMBER OF CREW AND
OFFICERS      =  "; N1
3992 PRINT #10, "N2 = NUMBER OF OFFICERS
ALONE         =  "; N2
3994 PRINT #10, " V = TRIAL SPEED OF VESSEL
(KNOTS)    =  "; V
4000 PRINT #10, " Z = MAX. NO. OF ALTERNATIVE
DESIGNS  =  "; Z
4001 PRINT #10, " U = REVIEW OF PREDICTED DE-
SIGNS      =  "; U
4002 PRINT #10, "  NOTE THAT YES = 0 AND NO =
1"
4010 PRINT #10, " "
4020 PRINT #10, "F1$ = BULWARK < 1; m OR ONLY;
GUIDRAILS = "; F1$
4022 PRINT #10, " F$ = FREEBOARD SIG. WAVE
2.9m HIGH     = "; F$
4030 PRINT #10, " "
4040 PRINT #10, " A = l1/LPP (l1=ERECTION
LENGHT/SHIP LENGHT  =  "; A
4042 PRINT #10, "B2 = h1/D (h1= ERECTION
HEIGHT/SHIP DEPTH    =  "; B2
4044 PRINT #10, " C = l2/lPP (l2= DECKHOUSE
LENGHT/SHIP LENGHT=  "; C
4046 PRINT #10, "D2 = h2/D (h2= DECKHOUSE
HEIGHT/SHIP DEPTH   =  "; D2
4050 PRINT #10, "R1 = REVOLUTION PER MINUTE
OF MAIN ENGINE    =  "; R1
4052 PRINT #10, "P0 = MAIN ENGINE POWER (KW)
=  "; P0
4058 PRINT #10, "E1 = WEIGHT RESERVE/TOTAL
WEIGHT OF VESSEL   =  "; E1
4060 PRINT #10, "F3 = MAIN ENGINE FUEL CON-
SUMPTION (T/KW/HR)  =  "; F3
4062 PRINT #10, "C3 = FUEL RESERVE/TOTAL FUEL
WEIGHT          =  "; C3
4064 PRINT #10, "F4 = AUX. ENGINE FUEL CON-
SUMPTION "
4068 PRINT #10, "      (T/MAIN POWER(KW)/HR)
=  "; F4
4069 PRINT #10, "N3 = NUMBER OF AUXILLIARY
ENGINES           =  "; N3
4070 PRINT #10, "O1 = LUBRICATING OIL CON-
SUMPTION (T/KW/HR)   =  "; O1
4072 PRINT #10, " G = MASS PER OFFICER AND
BAGGAGE (T)        =  "; G
4080 PRINT #10, " M = MASS OF CREW AND BAG-
GAGE (T)           =  "; M
4082 PRINT #10, "P1 = MASS OF PROVISIONS PER
MAN (T/HR)       =  "; P1
4084 PRINT #10, " N = MASS OF SANITARY WATER
PER MAN (T/HR)   =  "; N
4090 PRINT #10,
"^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
^^^"
4100 PRINT #10,
4110 END
```


3. RESULTS

Sample of input and output are presented to validate the program and are shown in Table 1 below. Many different owner requirements input has been run on this program to take care of debugging issues.

In the presented result 10 iterative result were feasible for the owners requirement input. 33 set of variable parameters of the design vessel is output from the program which includes dimensional and masses values. The first set is the **RBF** (regression best fit). You can see the maximum optimum **Mopt** and minimum optimum **Miopt** predicted vessel parameters from this result sheet. This relates mainly to the hull geometric parameters. The hull masses are not yet subjected to the optimization procedure in this program.

Table 1. Output result of the program SFVES (stored in sequential file named SVALT anD SFVESS)

******* OWNERS REQUIREMENT *************

FISH HOLD CAPACITY VH(M^3) = 131.6

ENDURANCE AT SEA H(HRS) = 480

NUMBER OF CREW + OFFICERS = 12

SHIPS TRIAL SPEED V1 (KNOTS) = 10.5

LEAST SQUARE FIT LBd(M^3) = 589.489

PROGRAM SFVES IS VALID FOR VESSELS

OF LENGTH BETWEEN PERPENDICULARS LPP = 15M TO 50 M

N	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
L(M)	26.22	26.72	27.22	27.72	28.22	26.22	25.72	25.22	24.72	24.22
B(M)	7.76	7.84	7.91	7.97	8.03	7.76	7.68	7.59	7.49	7.33
d(M)	2.90	3.01	3.04	3.07	3.09	2.90	2.98	3.08	3.08	3.04
D(M)	3.81	3.84	3.88	3.91	3.94	3.81	3.77	3.72	3.67	3.62
CB	0.52	0.53	0.53	0.54	0.54	0.52	0.52	0.52	0.51	0.51
DISP(T)	316.41	341.39	356.49	371.46	386.30	316.41	314.10	311,71	299.05	282.45
LPP/B	3.38	3.41	3.44	3.48	3.51	3.38	3.35	3.32	3.30	3.28
B/d	2.68	2.60	2.60	2.60	2.60	2.68	2.57	2.46	2.43	2.43
LBd	589.49	631.53	654.96	677.97	700.57	589.49	589.49	589.49	570.04	542.84
LBB(M^3)	774.87	805.31	835.19	864.53	893.33	774.87	743.86	712.27	680.10	647.34
B/D	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04	2.04
F/B	0.12	0.11	0.11	0.11	0.11	0.12	0.10	0.08	0.08	0.08
P(KW)	508.37	525.03	541.68	558.33	574.98	508.37	491.72	475.07	458.41	441.76
P/V(KW/Kn)	48.42	50.00	51.59	53.17	54.76	48.42	46.83	45.24	43.66	42.07
GRT	141.87	147.13	152.39	157.66	162.92	141.87	136.61	131.34	126.08	120.82
F(M)	0.91	0.83	0.84	0.84	0.85	0.91	0.78	0.64	0.59	0.58
F1	0.78	0.81	0.82	0.82	0.82	0.78	0.82	0.86	0.87	0.87
F2(M)	1.33	1.38	1.39	1.40	1.42	1.33	1.37	1.41	1.41	1.39
GM(M)	0.76	0.78	0.79	0.79	0.79	0.76	0.79	0.82	0.83	0.83
MS	92.63	97.23	100.95	104.63	108.30	92.63	90.10	87.58	84.09	80.21
MO	56.18	58.26	60.33	62.40	64.47	56.18	54.11	52.03	49.95	47.86
MM	11.07	11.34	11.61	11.88	12.14	11.07	10.80	10.52	10.24	9.96
MF	64.76	64.76	64.67	64.76	64.76	64.76	64.76	64.76	64.76	64.76
ML	6.51	6.72	6.93	7.15	7.36	6.51	6.30	6.09	5.87	5.66
MW	89.86	89.86	89.86	89.86	89.86	89.86	89.86	89.86	89.86	89.86
MSA	48.00	48.00	48.00	48.00	48.00	48.00	49.00	48.00	48.00	48.00
MP	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00	12.00
MCOB	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56	1.56
DWT	354.28	370.43	390.49	415.44	446.47	484.02	531.65	591.05	665.12	757.46
DISP2	171.08	171.08	171.08	171.08	171.08	171.08	171.08	171.08	171.08	171.08
DWT-BAL	0.41	0.46	0.47	0.48	0.48	0.30	0.27	0.24	0.19	0.15
HBMIN	3.43	3.51	3.58	3.65	3.73	3.43	3.36	3.29	3.22	3.15
	RBF				Mopt					Miopt

Table 1. continued

KEY:
S = STEEL, O=OUTFIT, MM = MACHINERY MASS, F=FUEL, L= LUB OIL, W=WATER, SA=SANITARY,
P=PROVISIONS, COB=CREW+OFFICERS+BAGGAGE, DWT=DEADWEIGHT,
DISP=(,2,)=DISPLACEMENT(DESIGNED, LIGHTSHIP, FULLY LOADED respectively),
F(,1,2)= FREEBOARD OR (+VE STABILITY, SIGNIFICANT WAVE HEIGHT<=1.4n
and SIGNIFICANT WAVE HEIGH <=2.9m respectively)

RECORD OF INPUT DATA
◎◎◎
V1= 65.8 SI= 0.5 H= 480
N1= 12 N2= 4 V= 10.5
0 0

A= 0.6 B2= 0.5 C= 0.26 D2= 0.5
R1= 1500 P0= 0 E1= 0.07
F3= 0.000213 C3 = 0.246 F4= 0 N3 = 2
O1= 2.667E-05 G= 0.15
M= 0.12 P1= 0.0020833 N= 0.008333
◎◎◎

4. DISCUSSION

There are many formulas for the preliminary design of fishing vessels. This method shown here has utilized some of the prominent ones with the aim of demonstrating concepts devised in this research. More formulas and methods need to be added to the program to enhance its power to predict more alternative feasible designs. More constraints need to be added to get better prediction of optimum design. These are such recent modifications on stability and sea keeping criteria including parametric motions especially rolling motions of ship. Although the program need be written in a higher professional computer language, the author used QBASIC so that the presentation will be easier, readable and understandable to many readers. Where the number of predicted feasible vessels is high it will be necessary to use a higher optimization technic to get the optimum from the large predicted design vessels based on reasonable objective maximize or minimize functions and procedures. The author presented a new method which he wishes to be modified enlarged and generalized for the preliminary optimum design of all types of vessels.

5. CONCLUSION

The lateral thinking concept is applied to preliminary ship design in other to generate many or all alternative designs for any particular owner requirements. The optimum design resulting from these alternatives are clearly seen and chosen by optimization principles. The concept is applied in the design of flow chart and a validated QBASIC program which show the complete algorithm satisfying the aim of this research work. The flowchart is shown in Fig 1. The listed QBASIC program is presented. The validated result from the program show ten feasible results of the design vessel with owner requirements as input, from which the maximum optimum Mopt design, the minimum optimum Miopt design and the regression best fit RBF design options are computed and presented by the computer program made by the author. Each of these options has 33 parameter variables values listed in Table 1 above.

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