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Net Drag Estimation of 18.0 m Semi Pelagic Trawl through Calculated Twine Area in Comparison to Projected Prototype Values by Model Studies

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Designing a trawl gear can effectively be accomplished by matching its size to the available horsepower. A simple method of trawl gear estimation at the design stage, utilizing the information available from a net drawing, will immensely ease the designing process without having to wait for the experimental values of net drag. Drag estimation through calculated twine area is attempted with 18.0m semi pelagic trawl and is compared with the total drag of the projected prototype values by 1/15th model studies conducted at the ship model testing tank at IIT, Chennai. Method of calculation of twine area in m^2 of the different webbings that go into the making of the gear is required to calculate the total twine resistance to enable to optimise the designed net and to optimally utilize the available horse power. Net drag estimation using calculated twine area and the total drag of the prototype arrived at by model studies are calculated and compared.

Key words: net drag, semi pelagic trawl, twine area, model.

The design features and construction of a trawl gear determine its drag and the designer's concerted effort will be to reduce this drag by applying precise design methods and by selecting correctly matched trawl components, to utilize the available onboard tractive force to tow a net of optimum size at a given trawling speed. Mac Lennan (1981) developed a simple, empirical 'net drag' formula (suitable for 200 to 2000 HP trawlers) based on the experimental results of 12 four panel high opening demersal trawls, to accuracies generally within 10%.

The net drag of 18.0 m unequal panel RMT 8p semi pelagic trawl designed by CIFT is calculated using Mac Lennan's formula and the results are compared with the total drag predicted from the model studies of this net, conducted earlier in towing tank of IIT, Chennai and the results show good agreement.

Materials and Methods

Model studies are taken up with the objective of visualising the performance of the trawl gear in a towing tank and to effect alterations in the design, method of rigging and operation based on the observations made, to reproduce full scale phenomenon at a lower cost (Fridman, 1986). They also provide further appreciation of the gear's hydrodynamic performance to study the net configuration, rigging and to quantify the functional relations, which govern the gear's functioning. Dickson (1959) Kawakami (1959), Perumal *et.al.* (1998) conducted model tests with demersal and semi pelagic trawls and obtained full scale values of net shape parameters and total drag by the application of scaling laws. A 1:15 scale model of the 18.0m RMT 8p semi pelagic trawl (1.2m HR length) in combination with 122x53 mm suberkrub otter boards (weighing 66 g in water) and bridle length equal to 1.5x HR length was tested in the towing tank of IIT, Chennai. The total drag for the prototype over a towing speed range of 2.6 to 4.2 knots were obtained by scaling up the model values. The model scale of 1:15 was chosen taking into consideration, the dimensions of the towing tank (Perumal *et.al.*1973). The net elements were modelled as per the methods adopted by Fridman (op. cit).

Experiments with full scale gear have shown that some 75% of the total drag is 'net drag' (Mac Lennan, op. cit) and the rest is the contributions from the otterboards, sweeps and warps. The term 'net drag' include the drag of netting, ground gear (bobbins or footrope) floats and any other appendages attached to the netting.

Earlier methods of calculation of 'net drag' were based on equation

Hydrodynamic drag of a body

$D = 0.5\rho V^2$ Cd.R.(1)

where ρ is density of seawater

v speed of body

R is a characteristic cross section area of the body

and Cd is drag Coefficient.

In the case of plane netting panel, R is twine area defined as the area of twines (and knots) projected on a plane which is every where parallel to the mesh; Cd is the function of the angle of orientation (d) of the plane net panel to flow and is determined from wind tunnel/ water flume experiments. The surface of trawl net while under tow, is curved. If the shape is known, then the orientation of surface (α) to flow at every point can be found. The whole surface can then be divided into 'i' number of elemented areas, each small enough to be considered plane. Cdi of element Ri can be determined from αi at location Ri and the formula for Drag (D) becomes.

$$D = 0.5 \ \rho \ v^2 \ \Sigma Cdi \ Ri \qquad (2)$$

To calculate the 'net drag' at design stage, the net surface shape is not known and hence the importance of calculation of net drag through notional twine area gains prominence. The method estimates net drag on the basis of R (twine area) only which can easily be calculated from design drawing and yielded drag values to within 12% of the measured drag (Mac Lennan, op. cit.) Following Reid (1977), Mac Lennan proposes an empirical relationship to describe dependence of net drag of high opening trawls on twine area 'R' and towing speed 'V' as

$$D = R\ [C+Av^2/(1+BV)] \quad - - - (3)$$

Where A, B & C are constants to be determined by fitting the formula to the experimental results. After fitting the experimental data, values of the constants are found and eqn (3) take the form.

$$D = R\,[61.2+46.6\ V^2/(1+0.0641V)] \quad - - (4)$$

Where D, R&V are net drag (Newtons), twine area (m^2) and towing speed (knots). Twine area R is given by R = Σmld,

Where l is half the stretched mesh size (knot centre to knot centre)

D is twine area, calculated from Tex No. and m is the no. of mesh bar in a panel and the sum is taken over all panels. This is an approximate expression for R, since area of knots is not taken into account. But the error is insignificant. 'd' is calculated from the tex No. of twine.

Ferro (1981) calculates the twine area in a tabular form with

$$R = \frac{L \times D\ (N+M)}{1000} \quad - (5)$$

Where R, L, D, N&M are twine area (m^2) stretched length of panel (m), twine diameter (mm), no. of meshes across top and base of panel, respectively. R, as above does not include the area of the knots. According to Mac Lennan (1979) R should include area of the knots and the contribution from knots reduces as d/l decreases. When d/l = 0.5, eqn(5) under estimates R by about 3%. For practical purposes, the small correction can be neglected.

Results and Discussion

The design diagram of 18.0m RMT 8P semi pelagic trawl (Fig.1) also depicts the

Table 1. Calculation of Nominal Twine area of 18m RMT-8P Trawl net

1 Netting Area	2 No. of rows K	3 Mesh size (mm) S	4 Stretched Length L (m)	5 Tex Number Tex	6 Twine Diameter D (mm)	7 Meshes across Top edge N	8 Meshes across bottom M	9 N+M	10 Twine Area A (m^2)	11 Number of similar area n	12 n x A
1	16	200	1.6	1217	1.5	4	25	29	0.0696	4	0.2784
2	60	200	6	1217	1.5	25	57	82	0.738	4	2.952
3	16	200	1.6	1217	1.5	4	24	28	0.0672	4	0.2688
4	60	200	6	1217	1.5	24	44	68	0.612	4	2.448
5	24	200	2.4	1217	1.5	150	134	284	1.0224	2	2.0448
6	24	200	2.4	1217	1.5	100	88	188	0.6768	2	1.3536
7	96	150	7.2	1217	1.5	180	116	296	3.1968	2	6.3936
8	96	150	7.2	1217	1.5	118	70	188	2.0304	2	4.0608
9	176	100	8.8	1217	1.5	174	86	260	3.432	2	6.864
10	176	100	8.8	1217	1.5	105	47	152	2.0064	2	4.0128
11	240	80	9.6	1217	1.5	108	48	156	2.2464	2	4.4928
12	240	80	9.6	1217	1.5	60	1	61	0.8784	2	1.7568
13	64	60	1.92	1217	1.5	64	48	112	0.32256	2	0.64512
14	370	30	5.55	1217	1.5	96	96	192	1.5984	2	3.1968
Total Twine Area											40.76832

netting areas in circled numbers and refer to the column 1 of Table 1. The following basic modelling scales are used as per Fridman (op.cit).

1. Linear scaling factor (SL) = Scale for overall geometric dimensions = 15
2. Scaling factors for mesh size and twine diameter (SM) = 2
3. Speed ratio (SV) = 2.69

The scale of forces (SF) is given by

SF= (SL X SV)^2 X ratio of densities of sea and tank water.

In this case SF= (15X2.69)^2 X 1.025= 1669

Using SV= 2.69 and SF =1669, the model speed and corresponding drag are scaled up to prototype speed and drag respectively. The results are shown in cols. 1 and 2 of Table 2.

Twisted PE twines (Tex.No.1217) are used for the whole net and the twine diameter.

D (mm) = √(Tex/541) – (Ferro, op.cit)

Hence in the case D = √1217/541 = 1.50mm.

Twine area is calculated by eqn (5) with the net data from Fig.1. The details are shown in Table I which is self-explanatory.

The net drag is calculated from eqn.(4) with R=40.77 m^2 for the speeds in Table II and the results are shown in Col.3 of Table II [Drag (kg) = (Newtons)/9.81]

As the net drag accounts for only 75% of total drag it can be rewritten as

Table 2. Comparison of drag predictions by empirical formula (eqn.4) and those by model tests.

(1) Speed	(2) Total drag Model prediction	(3) Net drag (eqn.4)	(4) Total drag (1.33 x 'net drag')	(5) Comparison (4)/(2)
(Knots)	(Kg)	(Kg)	(Kg)	(-)
2.75	2127	1501	1996	0.94
3.50	3180	2194	2918	0.92
4.50	4857	3298	4387	0.90

Total drag = 1.33 X 'net drag' and the total drag thus calculated are shown in col.4 of Table II. The comparison in col.5 of the total drag i) predicted from model tests and ii) those by 1.33 X 'net drag' calculated from eqn.(4) show that the latter under-predicts the total drag by 10% to 6% and is well within the prediction error anticipated by Mac Lennan (op.cit) in the range of 10 to 16%. Apparently the agreement is excellent. Since the experiments in Mac Lennan's case were carried out with high opening trawls with most design characteristics and geometry while in operation similar to semi pelagic trawls, the eqn.4 prediction in this case will be a valid one.

The estimation of net drag by utilising the calculated twine area (R) and the resultant empirical net drag formula in the case of high headline gear like semi pelagic trawls can be taken as an acceptable method to correctly match the trawl design to the available tractive force without actually going through the costly and time consuming process of onboard prototype tests.

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References

Baiju M.V., Varghese M.D., Vijayan V., George Mathai. P. and George V.C. (1995) Modelling techniques for trawl gear performance. *Proc. National Symposium on Ocean Electronics*, Cochin University of Science and Technology, Cochin.

Dickson, W. (1959) The use of model nets as a method of developing Trawl gear. *Modern Fishing gear of the World*, Vol.1, 166 p, Fishing News (Books) Ltd, London.

Ferro, R.S.T (1981) The Calculation of twine area of a Trawl net. *Scottish Fisheries Information Pamphlet, No.5*, 6 p, Department of Agriculture and Fisheries for Scotland.

Fridman, A.L. (1986) Calculation for fishing gear. *FAO Fishing Manuals*, Fishing News (Books) Ltd, London.

Mac Lennan, D.N. (1979) 'Hydrodynamic characteristics of trawl warps'. Scottish Fish. Res. Rep. No.16, 10 p.

Perumal M.C., Mukundan.M. and Rajendran.R. (1973) Model Experiments with 31.0m trawl and Comparison with field trials. *Ind. J. fish* **20,** pp 1-15.

Reid. A.J. (1977) A net drag formula for pelagic trawls. *Scottish fish. Res. Rep.* No.7, 12 p.

Vijayan.V., Varghese. M.D., Baiju. M.V., George Mathai P. and George.V.C. (1998) Model testing of semipelagic trawl with modified Suberkrub otterboards. *Advances and priorities in Fisheries Technology.* (Balachandran, K.K., Iyer, T,S,G., Madhavan, P., Jose Joseph, Perigreen, P., Raghunath, M.R. & Varghese, M.D., Eds), 139 p, Society of Fisheries Technologists (India), Cochin.