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EXPERIMENTAL RESEARCHES IN VIEW OF REALIZING THE PROPER PELAGIC TRAWL FOR THE ATLANTIC–TYPE SUPERTRAWLERS

Simion Nicolaev, Nicolae Uzun

Romanian Marine Research Institute - Constanța

ABSTRACT:

This paper presents the theoretical and experimental works carried out in view of realizing the pelagical trawl 170/140-222 for the ATLANTIC-type supertrawlers (3880 HP) belonging to the Romanian ocean fishing fleet. The results of applying various methods by working stages are compared to whose following the prototype tests.

INTRODUCTION

One of the ways of improving the fishery productivity, determining for the last ten years a spectacular evolution in the construction of the pelagic trawls, is represented by the increase of the filtration surface and trawling speed by enlarging the net meshes in the forward part. Various construction solutions are used for this purpose: rhombic and hexagonal meshes (having a side of up to 10 m) or parallel rows of sennits or belted ropes. But either the maximum sizes of meshes and the overall dimensions of trawls must be increased in a close correlation with the trawl deck size and vessel trawling force, taking into account the fact that large meshes are difficult to repair, and overall big sizes mean on the one hand the repairs will last longer and on the

other hand the seaway resistance will increase and affect the trawling speed. There must also be found the construction solutions providing horizontal and vertical openings as large as possible, having the same hydrodynamic resistance and a low material consumption.

This work belongs to the field of preoccupations set forth before and describes, by working stages, the methods used and results obtained in the construction of the trawl for the ATLANTIC-type supertrawler.

To start with and on the basis of a thorough analysis of the actual trawls performances, the following technical requirements and general solutions have been established, in order to begin the study of this problem:

- the nominal trawling speed to be 5.3 knots at 90% of the propulsion engine rated output;
- the vertical opening to be at least 27 m at nominal speed;
- the net meshes to be increased in the wings and belly part;
- a safety coefficient of 7.5 - 8 to be provided for establishing the diameter size of the ropes for the first mesh row of the belly.

The reference trawl is 128/86-17o type which is now in use in the ATLANTIC-type supertrawlers as well.

WORKS AND METHODS

In order to obtain the overall sizes of the trawl, it has been used the analytical method for calculating the trawl hydrodynamic resistance knowing the trawling force of the vessel corresponding to the nominal trawling speed, using the formula (2):

$$R_t = T_v - 2(R_{xw} + R_{xp} + R_{xi}) \qquad (1)$$

where: R_t = total hydrodynamic resistance of trawl;
T_v = trawling force of vessel;
R_{xw}, R_{xp}, R_{xi} = frontal components of the hydrodynamic resistance corresponding to the trawl warp, door and intermediaries bridles.

The value of T_v has been got from the vessel trawling diagram which has been detailed by our own measurements. The values of R_{xw}, R_{xp} and R_{xi} have been obtained by calculation and using the resistance coefficients to be found in literature(1,4).

For estimating the trawl construction elements, the cords resistance surface S_a has been chosen as a characteristic factor and it has been obtained as a product between the length and diameter of cords and ropes used in nets construction (2). The resistance surface is obtained from the formula:

$$R_t = C_x \frac{\rho}{2} v_t^2 S_a \qquad (2)$$

where: C_x = total resistance coefficient of trawl;
ρ = sea water density;
v_t = nominal trawling speed.

The coefficient C_x has been calculated on the basis of a series of data obtained by experiment from three pelagic trawls made of ropes.

Starting from the observations carried out on the reference trawl, the net segments having the mesh size a=30÷320omm have been more judiciously distributed and their resistance surface S_{a2} was calculated.

The difference:

$$S_{a1} = S_a - S_{a2}$$

is the basic element for establishing the size of the rope part having a =640omm corresponding to the anterior part of the trawl.

After that, the form and construction details in the anterior part of the trawl (especially wings) have been established, as well as the type and sizes of the fitting out system assuring the maximum functional parameters for the trawl when the efforts in the net are distributed as uniform as possible. To this purpose the mechanical imitation method was used (3). The model of the anterior part of the trawl, including the first segment of the belly, was installed on a special stand. The model was made at the scale 1/75 and the functional form has been assured under the action of a weight system imitating the static and hydrodynamic forces at a scale of 1/5ooo.

The form of the posterior section of the belly, where

the hydrodynamic forces were imitated, has been calculated at a coefficient of net meshes opening u_1 = o.2. The tests on some variants accompanied by measurements enabled to establish the details of the construction plan and fitting out system.

Because the construction solutions are new and calculation methods which have been used are approximate, the design was checked up before making the prototype. For economic and operative reasons, the solution of model tests was chosen, this permitting, in our opinion, a reduction by half of the expenses compared to those incured in prototype (supposing some defects exist).

The following reduction scales were used when making the model:

- reduction scale for the overall sizes and meshes:

$$c_l = c_a = 1/5$$

- reduction scale for the diameters $c_d = 1/4$.

The tests were carried out in the Black Sea, on board of a purse seine vessel (18o HP) adapted to the trawl fishing.

The functional parameters have been established by direct measurements using underwater apparatus and the working of some variants of the construction details has been directly studied by divers. After getting the information of this stage, it was possible to have final construction and fitting out drawings of the trawl 17o/14o-222.

The prototype was constructed using textile materials and ropes in our current production. In order to construct the experiment trawl, the same quantity of materials was used as for the reference trawl.

The technical and fishing tests were carried out in the summer of 198o, on the continental shelf of Namibia, in the Southwestern Africa, on board the supertrawler TIRNAVA (388o HP).

The working of the trawl has been watched during 151 hauls. The detecting apparatus on board the vessel have been used to determine the vertical openings and trawling speed: net sounder EQ-5o MK-3 and loch Doppler (SIMRAD made); the calculation based on the trawl warps divergence angle was used in order to find the horizontal openings between doors.

The catch per trawling hour was used when comparing the fishing productivity of the trawl 17o/14o-222 against the reference trawl 128/86-17o. Because during those tests no other supertrawler was fishing in that area, the productivity of the reference trawl was calculated on the basis of the fishing data of TIRNAVA using the reference trawl before tests.It was possible to make such a comparison because on the basis of the fishing data of some other types of vessels in that area, it has been proved the productivities obtained with the reference trawl during both periods were the same.

RESULTS AND DISCUSSIONS

Using the value of the total resistance coefficient of the trawl c_x = o.185 and the value of the trawling force of the vessel T_v = 23,oooKgf corresponding to the nominal trawling speed and on the basis of the formulas (1) and (2), the value of the resistance surface S_a = 276 sq.m. was calculated (Table 1).

Table 1

Calculation elements of the resistance surface S_a

No.		Resistance coefficient c_x	Construction characteristics	Hydrodynamic resistance (Kgf)
1.	Trawl warps	o.12	L = 35o m Ø = 28 mm	9oo
2.	Intermediaries	o.1o	L = 2 x 125 m Ø = 22 mm	43o
3.	Doors	o.3o	S = 8 sq.m.	1.87o
4.	Trawl	o.185	S_a = 276 sq.m.	19,8oo
5.	Vessel trawling	(T_v)		23,ooo

The general construction drawings of the trawl 17o/14o-222 as established on the basis of the resistance surface which has been calculated and construction solutions accepted following the model and prototype tests are presented in Fig.1.

As it can be seen, the overall sizes of the new trawl are much increased in comparison with the reference trawl, although the quantity of the material used is about the same.

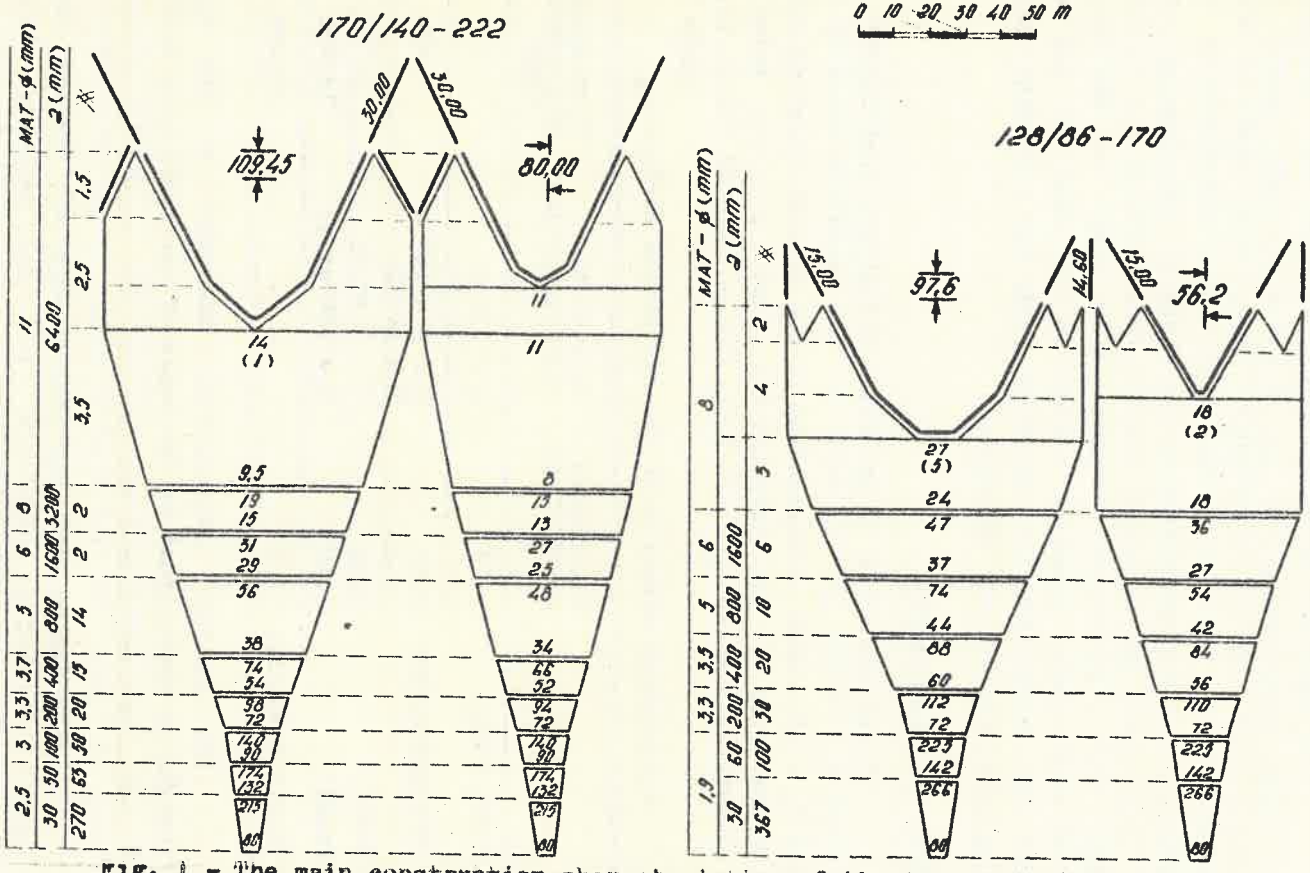

Fig. 1 - The main construction characteristics of the trawls 170/140-122 and 128/86-170

The mean values of the main functional parameters corresponding to the pelagic trawlings in the design stage (mock-up and model)and after testing the prototype are presented in Table 2.

Table 2

The results of the technical tests
of the trawl 17o/14o-222 against the design elements

Engine output (%)	Parameters	Design	Prototype	Error against prototype (%)
90%	Trawling speed (knots)	5.3	5.5	-3.6
	Vertical opening (m)	3o	29	+3.4
	Horizontal opening between doors (m)	~ 1oo	~ 1o5	-5.o
	Horizontal opening between wing bridles (m)	~ 55	-	-
75%	Trawling speed (knots)	4.6	4.8	-4.o
	Vertical opening (m)	32	32	o.oo
	Horizontal opening between doors (m)	~ 9o	~ 92	-2.o
	Horizontal opening between wing bridles (m)	~ 51	-	-

Compared to the design provisions, the values of the functional parameters of the prototype are close enough, the design error not exceeding 5%. Taking into account the fact that for the most of the fishing vessels the precision of determining the functional parameters is within the limits of this error, we can consider the designing method as being satisfactory.

The trawl 17o/14o-222 proved to be superior to the reference trawl from the point of view of the functional parameters (Fig.2). The vertical openings are 40% larger, the horizontal openings are 15% larger and the trawling speed is 9% higher, all these resulting in a water volume filtered within a time unit exceeding by 70% that of the reference trawl.

The mean productivity of the trawl 17o/14o-222 during the 151 trawlings was 8.15 tons per trawling hour, exceeding by 13-20% that of the reference trawl. Taking into account that over than 92% of trawlings have been carried out on the bottom, where

in the test period the South Africa horse mackerel (which was the main fishing object) formed more or less dense agglomerations, we can suppose the productivity will be more increased in case of pelagic trawlings.

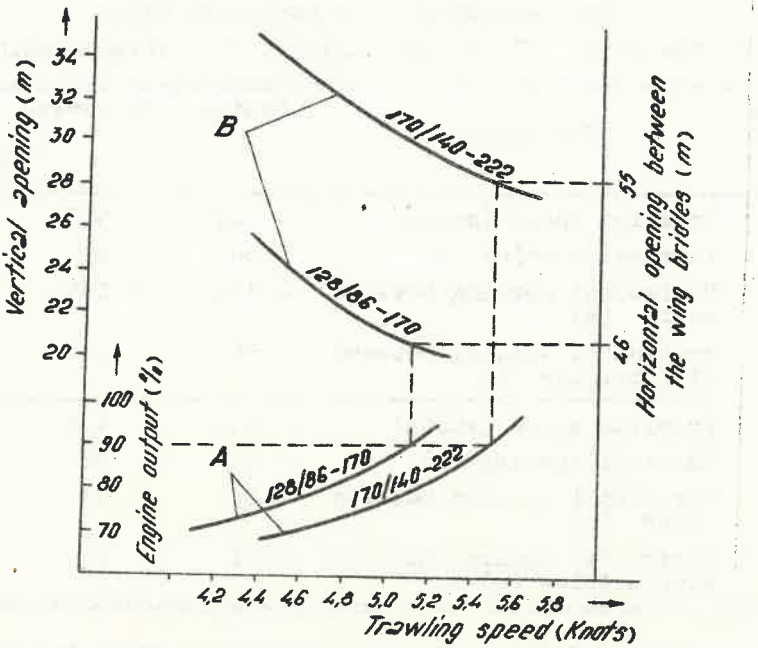

Fig. 2 - The comparative functional parameters of the trawls 17o/14o-222 and 128/86-17o (A - The trawling speeds depending on the engine output; B - The vertical openings depending on the trawling speed).

The trawl 17o/14o-222 also has a good manoeuvrability when changing the trawling level and better resistance in case of damages during bottom fishing. The experimental trawl has exceeded by twice the work quota of the reference trawl.

CONCLUSIONS

- A precision good enough for practical purposes is assured by using the theoretical method for establishing the pelagic trawls size on the basis of the calculation of the cord resistance surface and mechanical imitation for details of wing

construction and proper fitting out.

- The construction solutions used for the pelagic trawl 17o/14o-222 proved to be adequate as this trawl achieved functional and operating parameters superior to the reference trawl.

- The productivity of the pelagic trawl 17o/14o-222 is by 13-20% higher than that of the reference trawl, while the construction and estimated operation expenses are equal.

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