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Fishinger gear

EFFECTS OF MOUTH SHAPE OF CONICAL NETTING CONSTRUCTIONS ON PROPERTIES OF THEIR RESISTANCE

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Results of tests performed on 18 conical netting constructions, each construction being a simplified model of the netting part of a trawl, are presented. The constructions were mounted on elliptical frames the oblateness (b_1/a_1) of which being 0.25; 0.50; 0.75; and 1.00; additionally, 5 constructions mounted on square frames were tested. The results point out the resistance coefficient C_x in the ellipse-based constructions to be independent of the ellipse oblateness within the range of 0.25–1.00. Additionally, energy expenditure per mouth area unit of four-walled netting constructions hauled in water was shown to be minimal with a circular and square mouth and to increase, with elliptical mouth, in a reversed proportion to the ellipse oblateness, b_1/a_1.

INTRODUCTION

Underwater observations on trawls (Korotkov and Kuzmina, 1972) and on trawl models (Świniarski et al., 1979) showed the trawl mouth netting in cross-sections perpendicular to the trawl axis to take on a shape approaching an ellipse or a rectangle. From the trawl hydromechanics point of view it is important to determine an effect of mouth shape of netting constructions on their resistance properties. To date, the problem has not been treated in depth by the literature; some studies only (e.g., Zyn-Wan-We, 1966) attempted to deal with the problem.

The aim of the project presented was to determine, based on results of tests on conical and cylindrical netting constructions, effects of mouth shape of a netting construction on properties of its resistance.

MATERIAL AND METHODS

Materials

The constructions to be tested were made of polyamide (steelon) nettings manufactured by the Olsztyn Fishing Net Company–Korsze. The nettings used and their more important characteristics measured are given in Table 1.

The tests were performed on cylindrical and four-walled conical netting constructions conceived as simplified models of trawl netting elements. Details of the constructions manufacture can be found in Świniarski et al. (1979) and Dudko et al. (1982).

The constructions were mounted on elliptical frames, with a constant hanging proportionate, so that the mid-points of bases of triangular netting sections were in the ellipse tops (Fig. 1a). The constructions mounted on square frames had their selvedges originating in square corners (Fig. 1b).

The elliptical frames used for mounting the constructions were of the following values of the oblateness (short vs. long ellipse half-axis ratio, b_1/a_1): 0.25; 0.50; 0.75; 1.00. Square frames were used as well. Inner perimeters of the differently shaped frames were equal and corresponded to an inner perimeter of a circle with a diameter D = 0.960; 1.915; and 1.935 m.

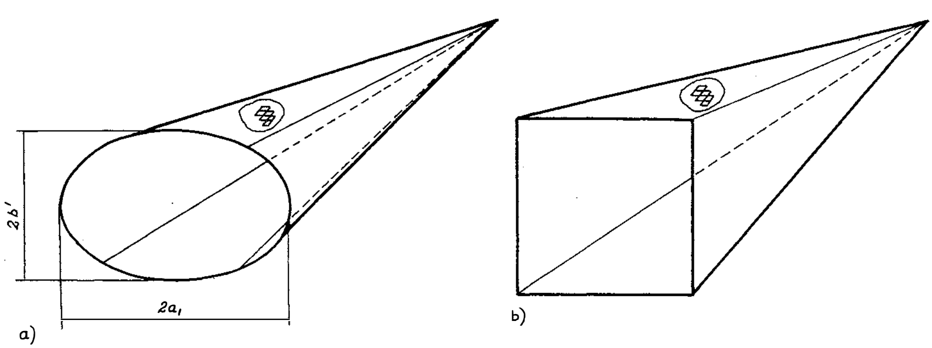

Fig. 1. Mouth shapes of the netting constructions tested

Table 1

Characteristics of netting used for manufacture of construction tested*

Netting type	Construction no.	Diameter, d (m)					Mesh side, a (mm)				
		Nominal value	True value	δ	v (%)	u (%)	Nominal value	True value	δ	v (%)	u (%)
1	2	3	4	5	6	7	8	9	10	11	12
23tex x3x3	1	–	0.77	0.02	2.04	0.76	20.00	21.66	0.06	0.27	0.10
23tex x5x3	2–11	–	1.00	0.04	4.10	1.54	40.00	40.89	0.19	0.46	0.17
94tex x5x3	12	1.60	1.97	0.04	1.83	0.68	150.00	152.01	0.43	0.28	0.10
94tex x7x3	13	2.00	2.28	0.05	2.58	0.96	100.00	102.09	0.47	0.46	0.17
94tex x7x3	14	2.00	2.30	0.05	2.03	0.76	50.00	50.84	0.21	0.41	0.15
94tex x7x3	15–16	2.00	2.33	0.08	3.45	1.29	100.00	104.45	0.16	0.15	0.06
94tex x7x3**	17	2.00	2.46	0.09	3.79	1.42	60.00	64.81	0.29	0.44	0.16
94tex x3x5x3	18	3.00	3.34	0.08	2.27	0.85	80.00	82.25	0.52	0.63	0.23

* measured when wet at 0.5 G/tex load
** raw netting, no physico-chemical finish treatment
δ = standard deviation
v = coefficient of variation
u = error of the mean

Table 2

Characteristics of netting constructions tested and results of tests

Construction no.	Construction characteristics						Netting section characteristics			$\bar{C}_x$				
	Frame i.d. (m)	u	one wet				C	n	m	$b_1/a_1=1{,}0$	$b_1/a_1=0{,}75$	$b_1/a_1=0{,}50$	$b_1/a_1=0{,}25$	„K”
			d (mm)	a (mm)	d/a	F (m^2)								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1.935	0,40	0.77	21.66	0.036	1.206	1N2B	94	93.5	0.310	–	0.328	0.300	0.265
2	0.960	0.20	1.00	40.89	0.024	0.708	„	46	45.5	0.136	0.139	0.136	0.133	–
3	0.960	0.31	1.00	40.89	0.024	0.303	„	30	29.5	0.191	0.207	0.217	0.200	–
4	0.960	0.42	1.00	40.89	0.024	0.164	„	22	21.5	0.338	0.350	0.344	0.361	–
5	0.960	0.51	1.00	40.89	0.024	0.110	„	18	17.5	0.416	0.450	0.460	0.417	–
6	0.960	0.42	1.00	40.89	0.024	0.076	AB	22	11.5	0.705	0.615	0.695	0.672	–
7	0.960	0.42	1.00	40.89	0.024	0.243	1N1B	22	31.5	0.270	0.230	0.259	0.232	–
8	0.960	0.42	1.00	40.89	0.024	0.459	N	22	31.5	0.146	0.122	0.138	0.115	–
9	1.915	0.30	1.00	40.89	0.024	1.242	1N2B	61	60.0	0.212	0.220	0.214	0.214	–
10	1.915	0.42	1.00	40.89	0.024	0.648	„	44	43.5	0.345	0.338	–	0.339	–
11	1.915	0.51	1.00	40.89	0.024	0.435	„	36	35.5	0.467	0.475	0.460	0.458	–
12	1.935	0.40	1.97	152.01	0.013	0.362	„	12	11.5	0.318	0.340	0.329	0.330	0.242
13	1.935	0.40	2.28	102.09	0.022	0.627	„	18	17.5	0.312	0.331	0.322	0.319	0.257
14	1.935	0.40	2.30	50.84	0.045	1.326	„	37	36.0	0.309	0.321	0.310	0.293	0.258
15	0.960	0.30	2.33	104.45	0.022	0.295	„	12	11.5	0.230	0.222	0.230	0.212	–
16	1.915	0.30	2.33	104.45	0.022	1.156	„	24	23.5	0.227	0.222	0.223	0.206	–
17*	1.915	0.41	2.46	64.81	0.038	1.028	„	28	25.5	0.363	0.365	0.343	0.342	–
18	1.935	0.40	3.34	82.25	0.041	1.206	„	23	22.0	0.290	0.293	0.298	0.283	0.236

* cut cone

Methods

The experiments were carried out in the field at the Model Studies Station -Ińsko, using the experimental assembly and techniques described by Świniarski et al. (1979) and Dudko et al. (1982). The results are presented in Table 2.

In order to determine effects of mouth shape of netting constructions on their resistance properties, a mean resistance coefficient, C_x, was calculated from 15 resistance and speed measurements, the latter ranging within v = 1.4–1.7 m/s. The resistance coefficient, C_x, was calculated from the formula

$$C_x = \frac{2 R_s}{\rho v^2 F_n} \quad (1)$$

where: R_s = netting construction (N) resistance,
ρ = water density (averaged as 1000 kg m^{-3}),
v = hauling speed (m s^{-1}),
F_n = the net surface (yarn surface) of netting (m^2).

RESULTS AND DISCUSSION

The results of Świniarski et al. (1979) allow to state that for similar netting constructions within the speed range of 0.6–3.2 m s^{-1} the relationship of $C_x = f(v)$ is weak. The speed range in question covers, in practice, all the trawl hauling speeds used at present.

In the present work, the hauling speed range was limited to v = 1.4–1.7 m s^{-1}. Within this range, the resistance of a netting construction, regardless of its mouth shape, is directly proportional to the squared speed (Fig. 2). Broken lines in the figure correspond to the relationship $R = f(v)^2$ determined by the least squares method for netting constructions mounted on differently shaped frames; the solid line represents a mean $R = f(v)^2$ relationship for elliptical netting constructions.

The following characteristics were taken into account when studying effects of mouth shape of netting constructions on their resistance properties: angle of incidence of the netting, netting materials assortment, netting size.

The results of tests performed on netting constructions with elliptical bases differing in their angle of incidence are presented in Fig. 3 and Fig. 4. The graphs show that, regardless of the angle of incidence magnitude determined by the cutting rate and hanging proportionate employed, values of the resistance coefficient, C_x, are practically independent of the elliptical base oblateness within its range of 0.25–1.0. The tests were performed on elliptical frames perimeters of which were equal to a D = 960 mm i.d. circle perimeter. To check if the nature of the relationship presented is similar in larger constructions too, 1915 mm i.d. frames were tested. The results obtained (Fig. 5) show

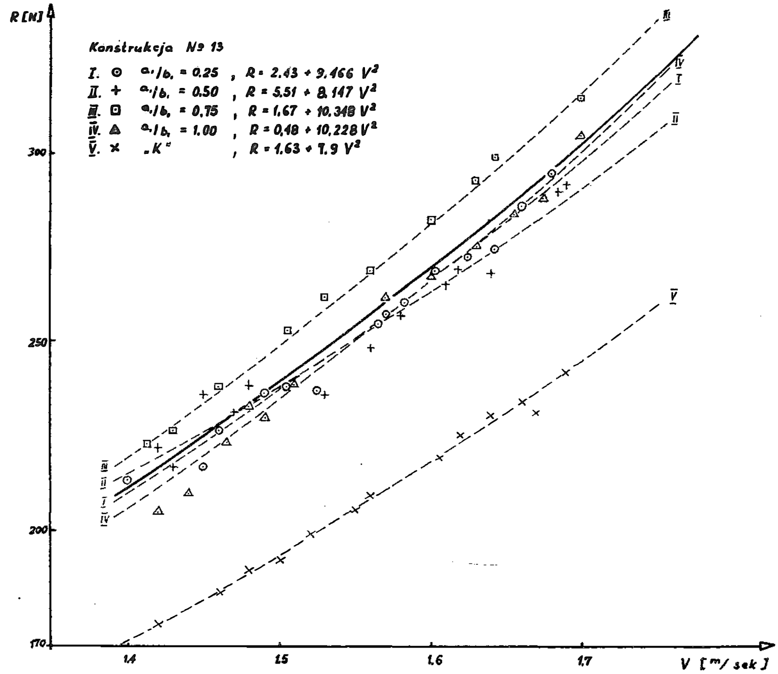

Fig. 2. Effect of speed on resistance of ellipse – and square-based netting constructions

the nature of the relationship to remain unchanged with altered linear dimensions of a netting construction.

In order to determine effects of netting characteristics (mesh size, yarn diameter, and their ratio) on the relationship $C_X = f(b_1 a_1)$, netting constructions produced of various

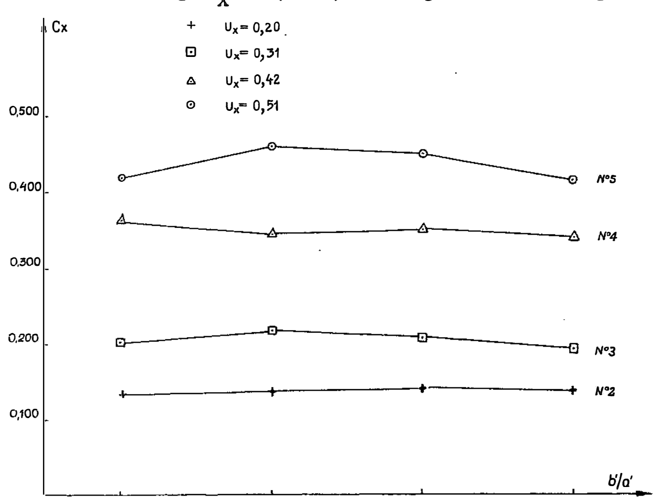

Fig. 3. Effects of handing proportionate and ellipse oblateness on resistance coefficient. C = 1N2B.

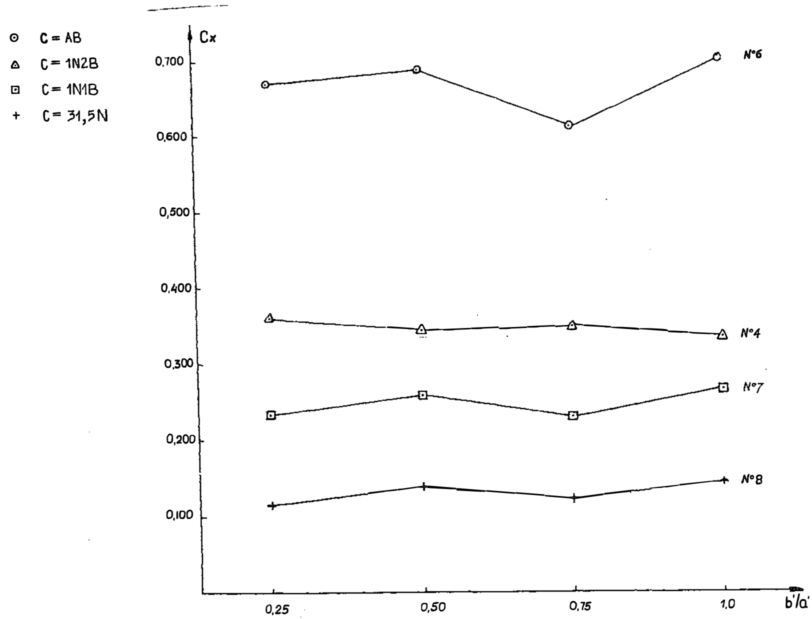

Fig. 4. Effects of cutting rate and ellipse oblateness on resistance coefficient. $\mu \approx 0.40$

types of netting materials were tested. The results, presented in Table 2 and Fig. 6, demonstrate the nature of the relationship to be only slightly affected by the type of netting. A slight increase in C_x values with b_1/a_1 growing from 0.25 to 0.75, most marked in those nettings of d/a larger than 0.40, lies within the accuracy range of the resistance coefficient determination. Under the circumstances, a quantitative analysis of $C_x = f(b_1/a_1)$ values is impossible to perform. Similar effects of netting characteristics on resistance properties of the respective constructions with mouths of different shapes are found for small and larges constructions (Fig. 5).

Effects of linear dimensions on the relationship $C_x = f(b_1/a_1)$ were analysed by comparing the results obtained for constructions of inner diameters amounting to 960 and 1915 mm (Fig. 5). The results presented show a high similarity of the C_x values, the similarity not exceeding the measurement accuracy. Based on the results presented here and on those reported by Dudko et al. (1982), it can be supposed that a similar relationshop would hold also for larger netting constructions.

Results of test performed on 5 netting constructions mounted on square frames show a clear decrease, by 15–26%, of C_x values as compared to the resistance coefficient values for the same constructions mounted on elliptical frames of b_1/a_1 = 0.25 to 1.00. It should be stressed that all the meshes located in the mouth of a four-walled netting construction hauled on a square frame are of an equal aperture. This evidences an even distribution of stresses in various knots of the netting, which ensures a satisfactory total strength of the construction. On the other hand, similar constructions mounted on elliptical frames show deformations, particularly evident near selvedges. The extent of

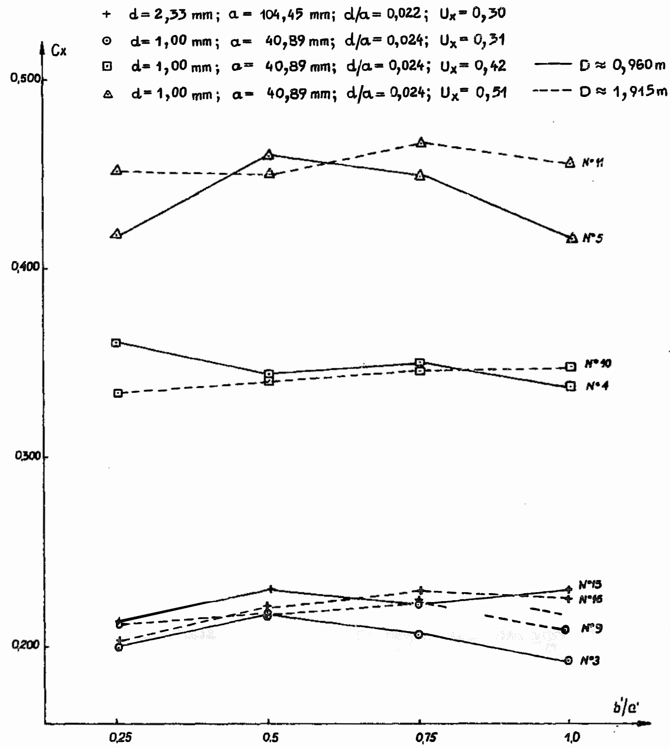

Fig. 5. Effects of handing proportionate, netting characteristics, construction size, and ellipse oblateness on resistance coefficient. C = 1N2B.

those deformations depends mainly on hanging proportionate values and cutting rate applied to the sides of the triangular netting sections.

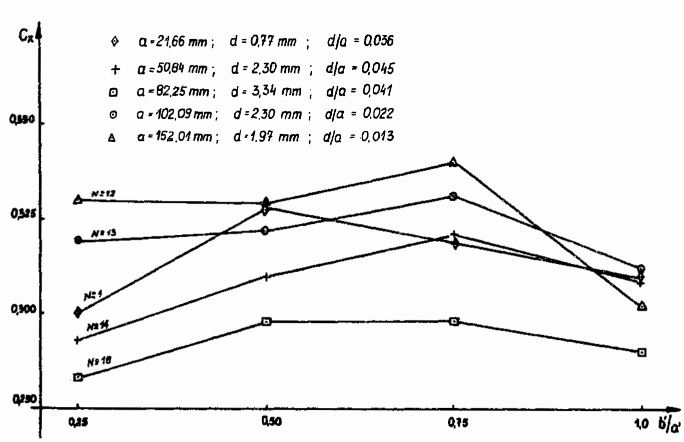

Fig. 6. Effects of netting characteristics and ellipse oblateness on resistance coefficient. C = 1N2B; $\mu \approx 0.40$

When evaluating a trawling gear, an index determining the magnitude of the resistance per m^2 of the mouth area is of importance. For netting constructions based on an ellipse, at the constant C_x and F_n, the resistance is independent of the ellipse oblateness within the range of 0.25–1.00. On the other hand, the mouth area changes according to the formula

$$F_{el} = F_c \cdot \frac{8\,(b_1/a_1)}{3(b_1/b_2)^2 + 2\,(b_1/a_1) + 3} \tag{2}$$

where: F_{el} = mouth area of an ellipse-based construction (m^2),
F_c = mouth area of a circle-based construction (m^2).

The resistance per m^2 mouth area index will change in an identical way. Therefore, in order to obtain satisfactory geometrical-resistance properties of trawls, constructions of mouth areas approaching a circle should be used.

The results of testing the netting constructions mounted on square frames show that in the case given,

$$R_{x\,sq} = (0.74\text{–}0.85)\,R_{x\,c} \tag{3}$$

where: $R_{x\,sq}$ = resistance of a square-based netting construction,
$R_{x\,c}$ = resistance of a circle-based netting construction.

At the same time, a ratio between the mouth area of a four-walled square-based netting construction (i = 4) and the mouth area of an identical but circle-based construction is determined by the relationship

$$\frac{F_{sq}}{F_c} = \frac{\pi}{i} = 0.785 \tag{4}$$

Comparing the formulae (3) and (4) it follows that

$$\frac{F_{sq}}{R_{x\,sq}} \approx \frac{F_c}{R_{x\,c}} \tag{5}$$

Energy expeditures on a mouth area unit in circle-based and square-based constructions are practically equal. However, square-based constructions require a higher materials supply (amount of netting) per mouth area unit. Owing to an even distribution of stresses along the netting perimeter, it is possible to reduce the yarn diameter and thus obtain an additional effect manifest as a lowered resistance.

CONCLUSIONS

1. Resistance coefficient of conical netting constructions based on an ellipse is practically independent of mouth shape within the range of b_1/a_1 0.25–1.00.

2. Energy expenditure per mouth area unit in four-walled conical netting constructions hauled in water is minimized with circular and square mouths and increases in ellipse-shaped mouths proportionally to changing mouth area as in the formula (2).

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WPŁYW KSZTAŁTU WLOTU STOŻKOWYCH KONSTRUKCJI SIECIOWYCH NA ICH CHARAKTERYSTYKI OPOROWE

STRESZCZENIE

W pracy przedstawiono wyniki badań 18-stożkowych konstrukcji sieciowych, stanowiących uproszczone odwzorowanie części sieciowej włoków. Stożkowe konstrukcje sieciowe osadzono na ramach eliptycznych o spłaszczeniu b_1/a_1 = 0,25; 0,50; 0,75; 1,00 z których 5 badano również na ramach kwadratowych. Wyniki badań wskazują, że dla konstrukcji o podstawach eliptycznych współczynnik oporu Cx nie zależy od stopnia spłaszczenia elipsy w granicach $0,25 \leqslant b_1/a_1 \geqslant 1,00$. Stwierdzono jednocześnie, że nakład energetyczny na jednostkę powierzchni wlotu dla czterościennych konstrukcji sieciowych holowanych w toni wodnej jest najmniejszy przy wlocie kołowym i kwadratowym oraz wzrasta, dla wlotów eliptycznych, odwrotnie proporcjonalnie do stopnia spłaszczenia elipsy b_1/a_1.

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ВЛИЯНИЕ ФОРМЫ ОСНОВАНИЙ КОНИЧЕСКИХ СЕТНЫХ КОНСТРУКЦИЙ НА ИХ ГИДРОДИНАМИЧЕСКИЕ ХАРАКТЕРИСТИКИ

Р е з ю м е

В работе представлены результаты исследований 18 конических сетных конструкций являющихся эталоном сетной части тралов. Сетные конуса были посажены на жесткие эллиптические рамы с соотношением полуосей - b_1/a_1=0,25 0,50; 0,75; 1,00.

Пять сетных конусов испытывали также на рамах квадратной формы. Результаты экспериментов показывают, что для конструкций с эллиптическими основаниями коэффициент сопротивления не зависит от степени сжатия в пределах $0{,}25 \leqslant b_1/a_1 \leqslant 1{,}00$. Одновременно обнаружено, что энергетические затраты на единицу поверхности устья для четырехпластных сетных конструкций буксируемых в толще воды являются минимальными для устьев круговой и квадратной формы. В тоже время растут они для эллиптических устьев (оснований) обратно пропорционально степени сжатия эллипса.

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