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CHANGES IN MESH SIZE OF POLYAMIDE NETS AS AFFECTED BY REPEATED LOADING AND RELAXATION

PROMJENA VELIČINE OKA U POLIAMIDNIM MREŽAMA POD UTJECAJEM VIŠEKRATNIH OPTEREĆENJA I RELAKSACIJE

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The paper presents the results of the study of changes in mesh size of polyamide trawlnets as affected by repeated loading and relaxation.

The testing of netting strength shows that at mesh stretching the twine very frequently comes out of the knot (slippage) rather than breaks, due probably to inadequate finishing of the netting.

At applying three different load ranges (2—6 cN/tex, 6—10 cN/tex and 10—14 cN/tex) the deformations of mesh size were greatest at the first load range connected probably with twine elongation and further knot tightening.

Under repeated loading-relaxation deformations are greatest during the first cycle.

INTRODUCTION

Trawlnets have been gaining in importance in the Yugoslav marine fisheries. They are used for fishing not only demersal, but also pelagic fish. This particularly applies to the small pelagic fish fishing by two-boat midwater trawls. The proportion of fish caught by this gear has recently considerably increased. So, for example, in 1986 the catch by bottom and midwater trawls made up 22.5% of the total catch, of which the small pelagic fish catch by two-boat midwater trawls constituted about 76%. This was a significant increase since in 1980 this proportion of catch by trawlnets did not exceed 14.5% of the total catch and the small pelagic fish catch by two-boat midwater trawls made up only 60% of that proportion.

Selectivity and catch per unit effort of trawlnets depends on a number of different factors of which mesh size is crucial. Mesh size mainly determines the trawlnet towing resistance as well as the size of fish and other marine organisms that are to be caught. Legislative measures, currently in force, for protection and regulation of marine fishing, require the use of smallest permitted mesh size in trawlnet fishing.

Meshes of trawlnets are frequently deformed by the effects of water and fishing condition, and first of all by the effects of different loads (Richert, 1968; Swiniarski, 1973; Zaucha, 1974; Cetinić and Swiniarski, 1985). This depends to a large extent on the type and quality of netting material as well as on the technology of their finishing (Swiniarski, 1976). Due to all that has been brought out the stability of mesh size, that is the quality of not being deformed during operation, is a very significant and acute problem of which the care should be taken during designation of fishing gear, solving of their selectivity as well as fishing regulation and proposing of protective measures.

The paper presents the results of the study of the effects of loading and relaxation on the trawlnet mesh size changes taking into consideration the following:

— breaking load,
— size of netting twine,
— application of technology in the netting finishing,
— hygroscopicity of studied material,
— mesh diameter,
— the number of loading — unloading cycles.

MATERIALS AND METHODS

Material

Polyamide material of trade name stylon made in Poland used in the construction of trawlnets was studied. Netting twine of 940 dtex/3x3 and 1880 dtex/4x3 (ø 2 mm) was tested along with the netting with the 50 mm bar length impregnated and not finished, made of the above mentioned synthetic fibre. Finishing of netting was performed by the use of osolan*. It is based on the saturation of netting by water solution of osolan, centrifugation of the excess solution and drying of netting under a defined load in a tunnel dryer at 90—100°C (363—373°K) temperature for 20 minutes.

Methods

The testing of the following parameters of mechanical properties of netting twine and netting studied was performed:

— true twine number in texes,
— the number of final twists of the twine per metre length,
— twine diameter in mm,
— length of the mesh bar in mm,
— mesh opening in mm,
— breaking load in daN
— extension at break in %.

Testing was made after Klust (1973).

* Osolan is a chemical substance used in Poland for finishing the netting.

The correlation between twine deformation and the load was determined by tensile testing machine shown in Fig. 1. Mesh deformation was examined at horizontal hanging coefficient $u_x = 0$, as given in Fig. 2, while the deformations of netting mesh size were examined at horizontal hanging coefficient $u_x = 0$ as given in Fig. 3, as well as at $u_x = 0.4$, $u_x = 0.6$ as shown in Fig. 4.

Expected mesh elongation was obtained by an appropriate length of the clamps of the machine.

Load at hanging coefficient $u_x = 0$ was 2 cN/tex, 6 cN/tex, 10 cN/tex and 14 cN/tex and at open meshes 6 cN/tex, 10 cN/tex and 14 cN/tex. New specimen was used for each load testing. The testing cycle consisted of a minute loading and 15 minutes relaxation. Dry and wet measurements were performed. Mean elongation was calculated from 30 regular testings. The following measurements were performed:

L_o = initial length acclimatized condition,

$\triangle_c$ = total absolute elongation or mesh size extension under load, in milimetres,

$\triangle_t$ = permanent absolute elongation or mesh size extension under load, in milimetres.

On the basis of tested obtained values L_o, $\triangle_c$ and $\triangle_t$ the following was calculated:

— total relative elongation in percentages (Σ_c):

$$\Sigma_c = \frac{\triangle_c}{L_o} \cdot 100\%$$

— permanent relative elongation in percentages: (Σ_t):

$$\Sigma_t = \frac{\triangle_t}{L_o} \cdot 100\%$$

Mesh size deformations at repeated and varying loading and relaxation were tested on impregnated netting constructed of the 2 mm twine. Testing was performed at three different conditions at horizontal hanging coefficient $u_x = 0.4$.

At the first condition the elongation test was performed at 5 repeated loading — relaxation cycles with the changing load of 6 cN/tex, 10 cN/tex and 14 cN/tex every sixth cycle.

At the second condition the sample was tested under 15 repeated cycles with gradually increasing load, which during the the first five cycles was 6 cN/tex, during the subsequent 5 cycles 5—10 cN/tex and during the last five cycles 6 cN/tex.

At the third condition netting was subjected to 15 cycles of gradually decreasing load, with 14 cN/tex during the first 5 cycles, 5—10 cN/tex during the subsequent 5 cycles and 6 cN/tex during the final 5 cycles.

A total of 30 measurements were performed per cycle. Obtained results were worked out statistically.

RESULTS AND DISCUSSION

The analysis of mechanical properties of netting twine and netting

The results of testing of mechanical properties of netting twine are presented in Table 1. As shown, the breaking load of the twine is lower if the twine is tested wet. This is, in fact, a property of polyamide fibres. Mean specific strength is decreased with the increase of twine diameter (thickness). The results of the tests of breaking elongation of wet and dry twine showed that extensibility was higher with the increase of the actual twine number. The extensibility ranged from 24.4—31.3% under acclimatized conditions, while in wet condition it ranged from 32.9—38.5%. These results are consistent with the other results on polyamide fibres (Klust, 1973).

Table 1. Basic indicators of netting twine mechanical properties

Parameter		Yarn figure Stylon 940 dtex/3 × 3	Stylon 1880 dtex/4 × 3 or Ø 2 mm
Actual number Rt /tex/		928	2413
Twine diameter in m		1.46	2.24
Number of twist per 1 m and twist directions		149 z	107 z
Mean knotless breaking strength in daN	dry	51.8	109
	wet	47.5	95.2
Relative strength wet in %		91.7	87.3
Specific strength in in cN/tex	dry	51.7	44.2
	wet	47.4	38.6
Mean breading linot strength in daN	dry	30.6	62.02
	wet	29.6	54.26
Relative strength wet, in %		96.7	87.5
Specific strength in cN/tex	dry	30.5	25.2
	wet	29.5	21.9
Extension at break in %	dry	24.4	31.3
	wet	32.9	38.5

Results of testing of basic mechanical properties of netting are shown in Table 2. Mesh size is greter wet than dry. The results of testing of breaking load show higher breaking load of impregnated netting. Breaking load decrease is smaller in wet impregnated netting. This is, at the same time, indicative of the fact that finishing of netting is positive. The analysis of breaking load of wet meshes shows that in many cases no mesh breaking occurs owing

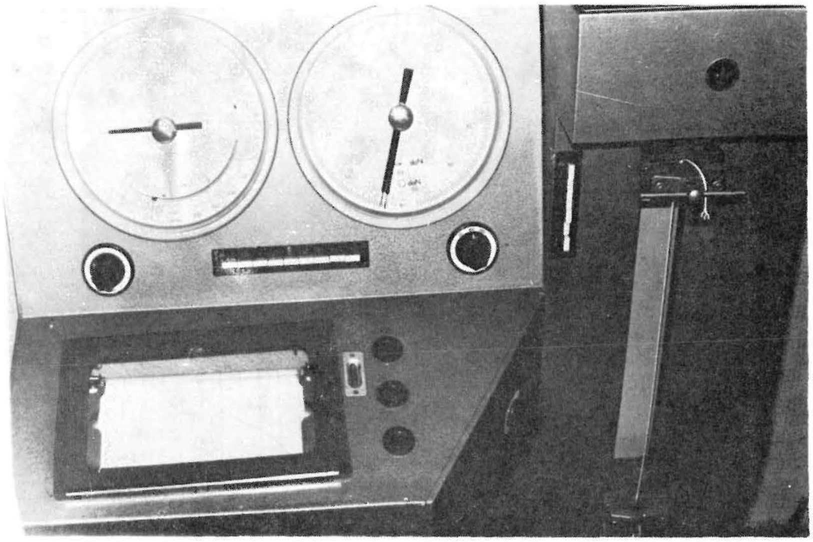

Fig. 1. Tensile testing machine ZT — 200 for twine elongation (deformation) measurement

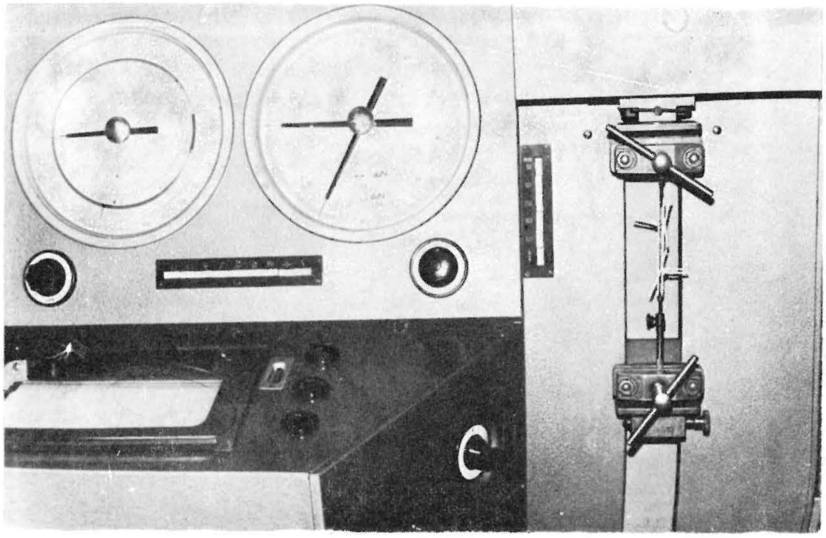

Fig. 2. Elongation (deformation) of individual meshes measured by the tensile testing machine

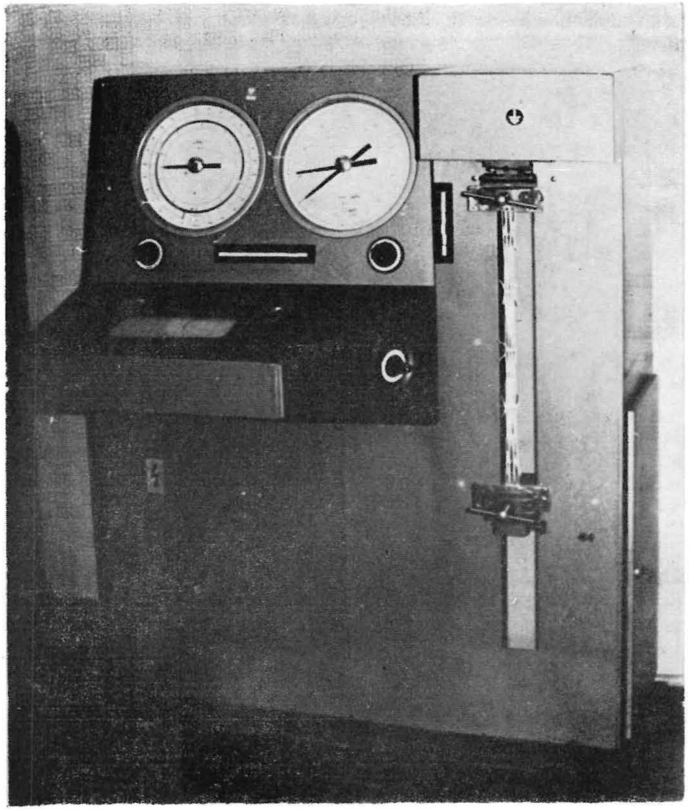

Fig. 3. Elongation (deformation) of netting meshes measured by a tensiometer at hanging coefficient $U_x = 0$

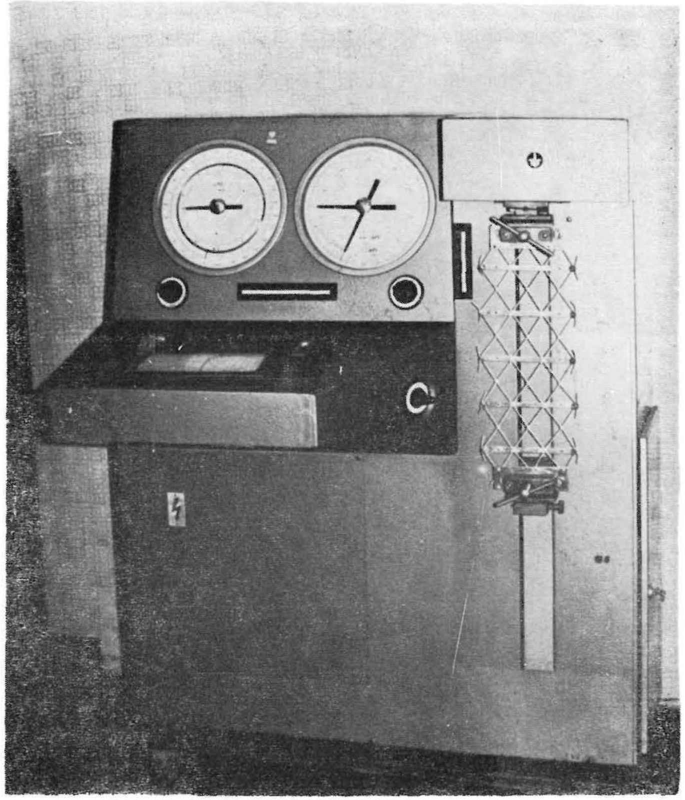

Fig. 4. Elongation (deformation) of netting meshes measured by tensile testing mashine at $U_x = 0,4$ and $U_x = 0,6$

Table 2. Basic parameters of mechanical properties of the netting

Parameter		Stylon 940dtex/3x3 Raw	Stylon 940dtex/3x3 Finished	Stylon 1880 detex/4x3 or Ø 2 mm Raw	Stylon 1880 detex/4x3 or Ø 2 mm Finished
Length of one mesh bar in mm	dry	50.57	50.53	54.80	51.56
	wet	51.74	52.30	53.30	52.80
Mesh opening in mm	dry	98.34	96.88	119.46*	97.40
	wet	99.19	99.95	100.28*	99.85
Breaking strength in daN	dry	48.90	56.56	92.50	119.40
	wet	34.95	44.90	74.97*	93.80
Relative strength in wet condition in %		71.47	79.40	81.04	78.53
Specific strength in cN/tex	dry	48.80	56.40	37.50	48.50
	wet	34.90	44.80	30.40	38.00
Extension at break in %	dry	44.49	35.03	57.17	54.75
	wet	50.10	35.34	69.82*	62.21

* Values are not quite reliable owing to knot slipping

to the elasticity. However, slipping of the twine from the knot occurs as a consequence of unsatisfactory technology of netting finishing (S w i n i a r s k i, 1976).

The analysis of mesh size deformation at varying loads

The results of testing of deformations of mesh size of analyzed netting as affected by varying loads are presented in Table 3. These results show that total and permanent deformations of mesh size are higher with increasing load.

The analysis of mesh size deformations at three repeated different load ranges (2—6 cN/tex, 6—10 cN/tex and 10—14 cN/tex) pointed to the fact that deformations were greatest within the first range, decreasing within subsequent ranges. This may be another evidence that during stretching of twisted fibres and knot tightening, greater deformations occur during the initital loading. The next characteristic of studied netting was that deformations were higher in wet condition than in dry condition and that impregnated netting was considerably less deformed under load than unimpregnated netting. This was confirmed by the reports of some other authors (S w i n i a r s k i et al., 1975; Z a u c h a, 1976).

The analysis of mesh size deformation under different loads led us to the conclusion that the relationship between the increase of total mesh size elongation in percentages and natural logarithm of load applied in centiNewtons per tex (cN/tex) was linear and that the permanent deformation of mesh size and applied load are correlated. This is shown in Fig. 5 and 6. The parameters of this correlation and correlation coefficients are given in Table 4.

Table 3. Deformations of mesh size under loading — relaxation at hanging netting coefficient $U_{\smile} = 0$

Netting type	Load in cN/tex	State of specimen	Total elongation in %		Permanent elongation in %	
			Raw netting	Finished netting	Raw netting	Finished netting
Netting of the 940 dtex/3x3 netting twine	2	in dry condition	4.06	2.98	0.89	0.51
		in wet condition	8.18	6.23	3.70	2.53
	6	in dry condition	12.46	10.59	2.89	1.68
		in wet condition	16.77	15.26	5.63	5.08
	10	in dry condition	18.36	16.11	4.62	3.55
		in wet condition	22.10	20.01	7.17	5.99
	14	in dry condition	22.54	19.40	6.12	4.94
		in wet condition	24.38	22.90	7.65	6.74
Netting of the Ø 2 mm twine	2	in dry condition	5.00	2.72	1.29	0.44
		in wet condition	5.33	7.90	—1.55	2.63
	6	in dry condition	16.20	14.27	4.20	2.41
		in wet condition	19.64	20.32	3.84	5.42
	10	in dry condition	24.26	21.95	7.44	4.36
		in wet condition	25.06	27.01	4.37	8.00
	14	in dry condition	26.68	27.87	9.17	6.78
		in wet condition	28.11	31.96	6.54	9.88

From the analysis of the above data the following generalized equation may be derived:

— equation of the total deformation of mesh size size as affected by loading:

$$\Sigma c_{o_1} = a_1 + b_1 + \ln P$$

where:

Σc_{o_1} = total deformation of netting mesh size under the influence of single loading and relaxation at horizontal hanging coefficient $u_x = 0$

P = load in cN/tex

a_1 and b_1 = equation coefficients (Table 4)

— equation of the correlation between permanent mesh elongation and the load:

$$\Sigma t_{o_1} = a_2 + b_2 P$$

where:

Σt_{o_1} = permanent deformation per loading

P = load in cN/tex

a_2 and b_2 = equation coefficents (Table 4).

Changes in mesh size as affected by the hanging coefficient of netting and load

The results of testing of deformations of mesh size of the finished netting under the load of the range 2—14 cN/tex at the coefficient of netting hanging $u_x = 0$, $u_x = 0.4$ and $u_x = 0.6$ are presented in Table 5. Both the total and permanent elongation increase with the horizontal coefficient of netting hanging equally in wet and dry conditions. Greater deformation of wet netting may, also be accounted for by its earlier shrinkage due to the immersion in water.

The analysis of the results show that the correlation between mesh size deformation in percentages and horizontal coefficient of netting hanging u_x is linear. This was proved by the analysis of forces acting upon the netting meshes as shown in Fig. 7.

During the application of extension load P, uniform tensions P_1 forces are calculated by the following formula:

$$P_1 = \frac{P}{2 \sin\alpha}$$

Since $\sin \alpha = U_y$ and $U_y = \sqrt{1 - U^2_x}$ then

$$P_1 = \frac{P}{2 U_y} \text{ and } P_1 = \frac{P}{2\sqrt{1 - U^2_x}}$$

Table 4. Coefficients of correlation between mesh size deformation and load applied

Netting type	Condition of the specimen	Total elongation: Equation coefficients		Total elongation: Correlation coefficient	Permanent elongation: Equation coefficients		Permanent elongation: Correlation coefficient
		a_1	b_1	r	a_2	b_2	r
Raw netting of the 940 dtx/3x3 twine	in dry condition	— 3.014	9.35	0.993	0.15	0.44	0.998
	in wet condition	2.17	8.44	0.998	3.36	0.33	0.970
Finished netting of 940 dtx/3x3 twine	in dry condition	— 3.31	8.39	0.994	— 0.36	0.38	0.996
	in wet condition	0.176	8.57	0.999	2.38	0.34	0.953
Raw netting of Ø 2 mm twine	in dry condition	— 3.21	11.44	0.995	0.15	0.67	0.993
	in wet condition	— 2.45	11.84	0.997	— 1.62	0.61	0.920
Finished netting of Ø 2 mm twine	in dry condition	— 6.84	12.68	0.993	— 0.70	0.52	0.998
	in wet condition	— 0.92	12.24	0.998	1.62	0.62	0.996

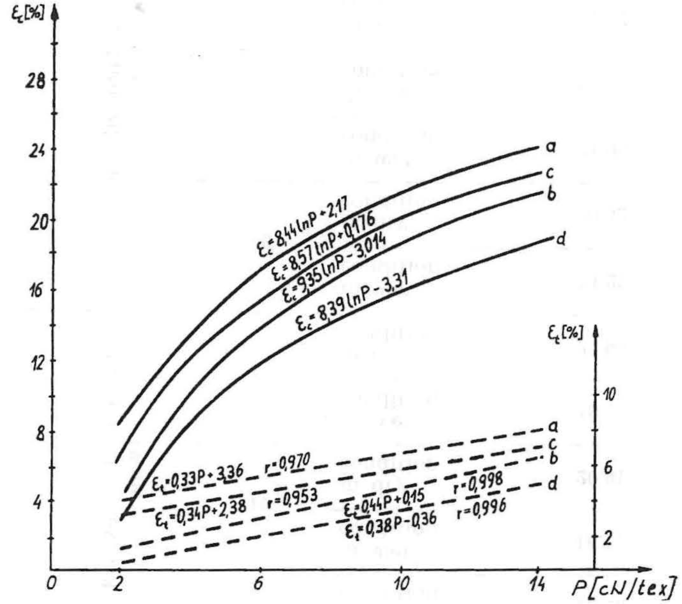

Fig. 5. Correlation between deformation of mesh size of the netting made of the 940 dtex/3x3, a — unfinished netting tested in wet condition, b — unfinished netting tested in dry condition, c — impregnated netting tested in wet condition, d — impregnated netting tested in dry condition.

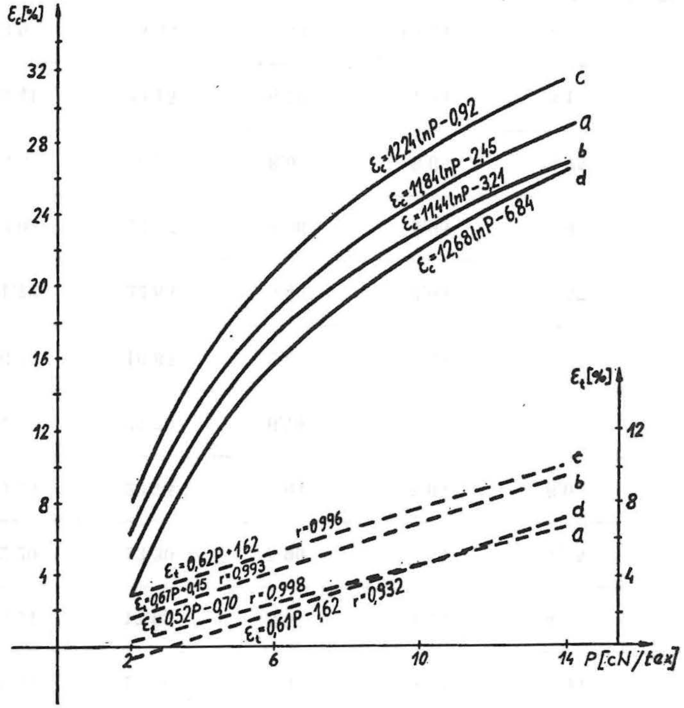

Fig. 6. Correlation between deformation of mesh size of the netting made of the 2 mm diameter twine, a — unfinished netting tested in wet condition, b — unfinished netting tested in dry condition, c — impregnated netting tested in wet condition, d — impregnated netting tested in dry condition.

Table 5. Deformation of netting mesh size as affected by the horizontal coefficient of netting hanging u_x and load applied

Netting type	Load in cN/tex	Condition of the specimen	Total elongation in %			Permanent elongation in %		
			$U_x = 0$	$U_x = 0.40$	$U_x = 0.60$	$U_x = 0$	$U_x = 0$	$U_x = 0.60$
Made of 940 dtex/3x3 twine	6	in wet condition	10.59	11.45	11.95	1.68	2.20	2.50
		in dry condition	15.26	16.80	17.50	5.08	5.50	5.95
	10	in wet condition	16.11	16.54	17.02	3.55	4.15	4.50
		in dry condition	20.01	22.20	23.30	5.99	6.65	7.15
	14	in wet condition	19.40	20.25	20.75	4.94	5.65	6.02
		in dry condition	22.90	24.80	25.70	6.74	7.45	8.05
Made of 2 mm diameter twine	6	in wet condition	14.27	16.25	16.85	2.41	2.85	3.25
		in dry condition	20.32	21.73	22.65	5.42	6.05	6.57
	10	in wet condition	21.95	23.05	23.67	4.36	4.95	5.45
		in dry condition	27.01	29.0	30.05	8.0	8.65	9.75
	14	in wet condition	27.87	29.41	30.15	6.78	7.55	8.10
		in dry condition	31.96	33.90	35.05	9.88	10.55	11.25

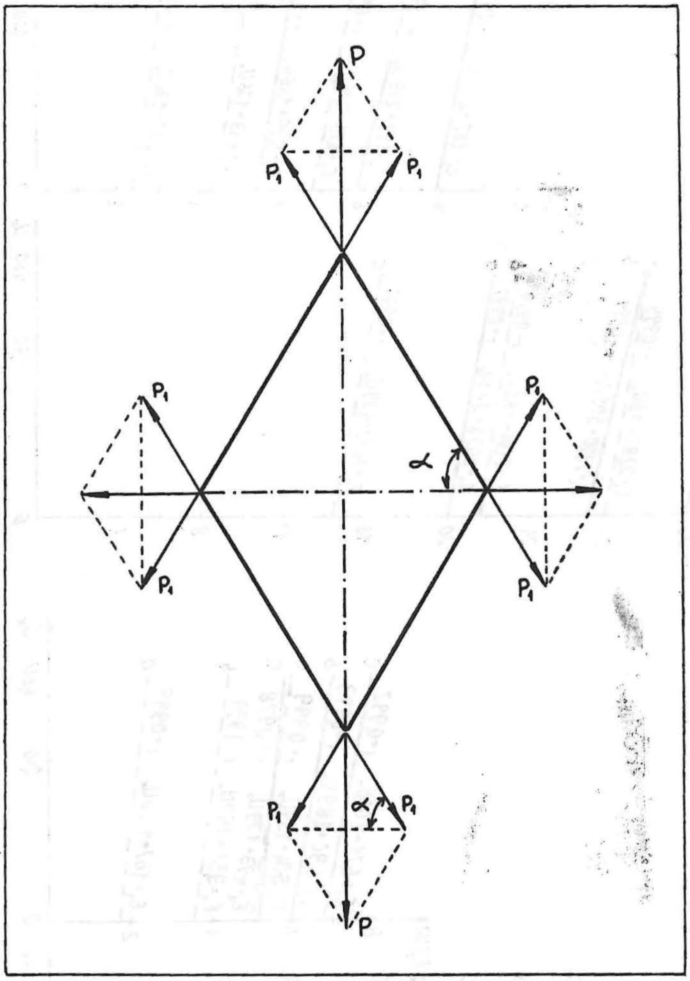

Fig. 7. Forces acting upon netting

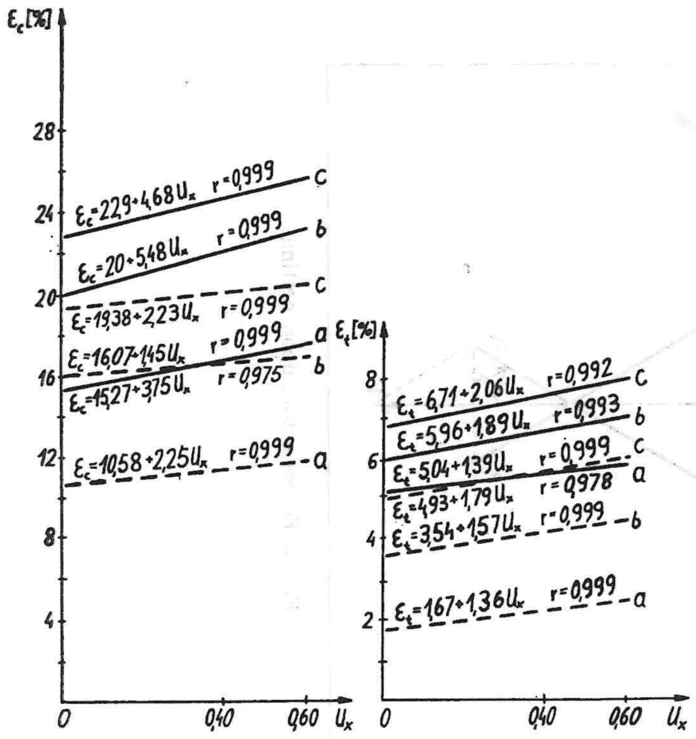

Fig. 8. Deformation of mesh size of netting made of 940 dtex/3x3 twine as affected by the horizontal netting hanging coefficient U_x, ------- in dry condition, ———— in wet condition, a — at load of 6 cN/tex, b — at load of 10 cN/tex, c — at load of 14 cN/tex.

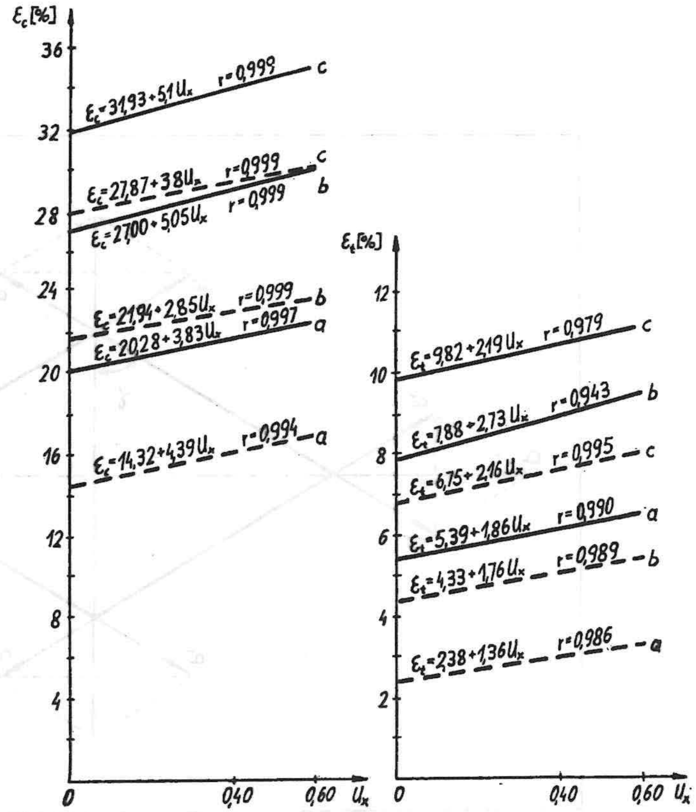

Fig. 9. Deformation of mesh size of netting made of 2 mm diameter twine as affected by the horizontal netting hanging coefficient U_x, ------ in dry condition, ———— in wet condition, a — at load of 6 cN/tex, b — at load of 10 cN/tex, c — at load of 14 cN/tex.

Table 6. Coefficients of correlation between mesh size deformation and horizontal coefficient of netting hanging U_x

Netting type	Load in cN/tex	Condition of the specimen	Total elongation: Equation coefficients C_1	Total elongation: Equation coefficients d_1	Total elongation: Correlation coefficeints r	Permanet elongation: Equation coefficient C_1	Permanet elongation: Equation coefficient d_1	Permanet elongation: Correlation coefficeints r
Made of 940 dtex/3x3 twine	6	in wet condition	10.58	2.25	0.999	1.67	1.36	0.999
		in dry condition	15.27	3.75	0.999	5.04	1.39	0.978
	10	in wet condition	16.07	1.45	0.975	3.54	1.57	0.999
		in dry condition	20	5.48	0.999	5.96	1.89	0.993
	14	in wet condition	19.38	2.23	0.999	4.93	1.79	0.999
		in dry condition	22.9	4.68	0.999	6.71	2.06	0.992
Made of 2 mm diameter twine	6	in wet condition	14.32	4.39	0.994	2.38	1.36	0.986
		in dry condition	20.28	3.83	0.997	5.39	1.86	0.990
	10	in wet condition	21.94	2.85	0.999	4.33	1.76	0.989
		in dry condition	27	5.05	0.999	7.88	2.73	0.943
	14	in wet condition	27.87	3.8	0.999	6.75	2.16	0.995
		in dry condition	31.93	5.1	0.999	9.82	2.19	0.979

where:
U_x = horizontal coefficient of netting hanging
U_y = vertical coefficeint of netting hanging

In the case of horizontal coefficient of netting hanging being equal to zero ($U_x = 0$) the P_1 is:

$$P_1 = \frac{P}{2}$$

$$P_2 = 0.5\,P$$

In the case of U_x coefficient increasing from 0 to 0.60 the tension value P_1 increases from 0.5 P to 0.625 P. Mesh size deformations increase with the increase of the horizontal coefficient of netting hanging U_x caused by the increase of the tension of the mesh bars. These correlations are graphically presented in Figs. 8 and 9. Calculated equation coefficients and correlation coefficients are given in Table 6.

The analysis of obtained results may be reduced to the following generalized equations:

— total elongation of the size as affected by the horizontal coefficient of netting hanging U_x.

$$\Sigma c_{u_1} = C_1 + d_1 U_x$$

— permanent elongation of the netting mesh size as affected by the horizontal coefficient of netting hanging U_x:

$$\Sigma t_{u_1} = C_2 + d_2 U_x$$

where:
C_1, C_2, d_1 and d_2 = the equation coefficients (Table 6).

The analysis om mesh size deformation under repeated loading relaxation cycles

The results of testing of mesh size deformation at repeated loading and relaxation (condition I) are given in Table 7. Changes in mesh size by individual cycles of loading and relaxation point to the fact that the greatest changes occur during the initial cycles. These changes are considerably smaller during the subsequent cycles. If the mesh length (2 a) is taken to be 100% during the first cycle then the lengthening in dry condition will be 1.22—2.47% during the fifth cycle and in wet condition 0.54—2.12%. Data from Table 7 show, at the same time, that deformations in wet condition are superior to those in dry condition. This is shown in Fig .10.

Table 7. Deformation of netting mesh size at repeated loading — relaxation (condition I)

Netting type	Load in cN/tex	Condition of the specimen	Total elongation in %					Total elongation in %				
			Cycle I	Cycle II	Cycle III	Cycle IV	Cycle V	Cycle I	Cycle II	Cycle III	Cycle IV	Cycle V
Made of 940 dtex/3x3 twine	6	in dry condition	11.64	12.37	12.72	13.01	13.19	1.50	1.92	2.20	2.40	2.51
		in wet condition	17	17.36	17.63	17.63	17.63	4.39	4.74	4.92	5.06	5.14
	10	in dry condition	16.73	17.37	17.75	17.95	18.21	2.93	3.64	4.08	4.35	4.47
		in wet condition	22.55	23.07	23.23	23.34	23.34	5.87	6.31	6.53	6.69	6.83
	14	in dry condition	20.62	21.59	22.09	22.44	22.81	4.75	5.66	6.25	6.59	6.86
		in wet condition	25.06	25.54	25.74	25.92	25.92	6.32	6.86	7.13	7.33	7.49
Made of 2 mm diameter twine	6	in dry condition	16.37	17.08	17.45	17.45	17.84	1.60	2.61	2.61	2.88	3.03
		in wet condition	21.86	22.39	22.87	23.17	23.31	4.20	4.83	5.18	5.39	5.57
	10	in dry condition	23.18	24.0	24.54	24.85	25.16	3.22	4.27	4.82	5.24	5.48
		in wet condition	29.15	29.96	30.29	30.52	30.77	6.82	7.76	8.27	6.62	8.91
	14	in dry condition	29.49	30.35	30.98	31.46	31.69	5.74	7.31	8.06	8.52	8.97
		in wet condition	34.15	35.07	35.66	35.87	36.02	8.58	9.80	10.52	10.92	11.27

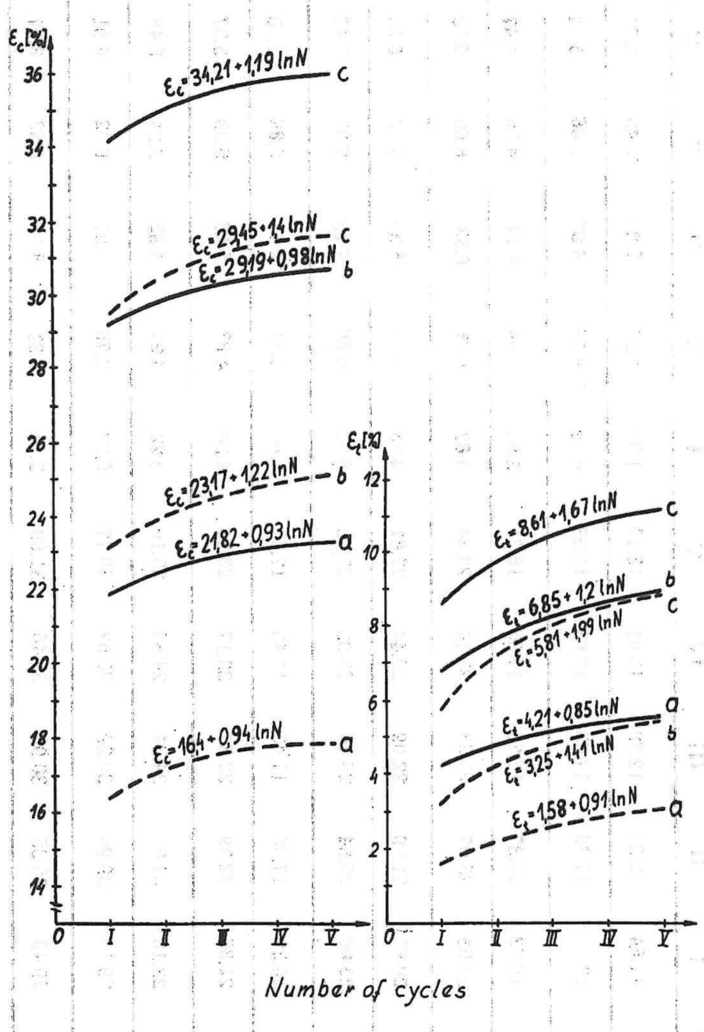

Fig. 10. Correlation between the deformation of mesh size of the netting made of the 2 mm diameter twine and the number of loading — unloading cycles, - - - - - - in dry condition, ———— in wet condition, a — at load of 6 cN/tex, b — at load of 10 cN/tex, c — at load of 14 cN/tex.

For the determination of total and permanent deformations of mesh size as affected by the number of loading — relaxation cycles the following linear model of the regression equation is applied:

$$\Sigma_c = e_1 + f_1 \ln N$$

$$\Sigma_t = e_2 + f_2 \ln N$$

where:

Σ_c = total mesh size deformation,

Σ_t = permanent mesh size deformation,

N = the number of loading and unloading cycles

e_1, e_2, f_1 and f_2 = the equation coefficients.

The values of coefficient e_1 is in all the cases almost equal to the total deformation of mesh size during the first loading cycle. The value of the coefficient e_2 is approximately equal to the extent of the permanent elongation of mesh size during the first cycle after removal of stress. Therefore the correlation between the total mesh size deformation and the number of loading — unloading cycles may be expressed by the following equations:

$$\Sigma_{c_n} = \Sigma_{c_1} + f_1 \ln N$$

$$\Sigma_{t_n} = \Sigma_{t_1} + f_2 \ln N$$

where:

Σ_{c_n} = total deformation of mesh size during the n^{th} cycle

Σ_{t_n} = permanent deformation of mesh size during the n^{th} cycle

Σ_{c_1} = total deformation of the mesh size during the first cycle

Σ_{t_1} = permanent deformation of the mesh size during the first cycle

The equation coefficients and correlation coefficients are given in Table 8.

The way of deformations of netting exposed to 15 cycle loading was determined during these studies. Load gradually increased every sixth cycle (cN/tex for the first five cycles, 10 cN/teh during the second five cycles and 14 cN/tex during the third five cycles) and vice versa, that is gradually reduced every sixth cycle (14 cN/tex during the third five cycles, 10 cN/tex during the second five cycles and 6 cm/tex during the first five cycles) .The variations in total deformation (or reversible elongation) of meshes as affected by the number of loading-relaxation cycles at gradual load increase (curve A) and gradual relaxation (curve B) are shown in Fig. 11, while permanent (irrevarsible) elongation is given in Fig. 12.

The The shape of the curve from Fig. 11 shows that at repeating loading — unloading cycles, earlier lower did not affect the total elongation of mesh size during subsequent cycles (curve A). However, under great loads during the initial cycles the total elongation of mesh size completely decreases during

Table 8. Coefficients of correlation between mesh size deformation and the number of loading - unloading cycles

Netting type	Load in cN/tex	Condition of the specimen	Total elongation – Equation coefficients		Correlation coefficient	Permanent elongation – Equation coefficient		Correlation coefficient
			e_1	f_1	r	e_1	f_1	r
Made of 940 dtex/3x3 twine	6	in dry condition	11.66	0.96	0.999	1.49	0.64	0.998
		in wet condition	17.05	0.41	0.956	4.40	0.46	0.999
	10	in dry condition	16.73	0.90	0.999	2.95	0.98	0.997
		in wet condition	22.62	0.50	0.968	5.88	0.59	0.999
	14	in dry condition	20.63	1.34	0.999	4.75	1.32	0.999
		in wet condition	25.10	0.56	0.986	6.33	0.72	0.999
Made of 2 mm diameter twine	6	in dry condition	16.40	0.94	0.996	1.58	0.91	0.997
		in wet condition	21.82	0.93	0.996	4.21	0.85	0.999
	10	in dry condition	23.17	1.22	0.999	3.25	1.41	0.999
		in wet condition	29.19	0.98	0.996	6.85	1.20	0.979
	14	in dry condition	29.45	1.40	0.998	5.81	1.99	0.997
		in wet condition	34.21	1.19	0.992	8.61	1.67	0.999

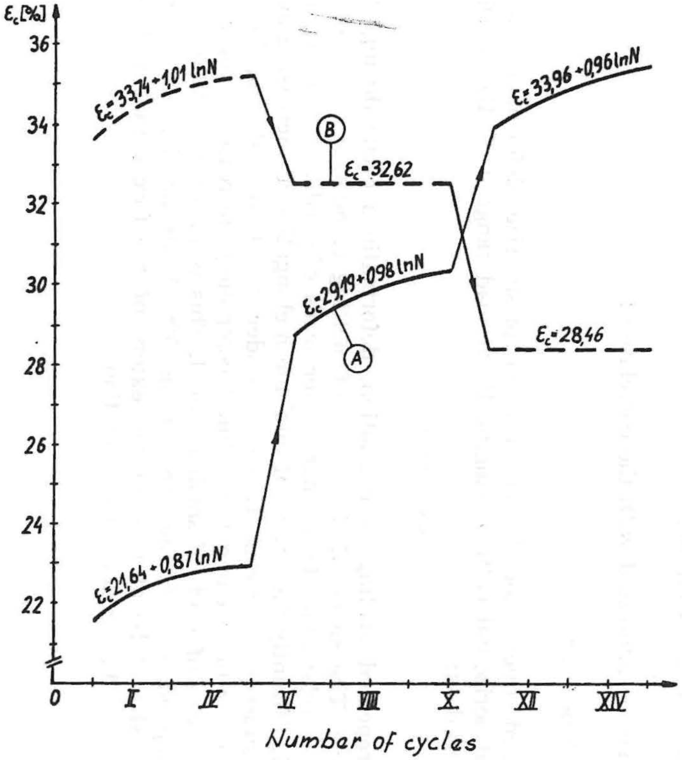

Fig. 11. Correlation between total elongation of mesh size of the netting made of the 2 mm diameter twine and the number of loading — unloading cycles, A — under loading condition II, B — under loading condition III.

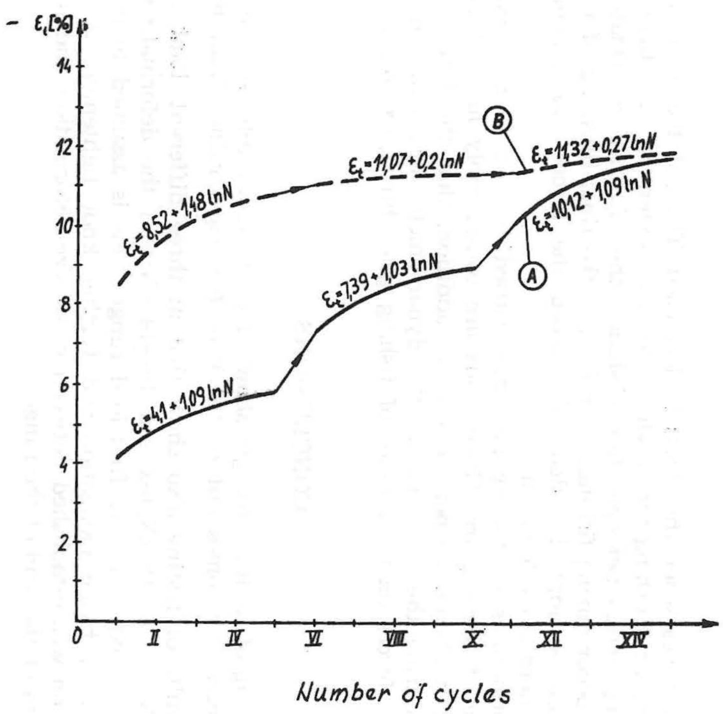

Fig. 12. Correlation between permanent elongation of mesh size of the netting made of the 2 mm diameter twine and the number of cycles, A — under loading condition II, B — under loading condition III.

the subsequent cycles when the stress is decreased. Thus, if the forces acting upon the netting at finishing the product are of an extent smaller than loads occurring during actual net operation (fishing), then further deformation of mesh size will occur during fishing. Therefore, at the final finishing of netting the loads should be applied which will exceed the forces acting upon the netting during normal exploitation.

Knot deformations of fishing nets are caused by the forces occurring during the use of these gears. These loads are considerably lower than the breaking load. It should be pointed out, in addition, that the forces acting upon meshes during the streching by the dynamometer are arranged differently than the forces on the meshes of fishing gear during exploitation.

CONCLUSIONS

1. The testing of netting strength shows that at mesh stretching the twine very frequently comes out of the knot (slippage) rather than breaks.
2. The results of testing also show that at three different load ranges (2—6 cN/tex, 6—10 cN/tex and 10—14 cN/tex) the deformations are of greatest extent at the first load range. This is assumed to be connected with twine elongation and further knot tightening. A linear correlation was established between mesh size deformation and natural logarithm of the load of the range

   $2 \text{ cN/tex} \leqslant P \leqslant 14 \text{ cN/tex}$

   which may be expressed with the correlation:

   $\Sigma_c = a_1 + b_1 + 1n\,P$

3. Established linear correlation between mesh size deformation and increased horizontal netting hanging U_x at load range $0 \leqslant U_x \leqslant 0.60$ is expressed as:

   $$\Sigma_c U_x = e_1 + d_1 U_x$$

4. Under repeated loading — relaxation, deformations occur during the first cycle. The shape of the curve of netting elongation at repeated loading — relaxation shows that earlier loads of smaller extent do not affect significantly the extent of total mesh elongation at increasing load during subsequent cycles. However, under great load during initial cycle, further mesh elongations almost completely decrease during subsequent cycles of loads of smaller extent. This requires very high loads to be applied at finishing the netting. The loads applied at netting finishing should be at least of the extent of the forces that will act upon netting during normal exploitation.

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PROMJENA VELIČINE OKA U POLIAMIDNIM MREŽAMA POD UTJECAJEM VIŠEKRATNIH OPTEREĆENJA I RELAKSACIJE

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KRATKI SADRŽAJ

Autori u radu iznose rezultate istraživanja o utjecaju opterećenja i relaksacije na promjene veličine oka mrežnog tega povlačnih mreža (koća). U radu je ispitivan poliamidni mrežni teg trgovačkog naziva stylon debljine konca 940 dtex/3×3 i 1880 dtex/4×3 (∅ 2 mm) i duljine jedne stranice oka 50 mm sa (impregniran) i bez finalne obrade te ribarski konac debljine 940 dtex/3×3 i 1880 dtex/4×3. Vodoravni koeficijent nabiranja kod ispitivanja pojedinačnog oka je iznosio $u_x = 0$ a kod mrežnog tega $u_x = 0$, $u = 0{,}4$ i $u_x = 0{,}6$. Opterećenje kod koeficijenta nabiranja $u = 0$ je iznosilo 2 cN/tex, 6 cN/tex, 10 cN/tex i 14 cN/tex a kod otvorenih oka 6 cN/tex, 10 cN/tex i 14 cN/tex. Deformacije su vršene dinamometrima. Rezultati ispitivanja, koji pokazuju mehanička svojstva konca i mrežnog tega, su prikazani u tabelama 1, 2, 3, 4, 5, 6, 7 i 8 te na slikama 5, 6, 8, 9, 10, 11 i 12.

Rezultate ispitivanja mehaničkih svojstava konca prikazuje tabela 1. a mrežnog tega tabela 2. Iz tabele 1. proizlazi da se u mokrom stanju smanjuje prekidna čvrstoća konca, čime se i odlikuju vlakna iz poliamidnih materijala te da se povećanjem debljine konca smanjuje njegova srednja specifična čvrstoća, dok tabela 2. pokazuje da impregnirani mrežni teg ima veću prekidnu čvrstoću te da je smanjenje prekidne čvrstoće u mokrom stanju znatno manje kod impregniranog nego kod neimpregniranog mrežnog tega.

Tabela 3. prikazuje rezultate ispitivanja deformacija veličine oka mrežnog tega pod utjecajem promjenljivih opterećenja kod koeficijenta nabiranja $u_x = 0$, ovisnosti deformacija od opterećenja slike 5. i 6, dok koeficijente tih ovisnosti s koeficijentima korelacije tabela 4. Navedeni rezultati pokazuju da se potpuna i trajna deformacija veličine oka povećava s povećanjem opterećenja te da su najveće deformacije veličine oka u prvom intervalu opterećenja (od 2—6 cN/tex), što može biti prouzrokovano izravnavanjem uvijenih vlakana, od kojih je izrađen ribarski konac te stiskanjem uzlova oka mrežnog tega.

U tabeli 5. i na slikama 8. i 9. su prikazani rezultati ispitivanja deformacija veličine oka mrežnog tega nakon finalne obrade pod utjecajem promjenljivih opterećenja i različitih vodoravnih koeficijenata nabiranja mrežnog tega ($u_x = 0$, $u_x = 0{,}4$ i $u_x = 0{,}6$), dok u tabeli 6. koeficijenti ovisnosti deformacije veličine oka od vodoravnog koeficijenta nabiranja mrežnog tega s koeficijentima korelacije. Iz navedenih rezultata istraživanja proizlazi da potpune i trajne deformacije mrežnog tega, podjedako u suhom kao i mokrom stanju, rastu s porastom vodoravnog koeficijenta nabiranja mrežnog tega.

U tabeli 7. i na slici 10. su prikazani rezultati ispitivanja deformacija veličine oka mrežnog tega pod utjecajem višekratnog opterećenja i relaksacije, dok koeficijente tih ovisnosti o koeficijentima korelacije prikazuje tabela 8. Iz navedenih rezultata proizlazi da najveće promjene kod mrežnog tega nastaju u prvim cikusima optrećenja i da su te deformacije izrazito veće kod mrežnog tega u mokrom nego u suhom stanju.

Slika 11. i 12. prikazuje ovisnost potpune odnosno trajne deformacije veličine oka mrežnog tega izrađenog iz konca promjera 2 mm od broja ciklusa opterećenja — rasterećenja.

Na temelju iznesenih rezultata istraživanja u ovom radu, mogu se izvesti slijedeći zaključci:

— pod utjecajem opterećenja ribolovnih alata kod čega nastaju rastezanja mrežnih oka u mnogim slučajevima ne prouzrokuju njihovo prekidanje već pomicanje konca na uzlovima, što svjedoči o neodgovarajućoj tehnologiji finalne obrade mrežnog tega,

— kod primjene tri intervala optrećenja (2—6 cN/tex, 6—10 cN/tex i 10—14 cN/tex) najveće deformacije veličine oka nastaju u prvom intervalu opterećenja, što se pretpostavlja da je povezano s izravnavanjem uvijenog konca i daljim stiskanjem uzlova,

— kod višekratnih opterećenja — relaksacija mrežnog tega najveće deformacije nastaju u prvom ciklusu optrećenja.