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A LABORATORY STUDY OF THE EFFECT OF BOTTOM SEDIMENTS ON MESH SIZE

by

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ABSTRACT

Seven types of netting made of different materials (polyamide, polyester and polyethylene) and of different construction (twisted or braided, single or double yarn) were submitted to the influence of bottom sediments (sand and mud) under laboratory conditions. The variation of the mesh size is given for 3 hours time intervals. The final mesh size after 60 hours of testing is compared with the initial mesh size and with the result of a blank test. The residual shrinkage after rinsing the samples penetrated by sand or mud and the difference between the mesh sizes in wet and dry condition are also discussed.

RESUME

Sept types de nappes de filets en différents matériaux (polyamide, polyester et polyéthylène) et d'une différente construction (câblée ou tressée, fils simples ou doubles) ont été soumis à l'influence de sédiments de fond (sable et boue) sous conditions de laboratoire. La variation de l'ouverture de la maille est donnée pour des intervalles de 3 heures. L'ouverture de la maille après une durée d'essai de 60 heures est comparée à l'ouverture de la maille initiale et au résultat d'un essai blanc. La rétraction résiduelle après rinçage des échantillons pénétrés de sable ou de boue et la différence entre l'ouverture de la maille en état sec et en état mouillé sont également discutées.

INTRODUCTION

The mesh size of netting for fishing nets is not constant but varies under the influence of several parameters such as humidity, load, sunlight, temperature and bottom sediments (Klust, 1982 ; Strange, 1984). Of these, fishermen regard the penetration of bottom sediments as one of the main causes of mesh shrinkage. Consequently this cause of shrinkage is regularly brought up for discussion when offence of the reglementation on minimum mesh sizes is established.

Unfortunately data based on systematic research with reference to this problem seem to be scarce. In order to fill up this gap a series of laboratory experiments on the effect of sand and mud on different types of netting were carried out.

MATERIALS AND METHODS

As the main objective of this work is a comparative study of mesh shrinkage caused by sediments in different types of netting, the replicability of the experiment was a main requirement in setting up the research method. A laboratory study was thus preferred, despite the limitations of this method with regard to the fishing conditions at sea. These conditions however are so variable that the results from investigations based on experimental hauls on board of fishing vessels can hardly be compared.

The nettings tested were made of twisted or braided polyamide (PA), polyester (PES) or polyethylene (PE) yarns. The main characteristics of these nettings are given in table 1.

From each netting test samples of size 4T x 4N were cut, yielding 25 meshes to be measured. As the knots at the edges of the polyethylene nettings tend to open, samples of size 5T x 5N were taken from which the 25 central meshes were measured.

Before starting the tests the mesh sizes of the samples were determined in dry (standard atmosphere : 20° ± 2 °C, relative humidity 65 % ± 2 %) and wet (minimum wetting time 12 hours in tap water of 20° ± 2 °C) conditions. Each sample was placed in a vessel (size 170 x 130 x 220 mm) containing 800 cc tap water and 400 cc sand or mud, which in turn was enclosed in a rotating drum. The rotation speed was 65 rev/min. The meshes were measured at intervals of 3 hours. A complete test lasted for 60 hours. The mesh size of the sample in dry condition was then again determined. Additionally a blank test without sand or mud was carried out in order to establish possible effects on the mesh size of the experimental technique.

Each set of tests was followed by a microscopic examination of the netting sample in order to evaluate the penetration of sediment particles into the yarns and to assess possible damage of the yarn filaments.

Subsequently the samples submitted to the sand and mud test were repeatedly rinsed in clear water in the rotating vessel until no more sand or mud particles were released. This took about 3 hours. Finally the meshes were measured once more in wet and dry condition.

For the mesh measurements an ICES mesh gauge at a pretension of 4 kg was used.

Table 2 gives the results of the grain analysis of both sand and mud, performed according to the method described by Buchanan (1971). The sand was mainly composed of medium sand, the mud of fine sand and silt.

RESULTS AND DISCUSSION

Table 3 gives the mean wet mesh sizes in mm of each netting at the start (new) and the end (60 h) of each set of measurements (sand, mud, blank), as well as the shrinkage expressed in percentages. This shrinkage is given in function of time in figures 1 to 7.

The influence of sand on the PA and PES nettings made of braided yarns is similar. After 60 hours of testing the netting yarns showed a slight penetration of sand between the strands which resulted in a more loose structure of the braids. Locally sand also penetrated between the multifilaments.

This sand absorption resulted in a shrinkage of the PA netting by 3.2 %. However, after the blank test the mean mesh size showed an increase of 1.7 %, so the real shrinkage due to sand absorption must be put at 4.9 %.

After the sand test the PES netting had shrunk by 6.9 %. No significant changes in mesh size were noted during the blank test.

The microscopic examination revealed an increased absorption of finer particles at the end of the mud test. Consequently the shrinkage caused by mud was more important than the shrinkage at the end of the sand test. After 60 hours of mud testing the PA netting shrank by 7.2 %, or 8.9 % with regard to the blank test, the PES netting by 8.8 %.

From the graphs in figures 1 and 2 it can be concluded that most of the sediment absorption, and consequently of the shrinkage, occurs during the first hours of testing. Afterwards the decrease in mesh size declines more slowly. A the end of the test the knots showed clear signs of wear.

The effect of the sediments on the nettings made of twisted PA yarns varied significantly according to the twist hardness of the yarns.

During the sand test the yarn with the lowest twist coefficient (PA-R6735 tex-α= 197) fluffed considerably and became saturated with sand (figure 8). At the end of the test the mesh size had decreased by 25.9 %. With reference to the blank test the shrinkage was 24.8 %. If the test is repeated with mud instead of sand, the fluffing is much less distinct and the shrinkage amounts only to 12.1 % or 11 % if referred to the blank test. It seems reasonable to conclude that the fluffing in the sand test is caused by the kinetic action of the coarser sand grains resulting in the loosening of the multifilaments.

From all netting samples tested, the one made of the harder twisted PA yarns (PA-R 3900 tex - α = 237 - double) resisted best to sediment absorption. The shrinkage is insignificant with sand and 3.6 % with mud. Again the higher shrinkage with mud is due to the higher proportion of finer particles which penetrate more easily between the multifilaments.

The less tight structure of the netting yarns made of PE-monofilaments offers little resistance to the penetration of sediments. This leads to high shrinkage values after the sand test : 7.4 % for the netting of single twisted yarns, 11.6 % for the double twisted yarns and 8.6 % for the braided yarns. Compared to the blank test the shrinkage even amounts to 10, 16 and 11 % respectively.

On the other hand, due to the relatively loose construction of the yarns the sediments are easily rinsed out again and the shrinkage soon reaches an equilibrium. This is particularly true for the mud test carried out on the two nettings made of single PE-yarns.

Figures 5 and 7 show that both samples shrank only during the first 15 hours of testing and then remained practically unchanged for the rest of the experiment.

For both nettings this shrinkage was about 6 %, 8 % if compared with the blank test. These values are lower than those obtained in the sand test as the finer mud particles are more easily rinsed out.

In the case of the PE-netting made of double twisted yarns these assessments are less clear. However, the 12.7 % shrinkage due to mud, 17.3 % with respect to the blank test, differs only slightly from the shrinkage caused by sand. This difference was much more pronounced with the samples made of the other materials tested.

After 60 hours of testing with sand or mud the knots showed clear signs of wear. A microscopic examination clearly showed a roughening of the filaments.

The effect on the mesh size of rinsing the samples after testing is given in table 4. The mesh measurements were performed on the nettings in wet condition.

From all nettings some of the absorbed sediment particles could be rinsed out, but the amount, and hence the effect on the final mesh size, differs according to the type of netting.

Rinsing the samples made of braided PA or PES yarns reduced the shrinkage caused by sand or mud by 2 to 3 %. This means that the final shrinkage of the PA-netting was practically zero for the sand tested sample, but still attains 5 % for the mud tested one. Higher values were noted for the PES-netting : 4 and 7 % for sand and mud respectively.

As could be expected the effect of rinsing is negligible on the PA netting made of the softer twisted yarn which fluffed during the sand test. The shrinkage due to mud is reduced by 4 % but the final value still reaches 8 %.

The low shrinkage of the PA netting made of the harder twisted yarns could almost be eliminated by rinsing the samples after the sand and mud test.

A lot of sand which had penetrated the PE-yarns could be washed out and resulted in a 4 % increase in mesh size. However, the netting made of double twisted yarns still showed a permanent shrinkage of 7 %. The effect of rinsing the PE samples previously subjected to the mud test was an increase in mesh size by 3 % for the single yarns and 5 % for the double twisted yarns. Here too, the permanent shrinkage is 8 %.

Table 5 gives the differences between the mean mesh sizes of the netting samples in dry and wet condition at the start as well as at the end of the tests. These differences are expressed as percentages of the mesh size in wet condition. The values obtained for the new netting samples correspond to what is to be expected : only small differences for the PES and PE nettings and smaller mesh sizes in dry condition compared to the mesh size in wet condition for the PA nettings (Klust, 1982). After the samples had been submitted to the influence of sediments some changes occur, especially if mud was used. Most nettings had larger dry/wet mesh size differences after this test. This was also observed with the sand tested PA netting made of the softer twisted yarn. Rinsing the samples reduced the dry/wet mesh size differences again to values equal to or slightly higher than those obtained with new netting.

CONCLUSIONS

The laboratory experiments carried out indicate that significant shrinkage of netting can occur due to the influence of bottom sediments.

Two mechanisms seem to be involved in the shrinkage process. First of all there is the penetration of the sediments between the fibres causing swelling and consequently shrinking of the netting yarns. Secondly there is the kinetic action of the particles which tend to loosen the filaments. This mechanism occurred only with sand (containing coarser particles than mud) and only on the PA netting made of the softer twisted yarn.

In the nettings with yarns made of multifilaments the shrinkage caused by mud was more important than that caused by sand. Obviously the finer particles penetrated more easily into the yarns. Only the PA netting made of the softer twisted yarns made an exception. These yarns fluffed during the sand test resulting in a considerable shrinkage of about 25 %.

Netting yarns made of monofilaments are less tight and do not easily withhold the finer particles. In this type of netting the shrinkage caused by mud was practically equal or even smaller than that due to sand.

Shrinkage caused by sediments can be reduced by rinsing the netting. For most nettings tested however the permanent shrinkage was still considerable, especially if it was caused by mud.

Penetration of the netting yarns by mud also leads to increased differences between the mesh sizes in dry and wet condition. After rinsing however these differences were only slightly higher than those of new nettings.

REFERENCES

BUCHANAN, J. 1971. Sediments. In : Methods for the Study of Marine Benthos, IBP Handbook no 16, pp. 30-51. Ed. Holme N.A. and McIntyre A.D. Blackwell Scientific Publications, Oxford.

KLUST, G. 1982. Netting Materials for Fishing Nets. 2nd ed. FAO Fishing Manuals. Fishing News Books Ltd, Farnham.

STRANGE, E.S. 1984. Mesh Shrinkage in Fishing Nets. Scottish Fisheries Information Pamphlet No. 11. Department of Agriculture and Fisheries for Scotland, Marine Laboratory, Aberdeen.

Table 1 - Main characteristics of the nettings tested

Material	Rtex	Yarn construction	Single/double yarn	Nominal mesh size (mm)
PA	12000	braided multifilaments	single	70
PA	6735	twisted multifilaments $\alpha = 197$ (1)	single	140
PA	3900	Twisted multifilaments $\alpha = 237$ (1)	double	75
PES	13000	braided multifilaments	single	80
PE	4440	twisted monofilaments	single	85
PE	4440	twisted monofilaments	double	80
PE	6770	braided monofilaments	single	115

(1) twist factor $\alpha = t/m \times \sqrt{\frac{tex}{1000}}$

Table 2 - Grain size analysis of the sediments

Description	Size (μ)	Sand	Mud
Shells, gravel	>2000	-	-
Very coarse sand	1000 - 2000	-	0.84 %
Coarse sand	500 - 1000	13.01 %	0.72 %
Medium sand	250 - 500	84.73 %	6.24 %
Fine sand	125 - 250	2.08 %	49.78 %
Very fine sand	63 - 125	0.07 %	9.06 %
Silt	<63	0.10 %	33.24 %

Table 3 - Mean mesh sizes and percentage of shrinkage

		Sand		Mud		Blank	
		new	60 h	new	60 h	new	60 h
PA - R12000 tex	mm	73.28	70.96	75.48	70.08	72.6	73.8
braided-single	%		- 3.2		- 7.2		+ 1.7
PES - R13000 tex	mm	79.6	74.08	80.28	73.2	79.64	79.56
braided-single	%		- 6.9		- 8.8		- 0.1
PA - R6735 tex twisted-single	mm	151.44	112.2	151.52	133.24	144.44	142.82
λ = 197	%		- 25.9		- 12.1		- 1.1
PA - R3900 tex twisted-double	mm	79.44	79.24	80.5	77.6	80.48	80.48
λ = 237	%		- 0.3		- 3.6		0
PE - R4440 tex	mm	85.2	78.92	92.04	87.0	89.56	91.96
twisted-single	%		- 7.4		- 5.5		+ 2.7
PE - R4440 tex	mm	81.72	72.28	81.56	71.2	84.36	88.2
twisted-double	%		- 11.6		- 12.7		+4.6
PE - R6670 tex	mm	112.72	103.08	115.16	108.28	114.76	117.64
braided-single	%		- 8.6		- 6.0		+ 2.5

Table 4 - Effect of rinsing.

		Sand			Mud		
		New	60 h	After rinsing	New	60 h	After rinsing
PA-R1200 tex braided-single	mm %	73.28	70.69 -3.2	72.6 -0.9	75.48	70.08 -7.2	71.76 -4.9
PES-R13000 tex braided-single	mm %	79.6	74.08 -6.9	76.24 -4.2	80.28	73.2 -8.8	74.56 -7.1
PA-R6735 tex twisted-single $\alpha = 197$	mm %	151.44	112.2 -25.9	113.88 -24.8	151.52	133.24 -12.1	139.32 -8.1
PA-R3900 tex twisted-double $\alpha = 237$	mm %	79.44	79.24 -0.3	80.12 0.9	80.5	77.6 - 3.6	79.36 -1.4
PE-R4440 tex twisted-single	mm %	85.2	78.92 -7.4	82.44 -3.2	92.04	87.0 -5.5	89.28 -3.0
PE-R4440 tex twisted-double	mm %	81.72	72.28 -11.6	75.8 -7.2	81.56	71.2 -12.7	75 -8.0
PE-R6770 tex braided-single	mm %	112.72	103.08 -8.6	108.12 -4.1	115.16	108.28 -6.0	111.52 -3.2

Table 5 - Comparison between the mesh sizes of the samples in wet and dry condition

		Sand						Mud					
		New		60 h		After rinsing		New		60 h		After rinsing	
		Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
PA-R12000 tex braided-single	mm %	73.28	67.72 -7.6	70.69	65.48 -7.4	72.6	67.28 -7.3	75.48	68.92 -8.7	70.08	59.6 -15.0	71.76	64.64 -9.9
PES-R13000 tex braided-single	mm %	79.6	78.84 -1.0	74.08	74.56 +0.6	76.24	75.52 -0.9	80.28	79.92 -0.4	73.2	69.64 -4.9	74.56	73.36 -1.6
PA-R6735 tex twisted-single α = 197	mm %	151.44	142.24 -6.1	112.2	99.68 -11.2	113.88	105.84 -7.1	151.52	142.4 -6.0	133.24	119.96 -10.0	139.32	128.56 -7.7
PA-R3900 tex twisted-double α = 237	mm %	79.44	75.16 -5.4	79.24	73.88 -6.8	80.12	75.92 -5.2	80.5	74.68 -7.2	77.6	70.8 -8.8	79.36	73.64 -7.2
PE-R4440 tex twisted-single	mm %	85.2	84.52 -0.8	78.92	80.68 +2.2	82.44	82.04 -0.5	92.04	91.6 -0.5	87.0	85.12 -2.2	89.28	88.48 -0.9
PE-R4440 tex twisted-double	mm %	81.72	80.52 -1.5	72.28	73.36 +1.5	75.8	75.24 -0.7	81.56	80.24 -1.6	71.2	70.52 -1.0	75	73.95 -1.4
PE-R6770 tex braided-single	mm %	112.72	112.08 -0.6	103.08	104.16 +1.0	108.12	108 -0.1	115.16	114.76 -0.3	108.28	104.52 -3.5	111.52	110.68 -0.8

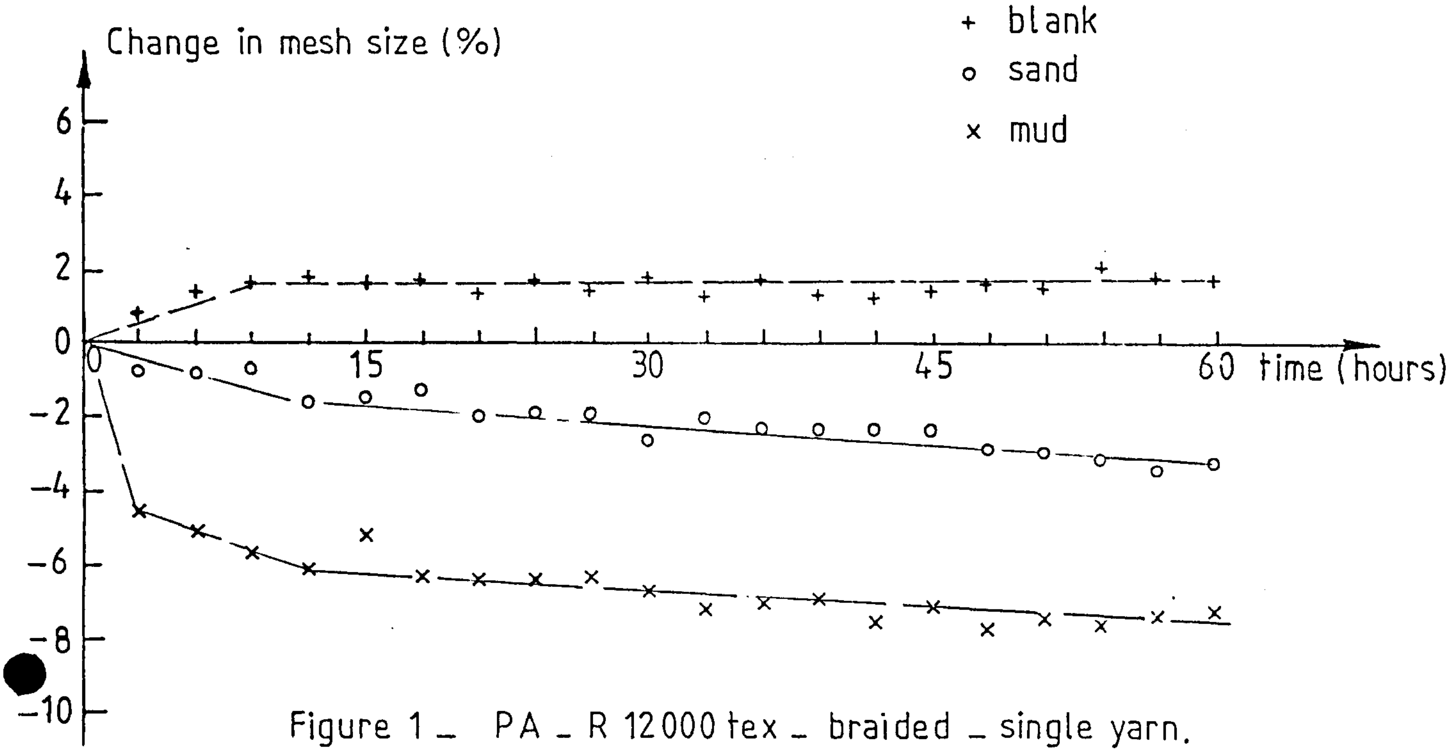

Figure 1 _ PA _ R 12000 tex _ braided _ single yarn.

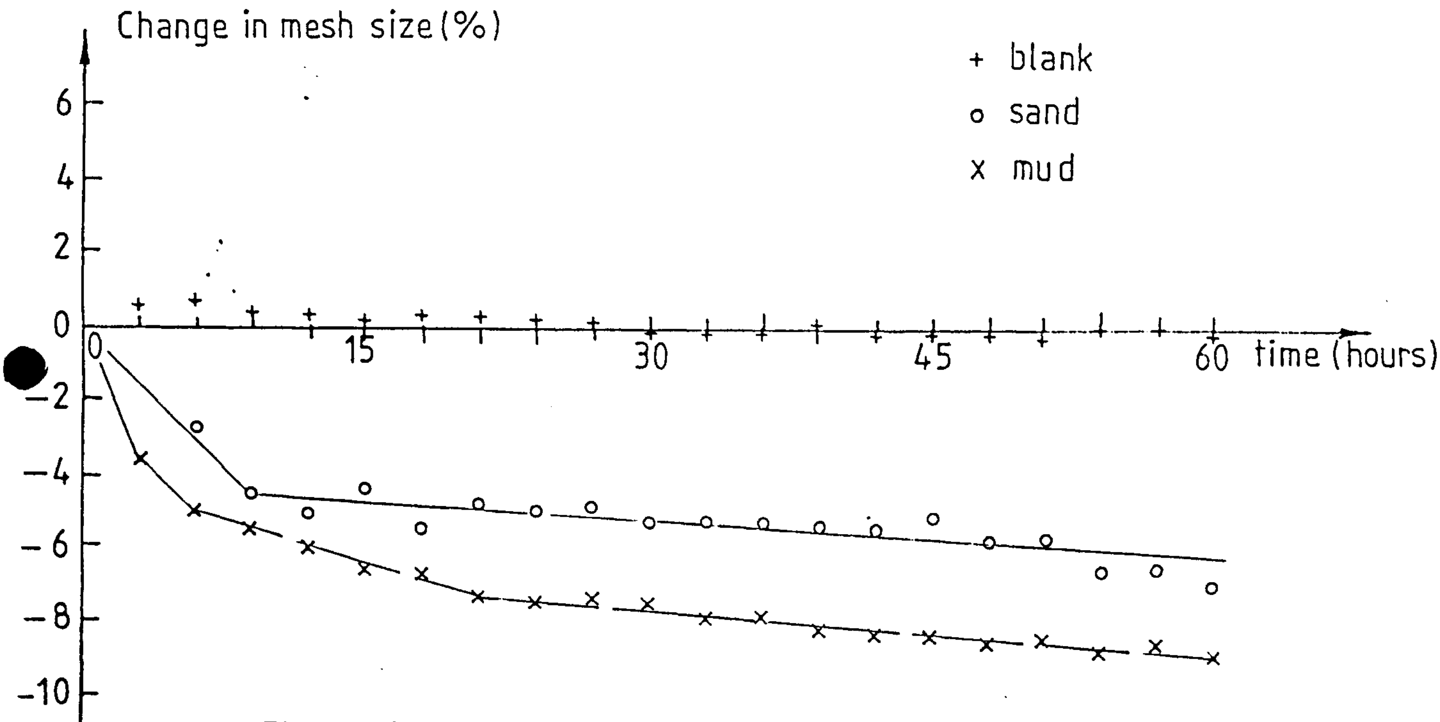

Figure 2 _ PES _ R 13000 tex _ braided _ single yarn.

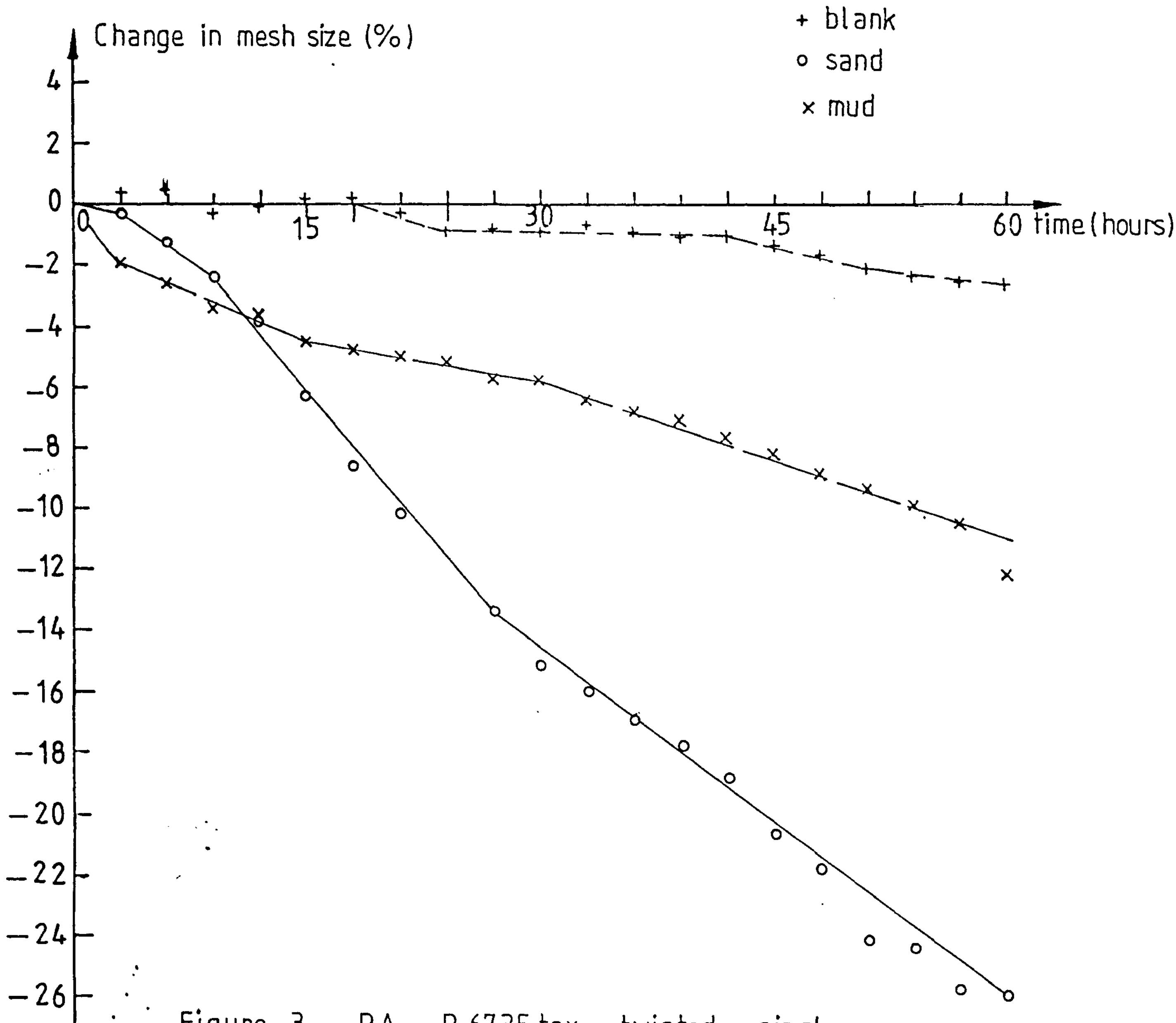

Figure 3 – PA – R 6735 tex – twisted – single yarn.

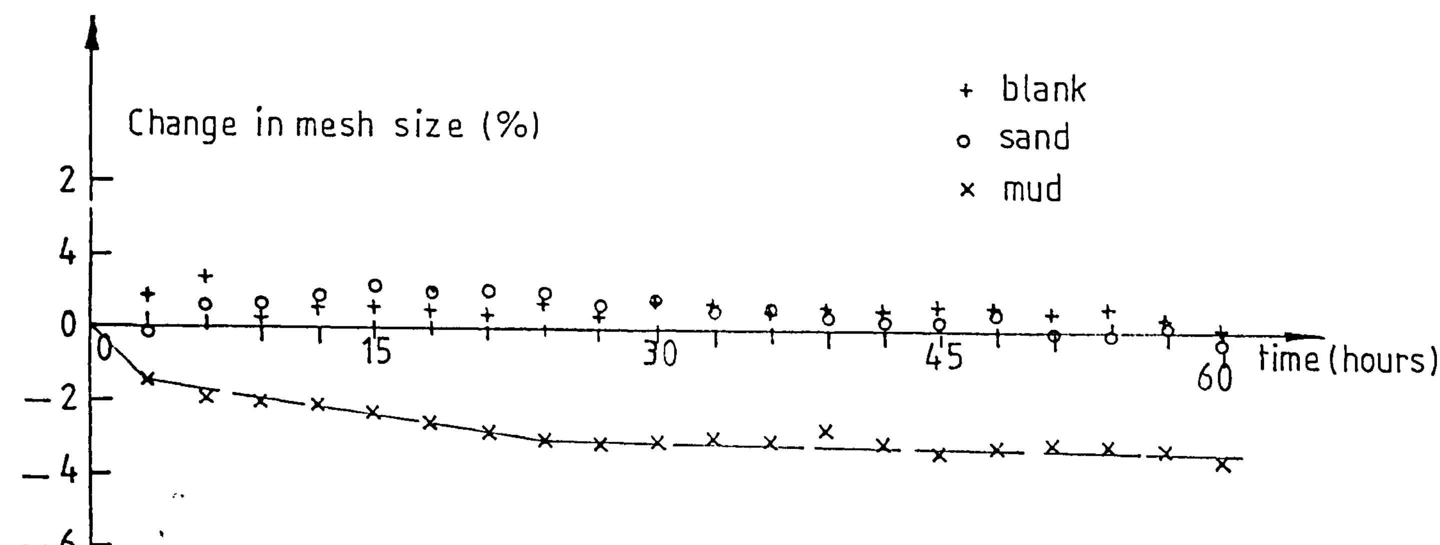

Figure 4 – PA – 3900 tex – twisted – double yarn.

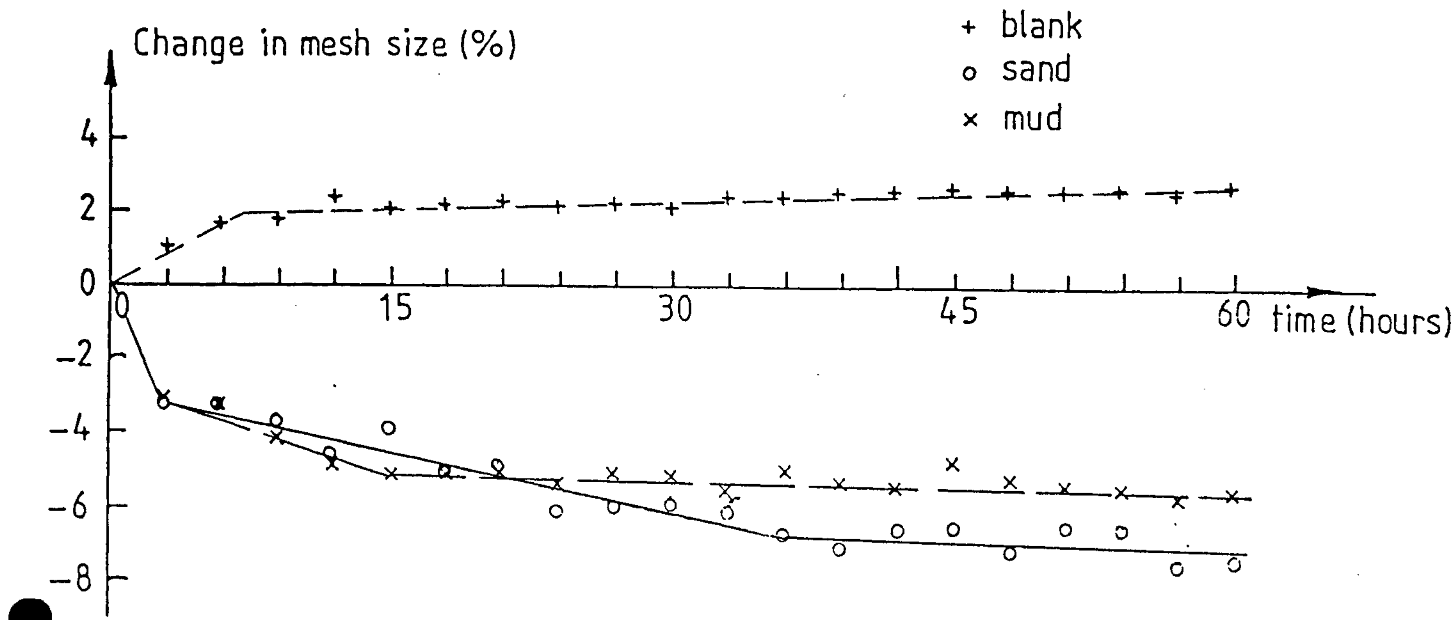

Figure 5 _ PE _ R 4440tex _ twisted _ single yarn.

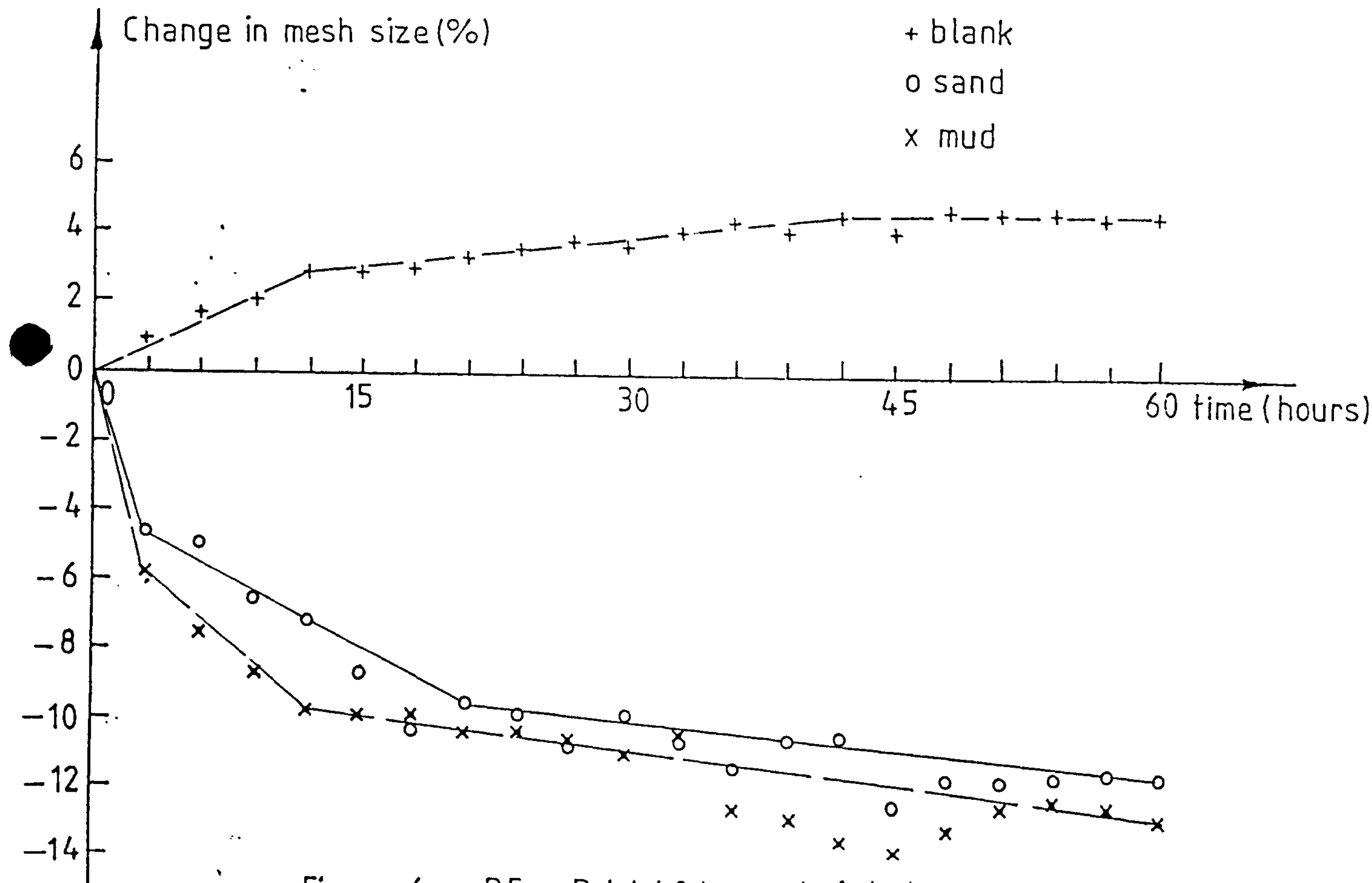

Figure 6 _ PE _ R 4440 tex _ twisted _ double yarn.

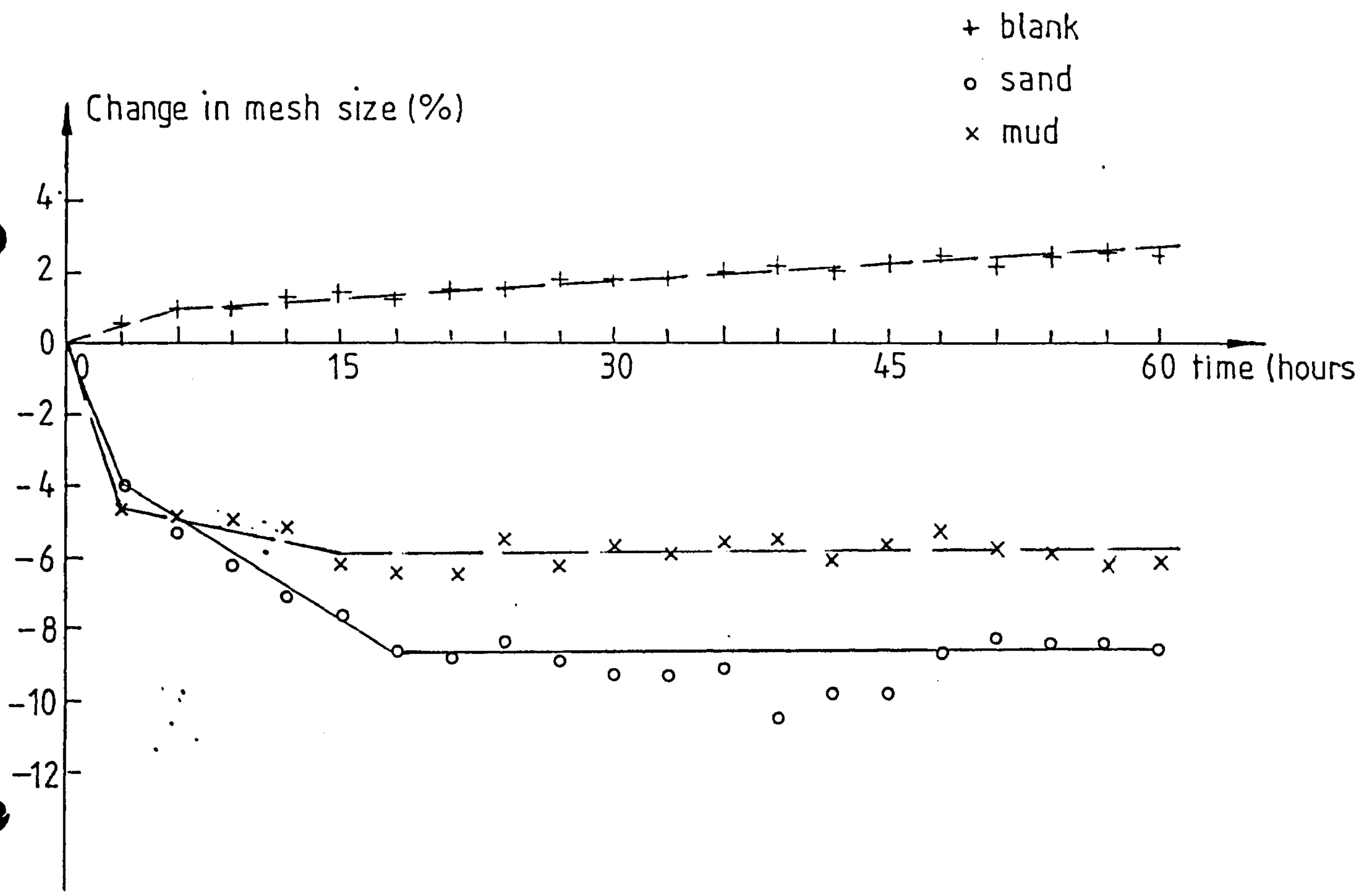

Figure 7_ P E _ R 7000 tex _ braided _ single yarn

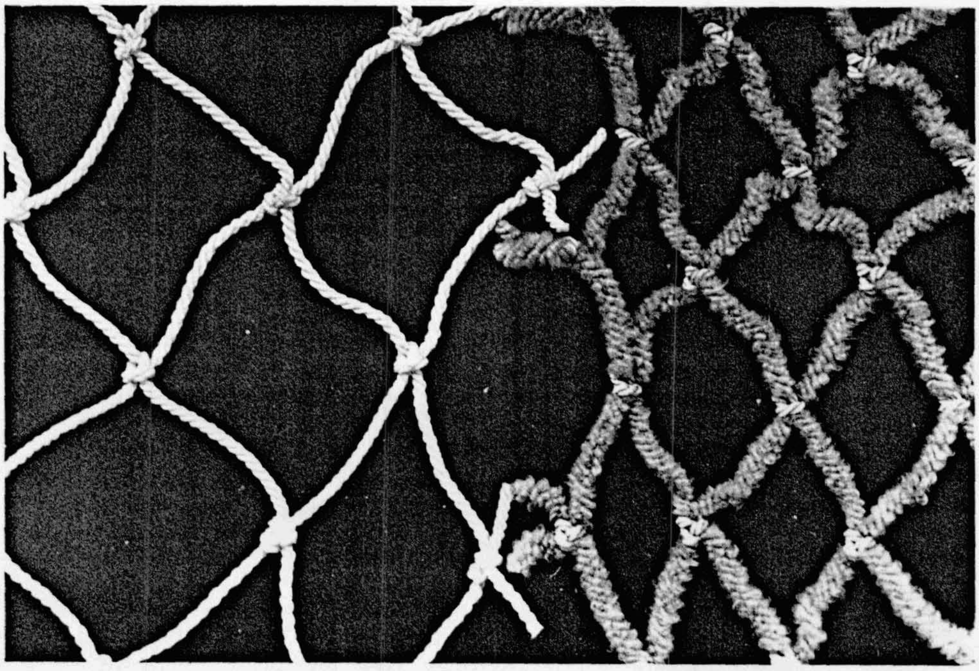

Figure 8 _ Netting made of the softer twisted PA multifilaments

Left : the new netting

Right: the fluffed netting after 60 hours of sand testing.