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†Standardization of polyamide monofilament yarns for fabrication of gillnet with reference to physical and mechanical properties

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Abstract

Yarns of 37 different sizes ranging from 0.08 to 3.0 mm diameter were found to be in use for fishing purposes, in South India. The physical and mechanical properties viz., linear density, runnage and the tensile break-load and elongation of nylon monofilament yarns were assessed. Of the 37 diameters tested, BIS (Bureau of Indian Standards) standards are available only for 17. Out of the 17 diameters of yarns tested, only 12 conformed to the standards with reference to runnage, 4 for break-load and all for elongation. Properties of yarns of 24 sizes in the range of 0.08 to 1.0 mm suitable for fabrication of gillnets are presented in this paper. The relationship between wet knot break-load and R-tex was found more significant than wet knot break-load and diameter. Samples of 0.16 and 0.20 mm diameter lost 55% of their original break-load at the end of 300 days exposure to sunlight while 0.23 mm lost 49 % and 0.32 mm diameter yarns lost 31% of original break-load. The standard specifications required for yarns of each diameter were worked out for the materials suitable for fabrication of gillnet which would help in selection of the yarns for a specific fishery

Keywords: Polyamide monofilament yarn, gillnet, break-load, elongation

Introduction

The synthetic netting yarns used in Indian fishing sector are polyamide (PA), polyethylene (PE) and polypropylene (PP). Of these, PA (popularly known as nylon) is the most used synthetic material in the gillnet fisheries. Nylon is available in India in the form of multifilament twisted netting yarns (twines) of 210dx1x2 to 210dx24x3 and monofilament yarns from 0.16 to 3 mm diameter (Meenakumari and Radhalakshmi, 2003). In India, the use of synthetics in gillnets started with nylon multifilament, and recently nylon monofilament has become very popular (Vijayan *et al.*, 1993; Rao *et al.*, 1994; Pravin *et al.*, 1998; Thomas, 2001).

PA monofilament yarn of different quality and sizes are available in the market and no standards exist for many of these. The scope of the BIS standard for PA monofilament yarn is limited to line fishing only (Anon, 2003) covering 17 diameters in the range of 0.16 to 3.0 mm. However, 37 sizes ranging from 0.08 to 3.0 mm diameter are available in the market. The properties such as physical and mechanical properties and weathering resistance of many of these new sizes of monofilament yarn have not been assessed and documented. Weathering studies conducted in India on fish netting twines were confined to PE and PA twines (Meenakumari *et al.*, 1985; Meenakumari and Ravindran, 1985; Meenakumari and Radhalakshmi, 1988) except a study by Thomas and Hridayanathan (2006) which covered PA monofilament also.

The aim of the present study is to document the physical, mechanical and weathering properties of

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PA monofilament yarns and to formulate standard specifications required for PA monofilament yarns suitable for gillnet fabrication.

Material and methods

Samples of PA monofilament yarns of different sizes from different centers in India were collected mainly through three sources *viz*., (i) directly from manufacturers, (ii) dealers and (iii) fishermen.

The diameter of the samples was measured as per Anon (1971). Mean value of 10 replicate tests was taken for computation. Linear density, the mass per unit length expressed as mass in g of 1000 m length of the sample (R-tex) was measured as per Anon (1970).

$$\text{Linear density, } (T) = (m / l) \times 1000$$

where m is the mass in g and l is the length of the specimen in meter.

Runnage, the length of yarn in meters for 1 kg of the yarn was calculated by the formula,

$$\text{Runnage, } R = (1000 \times 1000) / \text{R-tex}$$

The mechanical properties such as dry break-load & elongation, dry knot break-load and elongation, wet break-load and elongation and wet knot break-load and elongation were tested as per Anon (1993).

PA monofilament yarns of five different diameters were assessed by exposing the samples to natural sunlight. The test samples comprised commercial samples of PA monofilament yarn of four diameters *viz*., 0.16 mm (Tex 23), 0.20 mm (Tex 44), 0.23 mm (Tex 50), 0.32 mm (Tex 90) and 0.45 mm (Tex 185). The test samples were suspended without tension on aluminium nails set 1 cm apart on rectangular wooden frames of 1.5x0.5 m unbacked to provide ventilation and to prevent building up of temperature. The mounted samples were kept in north- south direction at an angle of 45° on the rooftop where sunlight falls

Table 1. Physical and mechanical properties of PA monofilament yarns

Diameter (mm)	R-Tex	Runnage (m/kg)	Dry break-load (N) and elongation at break (%)	Wet break-load (N) and elongation at break (%)	Knot break-load (N) and elongation at break (%)	Wet knot break-load (N) and elongation at break (%)
0.08	8.53 ± 0.10	143463	7.39 (26.16)*	5.63(28.81)	5.45(22.48)	4.74(22.5)
0.10	11.15 ± 0.12	93089	7.04 (22.57)	5.47(28.80)	5.97(18.10)	5.05(23.92)
0.12	15.64 ± 1.15	65377	10.79 (26.26)	8.92(30.68)	8.95(20.49)	7.71(25.31)
0.16	28.97 ± 7.67	37433	15.56 (25.13)	13.94(22.86)	12.27(18.75)	11.61(18.04)
0.18	31.20 ± 2.21	29792	21.44 (23.50)	19.82(25.75)	14.63(14.87)	13.62(16.12)
0.20	40.61 ± 4.11	24289	21.22 (27.03)	19.99(28.49)	15.77(19.99)	14.74(18.25)
0.23	56.97 ± 4.65	18525	22.15 (25.67)	19.81(27.13)	16.29(17.53)	15.29(19.24)
0.25	62.64 ± 6.74	15761	30.74 (29.17)	27.83(32.48)	21.41(27.14)	18.9(20.64)
0.26	69.57 ± 11.02	14607	46.07 (21.24)	40.34(22.68)	29.25(15.63)	30.2(16.03)
0.28	71.54 ± 6.62	12652	32.16 (26.08)	26.87(24.30)	23.52(19.03)	18.25(13.64)
0.30	89.36 ± 14.23	11069	40.99 (29.42)	37.85(31.46)	26.62(19.07)	26.24(19.53)
0.32	96.98 ± 17.08	9767	36.72 (27.47)	33.58(30.80)	25.80(16.44)	23.79(17.35)
0.35	123.98 ± 12.73	8210	51.41 (31.66)	46.68(34.57)	34.13(17.93)	30.48(20.08)
0.37	121.22 ± 11.22	7371	84.57 (27.49)	70.59(30.13)	40.77(22.73)	63.7(26.89)
0.40	148.72 ± 12.30	6338	62.06 (29.93)	56.99(32.04)	39.73(16.72)	36.79(17.12)
0.45	191.03 ± 14.15	5044	80.30 (28.04)	72.62(30.79)	48.66(16.17)	44.92(17.39)
0.50	225.00 ± 25.75	4112	90.98 (27.84)	83.19(31.94)	51.93(16.22)	46.64(17.54)
0.55	281.00 ± 22.46	3419	120.53 (30.65)	106.65(35.17)	66.30(16.80)	58.91(20.89)
0.60	335.64 ± 62.47	2888	112.52 (32.81)	100.14(36.61)	63.23(16.06)	56.09(20.2)
0.65	400.92 ± 52.31	2473	155.26 (28.85)	132.36(28.89)	74.75(15.98)	71.7(16.19)
0.70	446.23 ± 50.23	2142	154.90 (31.34)	147.05(29.54)	81.10(16.03)	74.11(16.05)
0.80	579.19 ± 72.67	1654	188.28 (33.27)	171.64(38.84)	101.59(16.92)	93.00(20.81)
0.90	774.60 ± 113.97	1316	201.96 (32.60)	191.33(38.75)	117.56(17.15)	107.8(17.38)
1.00	980.90 ± 134.94	1073	280.67 (31.64)	252.19(34.90)	153.79(16.93)	139.39(17.68)

*Values in parentheses denote elongation directly on the samples during the whole day. Sixteen samples were exposed to outdoor weathering for a period of 360 days from February 1, 2005. Sub-samples retrieved every 30 days were tested for break-load and elongation using Universal Testing Machine (UTM) model SHIMADZU AG 10 KNI. Ten replicates of each sample were tested at each sampling and the mean value was taken. Break-load after a given period of exposure was calculated as a percentage of the initial load of the unexposed control yarn of each test sample. The twine is considered unserviceable when the load is reduced to 50% of its original value (Brandt, 1959). Regression analysis of break-load (dry), wet knot break-load and runnage against diameter was carried out.

Results and Discussion

South India plays a significant role in production of PA yarns for fishing purposes. There were 244 sample sets of PA monofilament yarns covering 4 to 13 brands and 37 yarn diameters available for fishing purposes in South India. The cost of PA monofilament yarn irrespective of diameter was Rs. 400/- for imported brands and between Rs. 270/- and Rs. 350/- for Indian brands.

The physical and mechanical properties of the yarns of different diameters are given in Table 1. Out of the total 37 diameters tested, only for 17 BIS standards were available for runnage, break-load (dry) and elongation (Anon, 2003).

On an average, 38% decrease in load and 36% decrease in elongation was observed due to knotting. As the thickness of the material increased, there was corresponding decrease in knot break-load and elongation (Fig. 1 and 2). The fineness (R-tex) of the yarn causes change in break-load due to knotting, the finer the yarn the lesser the reduction in the load (Klust, 1959). Irrespective of thickness, there was decrease of 42% in break-load and 36% in elongation due to the combined effect of wetting and knotting. Here also, as the thickness of the material increased, the percentage reduction in knot break-load and elongation increased (Fig. 1 and 2). For fishing purposes, the wet knot break-load is the most important property of a net material to be considered (Klust, 1982). The wet knot break-load denotes the ability of a netting material to withstand stress during fishing.

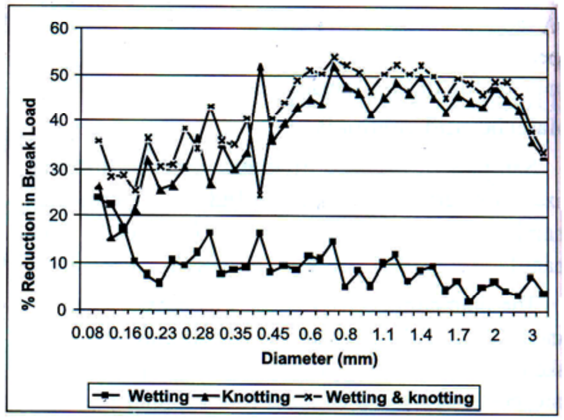

Fig. 1. Change in break-load of PA monofilament yarns due to wetting and knotting

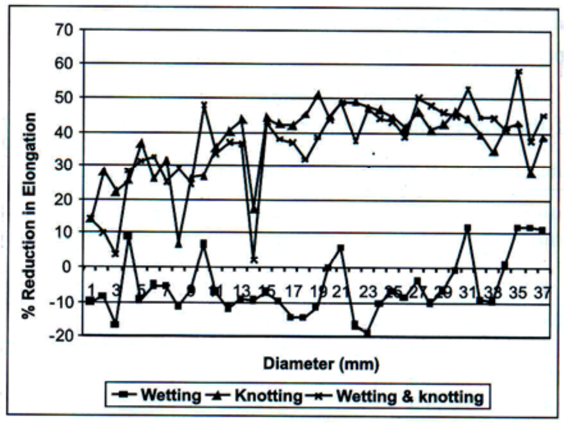

Fig. 2. Change in elongation of PA monofilament yarns due to wetting and knotting

A linear relationship was obtained between R-tex of the yarns and wet knot break-load (Fig. 3). Klust (1959) reported that the wet knot break-load is more related to R-tex than to diameter. Yarns exposed to outdoor conditions to study the weathering effect, had significant reduction in break-load and elongation at break ($P<0.01$) after 360 days exposure to sunlight. Irrespective of thickness, different samples retained 49 % of its initial break-load and 63 % of its initial elongation at break (Fig. 4). The break-load reduced linearly with duration of sunlight exposure indicating that the process is continuous. The regression line fitted to the graph depicting the relationship between break-load and exposure time indicated a linear relationship (R^2 = 0.948 and above for all dimensions). In the case of elongation at break also, the regression line fitted showed linear relationship (R^2 = 0.8558 and above for all dimensions). This shows that the rate of deterioration of properties over the exposure period was linear and this can help in predicting the service life of the material. Meenakumari and Radhalakshmi (1988) and Thomas and Hridayanathan (2006) also reported similar observation.

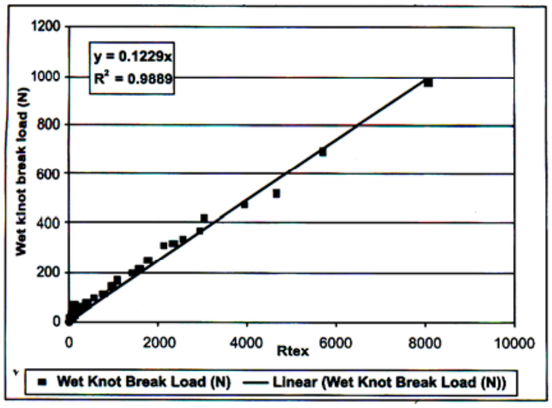

Fig. 3. Wet knot breakload against R-tex of PA monofilament yarn

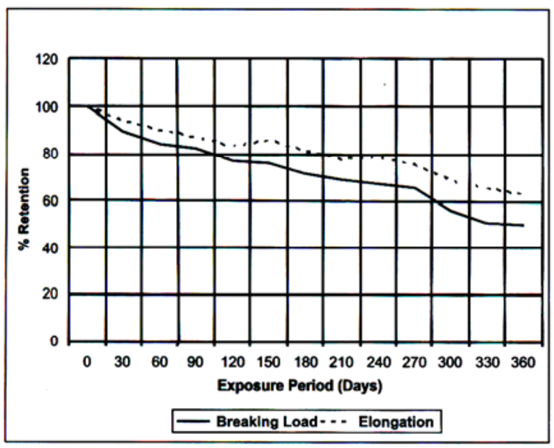

Fig. 4. Changes in properties of PA monofilament yarn exposed to sunlight

Samples of thinner diameters showed faster degradation in break-load and elongation than the thicker ones. Samples of 0.16 mm and 0.20 mm diameter lost more than 50% of their original break-load at the end of 300 days while 0.23 mm lost 49 % and 0.32 mm diameter lost 31% of original break-load. After 360 days exposure, 63.3, 59.2, 49.1 and 31.1% of the original load was lost by samples of 0.16, 0.20, 0.23 and 0.32 mm diameter respectively.

The results indicate that filament sizes and thickness affected the weather resistance. Ede and Henstead (1964) indicated that thicker monofilament gave better resistance. Alsayes *et al.* (1996) stated that thickness of material could be considered as a limiting factor for the ultraviolet penetration and consequently the degree of photochemical degradation of such materials. Thicker the yarn, the twine or the rope, better is the resistance due to lesser in-depth penetration by ultraviolet rays (Radhalakshmi and Nayar, 1973).

The standard specifications *viz*., linear density, runnage, break-load and elongation required for yarns to be used for the fabrication of gillnets were formulated. The linear density (y) of the yarns when plotted against diameter (x) gave the regression equation, $y = 862.93x^{1.8909}$ (Fig. 5). The dry break-load of the specimens (y) when plotted against diameter (x) gave the regression equation, $y = 271.58x^{1.5667}$ (Fig 6).

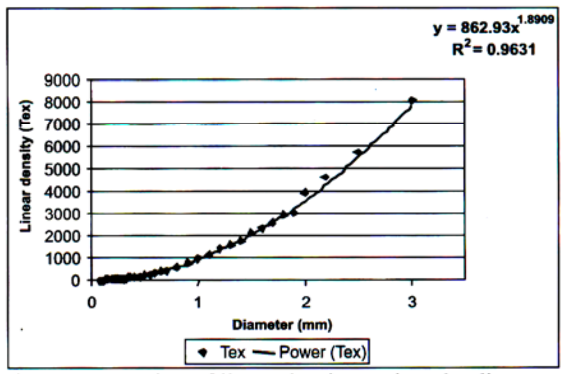

Fig. 5. Regression of linear density against the diameter of PA monofilament yarn

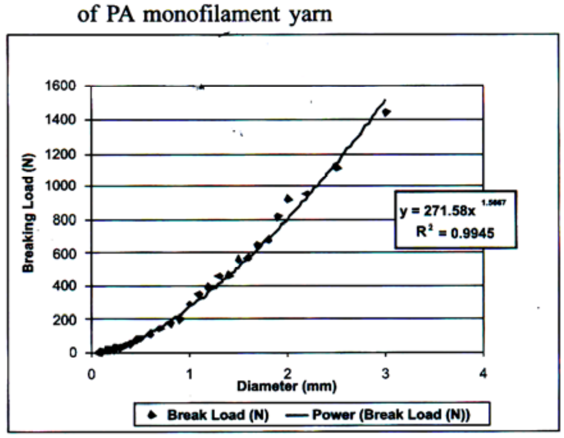

Fig. 6. Regression of dry break-load against the diameter of PA monofilament yarn

The standard specifications appropriate for fabrication of gillnets *viz.*, linear density, runnage, break-load and elongation at break worked out for PA monofilament yarns, are given in Table 2.

Table 2. Standard specifications of PA monofilament yarns for gillnets

Diameter (mm)	Linear density (Tex)	Runnage (m/kg)	Break-load (N)	Maximum elongation (%)
0.08	8.5	140640	5.2	60
0.1	11.2	91563	7.4	60
0.12	15.6	64481	9.8	60
0.16	29.0	37080	12.5	60
0.18	31.2	29564	15.4	60
0.2	40.6	24141	19	60
0.23	57.0	18451	22	60
0.24	58.0	17000	25	60
0.25	63	15717	27	60
0.26	70	14575	29	60
0.28	72	12639	31	60
0.3	89	11068	33	60
0.32	97	9776	37	60
0.35	124	8228	41	60
0.37	121	7394	46	60
0.4	149	6365	52	60
0.45	191	5075	57	60
0.5	225	4144	65	60
0.55	281	3450	78	60
0.6	336	2918	92	60
0.65	401	2502	106	60
0.7	446	2169	122	60
0.8	579	1678	138	60
0.9	775	1338	155	60
1.0	981	1093	191	60

Results from the present study have significance in the design and construction of gillnets for different target species. This would help in the selection of appropriate material with required properties in the design and fabrication of gillnets.

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