THE USE OF NEW HIGH STRENGTH NETTING MATERIAL

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REVIEW OF NEW NETTING MATERIALS USED IN FISHING GEAR

The main features of recent development in fishing gear and methods are the improvement of gear shape and more particularly larger gear sizes, increased towing speeds and gear handling (Fridman, 1986). In the late 1980s, Dutch State Mine (DSM) introduced high strength and high modulus polyethylene fibers. DSM has developed an improved gel spinning process that can produce polyethylene fibers having a higher strength 15 times more than a comparable steel wire and double the strength of any matching aramid (Joyce, 1993). Since then, new high strength netting material of high-performance polyethylene (HPPE) fiber has been introduced for use in fishing materials. HPPE fibers are now used in several parts of various types of fishing gear in Europe including bottom and pelagic trawls. In Japan, the HPPE net has been used for bottom gill nets and is under investigation for use in trawl nets. The reason for using HPPE is the significant advantage of the higher breaking strength as compared with the conventional netting twines. It also offers a reduction in twine size and reduces the resistance of the fishing gear in water, resulting in energy saving.

The actual selection of netting materials does not depend on one property alone, like high strength, but also other important factors like durability and cost that must be taken into account. The durability and cost of netting materials are an important consideration for material selection, because the expenses of nets represent the major part of the total investment for fishing equipment. Therefore, the higher cost of HPPE as compared with the conventional materials is still a considerable factor for wider use of this material in fishing gear.

Advantages of HPPE

It was reported that the breaking strength of HPPE was about 3 times higher than that of conventional twines of similar denier (Wanchana, 2002). Basically, the breaking strength of a twine can be estimated using its diameter as $T \approx k D^2$ where T is the breaking strength, k is a constant, and D is the twine diameter (Prado, 1990). So that the diameter of twines can be reduced by about 40% when using HPPE and yet be similar in breaking strength.In trawl nets, fishers should consider the reduction in drag to construct a bigger net size, or to reduce the fuel consumption, or even to use a less powerful towing engine in the boat. For these reasons, one advantage that should be discussed here is the use of HPPE for the drag force reduction in twines. Fridman (1986) described that the drag force in a straight line (twine, rope, etc.) can be estimated by the following formula.

$$R = C \times L \times D \times q \qquad \ldots(1)$$

where R is the drag force (drag resistance), C is the drag coefficient, L is the length, D is the diameter, and q is the hydrodynamic stagnation pressure ($= \rho V^2/2$: ρ = specific gravity, V = velocity of fluid flow). Fridman also described that the drag coefficient C depends mostly on the angle between the material (twine or rope) and the flow direction, because the pattern of dependence of C at any angle is similar for different types of material. When all terms except D are neglected, it can be seen in equation (1) that the reduction in drag resistance directly varies with the twine diameter. Similar to the results of estimation for the reduction in twine diameter, the drag reduction in twines using HPPE can be estimated to be about 40%.

The selection of netting material depends on the factors of high strength, long-term durability and price. The overall results studied by Wanchana indicated that HPPE had comparatively higher performance for long-term durability (high resistance to fatigue, high resistance to UV-irradiation, etc.) when compared to conventional twines. A comparison between the price of HPPE (about 10 times higher price than conventional netting: Torring, 2000) and conventional netting twines should be discussed more in detail on a weight basis. This is because netting materials are generally sold by weight and the assumption is that diameter reduction should compensate for its high cost. The weight of the netting twine can be calculated by the following equation:

$$W = \rho \times \pi \times D^2 \times L \qquad \ldots(2)$$

where W is the weight of netting, ρ is the specific gravity, $\pi = 3.14$, D is the diameter and L is the length. When comparing the difference in weight between PE and HPPE, HPPE twine is about 35 % lighter than that of PE because the reduction in diameter is about 40% yet having the same breaking strength. This shows that the cost of HPPE netting may be comparatively increased only by 3.5% even though the netting per unit weight is 10 times more expensive (Torring, 2000). It is clearly seen that even if the price of stronger netting material per unit of weight is higher, it can often be compensated by its lighter weight.

APPLICATIONS OF HPPE IN FISHING GEAR

Trawls

HPPE fishing nets are considerably easier to handle because thinner twines make lighter nets. The use of lightweight and thinner twines will reduce the resistance in the water (drag) and result in energy saving. The lower drag resistance will be advantageous by towing a larger net using a similar engine power or towing at a higher speed. As HPPE has a high strength and smaller twine, the total size of the net can be significantly reduced or larger nets can be assembled for the same weight of net. A consequence of the net size reduction will also be an advantage for storage space of the net on the fishing vessel. For instance, the same size of fishing vessel can store and use a larger net with the same volume of twine when using HPPE. Although the larger nets or towing at a higher speed with using HPPE nets may result in a higher catch, good balance between marine fishery resources and the catching effort must be taken into serious consideration to avoid over-fishing.

In a trial using HPPE for a pelagic trawl net, it was reported that knot slippage occurred in the front part of the net when HPPE was used all over the net (Kriele, 2000). Kriele also reported that the net became stable when using conventional PE in the wing parts and the rest of the net body using HPPE. This means that shape stability of the nets is an important factor to avoid knot slippage or even breakage caused by imbalance of the load. In another report, HPPE nets with double knots are being manufactured to prevent such knot slippage in the single knotted twines (Fishing News International, Oct. 1999). It can be suggested that the increase in towing speed when using HPPE should have more advantages in increasing catching efficiency in pelagic trawls because the swimming speed of pelagic fishes are considerably higher than those of demersal fishes.

Bottom trawl nets make particularly high demands on the netting material that should primarily have high knot strength, high extensibility, small diameter and high abrasion resistance (Klust, 1973). Because HPPE twine has lower elongation at breaks (small extensibility), the application of HPPE for the bottom trawl nets requires a proper net design, similar to that of the pelagic trawl as already mentioned. Although HPPE has a very good abrasion resistance, the service life is not longer than that of thicker conventional nylon when the bottom part of the net is in direct contact with the highly abrasive sea bottom (Kinoshita, 1998). It was reported that HPPE was used in combination with high-tenacity polyester twines (Fishing News International; Feb., 1995).

Generally, higher elongation twines will be able to absorb higher kinetic energy because of their load-elongation characteristics. The higher elongation twines can withstand shock loads (sudden changes of load in twines) better than low elongation twines (Kristjonsson, 1959). Kristjonson suggested that HPPE twine is slippery and has a low elongation, so that a sudden change of load in HPPE nets may cause knot slippage or even breakage. For this reason, the stability of the net shape using HPPE twines is an important factor to prevent local overloading. Therefore, a suitable trawl net design of using HPPE net for different towing conditions is very important.

Other fishing gear

As HPPE has a specific gravity slightly less than water, it floats. Therefore, the problem of fishing gear stuck on the sea bottom during fishing operations may be considerably reduced when using HPPE twines, for bottom longline and bottom drift gill net, this should be an advantage. Gill nets and most of the longlines are classed as passive gear, which are placed in the way of moving fish or fish schools (Klust, 1973). Therefore, good catch efficiency of these types of fishing gear requires a low visibility in water. The use of HPPE for some gill nets or longlines may have additional advantages because the thinner twine is considerably less visible. Although there are no current reports on the application of HPPE use for longline, HPPE could be used for longline fishing gear on the basis of thinner twine with high strength. A net manufacturer in Japan reported that HPPE nets have been used in lobster gill nets (Kinoshita, 1997).

APPLICATIONS OF HPPE FOR THAI FISHING GEAR

In Thailand, marine fisheries contributed about 79% of total fisheries production in 1996. Since the early 1990s, the marine fisheries production growth rate has been fairly steady, but is likely to reach a maximum sustainable yield in the near future (FAO, 2000). FAO reported also that small to medium-sized fishing boats of less than 50 gross ton decreased in number, those of more than 50 gross ton had increased in number in the past decade. It can be considered that commercial fishing gear has become more important for marine capture fisheries in Thailand. As critical economic conditions in Thailand were observed during the past few years, a problem of the declining numbers of people engaged in marine capture fisheries was also reported (SEAFDEC, 1993). Therefore, the use of new netting materials like HPPE for commercial fishing gear can be introduced to improve the catch efficiencies by reducing fuel consumption and the use of long-life netting materials, etc.

In 1995, total fishing gear registrations in Thailand were 17,950, including trawl nets (50.0 %), surrounding nets (7.4 %), gill nets (28.4%), push nets (4.0 %) and others (10.2%) (FAO, 2000). This indicates that most of the netting materials used in the Thai fishing gear are polyethylene and polyamide (nylon) according to the type of fishing gear. For trawl nets, HPPE can replace polyethylene because of the many advantages as already mentioned.

The problems in the fishing industries of the Southeast Asian countries, especially in Thailand, are mostly concerned with the decline of fisheries resources. The problems of over-fishing, less selective fishing gear, increased catching effort, low quality of the caught fish (especially the catch by trawl nets), and the increasing cost of fuel have been recently observed in Thailand. For trawl nets, the quality of fish catch could be improved by reducing the towing period (towing at higher speed) by using thinner-netting twines like HPPE. The thinner-netting twines should also incur less damage to the fish, and give a greater chance for small fish to escape from the net (Lowry, 1996). HPPE could also be used with the aim of reducing the cost of fuel consumption because it has less drag resistance.

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