Analysis on the Physical Performance of PP/MMWPE/EPDM Monofilament Modified by Blending

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Abstract. PP/MMWPE/EPDM monofilament was prepared by blending modify and its physical performance and the cost was studied. The results showed that the breaking strength of PP/MMWPE/EPDM monofilament was 16.8% higher than that of PE monofilament while its knot strength loss rate is 3.8% higher than that of PE monofilament. In addition, the cost of PP/MMWPE/EPDM cord can be reduced by 3.0%.

Introduction

Polyethylene resin has become the synthetic resin with highest output and demand in fishery production, for its excellent performance, low price, simple contour machining, etc. [1-3]. According to the molecular weight, polyethylene resin is divided into high-density polyethylene (HDPE, molecular weight in the range of 40,000 to 300,000, also known as general molecular weight polyethylene), medium and high molecular weight polyethylene (MMWPE, molecular weight in the range of 600,000 to 1 million, also known as medium molecular weight polyethylene) and ultra-high molecular weight polyethylene (UHMWPE, molecular weight more than 1.5 million, also known as ultra-high strength polyethylene), etc. [3-5]. UHMWPE fiber mesh has excellent abrasion resistance, aging resistance, tensile strength and wave resistance. At present, it has been applied in marine fishing and large aquatic farm fence. Based on the research about the pile type farm fence, UHMWPE fiber mesh has played an important role in wave resistance of ocean fisheries, open sea net cage aquaculture, large deepwater net cage aquaculture and large aquaculture fencing [6-9]. However, UHMWPE fiber is expensive, and post-processing of UHMWPE mesh is complex, UHMWPE mesh assembly has strict requirements, a series of standards of UHMWPE mesh are not ready, and there are few researches on systemic industrialized application demonstration projects of UHMWPE mesh... Due to the combined action of these factors, UHMWPE fiber has not been popularized and used in large area of aquatic technology field in China [6-8]. With the development of the modern fishery, higher physical performance of synthetic fibers is needed. The physical performance of general synthetic fibers can't meet the large scale, modernization and specialized

deepwater operation requirements of fishery production.

The medium and high strength fiber (strength between general PE monofilament and UHMWPE fiber) and its application in fishery, is possible to achieve these requirements [9]. Based on the above research results, this paper analyzes the physical performance of PP/MMWPE/EPDM monofilament modified by blending, so as to provide the scientific basis for selection of high performance material and optimization design of netting gears.

Materials and methods

Materials

PP resin, drawing grade S1004 produced by Yangzi Petrochemical, melt index 3.0g/10min~4.0g/10min. Spinning grade MMWPE resin, distributed by Zibo Meibiao Polymer Fiber Co., Ltd with melt index 3.0 g/10 min. EPDM resin and white oil available on the market. . HDPE resin, produced by Yangzi Petrochemical, melt index 0.6g/10min-1.5g/10min.

MMWPE resin, PP resin(addition amount 24.2 wt%~25.7 wt% of MMWPE weight), EPDM resin (addition amount 5.95 wt%~6.55 wt% of MMWPE weight), white oil (addition amount 0.11 wt%~0.16 wt% of MMWPE weight) raw materials are fully mixed using a blender to get toughened and blended particle PP/MMWPE/EPDM; toughened and blended particle PP /MMWPE/EPDM is extruded in molten state by a single screw extruder, the molten primary filament extruded from a spinneret hole is cooled by low temperature water in a cooling water box and pre-stretched by a first stretch roll, and the pre-stretched filament is thermally stretched twice to coil monofilament beam by a filament coiling machine with a torque motor. After filament splitting, PP/MMWPE/EPDM monofilament modified by blending with the linear density of 364 dtex is obtained.

General PE monofilament with the linear density of 410 dtex is processed with the spinning grade dry HDPE resin using the traditional melt spinning process [1-3].

Methods

INSTRON-4466 strength tester made in the U.K., FA2004N electronic balance made in China, and so on.The test sample is tested in a standard laboratory at constant temperature of 18℃-22℃ and constant relative humidity of 60%-70% after left standing in a laboratory for more than 12h. In the physical performance test of PP/MMWPE/EPDM monofilament modified by blending and PE monofilament, stretching speed of the INSTRON-4466 strength tester is 300mm/min, and the test sample is 750mm long.

The physical performance test of PP/MMWPE/EPDM monofilament modified by blending and PE monofilament follows the standard SC 5005-2014 *Polyethylene monofilament for fisheries* [10].

Valid data obtained from the test are processed with reference to the data processing provided in the corresponding standard. Knot strength loss rate (%) is calculated according to the following formula [11-14]:

Knot strength loss rate (%) = (breaking strength-knot strength) /breaking strengthx100.

Results and Discussion

The strength properties of PP/MMWPE/EPDM monofilament

Physical performance of monofilament includes strength (including breaking strength, knot strength), the loss rate of knot strength, elongation at break, etc. Netting gear is generally assembled with cord, meshes, netting twine, accessories, etc. The physical performance of monofilament and downstream mesh products (such as trap net, crab trap, scallop trap, ocean trawl, aquaculture raft,

rope for aquaculture ship, deepwater net cage, ocean net cage, and aquaculture fencing) affects the fishing adaptability of monofilament, water resistance of netting gear, labor intensity of fishermen and wave resistance of netting gear. The monofilament strength is directly related to the safety, use effects, consumption reduction, drag reduction and wave resistance of fishing mesh and netting gear products. Figure 1 shows the comparison of the physical performance and unit price of PP/MMWPE/EPDM monofilament and PE monofilament. As can be seen from Figure 1, compared with the PE monofilament, the PP/MMWPE/EPDM monofilament produced using special spinning technology of modification by blending has obvious advantages in strength. Its breaking strength and knot strength are respectively 16.8% and 15.1% higher than that of PE monofilament, and are respectively 24.2% and 25.3% higher than the industry standard indexes of the polyethylene monofilament for fishing. Factors influencing the strength of monofilament include spinning materials, spinning process, spinning equipment, internal aggregate structure of monofilament, etc. [1-5]. Compared with the PE monofilament, the PP/MMWPE/EPDM monofilament uses special spinning technology of modification by blending (for example, special toughened and blended particle PP/MMWPE/EPDM is used for spinning, and the addition amount of PP resin in the blended particle is 24.2%~25.7% of MMWPE resin weight), which improves the physical performance and internal aggregate structure of PP/MMWPE/EPDM monofilament, so that it has more compactly piled molecular chain, higher intermolecular force resulting in higher crystallinity.

Figure 1 shows that, the elongation at break of PP/MMWPE/EPDM monofilament produced using special spinning technology of modification by blending is 32.2% lower than that of PE monofilament. Elongation at break of monofilament depends on the spinning process, spinning equipment, spinning environment, spinning materials, etc. [1, 11-14]. The elongation at break of monofilament is not only related with the spinning materials, spinning equipment, spinning process, spinning environment, etc., but also closed related with the elongation ability of monofilament itself. Due to many reasons, PP/MMWPE/EPDM monofilament and PE monofilament have different elongation at break.

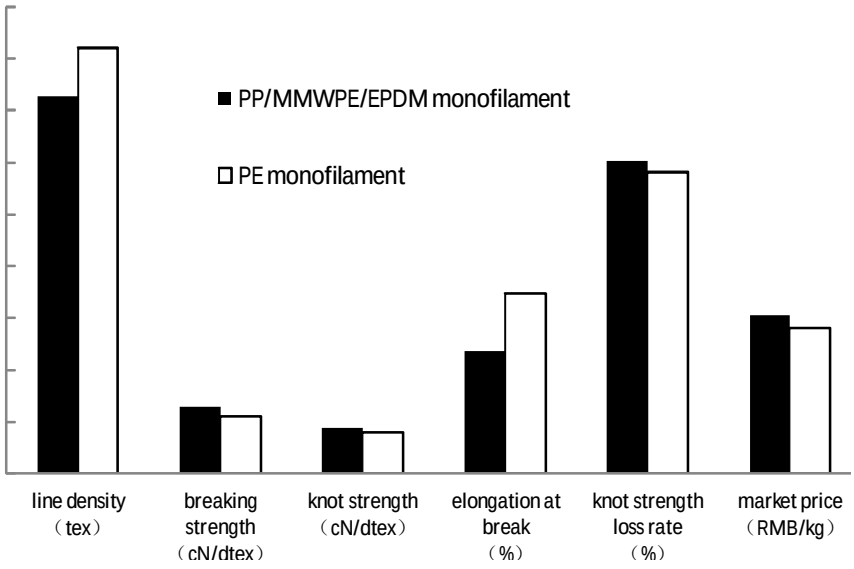

Figure 1 The comparison of the physical performance and unit price of PP/MMWPE/EPDM and PE monofilament

Analysis on the knot strength loss rate of PP/MMWPE/EPDM monofilament modified by blending

Knot strength loss rate is a physical parameter of great concern for the fishing industry, aquaculture industry, production units of fishing materials, people engaged in fishery engineering, etc. Shi Jiangao et al. have used the concept "knot strength loss rate" in related literatures [11-14]. Wo DingZhu et al. have also described the concepts close to the knot strength loss rate (such as hook joint strength loss rate, loop strength loss rate, strength loss rate, etc.) in literatures [15,16]. Figure 1 shows that the knot strength loss rate of PP/MMWPE/EPDM monofilament is 3.8% higher than that of PE monofilament, which goes against its knot strength. But the defect that the knot strength loss rate is slightly high can be offset by the strength advantage. Due to the combined effect, it still has better knot strength than PE monofilament. The knot strength loss rate of monofilament is closely related to the spinning process, spinning materials, monofilament type, internal aggregate structure of monofilament, etc. Due to relatively high crystallinity, PP/MMWPE/EPDM monofilament has high strength and low elongation at break. Its polymer chain is compactly arranged in order in the crystalline region [17,18]. Therefore, PP/MMWPE/EPDM monofilament with such a structure has slightly poor flexibility, thereby showing relatively high knot strength loss rate. In comparison, PE monofilament has low crystallinity, so that it has relatively good flexibility. Therefore, PE monofilament has low knot strength loss rate.

Analysis on the cost performance of PP/MMWPE/EPDM monofilament modified by blending

The cost performance is a business model parameter of great concern for technical workers of fishing materials, fishing material manufacturers, fishing material users, etc. The cost performance of fishing materials mainly depends on the unit price, overall performance, use level, etc. of fishing materials [1-16,19]. Compared with general PE monofilament, PP/MMWPE/EPDM monofilament has lower linear density and elongation at break, while relatively high unit price, breaking strength and knot strength (Figure 1). As can be seen from Figure 1, when other conditions are the same, general PE cord (produced with PE monofilament with the linear density of 410dtex) is replaced with PP/MMWPE/EPDM cord (produced with PP/MMWPE/EPDM monofilament with the linear density of 364dtex) of the same braiding process (including cord structure, total number of cord yarns, number of monofilaments used in each cord yarn, etc.) as the cord. In this way, the unit price of PP/MMWPE/EPDM cord is increased by 9.3%, but the weight of PP/MMWPE/EPDM cord is reduced by 11.2%, so the cost of PP/MMWPE/EPDM cord can also be reduced by 3.0%. This can not only guarantee that the breaking strength of PP/MMWPE/EPDM cord is higher than that of general PE cord, but also correspondingly reduce the diameter, weight and raw material consumption of the cord [1-3, 19-23].

Conclusions

The physical performance of PP/MMWPE/EPDM monofilament is analyzed. The results show that the breaking strength of PP/MMWPE/EPDM monofilament is 16.8% higher than that of PE monofilament, its knot strength is 15.1% higher than that of PE monofilament, its knot strength loss rate is 3.8% higher than that of PE monofilament, while its elongation at break is 32.2% lower than that of PE monofilament. Under the premise of maintaining the advantage in breaking strength, general PE mesh is replaced with PP/MMWPE/EPDM mesh modified by blending, so that the raw material consumption and water resistance of the netting gear are reduced, thereby achieving energy saving and cost reduction in fishery production.

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