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# USE OF THREADS FROM ULTRA-HIGH-MOLECULAR WEIGHT POLYETHYLENE FOR THE PRODUCTION OF REINFORCING FRAMES FOR FIRE PRESSURE HOSES AS ONE OF THE DIRECTIONS FOR IMPROVING THEIR OPERATING CHARACTERISTICS

**Abstract.** The problem of choosing the material of synthetic threads for the production of reinforcing cages of fire pressure hoses with improved performance is considered. A promising direction for the production of new durable and high-tech fire pressure hose is proposed. Using along with traditional polyester yarns based on polyethylene terephthalate (PET), ultra-high molecular weight polyethylene (UHMWPE-threads) which, along with carbon and aramid threads belong to the three "superthreads" and differ from traditional threads, it will increase the strength and resistance to abrasion. Such a fire pressure hose will have significantly higher operational characteristics compared to traditional sleeves based on only polyester threads. The resistance of fire pressure hose to abrasion wear will increase several times (due to the use of UHMWPE threads) under the same operating conditions in intensity, the reliability and durability of the fire pressure hose will increase several times, the strength of the fire pressure hose will increase by at least two, and it will meet the requirements of GOST not only on working pressure 1.6 MPa but also 3.0 MPa (at least for sleeves with a diameter of 38 mm, 51 mm, 66 mm, 79 mm) which makes it universal. The use of a complex synthetic threads consisting of a polyester threads and an equally strong UHMWPE threads in the fire pressure hose reinforcing cage will provide significantly higher performance characteristics of the fire pressure hose compared to traditional sleeves based on polyester threads. Despite the rise in price of the fire pressure hose, due to the use of UHMWPE threads, the strength, wear resistance, reliability and durability of the fire pressure hose increase in several times. A patent has been obtained for use in fire pressure hose of weft complex synthetic threads consisting of traditional polyester threads and UHMWPE threads.

**Key words:** a pressure fire hose, the woven reinforcing fire hose frame, breaking stress of weft threads.

**Introduction.** During operation, fire pressure hoses (FPH) are exposed to internal hydraulic pressure, mechanical wear, exposure to low and high temperatures, sunlight, the irreversible aging process of the material, accidental contact with chemically active substances, etc. [1,2]. In this regard, increased demands are placed on the material of synthetic thread of the FPH which must have high strength, resistance to abrasion, a relatively high melting point and resistance to chemically active substances. FPHs produced in Russia and operated in the Republic of Kazakhstan are made of polyester threads based on polyethylene terephthalate (PET) which have low creasing properties, excellent light and weather resistance, relatively high strength and melting point and good resistance to organic solvents. However, their abrasion resistance is not sufficient. The practice of using a FPH made of polyester threads shows that the main cause of hose rupture during operation is the abrasive wear of their main bearing element - a woven reinforcing frame that perceives fluid pressure inside the fire hose. In this regard, the urgent issue is the choice of the synthetic threads material for the manufacture of new high-tech fire prevention and testing equipment that surpasses fire hoses currently operating on the basis of polyester threads in strength, abrasion resistance and satisfying other requirements of GOST R 51049-97 (Russia) [3] on the FPH.

**Research results and discussion.** In our opinion, one of the promising directions for the production of new durable and high-tech FPHs is to use along with traditional polyester threads based on polyethylene terephthalate (PET), ultra-high molecular weight polyethylene (UHMWPE) threads which along with carbon and aramid threads, belong to the three "superthreads" and differing from traditional threads with exceptionally high strength and resistance to abrasion.

So, the specific breaking load of UHMWPE threads is 310-360 CN/Tex, while the same indicator for technical polyester threads is in the range of 60-85 CN/Tex. The abrasion resistance of UHMWPE - threads is more than four times higher than that for technical polyester threads. However, along with low negative operating temperatures (–100°C and lower), UHMWPE is a thermoplastic substance with a relatively low melting point (144-152°C) and thermal degradation (thermal destruction of the structure) at 112-115°C due to the molecular structure. Therefore, UHMWPE products are not recommended for operation at temperatures exceeding 100°C. The latter circumstance creates two problems in the use of UHMWPE - threads for the production of FPH.

The first problem is associated with the production technology of rubberized FPHs based on synthetic threads which is as follows. One of the technological operations of the FPH production is that a rubber shell with glue applied on its surface is introduced into the woven reinforcing carcass, and 5-6 atmospheres of steam with a temperature of about 150°C are applied under it to straighten the rubber sheath and stick it to the frame. Under the influence of this temperature even though this effect is transmitted not directly to UHMWPE threads but through a rubber sheath, the probability of thermal destruction of UHMWPE threads is high. The solution to this problem can be achieved by reducing the vapor pressure and, as a result, bringing its temperature to values close to 110°C, or by using instead of steam compressed air under a pressure of 5-6 atmospheres with a heating temperature of 80-100°C.

The second problem is due to the fact that a FPH with a reinforcing cage made only of UHMWPE - threads with a high probability will not pass the test on resistance to contact burning (regulated by GOST R 51049-97 [3]) due to the relatively low temperature of thermal degradation. This problem, in our opinion, can be solved by using an integrated synthetic thread in the reinforcing cage as a weft, consisting of a relatively heat-resistant traditional polyester thread and an equally strong first thread, but having a lower linear density of UHMWPE-thread. When designing the reinforcing framework of the FPH on the basis of the calculation methodology and rational design which is based on formula (1) [5], we conditionally assume that the breaking strength of a multifilament thread is equal to the breaking strength of a polyester thread included in its composition, and the strength we do not take into account the breaking of UHMWPE threads. The linear density of the polyester threads and the reinforcing cage parameters are selected so that they fully satisfy the GOST R 51049-97 requirements including the burst pressure, resistance to contact burning, etc. Thus, a FPH reinforcing frame with an actual double tensile strength of integrated weft thread will be designed, which, in our opinion, will be justified due to the following considerations.

As noted above, the main reason of hose rupture during operation is the abrasive wear of their surface due to polyester threads insufficient resistance to abrasion. But even the complete wear of the polyester thread, in our opinion, will not lead to a rupture of the hose, since the action of the internal hydraulic pressure will be perceived by the UHMWPE thread resistant to wear. At the same time, the presence of a relatively heat-resistant traditional polyester thread is necessary since the latter will provide the required resistance of the reinforcing cage to contact piercing.

It should be noted that such a solution of the problem will not lead to a significant overspending of the material and, consequently, to a significant increase in the mass of the FPH and its cost, since the additional consumption of UHMWPE threads will be only a few hundred grams for hoses of medium diameters.

On the other hand, such a FPH will have, as we expect, significantly higher performance compared to traditional hoses based on only polyester threads, namely:

1) the resistance of the FPH to abrasive wear will increase several times (due to the use of UHMWPE threads) under identical operating conditions in intensity;

2) the reliability and durability of the FPH will increase several times;

3) at least two times the strength of the FPH will increase, and it will meet the requirements of GOST not only for a working pressure of 1.6 MPa but also for 3.0 MPa (at least for hoses with a diameter of 38 mm, 51 mm, 66 mm, 79 mm), which makes it universal.

**Conclusion.** In our opinion, the use in the FPH reinforcing framework of complex synthetic thread consisting of a polyester thread and UHMWPE thread of equal strength, which will provide significantly

higher performance characteristics of the FPH compared to traditional hoses based on polyester threads, will justify itself, even despite the rise in FPH price due to the use of UHMWPE threads, since the strength, wear resistance, reliability and durability of the FPH are several times increased.

We have obtained a patent for the use weft complex synthetic threads consisting of traditional polyester threads and UHMWPE threads in FPH [6]. We consider this direction as one of the promising directions for the production of new, durable and high-tech FPH.

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## АСА ЖОҒАРЫ МОЛЕКУЛАЛЫҚ ПЛИЭТИЛЕНДІ ӨРТКЕ СУ СЕБЕТІН ТҮТІК ҚҰБЫРДЫҢ АРМИРЛЕНГЕН ҚАҢҚАСЫН ӨНДІРУДЕГІ ЖІП ҚОЛДАНЫСЫН ОЛАРДЫ ЖЕТІЛДІРУДІҢ БІР БАҒЫТЫ РЕТІНДЕ ҚАРАСТЫРУ

**Аннотация.** Қолдану сипаттамасы жақсартылған өртке су себетін түтік құбырдың армирленген қаңқасын өндіру үшін синтетикалық жіптерді таңдап алу мәселесі қарастырылған. Дәстүрлі полиэфирлі жіптен жасалған өртке су себетін түтік құбырды пайдалану тәжірибесі көрсеткендей, оларды қолдану кезіндегі ажыраудың негізгі себебі – сұйықтық қысымды су себетін түтік ішінде қабылдайтын негізгі элемент – тоқымалы армирленген қаңқаның түрпілік тозу жағдайы. Осыған байланысты өртке су себетін түтік құбыр жасауда материал таңдау мәселесі маңызды саналады. Өртке су себетін түтік құбырдың төзімді және жоғары технологиялық жаңа түрін өндіріп шығарудың басым бағыты ұсынылды. Полиэтилентерефталат (ПЭТФ) негізіндегі дәстүрлі полиэфирлі жіп әрі көміртекті және арамидті жіппен бірге «үздік жіптер» үштігіне кіретін және дәстүрлі жіптен өзгеше болып келетін аса жоғары молекулалық плиэтиленді жіптерді (АЖМПЭ-жіптерді) қолдану беріктігін және түйіршіктің қажалуға төзімділігін арттыруға мүмкіндік береді. Мұндай өртке су себетін түтік құбыр, тек бір полиэфирлі жіп негізіндегі дәстүрлі түтікше құбырлармен салыстырғанда қолданыс сипаттамасы жоғары болып келеді. Пайдалану қарқындылығы бірдей жағдайда өртке су себетін түтік құбырдың төзімділігі (АЖМПЭ-жіптерді қолдану есебінен) бірнеше есе артады, өртке су себетін түтік құбырдың сенімділігі және төзімділігі бірнеше есе артады және ол жұмыс қысымының 1,6 Мпа, сонымен қатар 3,0 МПа (кем дегенде диаметрі 38 мм, 51 мм, 66 мм, 79 мм түтікше құбырлар) МЕМСТ талаптарына сәйкес келеді әрі түтікше құбырды әмбебапқа айналдырады. Өртке су себетін түтік құбырдың армирленген қаңқасына полиэфирлі жіптен құралған кешенді синтетикалық жіп және соған төзімділігі тең келетін АЖМПЭ-жіптерді қолдану дәстүрлі полиэфирлі жіп негізінде жасалған түтікше құбырлармен салыстырғанда су себу түтікше құбырының жоғары қолданыс сипаттамасын қамтамасыз етеді. АЖМПЭ-жібін қолдану себебінен өртке су себетін түтікше құбыр бағасының қымбаттауына қарамастан, тозуға төзімділігі, тұрақтылығы және ұзақмерзімді қолданыс аясы артады. Өртке су себетін түтікше құбырда арқау жіп ретінде дәстүрлі полиэфирлі жіптен және АЖМПЭ-жіптерден құралған кешенді синтетикалық жіп қолдануға патент алынған. Тек полиэфирлі жіп негізінде жасалған дәстүрлі түтікшелермен салыстырғанда, мұндай FPH жоғары қолданысты сипаттамаға ие болып келеді.

**Түйін сөздер:** өртке су себетін түтікті құбыр, өртке су себетін түтікті құбырдың тоқымалы армирленген қаңқасы, арқау жібінің үзілу күші.

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## ИСПОЛЬЗОВАНИЕ НИТЕЙ ИЗ СВЕРХВЫСОКОМОЛЕКУЛЯРНОГО ПОЛИЭТИЛЕНА ДЛЯ ПРОИЗВОДСТВА АРМИРУЮЩИХ КАРКАСОВ НАПОРНЫХ ПОЖАРНЫХ РУКАВОВ КАК ОДНО ИЗ НАПРАВЛЕНИЙ УЛУЧШЕНИЯ ИХ ЭКСПЛУАТАЦИОННЫХ ХАРАКТЕРИСТИК

**Аннотация.** Рассматривается проблема выбора материала синтетических нитей для изготовления тканых армирующих каркасов напорных пожарных рукавов с улучшенными эксплуатационными характеристиками.

Практика использования напорных пожарных рукавов из традиционных полиэфирных нитей показывает, что основной причиной разрыва рукавов при эксплуатации является абразивный износ их основного несущего элемента – тканого армирующего каркаса, воспринимающего давление жидкости внутри пожарного рукава. В связи с этим становится актуальной проблема выбора материала для изготовления напорных пожарных рукавов. Предложено перспективное направление для производства новых долговечных и высокотехнологичных напорных пожарных рукавов, в основу которого положено использование наряду с традиционными полиэфирными нитями на основе полиэтилентерефталата (ПЭТФ), нитей из сверхвысокомолекулярного полиэтилена (СВМПЭ - нитей), относящихся наряду с углеродными и арамидными нитями к тройке «супернитей» и отличающихся от традиционных нитей исключительно высокой прочностью и сопротивляемостью абразивному истиранию. Использование в армирующем каркасе комплексной синтетической нити, состоящей из полиэфирной нити и равнопрочной ей СВМПЭ-нити, обеспечит существенно более высокие эксплуатационные характеристики напорных пожарных рукавов по сравнению с традиционными рукавами на основе полиэфирных нитей и оправдает себя, даже несмотря на удорожание рукавов из-за использования СВМПЭ-нитей, т.к. в несколько раз возрастает прочность, износостойкость, надежность и долговечность напорных пожарных рукавов. Такой рукав будет отвечать требованиям ГОСТа не только по рабочему давлению 1,6 МПа, но и 3,0 МПа (по крайней мере, для рукавов диаметром 38 мм, 51 мм, 66 мм, 79 мм), что делает его универсальным. Получен патент на использование в тканых армирующих каркасах напорных пожарных рукавов в качестве уточных комплексных синтетических нитей, состоящих из традиционных полиэфирных нитей и СВМПЭ-нитей.Такой FPH будет иметь значительно более высокие эксплуатационные характеристики по сравнению с традиционными рукавами на основе только полиэфирных нитей.

**Ключевые слова:** пожарный напорный рукав, тканый армирующий каркас пожарного рукава, разрывное усилие уточных нитей.

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