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Zh. U. Myrkhalykov[1], S. G. Stepanov[2], R. T. Kaldybaev[3], A. E. Aripbaeva[3], M. I. Satayev[1]

[1]SILKWAY International University, Shymkent, Kazakhstan;
[2]Ivanovo State Polytechnic University, Ivanovo, Russia;
[3]South Kazakhstan State University, Shymkent, Kazakhstan.
E-mail: myrkhalykov@inbox.ru, step-sg@mail.ru, rashid_cotton@mail.ru, akerke-1982@mail.ru, maratsatayev@mail.ru

ANALYSIS OF THE BASIC DIRECTIONS OF FIRE HOSES RUPTURE PRESSURES INCREASING

Abstract. The analysis of the main ways to increase the rupture pressure of these technical products was made based on the rupture pressures dependence in fire pressure hoses from the parameters of their woven reinforcing frame previously obtained by the authors. From a scientific and practical point of view, the main directions for increasing the bursting internal pressures in the FPH (Fire pressure hoses) are identified and analyzed. The developed methodology for calculating and designing of FPH is based on a relationship connecting internal hydraulic pressure *p-burst* with a breaking load *N-burst* in the weft thread and a number of other parameters.

To assess the influence of the parameters of the FPH woven reinforcing framework on the value of the internal bursting pressure, the latex FPH with a diameter of 77 mm manufactured by BEREG (Russia) made of polyester yarns and designed for a working pressure of 1.6 MPa, was chosen as the object of study.

The dependences of the bursting pressures values on the bursting strength of weft threads of FPH woven reinforcing frameworks, designed for a working pressure of 1.6 MPa, for various diameters of the arms cross sections are obtained. The influence of geometric densities on the basis and weft of the woven reinforcing frame on the value of internal burst pressure in the FPH is investigated.

When calculating the FPH strength under the action of internal hydraulic pressure, the effect on the value of the burst pressure in latex FPH manufactured by BEREG (Russia), designed for a working pressure of 1.6 MPa, such parameters as sleeve radius, geometric densities of base and weft was studied. When designing and creating new types of FPH, it is necessary to take into account the influence of these parameters on the burst pressure value.

Key words: pressure fire hose, reinforcing cage, polyester threads, internal rupture pressure.

Introduction. Fire pressure hoses (FPH) **-** one of the main means of extinguishing fires. Structurally, they are designed as flat-wound flexible piping systems on a fabric basis with rubber layers (layer) and serve to supply extinguishing liquid (water and aqueous foaming agents) under pressure at a distance to the fire site. In relation to the FPH, the requirement for their reliability and performance is extremely important, since the positive result in extinguishing fires directly depends on this, and as a result, the lives of people and property saved.

Due to the lack of its own enterprises for the production of FPH, the Republic of Kazakhstan purchases these products from foreign manufacturers.

The importance of purchases of FPH by Kazakhstan is explained not only by the fact that a significant part of the country belongs to the arid climate zone, but also by the fact that they become strategic in the event of emergencies associated with the occurrence of large fires in the country.

In order to reduce dependence on supplies of FPH from abroad, it is necessary to create our own production of new high-tech FPH in Kazakhstan. To achieve this goal, it is not enough just to have technology, production sites with equipment, and it is important to have our own scientific school in the field of theory, research, calculation and design of high-tech FPH. In this regard, in our opinion, it is of considerable scientific and practical interest to analyze the main directions of increasing the strength characteristics of the FPH - their burst pressures.

An indispensable part of the device of any type of FPH is a woven reinforcing frame (WRF), fully absorbing the forces from the fluid pressure inside the fire hose, when it comes to non-rubberized FPHs, and to a decisive extent, in the case of rubberized, latexed and double-sided FPHs. Structurally, the frameworks of most of the FPH are seamless single-layer woven plain weave shells made on round looms. Along its circumference of the FPH are weft threads, mutually interwoven with warp threads located along the length of the FPH.

Most often, FPH WRF is made from polyester yarns based on polyethylene terephthalate (PET)

The calculation of the strength of the WRF is reduced mainly to the calculation of the strength of their reinforcing frames.

To date, on the basis of the nonlinear theory of calculating single-layer plain weave fabrics [1,2] we have developed the basic theoretical provisions [3-6], the calculation and design technique for commissioning [7,8], and a set of experimental studies has been carried out on the calculation of the strength of the FPH with hydraulic effects [3]. The developed methodology for calculating and designing FPH is based on the obtained dependence of the bursting internal hydraulic pressure a weft thread N*rupt* and a number of other parameters of the reinforcing frame, having the form:

$$p\text{-}burst = \frac{2N\text{-}burst\, L_o}{R\left\{L_u(2L_o-\beta_o d_o)+L_o\left[2\left(L_u^2+(d_o\eta_{OB}+d_u\eta_{yB})^2\right)^{\frac{1}{2}}+\frac{0.212\cdot L_y^2\cdot(d_o\eta_{OB}+d_u\eta_{yB})^2}{\left(L_y^2+(d_o\eta_{OB}+d_u\eta_{yB})^2\right)^{\frac{3}{2}}}-\beta_y d_u\right]\right\}}$$

where in R- radius fire hose; L_o, L_u - geometrical density respectively to FPH base and weft of reinforcing cage; d_o, d_y, η_{OB}, η_{yB}- respectively the diameters of the warp and weft reinforcing cage fire hose threads and the coefficients of the vertical buckling threads; β_0, β_y - coefficients characterizing the lengths of the zones of contact between the threads in WRF in fractions of the diameters of the warp and weft threads.

The rupture pressure characterizes the strength of the FPH, i.e., the ability of FPH WRF to resist rupture under the influence of internal hydraulic pressure. GOST R 51049-97 (Russia) [9] sets the values of bursting pressures for all types and diameters of the FPH. All FPHs manufactured at enterprises of the Russian Federation and operated in Kazakhstan must necessarily comply with this GOST for bursting pressures.

Let us analyze the main directions of increasing explosive internal pressures in the FPH. For this purpose, we take as an object of study latex FPH with a diameter of 77 mm produced by BEREG Production Association (Russia), made of polyester yarns based on polyethylene terephthalate (PET) and designed for a working pressure of 1.6 MPa.

An analysis of the dependence of the bursting internal pressures in the FPH on the parameters of their woven reinforcing cage, based on formula.

In this case, the initial parameters of the FPH WRF necessary for such a study were determined using the methods described in [3].

The structure of formula is such that the burst pressure of the fire hose is directly and inversely proportional to the bursting force of the weft threads and the radius of the FPH. With an increase (decrease) in the breaking strength of the weft threads, the breaking pressure in the FPH (that is, in fact, the strength of the fire hose) increases (falls) according to a linear law. The dependences of the burst pressures on the bursting forces of the FPH WRF weft threads, designed for a working pressure of 1.6 MPa, for various diameters of the cross sections of the arms are shown in figure 1.

From the analysis of the graphs it follows that with a decrease in the diameters of the FPH cross sections, the steepness of the characteristics increases.

In general, based on an analysis of formula, it be concluded that with a decrease (increase) in the radius of the fire hose, its rupture pressure increases (falls).

An increase in the breaking strength of weft threads FPH WRF is one of the directions for increasing the strength characteristics of FPH. This direction can be implemented in two possible ways.

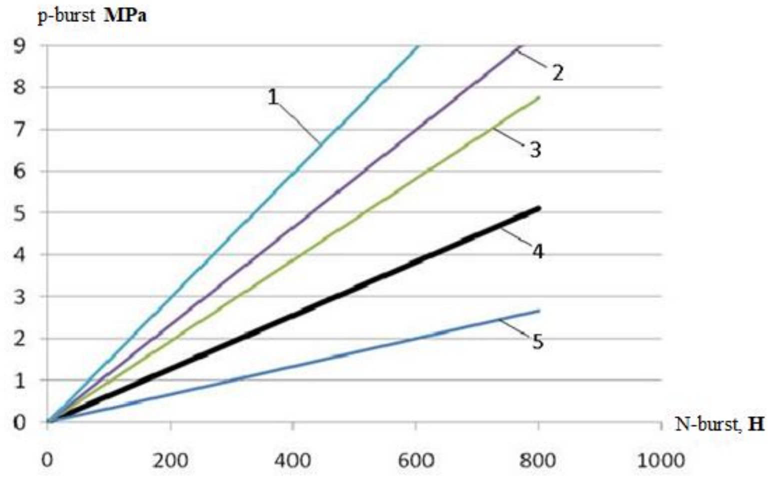

Figure 1 – The dependence of the rupture pressure p-burst on the breaking stress of the weft yarn of the FPH woven reinforcing frames at "BEREG" of different diameters: 1 - for the diameter of 51 mm; 2 - for the diameter of 66 mm; 3 - for the diameter of 77 mm; 4 - for the diameter of 89 mm; 5 - for the diameter of 150 mm

However, this path will lead to an increase in material consumption and weight of the FPH. The second method, in our opinion, is more acceptable, is that instead of traditional polyester threads, high-strength and wear-resistant threads, for example, ultra-high modulus (UHM) threads, or threads of ultra-high molecular weight polyethylene (UHMWPE) can be used as weft in the FPH was.

The first method consists in the fact that such weaving materials can be washed using such traditional materials for the production of such FPH WRF, such as, for example, polyester yarns.

But in this case, to increase the strength of the fire hose, it is necessary to use as weft threads of a larger diameter (greater linear density) and, accordingly, with a greater rupter strength. However, this path will lead to an increase in material consumption and weight of the FPH. The second method, in our opinion, is more acceptable, is that instead of traditional polyester threads, high-strength and wear-resistant threads, for example, ultra-high modulus (UHM) threads, or threads of ultra-high molecular weight polyethylene (UHMWPE) can be used as weft.

Based on formula, the influence of geometric densities on the base and weft of the woven reinforcing cage on the value of internal burst pressure studied (figure 2, 3).

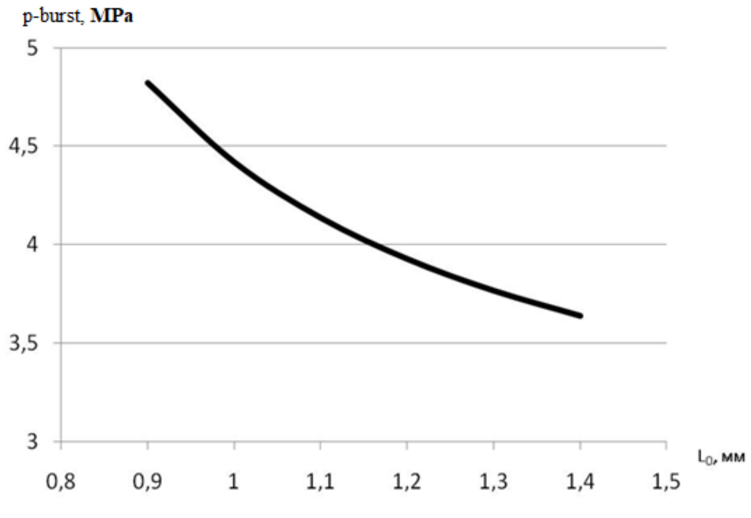

Figure 2 – The dependence of the rupture pressure p-burst from the geometric density on the basis of L_o fabric of FPH latex reinforcing frame MG "Bereg" with diameter of 77 mm

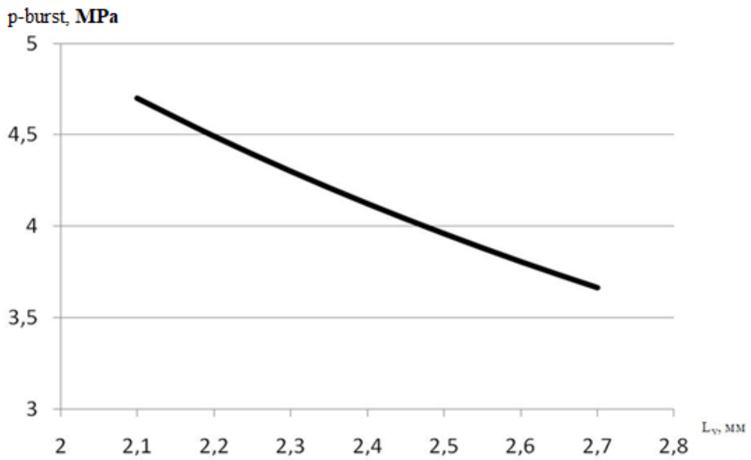

Figure 3 – The dependence of the burst pressure p-burst from the geometric density of the weft L_u of the fabric of FPH Latex reinforcing frame MG "BEREG" with diameter of 77 mm

The analysis of the presented dependences shows that the burst pressure in the FPH substantially depends on the geometric densities of the base and weft of the reinforcing cage fabric. An increase (decrease) in the geometric densities of the fabric of such a FPH results in a decrease. It is important to consider the significant dependence of the bursting pressure on the bursting forces of weft threads, sleeve radii, geometric densities on the warp and weft of the fabric FPH WRF when designing new hoses. Reducing the geometric densities of the warp and weft of WRF threads (if there are technological capabilities for this), along with an increase in the breaking strength of the weft threads, seems the most effective way of increasing the strength characteristics of the FPH under hydraulic action.

Conclusion. On the basis of the obtained formula for calculating the FPH strength under the action of internal hydraulic pressure, the effect on the value of the rupture pressure in the latex FPH produced by Bereg Production Association (Russia), designed for a working pressure of 1.6 MPa, parameters such as the breaking stress threads, the radius of the sleeve and the geometric density at the base and weft.

The influence of these parameters on the value of the rupture pressure turned out to be the most significant, which must be taken into account when designing and creating new types of FPH.

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Ж. У. Мырхалыков[1], С. Г. Степанов[2], А. Е. Арипбаева[3], Р. Т. Калдыбаев[3], М. И. Сатаев[1]

[1]«SILKWAY» Халықаралық университеті, Шымкент, Қазақстан;
[2]Иваново мемлекеттік политехникалық университеті, Иваново, Ресей;
[3]М. Әуезов атындағы Оңтүстік Қазақстан мемлекеттік университеті, Шымкент, Қазақстан

ӨРТКЕ СУ СЕБЕТІН ТҮТІК ҚЫСЫМЫН АРТТЫРУДАҒЫ БАСТЫ БАҒЫТТАРДЫ ТАЛДАУ

Аннотация. Қысымды өртке су себетін түтік – тегіс иілгіш құбыр жолдары көбіктендіретін су және су ерітінділерін өрт ошағына қысым жасалған қашықтыққа жеткізу үшін қолданылады. Қысымды түтіктердің сенімділігі мен жұмыс қабілеттілігіне қойылатын талап өте маңызды, өйткені өртті сөндірудің оң нәтижесі оған тікелей байланысты. Өртке су себетін түтіктің маңызды параметрлерінің бірі – ішкі қысым әсерінен шлангтың жойылуға қарсы тұру қабілеттілігін сипаттайтын жарылатын ішкі қысым. Осыған байланысты гильзалардың жарылу қысымын жоғарылату жолдарын талдау маңызды. Өртке су себетін түтік құбырдағы үзілу қысымының олардың тоқылған армирленген қаңқа өлшемдеріне авторлар бұрын алынған тәуелділікке сүйене отырып, осы техникалық бұйымның үзілу қысымын жоғарылатудың негізгі жолдарына талдау жүргізді. Өртке су себетін түтік құбырдың армирленіп тоқылған қаңқа өлшемдерінің ішкі үзілу қысымының шамасына әсерін бағалау үшін зерттеу объектісі ретінде ПО «БЕРЕГ» (Ресей) өндірісінің полиэфирлі жіптерден жасалған және 1,6 Мпа жұмыс қысымына есептелген диаметрі 77 мм латекстелген өртке су себетін түтік құбыр таңдап алынды. Жүргізілген зерттеулер үзілу қысымы кең дәрежеде арқау жібінің үзілу күшіне, су себу құбырының радиусына, армирленген қаңқа тоқымасының негіз және арқау бойынша геометриялық тығыздығына байланысты болып келетіндігін көрсетті. Арқау жіптерінің үзілу күші шамасының өсуі (төмендеуі) арқылы өртке су себетін түтік құбырының ажырау қысымы (яғни, су себетін түтігінің беріктігі) сызықтық заңы бойынша артады (төмендейді). Осылайша су себетін түтік құбыры көлденең қимасының төмендеуі негізінде құламалық сипаты өседі. Армирленген қаңқа тоқымасының негіз және арқау бойынша геометриялық тығыздығының өсуі (төмендеуі) өртке су себетін түтік құбырдың үзілу қысымының төмендеуіне (өсуіне) әкеледі. Ішкі үзілу қысымының арқау жіптерінің үзілу күшіне, түтікше құбырдың радиусына, армирленген қаңқа тоқымасының негіз бен арқау бойынша геометриялық тығыздығына аса тәуелді болатындығын жаңа өртке су себетін түтік құбырды жобалау кезінде есепке алған жөн.

Түйін сөздер: өртке су себетін түтікті құбыр, армирленген қаңқа, полиэфирлі жіптер, ішкі ажырау қысымы.

Ж. У. Мырхалыков[1], С. Г. Степанов[2], А. Е. Арипбаева[3],
Р. Т. Калдыбаев[3], М. И. Сатаев[1]

[1]Международный университет «SILKWAY», Шымкент, Казахстан;
[2]Ивановский государственный политехнический университет, Иваново, Россия;
[3]Южно-Казахстанский государственный университет им. М. Ауэзова, Шымкент, Казахстан

АНАЛИЗ ОСНОВНЫХ НАПРАВЛЕНИЙ ПОВЫШЕНИЯ РАЗРЫВНЫХ ДАВЛЕНИЙ НАПОРНЫХ ПОЖАРНЫХ РУКАВОВ

Аннотация. Напорные пожарные рукава – плоско сворачиваемые гибкие трубопроводы, применяемые для подачи воды и водных растворов пенообразователей на расстояние под давлением к очагу пожара. По отношению к напорным пожарным рукавам чрезвычайно важно требование к их надежности и работоспособности, так как от этого напрямую зависит положительный результат при тушении пожаров. Одним из важнейших параметров напорных пожарных рукавов является разрывное внутреннее давление, характеризующие прочность, т.е. способность рукава сопротивляться разрушению под действием внутреннего гидравлического давления. В связи с этим важно проанализировать пути повышения разрывных давлений рукавов. На основе ранее полученной авторами зависимости разрывных давлений в пожарных напорных рукавах от параметров их тканого армирующего каркаса выполнен анализ основных путей повышения разрывных давлений этих технических изделий. Для оценки влияния параметров тканого армирующего каркаса рукавов на величину внутреннего разрывного давления в качестве объекта исследования был выбран латексированный напорный пожарный рукав диаметром 77 мм производства ПО «БЕРЕГ» (Россия), изготовленный из полиэфирных нитей и рассчитанный на рабочее давление 1,6 МПа. Проведенное исследование показало, что в наибольшей степени разрывные давления зависят от разрывных усилий уточных нитей, радиусов рукавов, геометрических плотностей по основе и утку ткани армирующего каркаса. С увеличением (уменьшением) величины разрывного усилия уточных нитей разрывное давление в пожарных напорных рукавах (то есть фактически, прочность рукавов) возрастает (падает) по линейному закону. При этом с уменьшением диаметров поперечных сечений рукавов крутизна характеристик возрастает. Увеличение (уменьшение) геометрических плотностей по основе и утку ткани армирующего каркаса приводит к уменьшению (увеличению) разрывного давления пожарных напорных рукавов. Существенную зависимость внутреннего разрывного давления от разрывных усилий уточных нитей, радиусов рукавов, геометрических плотностей по основе и утку ткани армирующего каркаса важно учитывать при проектировании новых пожарных рукавов.

Ключевые слова: напорный пожарный рукав, армирующий каркас, полиэфирные нити, внутреннее разрывное давление.

Information about authors:

Myrkhalykov Zh., Academician of National Academy of Sciences of the Republic of Kazakhstan, Doctor of technical sciences, Professor, General Director of LLP "Research Institute of Innovation and Technological Modernization", SILKWAY International University, Shymkent, Kazakhstan; myrkhalykov@inbox.ru; https://orcid.org/0000-0002-4834-5089

Stepanov S., Doctor of technical sciences, Professor of Department of Mechatronics and Radioelectronics, Ivanovo State Polytechnic University, Ivanovo, Russia; step-sg@mail.ru; https://orcid.org/0000-0001-7648-832X

Kaldybaev R., Candidate of technical sciences, Docent at the department of "Technology of manufactured and consumer goods of textile and light industry", South Kazakhstan State University, Shymkent, Kazakhstan; rashid_cotton@mail.ru; https://orcid.org/0000-0002-1370-7553

Aripbaeva A. PhD, Senior lecturer at the department of "Technology and design of textile materials", South Kazakhstan State University, Shymkent, Kazakhstan; akerke-1982@mail.ru; https://orcid.org/0000-0003-1005-0856

Satayev M., Corresponding member of National Academy of Sciences of the Republic of Kazakhstan, Doctor of technical sciences, Professor, Deputy Director of LLP "Research Institute of Innovation and Technological Modernization", SILKWAY International University, Shymkent, Kazakhstan; maratsatayev@mail.ru; https://orcid.org/0000-0001-9308-1839

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