Compensation method of long high-pressure hose coating formation

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Abstract. Operational reliability of modern machinery is one of the topical tasks in different fields of mechanical engineering. Machines and devices as well as their particular units and parts operating in conditions of high temperatures, aggressive environment and significant loads require additional protection means. Various coatings are known to be widely used for protecting products and their parts such as gas turbine parts fire-proof and thermal protection coatings.

1. Introduction

Nowadays there is a wide range of coatings with different purpose. Moreover, there are coatings meant for both long term protection from high temperature destroying factors and supporting systems and machinery functioning in case of complicated emergency situations or fire. The range includes fireproof coatings for protection of high-pressure hydro systems hoses that are the most susceptible parts of aviation machinery. Performance capability of the above-mentioned systems in critical situations provides more time required for saving the crew, passengers and the flying vehicle. Therefore, such a particular emphasis is made on improvement of high-pressure hoses fire resistance.

However, to reach the required fire resistance of flexible high-pressure hoses fire protection coatings and covers from flame-retardant heat-insulating and heat-absorbing materials are used [1-3]. The above-mentioned covers cut on smoke and toxic gas substances production in case of fire. Fire protection properties of such covers and coatings are justified by the materials with high temperature impact resistance at fire and thermal and physical characteristics thermal stability under high temperature within the given time.

2. The research part

Anyway, fireproof flexible pipelines [3,4] consist (figure 1) of the flexible part (fluoroplastic pipe (1) in power metal braid), connecting fittings (3,4,5,7) and fireproof coating (6).

To provide hoses with a fireproof cover special device with press tools are used. The shown device (figure 2) for fireproof hose coating production contains a rigid mandrel, flanges (bushing), external shell (body), binder with lodgment bolt connection. With the regard to diameters of the mandrel and external shell fireproof coating with the required wall thickness and set conventional diameter is formed [1,3].
One of the most important parameters of flexible pipelines is wall thickness evenness. During the production of long (over 2000 mm) hoses with small inside diameter the mandrel slacks causing variable wall thickness in the middle part of the fireproof cover length (figure 3 and figure 4).

Figure 1. Flexible fireproof high-pressure hose (1 - fluoroplastic pipe, 2 - power metal braid, 3,4,5,7, - connecting fittings, 6 - fire proof coating (cover)).

Figure 2. General view of the device with the press tool (1 - metal mandrel with antiadhesion cover, 2 - press tool working surface, 3 - press tool body, 4 - bandage, 5 - clips).

Figure 3. Variable wall thickness of the fireproof cover caused by mandrel slacking in the middle part of the fireproof cover (1 - inside braid, 2 - fire proof cover, 3 - cover wall thinning area, 4 - cover wall thickening area).

Figure 4. Fireproof coating wall thickness change with the regard to hose length.
3. Research results:
To prevent variable fireproof cover, thickness the authors suggested and studied a method based on the compensation of the mandrel heaviness by a magnetic field with the direction opposite to the gravity force (figure 5).

![Diagram](image)

**Figure 5.** Providing fireproof cover wall thickness evenness with the compensation method. (1 - mandrel; 2 - fire proof material braid; 3 silicon rubber paste; 4 - mould; 5 - cylinder mould longitudinal axis; 6 - mandrel longitudinal axis; 7 - magnetic field, P - mandrel heaviness, F - magnetic field force applied to the mandrel, f - mandrel slacking under its weight: А-А and В-В show correspondingly; fire proof hose cross section before and after the application of the magnetic field compensating the mandrel weight; down arrow - mandrel heaviness force, up arrow - compensating magnetic field force).

Production of the fire-proof hose is performed in the following way (figure 5). The braid (2) made of fireproof material (for example siliceous fabric soaked with organosilicon rubber solution and polymerized to the rubber-like state) is put onto the mandrel (1). The cylinder mould 4 of the external surface of the formed hose is filled with paste 3 made of organosilicon rubber. The mould 4 consisting of an upper and lower part is filled with paste 3. Mandrel 1 with the braid 2 on is put into the mould 4 with the paste 3 matching the mandrel longitudinal axis with the longitudinal axis of the above mentioned mould 5, that causes an even clearance between mandrel 1 and the inside surface of the mould 5. The clearance is filled with the braid 2 and paste 3 forming hose walls. The mould 4 is closed and paste 3 is polymerized. A long mandrel 1 made of magnetic material (for example carbon steel) is used. Mandrel 1 and closed mould 4 are put in the magnetic field 7 setting the magnetic field force impact F to compensate slacking of the long mandrel 1 caused by its weight impact. (To reach it for example before fireproof hose production mandrel one ends are fastened to two supports, the distance to a flat plate under mandrel 1 serving as a measuring base is measured, slacking f is measured, the magnetic (electromagnetic) field is switched on, its force is set providing zero mandrel 1 slacking, magnetic field intensity value is fixed for attaching it to the assembled mould 4 with mandrel 1). The magnetic field 7 (figure 5b) provides even thickness of the hose walls thanks to the compensated mandrel slacking caused by its weight impact. Then paste 3 is polymerized and the hose is removed from the mould 4 and mandrel 1 is removed from the inside hose cavity.

Picture (figure 6) shows the length middle part cross section in the long fireproof cover formed with compensating magnetic field application.
Studies conducted on the middle part of the fireproof cover showed the following values of uneven thickness. Mandrel length (Dn 8 mm) is 2000 mm, mandrel length (Dn 20 mm) is 3000 mm. Thickness unevenness without the magnetic field impact: mandrel (Dn 8 mm), 1.1 mm, mandrel (Dn 20 mm) 0.8 mm, with the magnetic field impact: mandrel (Dn 8 mm), 0.2 mm, mandrel (Dn 20 mm) 0.3 mm.

4. Conclusion
Complicated emergency and fire situations require high functioning durability of flying vehicles systems and high fire resistance of aviation machinery.

Hydro systems reliability depends on flexible high-pressure hoses protection, they should be resistant to high pressure and its changes, vibrational load and high temperatures.

During production of significantly long high-pressure hoses fireproof covers with press-tools mandrel slacking causes uneven wall thickness that results in decrease of flexible pipelines operational reliability.

Method of mandrel slacking magnetic compensation for significantly long high-pressure hoses fireproof covers production provides more even cover walls thickness.

References
[1] Zavarnov S A, Nabiullin V H, Tuk D E 2007 Fire protection of fluoroplastic hoses in FV systems with metal armoured braids *New Turn of Aviation Science International Conf.* (Moscow: CAI)
[2] Nabiullin V X et al 2009 Method of production of polymerized hose in two meshy braids Pat. of the Russian Federation No 2367835 IPC 2008111610/06
[3] Vakhitov A M et al 2009 Method of production of metal armoured braided hoses Pat. of the Russian Federation No. 2350821 IPC 2007119363/06
[4] Goryainova A V 1971 *Fluoroplastics in mechanical engineering* (Moscow: Engineering) p 233