Protection of Tent Materials on the Basis of Capron Using Polymers

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Abstract. The object of the paper – is to improve abrasion resistance of capron-based awning material. The objectives of the present research are the following: to investigate the impact of polymer compounds, on the base of urethane thermoplastic material UK-1 structured by A-grade polyisocyanate, on the base of Z-grade chlorosulfonated polyethylene containing vulcanizing agents, stabilizers and pigment groups, on abrasion resistance of awning material with the pressure base of capron fabric. Research methods: test samples have undergone the complex of laboratory experiments for alteration of parameters of physical and mechanical properties before and after accelerated heat-and-light ageing in the STS apparatus. Abrasion tests have been carried out on the PIT-2 apparatus. Instrument measurements of physical and mechanical properties as well as visual evaluation of protective polymer coatings’ state have been taken as control parameters of abrasion resistance. Results obtained: the investigation has shown that abrasion resistance of soft barriers of awning structures and, correspondingly, their service life could be increased essentially by means of applying an additional layer of protective screen coating and its intermittent resurfacing adjusted for wear while in service. Resurfacing intermittence should be done every 2 years provided the coating thickness of 100 micrometers.

1. Introduction
In the practice of domestic and overseas construction, awning structures of various applications are widely used nowadays [1-3]. These are lightweight and graceful exhibition pavilions and mobile multifunctional halls, as well as agricultural structures with the wide range of applications (green glasshouses, conservatories, shelter for grain, vegetable and machinery storage) and special facilities.

The main parameters ensuring wide scope of applicability for awning structures include their light weight, mobility, the ability to span large bays and arches, transformation speed, degree of structure prefabrication, cost-effectiveness and the most beneficial use of the properties of materials in structures’ behaviour [1]. Along with that, effective use of light structures with the coatings of textile-membrane materials is mainly determined by their qualitative characteristics [2, 4].
In order to develop the existing awning structures on the base of membranes, linen tent-cloth and duck fabrics, textile with polymer coatings is presently widely applied. However, while in service and exposed to the environmental factors, this material impairs its physical and mechanical parameters and external appearance. Furthermore, among the complex of unfavourable impacts one could distinguish mechanical wear, in particular abrasive one that leads to sharp decline of qualitative characteristics of awning structures and the loss of their service life [5-7]. In view of this, the selection of polymer compound for re-surfacing protective coating of awning structures with the purpose of enhancement of their abrasion resistance is of utmost importance.

2. Methodology

The selection of polymer compound for recovery of protective coating of soft barriers for awning structures was implemented using the example of awning material with the pressure base of carbon fabric. One of the main requirements for polymer compound is its chemical compatibility with the principal protective coating and good adhesion. Taking into account the above-mentioned factors, the following variants of polymer compounds have been used: on the base of urethane thermoplastic material UK-1, structured by A-grade polyisocyanate; on the base of chlorosulfonated polyethylene of Z-grade; on the base of polychloroprene containing vulcanizing agents, stabilizers and pigment groups. These compounds have been solved in organic dissolving agents and then spread on the samples of awning materials and their bandings by brushing, dipping or pulverizing. Their specific features are high elasticity and abrasion resistance, intrinsic properties of resins. Moreover, aluminium fine powder has been introduced into the above-mentioned compositions. The particles of pigment and aluminium fine powder are moisture-, oxygen- and lightproof. Performing like a screen, the aluminium particles do not permit ultraviolet rays through protective coating. That being said, while preserving and restoring the integrity of protective coatings with the help of aluminium paint, we increase abrasion resistance of soft barrier not only by enhancement of its resistance to mechanical abrasive actions of its coating surface, but mainly by preventing destruction of the pressure base.

The samples have undergone the complex laboratory tests for the change of physical and mechanical parameters before and after artificial heat-and-light ageing in the apparatus STS. Abrasion tests have been carried on the PIT-2 apparatus. Instrument measurements of physical and mechanical properties as well as visual evaluation of protective polymer coatings’ state have been taken as control parameters of abrasion resistance.

3. Result and discussion

When visually evaluating tested samples, it has been discovered the loss of decorative qualities of screen protective polymer coatings: polyurethane composition has given the change of colour form silverly to dark-purple one; the compound on the base of modified chlorosulfonated polyethylene has changed its colour from silverly to yellowy-brown one; for the composition of the base of chloroprene elastomer, insignificant yellow discoloration has been observed.

The measurement data of physical and mechanical properties of the tested specimens before and after ageing are laid out in the table 1.
As is clear from experimental data presented in the table 1, screen coating on the base of stabilized chloroprene elastomer [8-11] demonstrates the most efficient protective properties. The coatings on the base of chlorosulfonated polyethylene [12-16] and urethane elastomer [17-20] have shown lower...
results in rupture strength and the value of elongation per unit length. This is obviously connected with the chemical constitution and spatial structure of modifier as well as its physical, chemical and mechanical parameters (abrasion resistance, adhesion to fabrics, tear resistance, ultimate tensile strength and others).

The compound on the base of stabilized chloroprene elastomer has been tested as a material for re-surfacing of protective coatings of soft barriers for awning structures with the purpose of enhancement of their abrasion resistance.

The change of physical and mechanical properties of awning material with protective coating and non-coated one before and after ageing is presented in the table 2. The results have shown that alteration of chemical nature of outer layer has insignificant impact on strength properties of protected pressure base of material. Its value is seen when the breach of protective layer’s integrity takes place and exposed pressure base, due to wear, starts to reduce its physical and mechanical characteristics thanks to degradation when exposed to sunlight and weather and other atmospheric factors.

Capron-based awning material with exposed pressure base after heat-and-light ageing during 78 hours has lowered its rupture resistance for 87%, at the average, and has almost lost its ability to resist tear, as shown in the table 2.

**Table 2. Physical and mechanical properties of capron-based awning material after pressure base exposure.**

| Parameter                        | Direction | Without re-surfacing screen coating | With re-surfacing screen coating with the width 100 micrometers |  |
|----------------------------------|-----------|-----------------------------------|---------------------------------------------------------------|---|
|                                  |           | Before ageing                     | After heat-and-light ageing                                   |  |
|                                  |           | intact 100 wear cycles            | intact 100 wear cycles                                        |  |
| Rupture resistance, N/cm²       | B         | 960                               | 119               | 68          | 1028 | 874 | 626 | 493 |
|                                  | F         | 946                               | 110               | 37          | 893  | 587 | 458 | 332 |
| Elongation per unit length, %    | B         | 25.5                              | 5.2               | 2.7         | 29.0  | 16.5 | 15.7 | 12.0 |
|                                  | F         | 39.0                              | 10.3              | 5.0         | 35.2  | 19.0 | 18.3 | 14.3 |
| Peel strength, N                 | B         | 262                               | 7                 | -           | 288  | 71  | 53  | 19  |
|                                  | F         | 298                               | 12                | -           | 315  | 104 | 66  | 25  |
| Resistance to flexing (cycles)   | B         | >50000                            | >50000            | >50000      | 19743 | -  |     |     |
|                                  | F         | >50000                            | >50000            | >50000      | 42195 | -  |     |     |
| Stiffness, N                     | B         | 0.100                             | 0.123             | -           | 0.194 | 0.302 | -  |     |
|                                  | F         | 0.062                             | 0.0995            | -           | 0.269 | 0.295 | -  |     |
| Relative reduction of material’s strength at wear A=(P₁-P₂)/P₁*100% | B | 74.5 | 42.9 | 15 | 21.3 |
|                                  | F         | 84.6 | 66.4 | 34.3 | 27.5 |

Relative reduction of material’s strength at wear

\[ A = \frac{(P_1 - P_2)}{P_1} \times 100\% \]
When re-surfacing protective layer with the width of 100 micrometers for the compound on the polychloroprene after heat-and-light ageing, it has improved tensile breaking strength by a factor of 5 along the base and by a factor of 4 along the face, and peel strength – by a factor of 7.5 along the base and by a factor of 5.5 along the face if compared with non-coated material.

Correlation of the experimental tests results and the field survey data has shown that 100 wear cycles of the material of awning barrier with restored protective coating on the PIT-2 apparatus corresponds to two field use operational cycles in the excessive wear zones and leads to deterioration of screen protective layer and exposure of pressure base of both barrier material and the conjunction of structural joints. After 100 wear cycles, non-protected conjunction has lowered its strength after heat-and-light ageing by 20%, and protected one – by 9%.

Thus, the research results have proved that abrasion resistance of soft barriers of awning structures and, correspondingly, their service life could be significantly increased by applying additional layer of screen protective coating and its intermittent resurfacing adjusted for wear while in service. Resurfacing intermittence should be done every 2 years provided the coating thickness of 100 micrometers.

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