

INFLUENCE OF THE POLYMER COMPONENT ON THE PROPERTIES OF HYBRID THERMAL INSULATION COMPOSITES

Monakhov S.V., Fedorenko O.Yu., Ryabinin S.O., Otroshchenko M.S.

National Technical University

«Kharkiv Polytechnic Institute», Kharkiv

Thin-layer thermal insulation of the new generation is designed to reduce heat losses in pipelines of industrial and residential structures. Validation of scientific and technical information regarding the effectiveness of thermal insulation paint indicates the potential to reduce condensate formation by 90 %, decrease heat losses by 20 – 30 % (with a coating thickness of 2 mm), provide corrosion protection, and ensure long-term retention of these functions. Additionally, thin-layer thermal insulation does not require dismantling, unlike traditional methods that involve the use of mineral wool or polyurethane foam.

The properties of thermal insulation paints with microspheres largely depend on the polymer matrix type, which determines adhesion, mechanical characteristics, and resistance to external factors (temperature, humidity, ultraviolet radiation, and aggressive substances). Among the main types of polymers used as binders for thin-layer thermal insulation are acrylic, silicone, and polyurethane compositions. The selection of the polymer matrix composition for thin-layer thermal insulation should consider the operating conditions.

The thermal conductivity of acrylic compositions is higher ($\lambda = 0.15\text{--}0.25\text{ W/m}\cdot\text{K}$) compared to silicone ($\lambda = 0.08\text{--}0.12\text{ W/m}\cdot\text{K}$), epoxy ($\lambda = 0.13\text{--}0.2\text{ W/m}\cdot\text{K}$) and polyurethane ($0.02\text{--}0.05\text{ W/m}\cdot\text{K}$) compositions. Acrylic loses elasticity at temperatures above 80 °C, though some modified compositions can withstand temperatures from –40 °C to +120 °C. This makes it unsuitable for paints used on steam pipelines. In cases of mechanical impact or contact with aggressive environments, the coating integrity may be compromised. Additionally, acrylic is flammable, making the use of thermal insulation paints based on it undesirable for exposed pipelines.

Epoxy resins are less effective in thin layers; under prolonged temperature exposure or mechanical stress, they are prone to cracking. However, they are chemically resistant, which is crucial for insulating pipelines operating in aggressive environments, such as in chemical production.

Silicone compositions are stable at temperatures from –60 °C to +250 °C, making them the best choice as a base for thermal insulation paints for heating pipelines and industrial steam pipelines. They are characterized by high adhesion to metals, thermal stability, and hydrophobicity, which provides protection against moisture and corrosion. Furthermore, these compositions do not require thorough pipe preparation, and their relatively high mechanical strength and elasticity allow them to withstand minor deformations caused by pipeline vibrations.

The operating temperatures of polyurethanes range from –65 °C to +150 °C. They maintain strength and elasticity under prolonged thermal cycling and are fairly resistant to moisture, oils, and weak acids. This combination of properties makes them suitable as a base for thermal insulation of external pipelines.

Information on the influence of the polymer matrix composition on the hybrid composites properties was used in the development of a thin-layer thermal insulation line for various purposes pipelines.