THERMAL PROPERTIES RESEARCH INTO FOAM POLYURETHANE USED FOR PIPE INSULATION

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Semi-rigid foam polyurethanes can be used successfully to insulate flexible heating and hot water pipelines with an operating temperature up to 130°C. Higher temperatures intensify the processes of thermal and thermo-oxidative destruction of polyurethanes due to the de-compounding of urethane groups and ether links. The necessary increase in the thermal resistance of foam insulators for pipelines with operating temperatures up to 180°C can be achieved with the right modifications – by adding polyurethane polyisocyanurate compounds, and by the aromatic isocyanate cyclic trimerisation process.

A system with a higher content of isocyanate and trimerisation catalysts is used to achieve modified foam plastics. The isocyanate index is used as an evaluation criteria for polyisocyanate content in foam plastics.

We have studied the thermal, physical and mechanical properties of polyurethane foams made in reaction systems with isocyanate indexes ranging from 150 to 470.

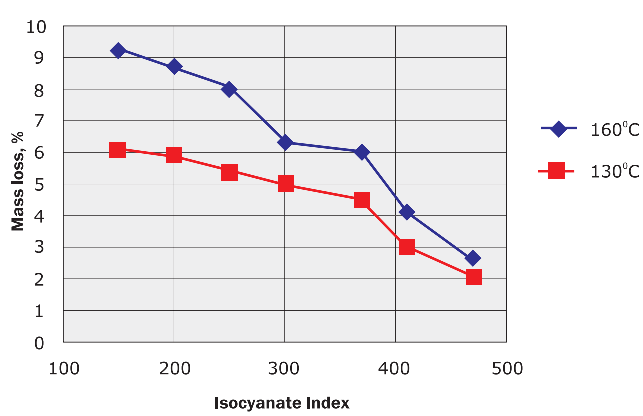
Thermal resistance of foam plastics was evaluated by dynamic thermo-gravimetric analysis in argon and air, at a heating rate of 10°/min and a gas flow velocity of 50 ml/min, also at mass loss at isothermal heating of 130 and 160°C for 6 days.

The elasticity of plastics is checked by their deflection values in a bending test according to GOST 18564.

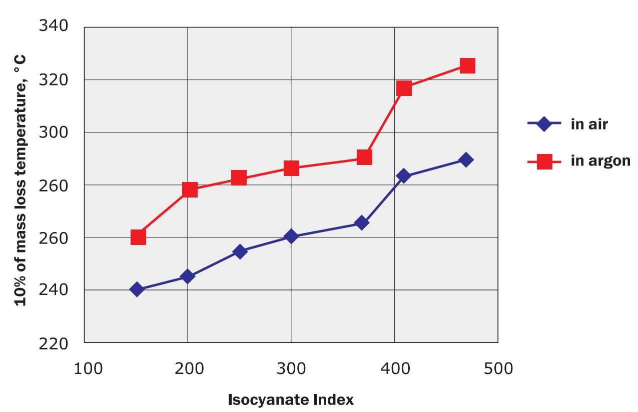
The tests results shown in graphs 1–3 confirm that the thermal resistance of foam plastics increases with the increase of the isocyanate index (due to their increased number of cyclic links) which significantly reduces their elasticity.

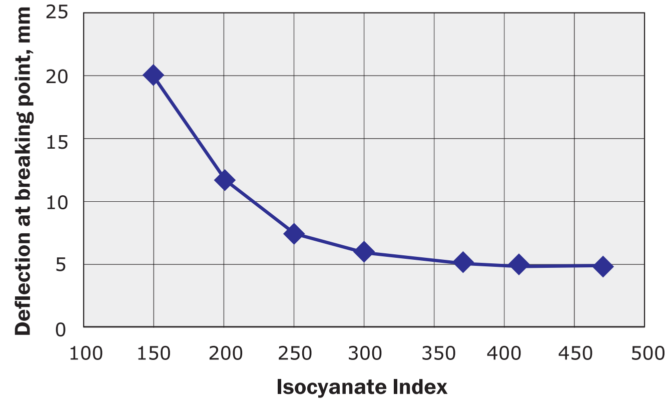
We have also studied the possibility of regulating foam plastics properties by changing the isocyanate:polyol ratio in the reaction system.

Graph 1. Foam plastics thermal resistance in isometric mode

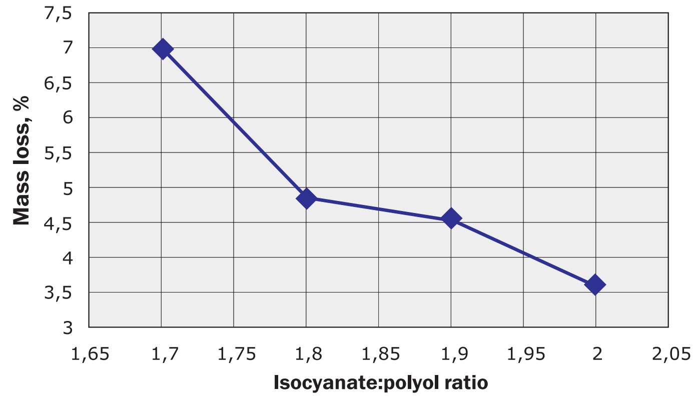


Graph 2. Foam plastics thermal resistance in dynamic mode





Graph 3. Foam plastics deflection strength



Graph 4. Thermal resistance in isometric mode

The components ratio (isocyanate:polyol) in the initial reaction system was in the range from 170:100 to 200:100. A reduction in the isocyanate content below the marked level was not considered due to its tendency to reduce the hardness of foam plastics. An isocyanate increase above the level shown here will also be unreasonable due to the reduced elasticity of foam plastics.

The thermal resistance of foam plastics was evaluated by mass loss at isometric heating at 160°C during 5 days. Vicat softening temperature was determined in accordance with GOST 15088-83 at a heating rate of 120°C/hour and 51 N load.

The test results are shown on graphs 4–5.

As can be seen from the above results, thermal resistance and stability increase with isocyanate: polyol ratio increase in the reaction system is due to an increased content of cyanurate links in the foam plastics structure.

The long-term thermal stability of the insulation was also checked (according to GOST 54468-2011) by determining the relative strain of the foam plastic sample under constant pressure and temperature, corresponding to the operating maximal temperature (180°C) for 300 hours.

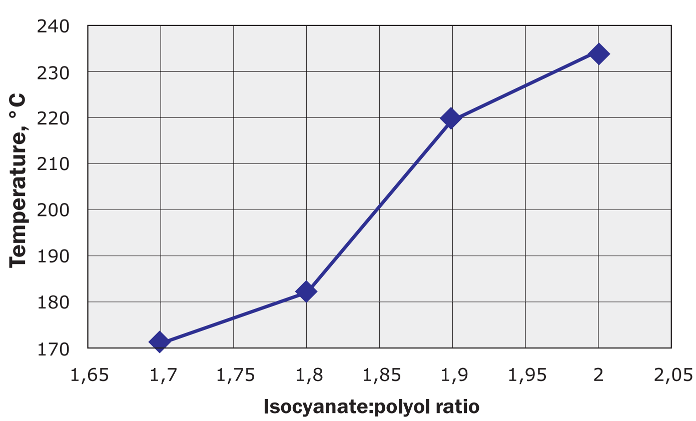
Relative strain at the given data shall not exceed 10%. Long-term thermal stability results in graph 6 show that the relative deformation of plastic samples reduced at isocyanate:polyol ratio increase in the reaction system and the deformation is significantly lower than accepted.

Other properties (density, water absorption, compression strain at 10% deformation) of tested foam plastics are satisfactory and comply with relative technical specifications. Components ratio changes in the reaction system do not influence the heat conduction coefficient (0.027 W/m·K).

The results obtained show that the tested foam plastics have high thermal resistance, necessary thermal stability and that their heat conducting, physical and mechanical properties are in compliance with technical requirements.

The final choice of components ratio of reaction systems should be done with consideration of technology and economic factors.

Graph 5. Vicat heat stability



Graph 6. Long-term thermal stability of foam plastic