"Polymer pipelines for mining industry"

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Abstract. The main factors determining the overall productivity and cost of operation of industrial pipeline hydrotransport systems for pulp (slurry pipelines) are reduction in the labor intensity of maintenance work, reduction in the energy intensity of hydraulic transportation processes and durability. The current trend towards increasing the productivity of processes in mining and other enterprises ultimately leads to the fact that one of the most important issues in the design of pipelines is durability, since pollution of the environment and working area, production downtime due to unscheduled and forced repair work associated with the need for capital investments, dismantling and installation of pipeline systems, significantly reduce the economic efficiency of production.

Pipelines made of thermoplastics, for example, from compositions based on copolymers of ethylene with 1-hexene or 1-butene (PE 100), including heat-resistant polyethylene compositions (PE -RT – copolymer of ethylene and 1-octene; PE-X – cross-linked polyethylene) are actively used in the chemical and energy industries. However, the use of pipeline systems with a working surface made of polyethylene for transporting slurry is rather limited due to insufficient wear resistance. Industrial hydraulic transport systems used in Russia to move slurries are traditionally made of inexpensive steel grades. Carbon steel pipes are characterized by resistance to high operating pressures, but are susceptible to chemical corrosion, and high hydraulic friction coefficient leads to noticeable pressure losses and an increase in specific energy costs. As a result of wear by flows of suspended abrasive particles, such pipelines fail quickly.

Based on the above, the development and research of polymer pipeline systems with increased resistance to hydroabrasive wear is a very urgent scientific and technical problem.

The purpose of this work:

Development of the design and production technology of specially designed polymer pipes resistant to hydroabrasive wear for use in hydraulic transport systems.

To achieve this goal, the following main tasks were formulated and solved in the dissertation work:

• comprehensive comparative study of resistance to hydroabrasive wear of polyolefins; thermoplastic elastomers of various chemical structures, including thermoplastic polyurethanes used for lining the inner surface of hydraulic transport systems; mixtures based on polyolefins and thermoplastic elastomers; steel;

• study of dynamic mechanical properties and the influence of rigidity (according to indicators: elastic modulus, Shore hardness) on the resistance to hydroabrasive wear of polyolefins and thermoplastic elastomers of various chemical structures;

• comparative study of rheological properties of pipe grades of polyethylene and thermoplastic elastomers resistant to hydroabrasive wear;

• development of technology for the production of polyethylene pipes with an inner layer of thermoplastic elastomer with increased resistance to hydroabrasive wear;

• study of hydraulic characteristics during hydraulic transport of iron ore tailings in pipelines made of carbon steel, high-density polyethylene and thermoplastic elastomer with increased resistance to hydroabrasive wear;

• assessment of the influence of speed, concentration and dispersion of slurry on the wear rate of polymer and steel pipelines.

Scientific novelty:

• studies of mixtures of polyolefins and thermoplastic elastomers have revealed the dependence of resistance to hydroabrasive wear on the rigidity of the polymer compositions;

• for the first time, a relationship between the mechanical loss modulus in dynamic loading conditions and hydroabrasive wear for polyolefins, thermoplastic elastomers of various chemical structures and their mixtures has been established;

• for the first time, the presence of an incubation period in the process of destruction of thermoplastic vulcanizates under hydroabrasive action of slurry has been experimentally proven.

Theoretical and practical significance. A technology has been developed for the production of pipeline systems with increased resistance to hydroabrasive wear. The pipes are a two-layer structure with an outer layer of high-density polyethylene, which bears internal hoop stress, and an inner co-extruded wear-resistant layer of thermoplastic vulcanizate Armlen PP TEP 12-55A. Connecting parts (fittings) are made from pipe sections by heated tool butt welding. Bends are also manufactured by hot bending of pipe sections. Flange bushings are made by turning process using a cutting tool to remove part of the material from the outer surface of a pipe section with a corresponding internal diameter and increased wall thickness. The flange part can also be made by winding polyethylene tape onto a piece of pipe and subsequent turning to the specified dimensions.

Based on the results of full-scale tests at the slurry pumping site of the Zhezkazgan Mining and Processing Plant, which is part of the Kazakhmys holding, and at the pilot industrial site of the gold mining plant of OJSC Matrosov Mine (PJSC Polyus), pipeline systems are recommended for use as an alternative to reinforced rubber and metal pipelines, including lined ones.

Technical specifications TU 22.21.21-049-73011750-2022 “Polyethylene pressure pipes with increased resistance to hydroabrasive wear” and instructions for construction and installation work IM.GPP.19-19-2 “Installation of polyethylene pipes “MULTIPIPE IS” and "MULTIPIPE IS PROTECT" with increased resistance to hydroabrasive wear", including recommendations for butt welding.

Pipeline structures are certified for compliance with technical specifications (SS No. ROSS RU.HB24.APTS H00139/23) and industrial safety requirements (SS No. S-RTE.002.TU.01194) and are mass-produced at the enterprises of POLIPLASTIC Group LLC under the trade mark MULTIPIPE IS in a standard version, as well as with special protective coatings: MULTIPIPE OS IS in a flame-retardant version and MULTIPIPE UV IS with a special coating resistant to UV radiation for open installation.

Currently, the pipes are reliably operated at the Gremyachinskoye potash deposit of the EuroChem-VolgaKaliy project and the Natalka mine.

Provisions to be defended:

• results of a comparative study of a complex of physical and mechanical characteristics of polyolefins and thermoplastic elastomers of various chemical structures;

• results of a comparative study of dynamic mechanical characteristics in the temperature range from minus 100 to plus 100 ˚C of polyolefins, thermoplastic elastomers and their mixtures;

• dependence of resistance to hydroabrasive wear on the magnitude of the mechanical loss modulus of polyolefins and thermoplastic elastomers of various chemical structures;

• results of a model experiment to study the influence of slurry composition on the wear resistance and coefficient of hydraulic resistance of pipelines with an internal surface made of steel, high-density polyethylene, thermoplastic vulcanizate and thermoplastic polyurethanes;

• technology for the production of multilayer pipes with an internal wear-resistant layer of thermoplastic vulcanizate.