Research Group

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Review of Russian Market of Composite Pipes

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Introduction

For many years, systems of inner cold and hot water supply, as rule, were made of galvanized steel pipes. At the same time, a number of disadvantages of these pipes, electric conductivity, incomplete meeting sanitary regulations, corrosion, low resistance in chemically aggressive media, difficulties in mounting, requiring high qualification of workers, etc.) forced specialists to look for alternative materials for application in water supply systems.

At present time, pipes, made of polymer materials or with their use find wide application in cold and hot water supply and heating systems.

Among advantages of polymer pipes are their long service life, corrosion resistance, low weight (costs of loading, transportation and mounting these pipes are much lower than those of steel pipes), easy installation.

At present time, several kinds of pipes from plastic materials are presented at building market. Pipes of cross-linked polyethylene (PEX) and composite pipes found the widest application in heating systems.

Composite is a macro-composite (PE-AI-PE) piping with a longitudinally lap-welded aluminium pipe surrounded by an adhesive bonded to inner and outer layers of polyethylene. Polyethylene layers can be presented by common or cross-linked (PEX) polyethylene in various combinations. In title of a pipe, on the first place, material of inner layer is give, and, on the last place, material of the outer layer of the pipe is presented.

Inner protecting polyethylene layer protects pipe from flowing aggressive components and provides smoothness of inner part of a pipe (much higher compared with steel pipe). Outer polyethylene layer protect a pipe from external actions and insulate the pipe from water condensate.

Continual aluminium layer-envelope increases mechanical strength of a pipes, provides impermeability of a pipe for oxygen and air (to prevent further corrosion of auxiliary piping equipment), and smoothes temperature elongation of pipe (thermal elongation coefficient of aluminium is much lower than that of polyethylene pipe).

In some cases, polypropylene-based pipes with punched Al foil or with special fibre composition in middle part of a pipe are also referred to composite pipes. But, according to international classification, these polypropylene-based pipes refer to reinforced but not to composite pipes.

The main end-use of composite pipes is systems of internal heating and hot water supply. Heating systems on the base of composite pipes can be constructed using any method of disposition pipes: one-pipe, two-pipe, warm floor system.

Besides, composite pipes can be used in conditioning systems and in many other kinds of pipelines: for compressed air, hydrothermal and sea waters, food liquids, industrial liquids.

In Table 1, averaged technical characteristics of composite pipes are given.

Table 1: Technical characteristics composite pipes.

Technical characteristics	Value
Density, g/cm^3	0.93
Working pressure at 95^{o}C, atm	10
Working temperature, ^{o}C	-40+95
Peak temperature, ^{o}C	110
Coefficient of thermal conductivity W/m°K	0.24
Coefficient of linear thermal expansion mm/m°K	0.026
Surface undulation, mm	0.02
Relative elongation up to break, %	800
Corrosion resistance	The pipes are not subjected to corrosion and healing
Service life, years	25-50

The pipes up to 25 mm in diameter can be manually bent and stays that way (does not spring back).

PEX, used in composite pipes, is characterized by high chemical resistance, for instance, in many common solvents – hydrocarbons: aromatic (toluene, benzene) and aliphatic (petrol), as well as in any detergents and antifreezes.

However, the PEX is ruptured by concentrated nitric acid, sulfuric acid, chlornitric acid, chlorophorm, sulfur dioxide, methyl-chloride, ethyl ester, fluorine, hot organic oils and fats, tri-chloro-ethylene.

Polyethylene is electrically neutral to dissociated components of a flow; thus, deposition of salts on walls of composite pipes Valpex does not take place, independently on temperature. Extrusion manufacture methods allows to obtain composite pipes with ideally smooth surface.

I. Technology of production of composite pipes and raw materials used

I.1. Methods of production of composite pipes

Technology of manufacture of multi-layer (composite) pipes with aluminium foil layer was elaborated by English company KitecBV in 1979.

Structurally composite pipes differ in method of joining (welding) aluminium layer: end-to-end or overlapped. In reliability of resulted pipes both the methods are similar and provide pipe working pressure of 10 atm, passing regulated tests similarly without any breaks. The difference is that end-to-end welding requires more thick and, thus, more expensive al foil that results in lower elasticity and higher cost of final pipe (as well as higher cost of the productive line itself).

Nevertheless, the end-to-end method is more widespread; for instance, companies Henco, Prandelli, LG Chem, Frankische, Hewing, Oventrop, CoES manufactures their composite pipes by this process.

Overlapped welding is applied in Russian composite pipe Liral, Metallopolimer, composite pipes of companies Unipipe, pipes Valtec Super of company "Valtrompia Technic s.r.l.", Super Pipe (Metzerplas).

Besides, pipes with various polymer layers are manufactured. For instance, UNICOR (Germany) produces pipes (Unipipe) not from cross-linked polyethylenea, but from polyethylene of medium density (MDPE). In design, these are composite pipes too, but they are not capable to work for 50 years at t =95°C and P =10 bar. At this pressure they can work for 50 years at working temperature below 70°C. Thus, they can be applied in systems with colder heat carrier.

For composite pipes manufacture, mainly cross-linked polyethylene (PEX) is used. Cross-linking initial common polyethylene improves its long strength, chemical resistance, resistance to cracking, shock strength and frost-resistance.

Cross-linking polyethylene is a process of formation of cross and fore/aft three dimensional molecular bond created within the structure of the polymer between long molecules of the polymer and is conducted by several processes, including PEXa (peroxide process, provides up to 85% cross-linking)), PEXb (Silane process, above 65%), PEXc (action of electron flow in electromagnetic field on polyethylene, above 60%), PEXd (treating with the use of nitric compounds). Optimum degree of cross-linking is 68% (too high degree increases rigidity of pipes, whereas too low degree increases their tendency to cracking.

Uncrosslinked polyethylene is usually rated at 75°C, not due to heat aging, but due to the fact that the material becomes soft and will flow at higher temperatures. Properly compounded and crosslinked polyethylene may have a temperature rating as high as 125°C. The material no longer flows at elevated temperatures and therefore can be effectively used at a higher temperature.

The most widespread process of cross-linking polyethylene is the Silane or Silicone method – "PEXb". A special, pre-mixed polyethylene-based resin with

silane additives is extruded. The non-crosslinked pipe is wound onto large coils after cooling. Coils are then subjected to steam (sauna) or submerged in hot water to cause cross-linking. This process takes hours to accomplish. The degree of cross-linking is 65-70%.

For joining parts of a composite pipe, special polymer-based adhesive is applied to provide both gluing and its serving as elastic gasket between Al and PEX to compensate difference in linear elongation coefficients of the materials. The adhesive grade determines elasticity and lifespan of a pipe. If the adhesive loses elasticity, a pipe begins to flake and leak in joint sites.

In Table 2, data on consumption of materials in production of composite pipes in a Russian production line (of company Mayak-93 manufacture).

Table 2: Consumption of resources in production of composite pipes, g/running m.

Diameter of pipe, mm	Raw material					
	Polyethylene	Adhesive	Pigment	Silane concentrate	Gloss agent	Al
16	73.00	12.6	2.16	3.96	0.39	26.7
20	92.65	16.8	2.67	5.10	0.49	39.6
25	147.77	21.0	3.57	8.15	0.76	53.4

Source: data of "Mayak-93".