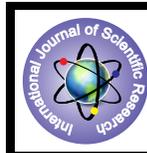


# The Function of Polystyrene in Building Construction



## Engineering

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### ABSTRACT

*The purpose of this study is to examine the advantages of polystyrene as polymer material in modern market of thermal insulators. In order to be considered as insulation materials, materials should satisfy a number of precisely defined requirements, such as: low volume mass, good mechanical properties, low water absorption, good thermal insulation properties, good conductivity of steam and gases, frost resistance, resistance to the effects of fire, price and ability of recycling. When the improper material is used, many serious problems can occur such as moisture, rotting of materials, mildew, blooming, flaking and frost damages. In this paper mechanical, chemical and thermal properties of polystyrene. We also presented its advantages comparing to other thermal insulation materials. Despite having some disadvantages, polystyrene is one of the best thermal insulation materials used in building constructions. The findings suggest the need for work on optimization of properties in order to exceed the lifelong of polystyrene. The paper itself can be used as a useful resource for the future research.*

### 1. INTRODUCTION

Purpose of installing thermal insulation on buildings is to provide comfort, to protect the man from too much or too less heat, to provide savings of heating energy, and to protect buildings from damage occurring due to the insufficient or incorrectly installed insulation what cause thermal flow and water vapor condensation (Ludwig, Neufert, 2002).

In terms of insulation, final products of polymers are called: "plastics". These products contained polymers and additives that are improving or modifying the characteristics of polymer material. Polystyrene is one of the products of polymers. Polystyrene is used generally as thermal insulation material because of its good mechanical and chemical properties. There is very big utilization of polystyrene: building, cups, food packets etc.

There are many advantages and disadvantages, but the most important characteristics of polymers is that, they are corrosion resistant and they have low coefficients of friction. What's more, the properties of polymers depend on temperature, which means that changing the temperature; they can become tough or brittle.

### 2. POLYSTYRENE AS POLYMER

Polystyrene is a long chain hydrocarbon where alternating carbon centers are attached to phenyl groups, the aromatic ring benzene. According to polystyrene's chemical formula (C<sub>8</sub>H<sub>8</sub>), there are chemical elements carbon and hydrogen. Polystyrene is a vinyl polymer, made from the styrene monomer by free radical vinyl polymerization (Ćatović, 2001).

There are two widely used types of polystyrene: EPS (expanded polystyrene and XPS (extruded polystyrene). They are made of same plastic, but the manufacturing processes are different.

### 3. MATERIAL CHARACTERISTICS

Polystyrene is solid or glassy at normal temperature, it is actually transparent plastic that is rigid. When heated, it flows and can be used for extrusion and molding, and it becomes solid again when cools off. Polystyrene has no color and has limited flexibility. It can also be transparent or made in different color.

#### 3.1. Thermal Characteristics

EPS, as a product of polystyrene, has air in its cellular structure. It is the reason why polymere has low thermal conductivity. Due to the system of closed cells, it doesn't have capillary absorption of water. Actually, EPS is weak thermal conductor, and its thermal conductivity depends on volume mass. Also, thermal con-

ductivity depends on percentage of wetness.

When it comes to thermal diffusivity, polystyrene has a very small thermal diffusivity. That represents longer transfer of heat through polystyrene.

When temperature changes, there is a tendency for material to response to new environment by changing its volume. When thermal expansion of polystyrene compared with other materials, volume of polystyrene expand more than other materials such as ceramic and glass.

Thermal stress occurs when material is cooled or heated but with prevention of expanding or contracting. Thus, when expansion or contraction of material is prevented, thermal stress occurs. Polystyrene has more thermal coefficient of expansion and more value of modulus in comparison with ceramics and metals.

#### 3.2. Mechanical and chemical characteristics

For EPS, it can be said that it has very low volume mass, it has relatively good mechanical characteristics, it has great insulation characteristics, and it has very low absorption of water. Polystyrene is hard material and brittle and has a density of 1.050 g/cm<sup>3</sup>. Polystyrene is resistant to all construction adhesives, mortars, plasters, with or without the water dispersion of polymer (usually acrylic) (Ashby, 1999).

As for the effect of temperature on polystyrene, there is practically no lower limit to its application - installation. When the upper limit is about 85°C, but it can handle a current temperature over 100°C. However, longer exposure to high temperatures leads to its softening and sintering, so it is resistant to bitumen products to 80°C and cold bituminous products free of organic solvents (benzene, acetone, etc.) not resistant to direct impact as hot bitumen and adhesives containing organic solvents such as glue for rubber and plastics (R.W.Cahn, P.Haasen, E.J.Kramer, 1993).

To reach improved properties of copolymers of polystyrene, other polymers with desired properties are added such as polybutadiene rubber, during the process of polymerization. Some examples of copolymers include high impact polystyrene and acrylonitrile butadiene styrene.

Biological characteristics of EPS is also a matter of interest. EPS has resistance to fungi and bacteria, it doesn't attract termites, ants and rodents. It has also resistance to rotting.

Polystyrene is nonreactive and is used for making even food items. The chemical stability is provided by transformation of carbon-carbon double bonds into less reactive single bonds. EPS is water resistant and has resistance to diluted acids and bases, to aliphatic alcohols, to glycols and polyglycols.

In terms of flammability, like most organic materials, polystyrene is also flammable. In its combustion, the products are released as follows: carbon monoxide, carbon dioxide, water and soot. EPS due to the low mass per unit volume are released during burning a minimal amount of heat, which creates a small fire load.

#### 4. APPLICATION OF POLYSTYRENE IN CONSTRUCTION

To be competitive in the modern market, thermal insulation materials should satisfy a number of strictly defined requirements, in which certainly include: low volume mass, good mechanical properties, low water absorption, good thermal insulation properties, good conductivity of steam and gases, frost resistance, resistance to the effects of fire, price and recyclability.

Polystyrene is one of materials that already takes place in buildings and it is used in many components of construction. It is used as insulation on outer walls, on socles, in floor constructions, roof and in heating systems.

Polystyrene that is used for wall insulation is a product that must be more than 15 kg/m<sup>3</sup> in weight. (70 kPa). Polystyrene used on outer walls are not harmful for humans and can be used in every climate condition. Also, some additives are used to improve insulation properties, such as graphite.

Originally shaped plates are used for socle. Water absorption is less than 2%. Thermal conductivity of this type of EPS plate is 0.037 W/mK. This special production of EPS for socle is also used for balcony and terrace.

Standard produced polystyrene cannot be installed in floor construction because of the acoustic conductivity. So, the new program of EPS is invented with small rigidity value (10-20MN/m<sup>3</sup>). With this type of EPS, the acoustic impact is decreased. It decreases sound conductivity until  $L_w=34$  dB. It doesn't have harmful impact on human health.

Special type of EPS is produced for roof construction. It is very light material and very easy to install. It has very good thermal insulation property.

Panels of expanded polystyrene (EPS) with plugs for pipe laying are used for underfloor heating. The upper side is vacuum coated with PE film. There are two types of panels. One is for ordinary, and second one is for hard loads. This kind of insulation is very important for energy savings.

#### 5. ADVANTAGES AND DISADVANTAGES OF USING POLYSTYRENE

In architecture, space is a special thermodynamic system defined by its size and characteristic limitations. The system is naturally open (it exchanges matter and energy with environment) but it is theoretically homogenous. It is defined by volume, mass, energy amount, temperature, pressure etc. The final aim is to provide comfortable space for human being (Hadrović, 1996).

There is no perfect material so ever. Every material has its good and bad sides. Polystyrene has many advantages, some of them are low density, chemical stability, consumption resistance, low factor of friction, ability for vibration control, good electrical insulation properties, good processability, good deformation processing, non-toxicity, and recycling, economical serial production of polystyrene (Ashby, 1999).

The disadvantages of using polystyrene are dependence of the properties of the various influences, high thermal tensile, low modulus of elasticity, low surface hardness, susceptibility to aging, susceptibility to creep and relaxation, low thermal conductivity and poor stability at elevated temperatures.

#### 6. CONCLUSION

Investments in thermal protection are economically justified because of the energy savings for heating. Polystyrene does not contain and does not develop greenhouse gasses. Pentane, the gas that is used in polystyrene production has no effect on the degradation of the ozone layer in the stratosphere. Released gas during production, pentane, is destroyed by photogradation on 2-3 km from earth by sun radiation. And, in contact with soil, it is destroyed by microorganisms. Polystyrene is used in building construction because despite having great thermal insulation properties, it is unique eco material among all thermal materials.

When we want to decide which thermal insulation material to use, we need to take in consideration these facts: coefficient of thermal conductivity, specific heat, factor of resistance to water vapor diffusion, coefficient of thermal elongation, and density of materials.

In the comparison with other thermal insulation, materials that are usually used in building constructions, polymers are highly ranked. Thermal materials with mineral origin such as rock and glass wool have good fire resistance, but they absorb water, not having moisture and frost resistance.

Natural materials with organic origin are cane and wood fibers have good connection with mortars during application, but they can be damaged by fire or rodents by the time, and rotting also occurs.

The market has a lot of different thermal insulation materials (in sufficient quantities), and the effects of their use primarily depend on:

selection of appropriate thermal insulation material,

thickness of layer of insulating material selected

proper installation of the timber element (pitched and flat roofs, external and partition walls, floors, etc.).

Also, while making decision which material to use as thermal insulation, analyzing properties of thermal insulation material relative to the properties of other materials used to construct the specific elements of the structure is very important. What's more, we need to analyze the position of the structural element in relation to the environment and analyze thermo-hydrometric condition of environment.

EPS is used the most in term of thermal insulation function. If we only take thickness of thermal insulation, we can see that EPS has lowest value of material thickness to achieve same resistance to heat conduction. Also it can be observed that polystyrene has the smallest value of volume mass or density, what is very important not just for mechanical properties, it is important for transport and application as well. Then, the only question we can pose is: What will be the future of the polystyrene? Is the future in new chain to improve characteristics that we have nowadays?

The future of polystyrene should be focused on improvement of lifetime of polystyrene, because of wasting properties during the time.

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