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New binding materials based on recycling polystyrene foam for foundry

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Abstract. The possibility of using waste polystyrene foam for new connections in the foundry were considered. Studies of molding and core mixtures with new binders were made. The purpose of the work is the search for new binding materials based on polystyrene for recycling purposes foundry. This will improve and develop new molding processes more efficient and would reduce this waste, that will be used to improve environmental conditions. This solves an important problem of man-made waste processing and ensuring high quality foundry binder.

To realize this goal was to compare the characteristics of known organic and inorganic solvents polystyrene and determine optimal in terms of their minimal toxicity and high dissolution rate they polystyrene and explore the physical and technological characteristics of polystyrene solutions in selected solvents and molding and core mixtures on their basis

Keywords: new binders, styrofoam waste, foundry

1 Introduction

Currently in the world received widespread polystyrene foam materials. They are used for the manufacture of technical and consumer packaging and containers for food. In the foundry industry, there is a technological process of casting on foam-styrene models. Its use is related to the production of foam polystyrene waste, especially in the manufacture of models from block polystyrene foam. Polystyrene and Styrofoam got out of it is a material that does not interact with water and not subjected biodegradable.

They can not be burned like other materials due to the fact that at such a temperature, high-polymer decomposition occurs with the formation of very toxic gaseous products. [1]. Therefore waste polystyrene progressively accumulate in large quantities in various repositories, which creates certain environmental problems in the environment.

However, there is evidence that polystyrene can be used as an adhesive material [2]. Abroad polystyrene supplied to consumers in the form of a solution in organic solvents, which is able to harden at room temperature.

There are a number of data on the use of polystyrene emulsion as a binder in modeling mixtures [3], the use of polystyrene molding the mixture into a 40% solution in xylene [4]. There were no data on the use of waste polystyrene similar purpose. According to these fragmentary data polystyrene has a very high binding ability and adhesion to non-metallic (foundry molding materials) and metal (chill, molds, etc.) and therefore can be effectively used as a binder material during casting of ferrous and non-ferrous alloys.

However, the available data are sporadic. There are no serious studies on the conditions for obtaining solutions from polystyrene wastes, their properties, the effect of the concentration and composition of solutions on their adhesiveness, with the study of optimal methods for hardening these solutions, etc. In connection with the above, the purpose of the work is the search for new binding materials based on polystyrene for recycling purposes foundry. This will improve and develop new molding processes more efficient and would reduce this waste, that will be used to improve environmental conditions. This solves an important problem of man-made waste processing and ensuring high quality foundry binder Ukraine.

To realize this goal was to compare the characteristics of known organic and inorganic solvents polystyrene and determine optimal in terms of their minimal toxicity and high dissolution rate they polystyrene and explore the physical and technological characteristics of polystyrene solutions in selected solvents and molding and core mixtures on their basis.

2 Literature Review

Polystyrene is known to be soluble in many solvents — low organic hydrocarbons [5]. Many of them are characterized by high and very high toxicity. These include benzene (MPC - 5 mg / m³), toluene (MPC - 50 mg / m³) and others. The solubility assessment of waste polystyrene in various solvents was performed using special glass and sealed tubes with a capacity of 100 ml, 250 ml and 500 ml.

The concentration of the solution was determined in percent by weight.

. To obtain a solution of a given concentration, test tubes were weighed on a laboratory electronic scale model VL E134, then the required amount of solvent was poured into them and sealed with a stopper. Next, weigh the required amount of expanded polystyrene, the volume of which is many times greater than the volume of the tube. Therefore, polystyrene is loaded into the tube many times as it dissolves or swells. The transparent white glass of the test tube made it possible to clearly observe the dissolution of polystyrene under the conditions of tightness of the test tube

Whole world there are more than 200 different solvents. Therefore, the choice of solvent for polystyrene foam that meets accessibility requirements of efficiency and environmental security is not an easy task.

The selection and comparative characteristics of a number of solvents are given in Table 1 [6].

After analysis, it becomes clear that solutions from polystyrene wastes as solvents with molding and core blends, coatings for casting molds, require high MPC solvents and low volatility. Only in this case it becomes possible to create low-toxic mixtures and coatings for casting molds.

As we established, such a solvent of polystyrene, which meets the stated requirements, is gum turpentine [7]. It is produced from pine resin, which is pre-disposed and divided into a volatile fraction — turpentine and nonvolatile sediment — rosin.

Zhivichny turpentine is a clear colorless or slightly colored liquid with a density of 0.855 - 0.863 g / cm³. Zhivichny turpentine has maximum concentration limit of 300 mg / m³, ie, it is much higher, than in the above group of solvents maximum concentration limit of 200 mg / m³. At the same time, it dissolves polystyrene waste well and has a very low volatility.

Together, this allows the preparation of modern low-toxic binders for molding and core sands and coatings for casting molds. In turn, this allows for the improvement and development of new, more efficient casting processes, as well as of economic importance for reducing these wastes and improving the ecological situation as a whole.

Table 1. Comparative characteristics of a number of solvents, %

№	Name and chemical formula	molecular mass	density g/cm ³	Temperature Flash Light °C	boiling point, °C	MPC мг/м ³	Volatility in Eth. Ester, %
1	benzene C ₆ H ₆	78,11	0,879	-11	80,1	5	3,0
2	Toluene C ₆ H ₅ CH ₃	92,14	0,8669	-4,4	110,62	50	6,1
3	Xylene, mixture of isomers (CH ₃) ₂ C ₆ H ₄	106,16	0,862-0,878	29	144,411	50	13,5
4	solvent	-	0,85-0,86	20	110-120	100	27
5	Ethanol C ₂ H ₅ OH	46	0,78927	13	78,39	1000	8,3
6	Ethyl acetate CH ₃ COOC ₂ H ₅	88,11	0,9001	2	77,1	200	2,9
7	n-Butyl CH ₃ COO(CH ₂) ₃ CH ₃	116,16	0,870-0,890	25-29	126,3	200	11,8

8	Butyl alcohol C ₄ H ₉ OH	74,12	0,8099	34	117,4	-	33,0
9	Acetone CH ₃ COCH ₃	58,079	0,7920	-18	56,10	200	2,1
10	Methyl ethyl ketone CH ₃ COC ₂ H ₅	72,12	0,8054	-6	79,6	200	6,3
11	tetralin C ₁₀ H ₁₂	132,21	0,9702	71,1	207,62	100	190
12	Etyltselozolv C ₂ H ₅ OCH ₂ CH ₂ CH ₂ OH	90,12	0,9311	48,90	135,6	740	-
13	White spirit	-	0,770	33-36	147- 200	300	40-60
14	Turpentine oil C ₁₀ H ₁₆	136	0,855- 0,863	34	160	300	-
15	Petrol "Kalosha"	-	0,70-0,73	-17	80	300	3,5

3 Research Methodology

Evaluation of the strength of molding and core mixtures at gas permeability, crumbling, and crumbling.

Staroverovsky career (Kharkiv region) brand 2K1O1025.

A binder for all mixtures. 30% solutions and 50% solutions of waste polystyrene foam in gum turpentine were also tested. Samples with a 30% solution of expanded polystyrene had very low raw strength; they could not be removed from the tooling without destruction. This is an undesirable phenomenon [8].

It is not a problem that the process of preparation during the preparation.

Therefore, a 40% solution of binders.

It is clear that there is a tendency for a dose of 20 mg.

Weighing 400-500 g of the mixture weighing it under the hood in a desiccator. The duration of mixing - 5 minutes

It was confirmed that the process was carried out.

Tensile tests of samples (eights) with a tensile strength of up to 3.04 MPa. Compression, stretching (rupture), gas permeability, crumbling were carried out in accordance with the standards.

For the preparation of mixtures used molding sand Staroverovsky career (Kharkiv region) brand 2K1O1025.

A 40% solution of polystyrene foam waste in gum turpentine was used as a binder for all mixtures. 30% solutions and 50% solutions of waste polystyrene foam in gum turpentine were also tested. Samples with a 30% solution of expanded polystyrene had very low raw strength; they could not be removed from the tooling without destruction. This undesirable phenomenon is due to the high content of the liquid phase in the mixture[9].

50% solution of polystyrene in gum turpentine has a high viscosity, it practically does not flow, greatly complicates the possibility of its uniform distribution in the volume of the mixture during its preparation [10].

Therefore, a 40% solution was chosen optimal for the preparation of mixtures of polystyrene binders.

Weighing the components of the mixture was carried out on a scale with a weighing error of 10 mg, as well as on a scale with a tare compensation mechanism and an error of 20 mg.

Preparation of a mixture weighing 400-500 g was performed manually under a fume hood in a desiccator. The duration of mixing the components of the mixture - 5 minutes

The strength of the mixtures was achieved as a result of the removal of the liquid phase (gum turpentine) from it by drying the samples in a laboratory resistance chamber furnace [11].

Tensile tests of samples (eights) were carried out on the device model RP-100 with a tensile strength of up to 3.04 MPa.

4 Results

The hardening of the forms and cores to the technologically necessary strength occurs as a result

remove from the mixture of liquid composition - gum turpentine.

If from the point of view of the requirements for sanitary and hygienic working conditions, low volatility of gum turpentine is a positive factor, then from the point of view of the need for accelerated hardening of molds and rods, this factor is negative, since it requires the forced removal of turpentine mixture.

There are several ways to remove the liquid composition of the mixture:

- vacuuming;
- blowing the mixture with dry air;
- temperature effects in the oven.

Studies were conducted depending on the compressive strength of the mixture, the exposure time for different samples of the mixture at 20 ° C and for the mixture depending on the air permeability for drying for mixing different compositions.

The results of the study are shown in figures 1 and 2.

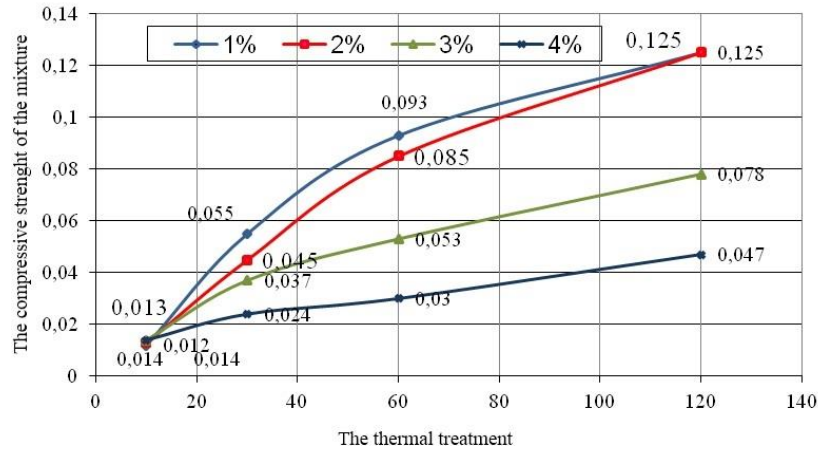


Fig. 1. Effect of heat treatment period the mixture at 20 °C for its compressive strength polystyrene solution containing 1 to 4%

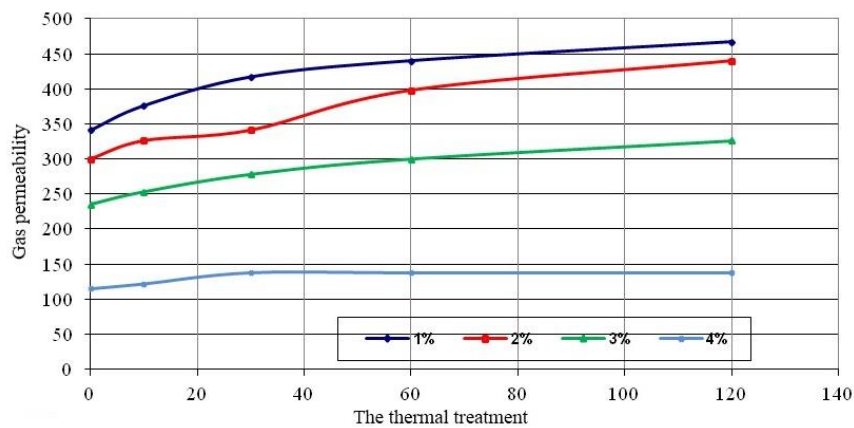


Fig. 2. The impact polystyrene solution binder content in the mixture at its gas permeability at 20 °C

As can be seen from the data, all mixtures showed very low raw strength. Testing is possible only after 30 minutes of standing in the air. At the same time, the compressive strength of the mixture is in the range of 0.024-0.055 MPa. The strength of the mixture increases, reaching after 2 hours the value of 0.047-0.125 MPa. You may also notice that a large value of strength correspond to a mixture with a lower content of binder polystyrene and, therefore, a smaller amount of liquid composition - turpentine.

The decrease in sample mass after 2 hours is small. So for a mixture with 1% polystyrene - just less than 1%.

The gas permeability of mixtures during maturation increases significantly. With an increase in the amount of binder in the mixture, the gas permeability decreases significantly.

The rather low precipitability of the mixture with a binder solution of polystyrene in gum turpentine is only 0.10% -0.13%.

In general, it can be noted that the method of maturation of the forms and rods in the air for the purpose of their hardening can be considered technological due to the low volatility of gum turpentine. And it is precisely this increase in strength that requires a significantly accelerated removal of the liquid composition from the casting molds and cores.

Therefore, they are dried in a dryer in a special mode. - This is one of the main technological operations of the process of manufacturing such products.

Studies have been conducted in FIG. Tables 3 and 4 show laboratory data on the effect of temperature - 120 ° C and the duration of drying of samples from a mixture of 1% - 4% polystyrene on tensile strength and weight loss.

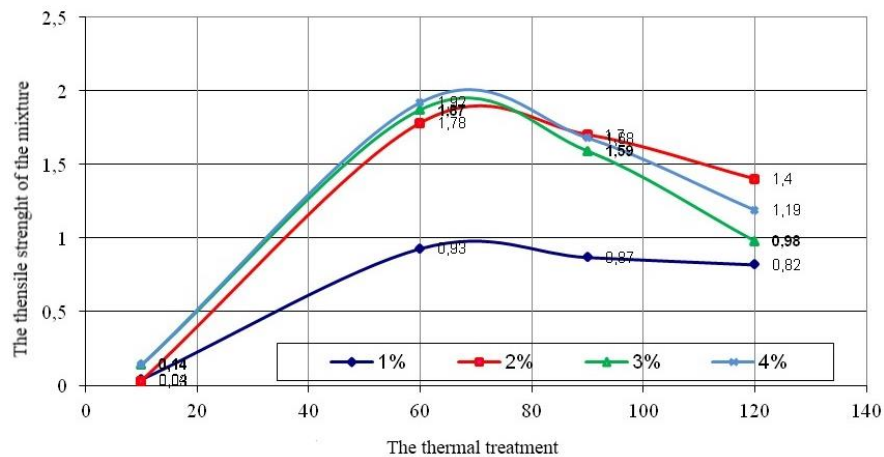


Fig. 3. - Impact term heat treatment at 120 °C mixture of its tensile strength polystyrene solution containing 1 - 4%

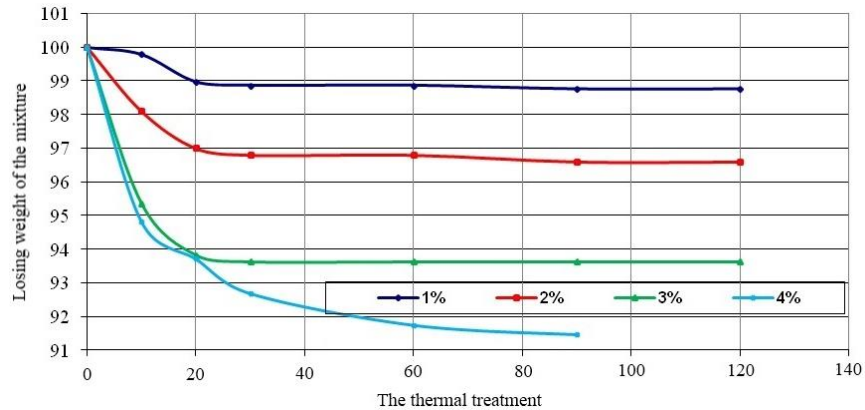


Fig. 4. - Effect term heat treatment mixture samples at 120 °C for loss of weight, depending on the content of polystyrene binder (1% -4%)

As can be seen from these figures that after 60-70 minutes of strength tensile mixture reaches its maximum in the range of 1,78-1,92 MPa for a mixture of 2-3-4% polystyrene. The strength of a mixture of 1% polystyrene much lower - 0.93 MPa after 60 minutes. With further increase in the duration of drying observed decrease in tensile strength mixture, indicating the feasibility of drying molds and cores of these mixtures for no more than 60-70 minutes. At the same time, a very important practical conclusion about the optimal composition of the mixture follows from the data. Since the data on tensile strength in a mixture with polystyrene of 2-3-4% at the optimal drying time is very close (Fig. 3), the polystyrene content in the working mixture should be within 2% -3%.

These are natural mass losses of these samples — at a temperature of 120 ° C, depending on the content in the mixture of polystyrene binder and the duration of drying of these samples.

It can be explained that the more we inject the binder into the mixture in the form of a 40% polystyrene solution, the more liquid the composition — the gummies — must be removed during drying. The weight loss for a mixture of 1% polystyrene is 1.15%, for a mixture with 2% polystyrene - 1.53%, for a mixture with 3% - 6.38%, with 4% - 8.26%. It is interesting to note that the stabilization of the mass loss for samples with 1% -2% -3% polystyrene is observed already after 30 minutes of drying; for a mixture with 4%, the process is slow; it ends after 1 hour.

Comparing these processes of mass loss with the maximum strength of the samples, the following can be noted. For a mixture with 1% -2% -3% polystyrene, the process of increasing maximum strength is not directly related to the presence of a liquid composition in the mixture. So, after the introduction of the liquid composition into the mixture, the polymerization processes of the binder itself occur during drying, which at given temperatures and durations lead to an increase in the tensile strength of the mixture to its optimum values for these conditions.

Figure 5 shows the effects of high temperature (200 ° C) on the tensile strength of the mixture, depending on the content of polystyrene binder (1% -4%) and the duration of heat treatment (10-120 min).

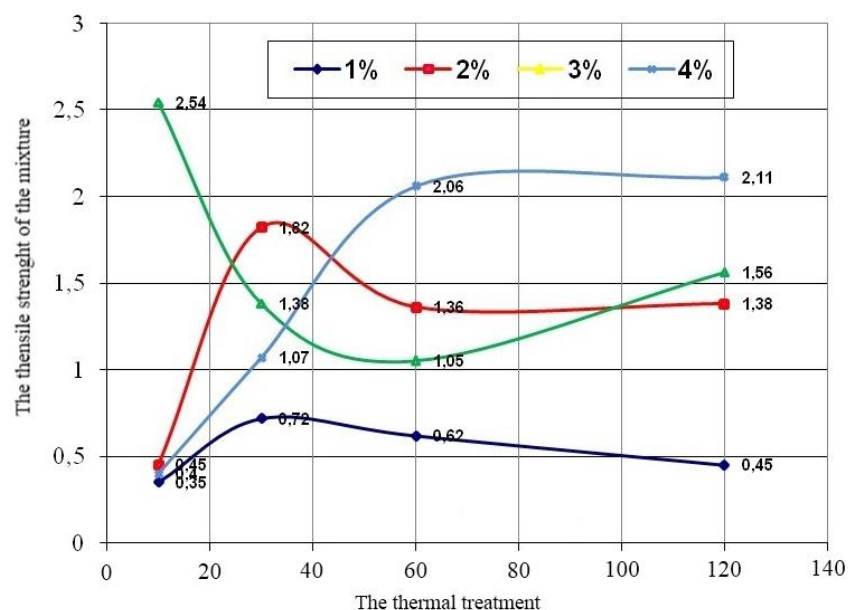


Fig. 5. Effect of heat treatment period the mixture at 200 °C for its tensile strength solution containing polystyrene (1- 4%)

According to the information received, drying samples at a higher temperature accelerates the increase in strength to an acceptable level of technology. So, when drying at 120 ° C, optimum strength is achieved in 60-70 minutes, then at 200 ° C it decreases to about 30 minutes. A mixture with 4% polystyrene showed a tensile strength of 2.06 MPa and 2.11 MPa when dried for 60 minutes and 120 minutes, respectively.

Thus, the recommended drying time at 200 ° C can be no more than 60 minutes. A drying temperature of 200 ° C should be considered excessive for this process. Should focus on a lower drying temperature and the minimum duration of the process.

In fig. 6. The effect of the drying time of samples with 1% -4% polystyrene at 200 ° C on the weight loss is shown.

As can be seen from the above data, when drying samples at 200 ° C for 1 hour, the mass loss practically stops regardless of the content in the mixture of polystyrene binder. Thus, after 30 minutes of drying, the samples showed sufficient technological strength of the mixture in the range of 1.07-1.82 MPa. It is assumed that after the cessation of drying of the samples at 200 ° C, there is some weight loss due to the removal of gum turpentine from the mixture and a further increase in its strength. Therefore, drying samples for 30 minutes can be considered optimal.

Mixtures with polystyrene binder are characterized by relatively low frittability. This fact is an important feature of such mixtures. In a mixture with 1% -3% polystyrene

shedding is only 0.10% -0.13%. The friability of the mixture with 4% polystyrene is 0.9%, which is also a small value

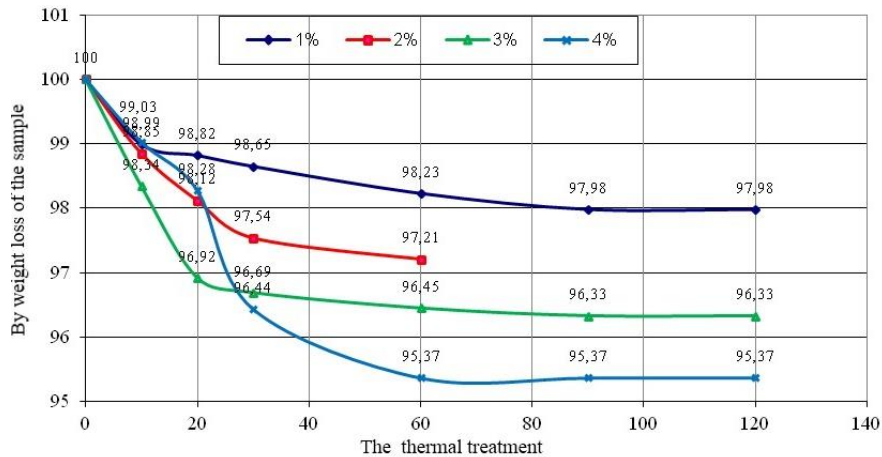


Fig. 6. - Effect of heat treatment samples term mixture at 200 °C for their weight loss depending on the content of polystyrene binder (1% -4%)

5 Conclusions

Analysis of the literature review revealed the current understanding of the mechanism of high polymer dissolution in organic solvents, hydrocarbon and on this basis to justify the need for research on the recycling of waste polystyrene and their subsequent use for new highly efficient binders for foundry.

The study polystyrene solubility in various organic solvents hydrocarbon found that polystyrene is very easily soluble in gum turpentine, which has the lowest volatility and MPC equal to 300 mg / m³, which is 50-60 times less than many known solvents (toluene, benzene, xylol). The last allows to obtain solutions based on polystyrene virtually any concentration up to 50%.

On the basis of studies of the kinetics of dissolution of polystyrene in a solvent effect concentration binding polystyrene based on physical, mechanical and technological properties of molding and core mixtures developed technological scheme (compaction) polystyrene in low emission gum turpentine, cladding polystyrene dispersed reinforcing phase, obtaining polystyrene binders and their use in foundries [7].

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