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BASED ON THE TECHNOLOGY OF MANUFACTURING WELL COVERS FROM LOCAL POLYMER WASTE RAW MATERIALS

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Abstract

Todays, polymer composite materials are used to produce parts and products of various shapes and sizes. In this research work, several research works on existing and modern methods on a number of technologies for the production of well caps were analyzed, and the technology of obtaining well caps from local polymer waste raw materials was justified scientifically and practically. In particular, in the creation of well caps, the formation of a composition in the composition and microstructure of the materials was studied, and a mixture based on the mass fraction of secondary polyethylene, dibutyl phthalate (DBP), polyethylene polyamine (PEPA), pigments and sand raw materials was formed. A mixture was prepared from the secondary raw material by extrusion method, and the cover was formed using the mixture press mold and the finished part was obtained. The chemical resistance, relative bending strength, pressure resistance indicators of product were determined by scientific-research work. On the basis of the obtained results, the construction and road construction industry was founded on the technology of production of products that are six times cheaper and lighter than traditional cast iron manhole covers.

Keywords

Polymer, composite, cover, cellophane, waste, extruder, urban planning, hydraulic engineering, sand.

INTRODUCTION. In the world, urban planning, road construction, metallurgical and mechanical engineering industries are one of the sectors that make a huge contribution to the development of the economy. In the development of modern construction and urban planning industry, the demand for raw materials and materials for the production of various devices and parts is increasing day by day.

In this regard, the fact that the available resources on earth are decreasing, the limited resources are forcing experts in the field to conduct constant scientific research. In this regard, it is important to create improved technologies for the creation of products that meet global requirements, competitive and import substitutes for various fields of production, and the development of methods for obtaining new improved parts of structures and mechanisms [1].

In the last 10-15 years many directions for the production of plastic products and structures have been established, in particular secondary products also may be recycled in the development of products too. Currently, a period of radical technological changes in materials and raw materials is taking place. In particular, instead of metal, wood and other materials, plastic materials are used as an alternative and the intended goals are being achieved [2].

The purpose of the research is to develop a technology for obtaining light and compact polymer composite well cover details based on secondary polymer (waste) materials with an effective composition of polymer-composite materials.

Tasks of research:

-to develop lightweight and compact polymer composite well cover details, to create an effective composition of polymer-composite materials from secondary raw materials and to research the possibilities of obtaining well cover details from them in the casting method;

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-development of modern methods and means of experimental research of structural materials used in construction and urban development by increasing the chemical integrity and impact viscosity index of composite materials of the cover polymer;

-increasing the density of the composite material of the polymer cover by pouring it in furnaces and annealing the casting, determining the effect of the deformation characteristics and structures of the materials during the preparation of the covers;

-the application of the method of casting soluble models of the cover detail as a technology of vacuum casting;

-evaluation of technical and economic efficiency of well cover details produced from polymer-composite material obtained on the basis of import-substituting local raw materials in the applied results;

-ensuring their reliability through mathematical modeling and processing of research results.

The scientific novelty of the research is as follows:

- ✓ a new polymer composite material with an effective composition was created using secondary polymer waste to obtain cover parts which used in urban planning and hydro technical engineering;
- ✓ a technology has been developed for the manufacture of well parts based on the created new polymer composite material;
- ✓ based on local production of polymer composite materials of the hydro well cover that replaces imports;
- ✓ the optimal composition of fillers added to improve the material composition and properties of the well cover details obtained by casting under pressure from secondary raw materials is determined.

The practical results of the research are as follows:

The well which used in the urban planning and hydraulic engineering industry was made of secondary polymer waste;

Well covers which are compact, light, replace metal and provide optimal use of energy resources are proposed;

A new method of extracting well caps under pressure was created and applied in local conditions;

Optimal compositions of polymer-composite materials of well caps which used in urban planning and hydraulic engineering and technologies of their production are proposed.

The scientific significance of the research results is explained by the use of secondary raw materials for road construction and parts of hydraulic wells, the enrichment of sorted fillers to improve the properties of the raw materials, the study of the mechanical and operational characteristics of the obtained products by pressing and the scientific validity of optimal operating modes of technological equipment.

The practical importance of the research results is explained by the fact that using secondary polymer waste, light and compact polymer wells were obtained that replace metal in urban planning and road spheres, with high stability, physical, mechanical and operational properties.

MATERIALS AND METHODS. The well cover is mainly in the form of a round or square plate. They are usually located on sidewalks or highways. Therefore, they must be very strong and durable, able to withstand the constant weight of loads and vehicles. A hatch or technical hole is a high opening of an underground warehouse used to house an entry point for underground and buried utilities or other services, including sewerage, telephone, electrical, rain drains, and gas or maintenance connections. It is covered with a protective manhole cover (usually metal) [3].

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They are usually made of cast iron and sometimes of concrete for heavy loads. They usually weigh around 60 kg, depending on the material used and size, and are often circular in shape. Since the hatches themselves are circular, the manhole cover will also have the same shape. The round hatch pipe indicates that it can withstand the highest level of earth pressure. In addition, the round shape of the manhole cover facilitates rolling, manufacturing, installation and maintenance.

There are a number of problems with well covers. Among such problems, the frequently used material is a very expensive, stable and useful material. Most often, this leads to street oppression and melting of manhole covers and their sale in local markets. In these cases, the Chinese government can be seen trying to combat the problem of oppression. According to a recent article in the Age newspaper, "Chinese government efforts to reduce well enlargement have reduced the annual oppression of wells in Beijing from 24,000 in 2018 to 4,000 in 2019" [5]. Turning the covers of this hatch can lead to a serious problem. This problem is visible not only in China, but also in Uzbekistan and other developing countries. After rotation of the cast metal manhole covers, the hatch opening remains open (Figure 1). These open holes can cause the following hazards:

1) Any child or baby running around can accidentally fall into one of these open wells;

2) People can throw waste into such open wells. This leads to blockage of the sewage system;

3) Chemical and corrosive substances released from the sewage system may be released into the air. As a result, it can cause danger to human health and toxic pollution;

4) Vehicles moving on the road can have an accident as a result of falling into an open hole. As a result, the car can be seriously damaged, along with the driver and passengers in the car. All of these problems are related to the stolen of hatch covers. And this growing situation remains a problem.

Figure 1. Open wells

As a solution to this problem, it is important to make it from a light construction, but durable, cheap and competitive material. Such a material is a composite polymer material and secondary polymer waste was recommended in order to economically reduce its preparation without reducing the requirements of the cover structure and to effectively use secondary polymer materials [9].

Today, cotton is grown on about 79,000 hectare areas in Andijan region. About 60% of these cotton fields are seeded under cellophane, and after the seed has germinated, the cellophanes are discarded (Figure 2). This cellophane waste can be used as a secondary raw material [4].

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Figure 2. Cellophane waste which in cotton production

If cellophane waste remains in the soil, it will decompose for hundreds of years and it will have a long-term negative effect on the environment. In order to prevent the negative impact of cellophane waste on the environment, it may be effectively used by recycling them. Also, in addition to cellophane waste from cotton fields, plastic types of household waste also amount to several hundred tons. Such waste may be common plastic bottles, cellophane wraps and other forms of PVC (Figure 3).

Figure 3. Household plastic waste

Raw material in the form of granules is prepared by processing the collected waste. The simplest plastic processing processes are collection, sorting, crushing, washing, melting and granulation. Plastics processing plants mainly use the following two step process:

First step: Automatic or manual sorting of plastics to ensure that plastic waste is free of all contaminants.

Second step: Melting plastics directly in their fresh form or crushing them into flakes and then melting them before processing them into pellets (Figure 4).

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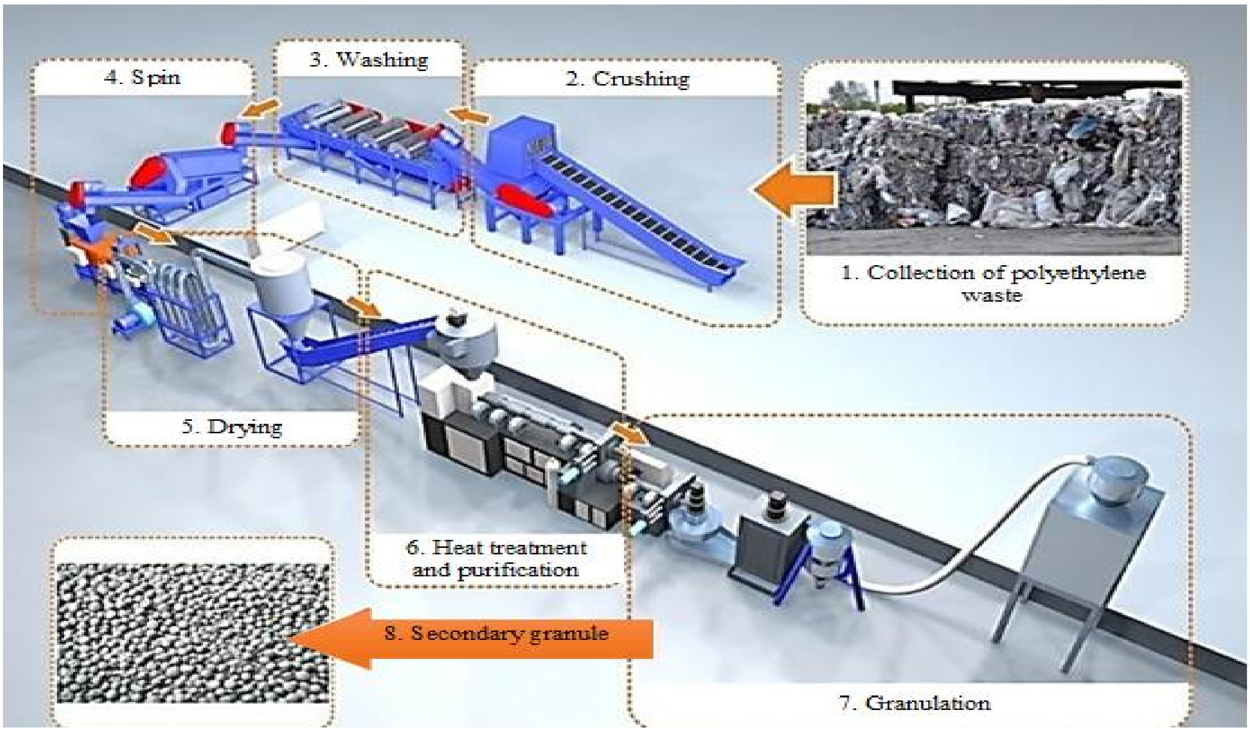

Figure 4. Technological process of secondary polymer waste processing

The procedure for conducting experiments begins with measurement. Apportioned amounts of each material are added to the specified mixture. Elements are added to form a mixture with a total weight of 30 kg (Table 1).

PCM composition of the 30 kg well cap used in the study

Table 1

№	Material	Amount, (kg)	function
1	Secondary polyethylene cellophane	24,4	raw material
2	Dibutyl Phthalate (DBF)	0,2	Plasticizer
3	Polyethylene-polyamine (PEPA)	0,2	Freezer
4	Pigments	0,2	Colorant
5	Sand	5	Filler

The machine used to convert the mixture into a semi-melted paste is an extruder machine, which has several components (Figure 5). The machine has two electric heaters. The first heater heats the mixture to the desired temperature and melts it properly. The second heater provides a flow of molten polymer.

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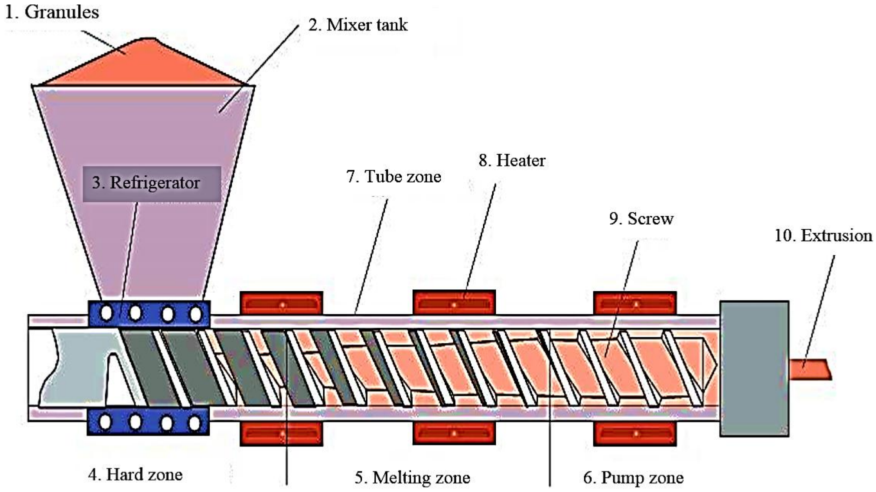

Figure 5. Drawing of a polymer extruder

The first heater is heated to a temperature of 150°C, and the second heater is heated to a temperature of 250°C. The heaters are insulated and covered with a glass barrier to contain the heat and minimize heat loss. Solid granules are slowly introduced from above through the tank. The mixture is placed gradually so as not to clog the rotating screw. After the mixture is heated, it melts and cools and starts to flow out of the nozzle. When leaving the nozzle, it is necessary to pull the paste by hand and place it evenly on the wooden base. Otherwise, the nozzle may get stuck in the mouth and adversely affect the performance of the extruder. The paste will be very soft when it comes out of the machine. For this reason, the paste is dried in the sun for about 30 minutes on a wooden board and slightly hardened, and then it is placed in a press mold to form a cover [6].

When extruding and melting granule polymers, it is necessary to form a melt pool. It is necessary to calculate the hydrodynamics of the polymer flowing through the channel as a liquid. We present a mathematical model of the rheological parameters of the material during the extrusion process.

$$C_s p_s V_p \frac{\partial T}{\partial z} = \frac{\partial}{\partial x}\left(\lambda_s \frac{\partial T}{\partial x}\right) + \frac{\partial}{\partial y}\left(\lambda_s \frac{\partial T}{\partial y}\right)$$

Here,

C_s p_s,λ_s – Heat capacity, density and coefficient of thermal conductivity corresponding to polymers in the solid state;

V_p – Grinding speed of granules [1].

Machines for extruding polymers in a liquid stretchable state by melting polymers have evolved considerably. Extruder worms have different mobility and are used to grind and melt hard and viscous plastic and polymer composite materials. When the hardness of the extruding material is 40-50 HB, the counter-rotating worms are crushed at a speed of 80-120 m/s, when the hardness is 30-40 HB at a speed of 50-70 m/s [2]. Worm materials are made of heat-resistant alloyed steels, which do not break or deform during heating and friction. Types of extruder worms are illustrated in the figure below (Figure 6).

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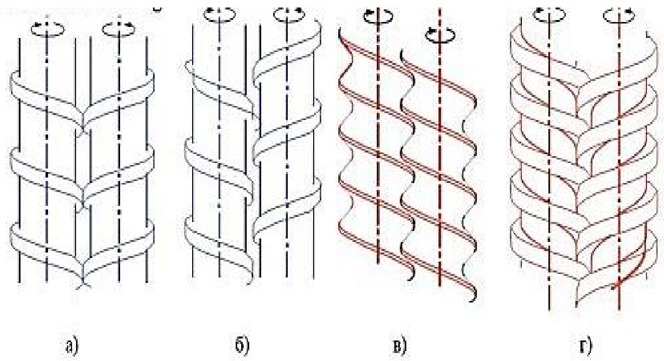

Figure 6. Types of extruder worms

a) - closed worm; b) - an open worm; v) - rotating to the side; g) opposite side rotating worm.

One of the most common types of extruders are plastic extruders. The most common of such machines is the machine used for coating cellophanes and wires under pressure. Polymer granules are placed in the mixing bowl and the material is mixed and moved downwards. The crushed granules are moved from the hardening zone to the melting zone by means of a screw. Heaters ensure that the material melts. The pumping zone compresses the molten viscous material into a ready-to-extrude state. In this research work, a unidirectional type of extruder worm was used (Fig. 7) and a semi-finished product in the form of a plastic paste was obtained (Fig. 8).

Figure 7. The rotator of the mixing machine

Figure 8. Recycled plastic paste after exiting the extruder machine

During the scientific research work, various methods of processing secondary polymer products, modern production technologies were studied, and a scheme for the production of well caps from secondary polymer waste in accordance with local secondary raw materials was developed (Fig. 9) and well caps from secondary polymer waste were produced in the existing small production workshop. produced (Figure 10).

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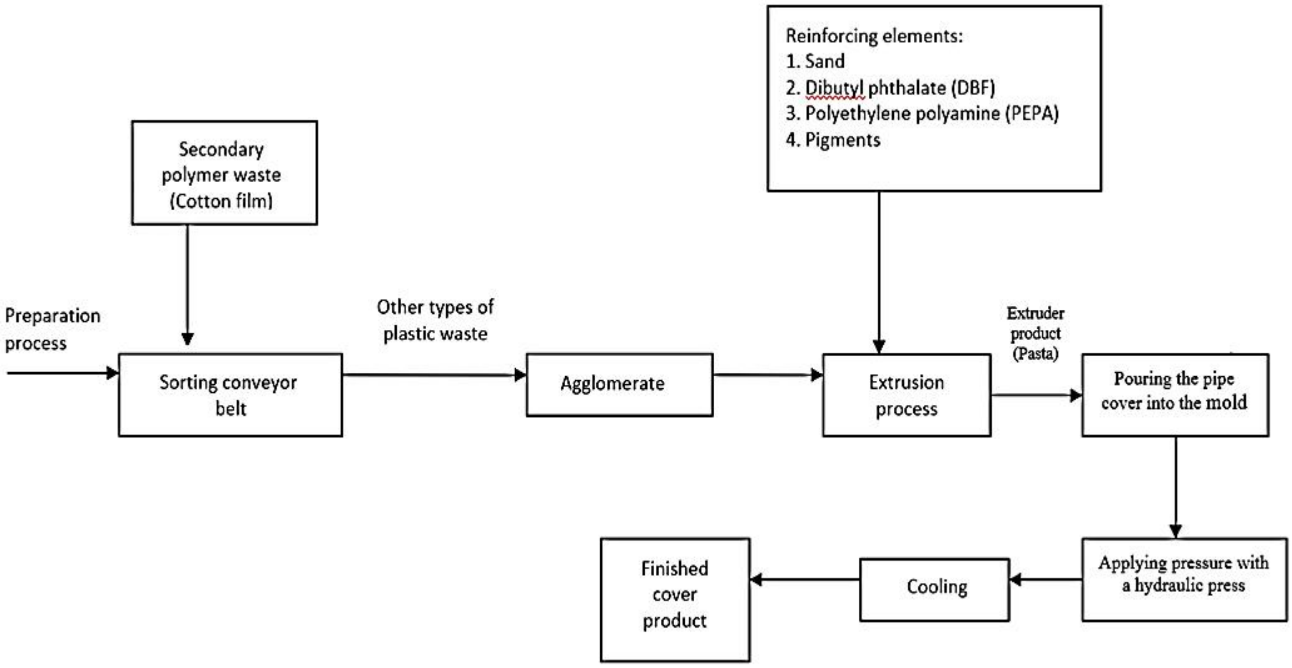

Figure 9. Production scheme of well caps from secondary polymer waste

Figure 10. Hatch covers made of plastic scraps

RESULTS. Methods of melting plastic waste and strengthening its weight with ordinary sand in proportions of 10%, 20%, 30% and 40% were studied in the scientific research work [10]. According to studies, it can be seen that the flexural strength with 20% sand content is very acceptable. Such flexural strength is considered higher than the strength limit for pavement and light pavement bricks[8]. According to this, it was determined that the sand with 20% content is the best in terms of pressure resistance (Table 4).

Polymers with added sand has been studied as a reinforcing agent extensively. An important factor related to PCM products is the amount of sand included in the product. The content for scientific research was made on the basis of the materials presented in the following tables (Tables 2-3).

PCM and fillers used in research work

Table 2

№	Material	Function	Normative document
1	Secondary polyethylene cellophane	raw material	
2	Dibutyl Phthalate (DBF)	Plasticizer	GOST 8728-16
3	Polyethylene-polyamine (PEPA)	Freezer	ТУ-6-02-595-70
4	Sand	Filler	GOST 879-52

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PCM composition of the 30 kg well cap used in the study

Table 3

№	Material	Amount, (kg)	function
1	Secondary polyethylene cellophane	24,4	raw material
2	Dibutyl Phthalate (DBF)	0,2	Plasticizer
3	Polyethylene-polyamine (PEPA)	0,2	Freezer
4	Pigments	0,2	Colorant
5	Sand	5	Filler

Physical-mechanical properties of PCM with added plasticizer

Table 4

№	Physical-mechanical properties	Weight percentage of plasticizer, %			
		10	**20**	**30**	**40**
1	Microhardness, MPa	203	182	158	125
2	Glass transition temperature, К	355	339	310	322
3	Percussive viscosity, MPa	1,8	2,1	2,9	3,2
4	Surface resistance, Om	15,8	15,9	15,2	15,1

Tests were conducted on 10 samples of 5 of 2 types (cast iron cap, polymer-sand cap) according to the tensile strength index. Tests were conducted to determine the tensile strength of the samples. A tensile strength test was performed. For this, to determine the ultimate tensile strength and area under the curve, samples with dimensions of 25 x 250 x 2,5 mm were tested (Fig. 11) and the results were obtained (Fig. 12).


Figure 11. Universal testing machine and specimen held in grips

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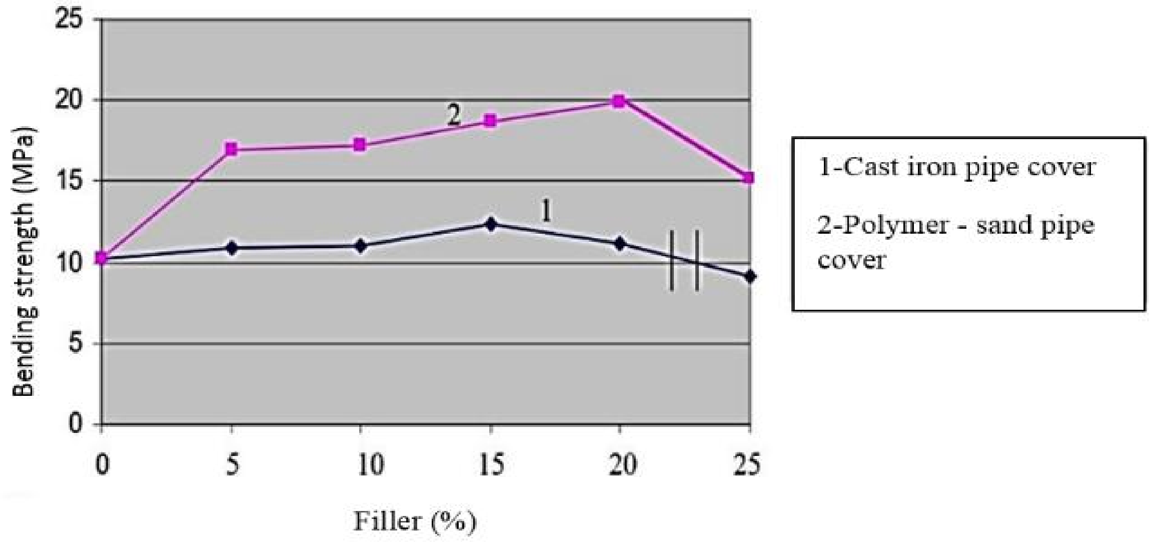

Figure 12. Tensile strength index

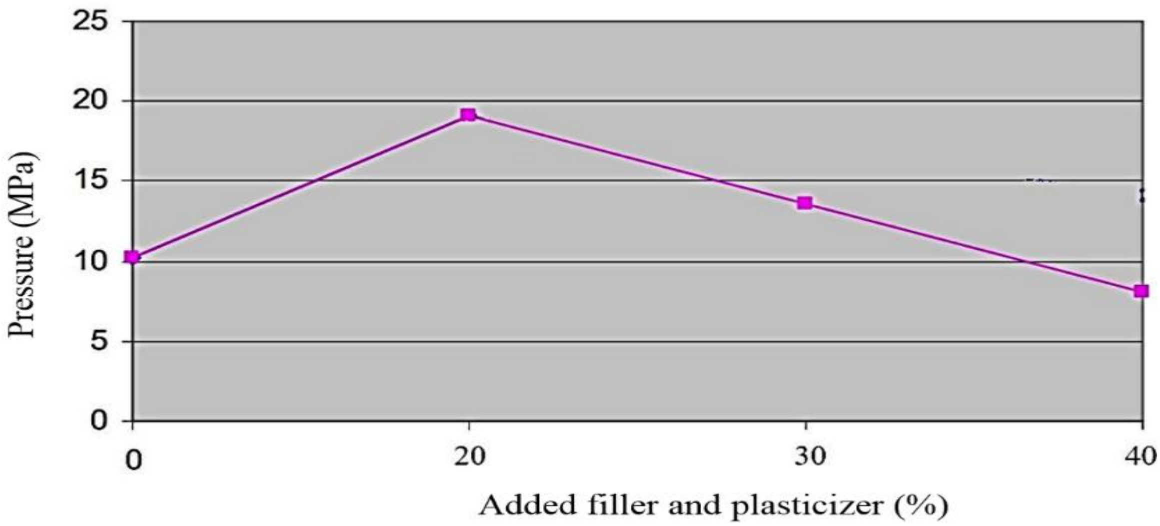

Figure 13. Compressive strength index of secondary polymer waste with filler and plasticizer

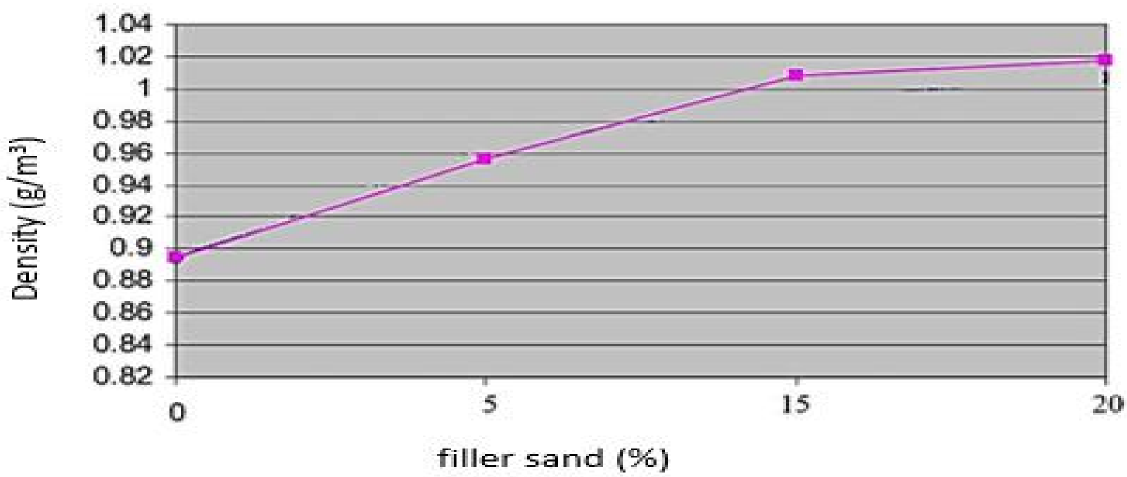

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Figure 14. Density indicator of filler sand

Tests to determine the chemical resistance characteristics of the samples were carried out in accordance with the GOST 12020-72 standard. The product must withstand the acidic environment of the sewage system. For this reason, the well casing samples were tested in an acidic environment, such as sewage water. The pH varies up to 3 or 4 due to the active effect of the acidity level of sewage systems. Sulfuric acid was chosen for the tests. Since sulfates are also corrosive, this property should be checked.

The samples were brought to the same size and weight before acid immersion. Then they were immersed in acid for 7 days (Figure 15). Samples were removed from the acid on the 8th day and reweighed. The measured results were compared with the previous measurements. Samples with a difference in results were examined. The obtained results reflected positive conclusions. PCM prepared from polymer-sand did not undergo any structural changes in acidic environment.

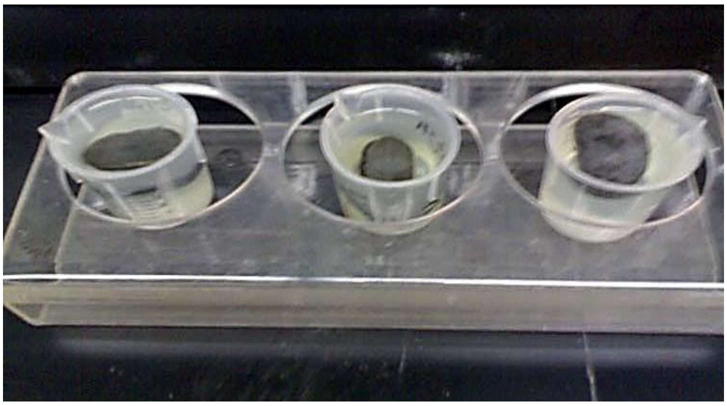

Figure 15. Samples which immersed in sulfuric acid

Figure 16. The process of pressurizing with a hydraulic press

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Figure 18. Experimental test results

CONCLUSION. The following results and conclusions were obtained as part of the research work:

1. Several research works on existing and modern methods for the production of urban planning and hydraulic manhole covers, including a number of technologies have been analyzed. The main requirements for well cap materials were scientifically studied the main production processes in terms of strength and pressure resistance.
2. Types and compatibility of polymer and polymer composite materials were studied. It was determined that it is necessary to start production on the basis of new methods and technologies based on the requirements of local conditions rather than the existing method of obtaining the material.
3. It has been studied that the proposal of obtaining material from secondary materials in local conditions can be solved and that it requires special processes.
4. The formation of composition in the composition and microstructure of the material during the creation of urban well covers was studied. The effectiveness of press processing was realized during processing of polymer raw materials. The durability of the obtained product increased several times, it was found that the defects on the working surfaces decreased several times.
5. The influence of the levels of fillers added to the secondary polymer waste on the pressure resistance index was determined by research, and the required mass composition was determined. The hydraulic press pressing process and press processing efficiency were tested.
6.Environmental damage has been eliminated by recycling local waste polymers. On the basis of secondary polymer waste, it was possible to obtain a well cap product that does not undergo deformation at temperatures from -20^{o}C to +400^{o}C.

8. The weight of the plastic caps offered by us is 30-35 kg, and the price is 90-100 thousand soums. As a result, cheap and light products are delivered to the population. Technical and

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economic efficiency was found to be about 6 times cheaper than conventional cast iron manhole covers.

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