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THE TECHNOLOGICAL HEREDITY IN THE MANUFACTURE OF THE METALLOPOLYMERIC BUILD-FORMING MOLDS

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ABSTRACT

The article deals with the problem of the technological heredity in the manufacture of plastic products in a mold with the metallopolymeric build-forming. The analysis of the hereditary connections and elements-carriers of hereditary information is done, the result of which is a certain system of graph, which essence is explained by the corresponding pattern. The experiment by the definition of influence of separate elements of hereditary system on a finished product is given. The influence of time of mixing of the metallopolymeric composition on its air saturation is investigated. The experiment by the definition of indicators of the thermal conductivity of the metallopolymeric composition, that has asignificant impact on technological process of molding of plastic, was made. The analysis to the obtained data during experiment is also given. The solutions to eliminate the negative properties of the elements of the system of inheritance discovered during experiments have been proposed. Thus, by authors it is proven that application of the degassing in the manufacture of the metallopolymeric build-forming mold is a necessary condition of receiving quality equipment for molding of thermoplasticsin the mold.

Keywords: metallopolymer, imprint, additive technology, porosity, degassing, technological heredity, mold.

INTRODUCTION

The failure of the modern technological systems to provide the prompt receiving details or products while ensuring the given quality characteristics, and also orientation of production of machine parts, usually on the basis of technological processing of machining during which work pieces transform into machine parts, necessitate to study and application of new methods of receiving machine parts.

Among all the methods of plastic recycling, known in the production, one of the most difficult in terms of the used tool is injection molding. In this method, it is necessary to design and make the mold for each detail or groups of details in their production. Details of molds are divided into normalized and special. The construction of the normalized mold details can be established in advance, irrespective of structural features of the cast products in the mold.

As it has been described in [1], the receiving build-forming molds for molding of thermoplastics perhaps by obtaining an imprint of master-model in the metallopolymeric composition. Such technology was tested on the example of manufacture of the metallopolymeric build-forming mold for the product "hook" and described in [2].

The main part

For quality understanding of the process of forming of plastic products received by molding of thermoplastics in the mold, it is necessary to apply to theory of the technological heredity. The technology of mechanical engineering as science hasa challenge of the detailed and comprehensive analysis of production conditions and the establishment of the quantitative side of the technological heredity. In practice, these means that the properties of machine-building products reducing their quality should be removed primarily on blanking or initial machining operations and the properties providing improvement of quality should be preserved and developed to the final stage of production-assembly. According to [3], the technological heredity is called the phenomenon of transfer of properties of the objects from the previous technological operations to the subsequent. These properties can be both useful and harmful. Preservation of these properties of the objects is called technological heredity. The hereditary information plays an important role in the process of transfer of properties. It consists of the material of the details and surface layers of these details. The information represents a large list of indicators of quality. The quality of build-forming molds is characterized by the geometrical parameters, physical-mechanical and operational properties.

The technological heredity includes both interconnection of separate elements of system and object of processing itself. The system is understood as the technological process. In order to demonstrate the influence of the technological system on quality of the product received in the mold with metallopolymeric build-forming surface and also determining of the hereditary connections it is necessary to construct a system of graph (Figure-1), where A_1- material of build-forming mold, A_2– the master-model, A_3- the dividing composition, C - form-building mold, D - finished product. In the best thing according to the offered technology the finished detail should be inherited sizes, form and quality of the surface of master-model through a transitional link of the build-forming mold. In other words, build-forming mold inherits parameters of the master-model by obtaining imprint in the metallopolymeric composition and transfers these parameters to finished product during the molding of thermoplastics in the received build-forming mold.

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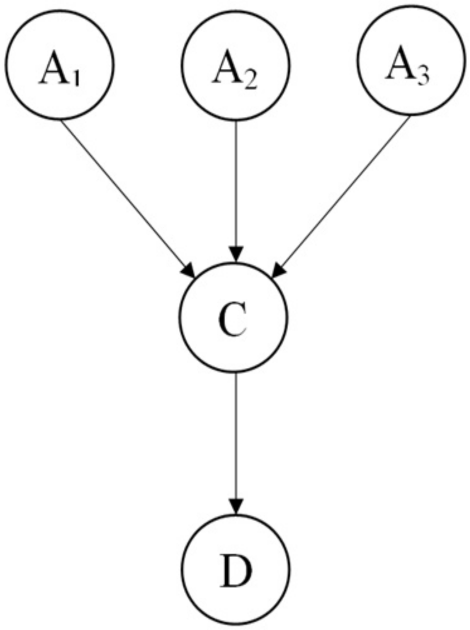

Figure-1. System of graph of the technological heredity in the manufacture of the metallopolymeric build-forming mold.

From the simplified system of graph, it can be seen that separate links of the system influence directly on quality of the finished product, thanks to the technological heredity. Considering novelty of the offered technology of obtaining build-forming mold, it is necessary to consider in more detail influence of each element of the system on quality of the finished product, to define the inherited properties, to eliminate the negative properties and to increase the positive.

The element of the system A_1 is material, which transfers mechanical properties for build-forming mold (bond A_1C) such as hardness provides wear resistance and resistance to the deformations arising under pressure of plastic melt, the heat resistance allowing build-forming to work at temperatures of plastic melt, heat conductivity necessary for heat removal and cooling of the finished product in the mold. Earlier in [1, 2], the authors had considered and proved that application of the metallo polymeric composition with aluminum as filler [4, 5] meets the conditions required for materials of build-forming mold.

The element of the system A_2 is master-model. The use of accurate master-model is a necessary criterion for obtaining quality imprint in metallopolymer [6],as according to the graph shown in figure-1, the surface of the build-forming mold will inherit the surface quality of the master-model (bond A_2C), and then this quality will inherit the finished product (bond CD).

The element of the system A_3 is the dividing composition necessary for the facilitated extraction the master-model from the metallopolymeric solidified composition. The element of the system A_3 is a technological element and doesn't directly affect the quality of the received imprint of master-model in the metallopolymer.

In assessing the simplified system of graph presented in Figure-1 and having four connections from the materials used for manufacture BFM (build-forming mold) and to the finished product, it is possible to conclude that the system has much less connections than the classical system of manufacture the mold by means of machining metal work piece. It suggests that the technology of obtaining metallopolymeric build-forming mold by the method of imprint of master-model demands less labor and time costs, that affects the economic efficiency of manufacture of products from thermoplastics.

Based on the theory of the technological heredity and defining the hereditary connections, it is necessary to solve the problem of preservation of positive qualities and exception the negative, and also to identify the new hereditary connections. In [6] an experiment of obtaining imprint in metallopolymer was carried out and also the conditions of obtaining the quality imprint of master-model (Table-1) which belong to the elements of system of the hereditary connections, are given.

The parameters of surface quality and the arising defects when using such technology became the main conclusions of the article [6], received during experiment of obtaining imprint in metallopolymer. The surface should be specularly smooth and not have cavities.The lack of porosity caused by the air saturation of the liquid metallopolymeric composition [7, 8] is also necessary for preservation of heat conductivity and leakproofness of connections.

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Table-1. Conditions of obtaining the quality imprint of master-model.

Conditions of obtaining the quality imprint	The defects arisingduringnon-compliance with conditions
Production of quality master-model with the given parameters: 1) sizes; 2) roughness	1) The complexity of the demolding. Discrepancy between the sizes received in the form and the design parameters; 2) The hereditary transfer of roughness to product. The points of concentration of tension are created. At the solidification of the material of the product there is the difficulty of the demoldind, leading to destruction of the form.
The correct basing of master-model concerning the well, in which the production of imprint is carried out.	Discrepancy between geometry of the product and the design parameters.
Preparation of metallopolymeric compositionfor filling, possessing the necessary consistence.	The porosity of themetallopolymer after demolding, formation of air cavities. The thick consistency, leading to incomplete filling of theform cavity.
Use of the dividing composition for extraction the master-model from the metallopolymeric solidifed form.	The destruction of the form because ofgluing of master-model and metallopolymer.
Preparation of the well surface, deflashing and degreasing.	Lack of adhesion of metalcomposite with interfaced well surface.
Compliance of temperature conditions of the solidification of the metallopolymeric composition.	Loss of mechanical properties of the metalcomposite form.Increase in time of the solidification.
Right choice of the method of filling of the form.	Formation of air cavities

For assessing the surface quality and the influence of various factors and conditions when receiving imprint the series of experiments according to the plan presented in Table-2 was carried out.

Table-2. The plan of experiment for assessment of the surface quality.

Influence of time of mixing of the metallopolymeric composition on air saturation	Influence of type of the dividing greasingon the surface quality of the imprint and the complexity of extraction the master-model from the obtained form	Influence of the application of the degassing on the porosity of the metallopolymeric
5 min	Without greasing	Solidification under atmospheric pressure
10 min	Antistatic polishPLAK	Solidification in the vacuum
15 min	Silicone sealant	
20 min	Silicone spray	

Influence of time of mixing of the metallopolymeric composition on air saturation

For the experiment, four plastic trapezoidal forms, the device of mechanization of mixing with an electric drive and a metal two-bladed shovel for mixing were prepared. According to the recommended proportions [4] the composition was prepared and filled into identical in form and sizes forms with different time of mixing (5,10,15,20 minutes), as shown in Figure-2.

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Figure-2. Forms filled with liquid metallopolymeric composition with the different time of mixing.

After the solidification of metallopolymeric composition within 24 hours, castings were removed from forms. The received surface is shown in Figure-3.

Figure-3. Surface of metallopolymeric casting at the different time of mixing of composite structure.

It should be noted that the form was degreased and dried, the dividing greasing hadn't been applied. Thanks to significant slopes of the form, smoothness of the surface, and also the fact that the form was thin-walled and had the opportunity to deformation, the demolding was performed without any effort.

For assessing the surface quality from the time of mixing of the metallopolymeric composition the schedule of dependence of quantity of air cavities on the casting surface from time of mixing of metallopolymeric composition was designed (Figure-4).

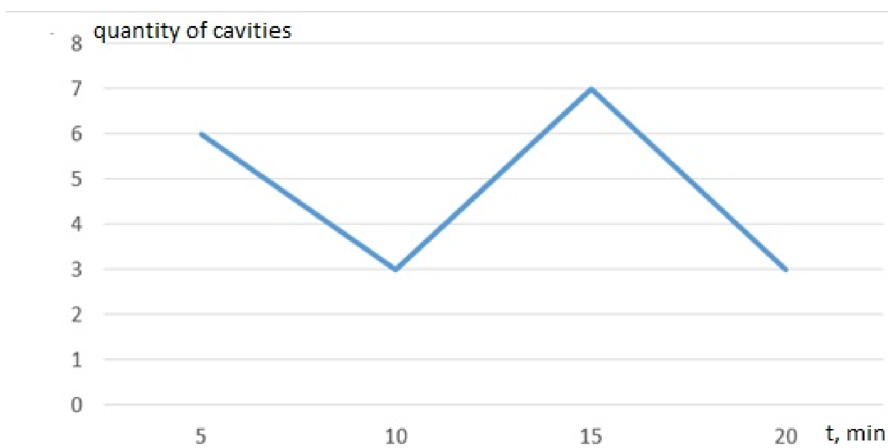

Figure-4. The schedule of dependence of quantity of air cavities on the casting surface from time of mixing of metallopolymeric composition.

The schedule shows that the pattern of influence of time of mixing of metallopolymeric composition on the quantity of air cavities on the casting surface is lacking.

Based on the results, it is possible to conclude that the optimum time of mixing of metallopolymeric composition is 3-5 min. This time would be sufficient for adhesion of filler, hardener and thinner. Increasing the time of mixing leads to reduction of the residence time of the composition in the liquid aggregate state, to deterioration of the molding properties of the composition relating to the solidification of composition, and as a result

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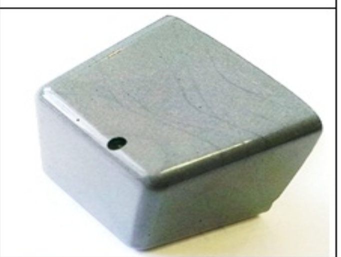
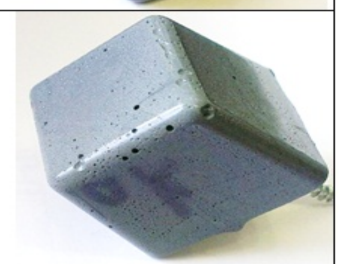
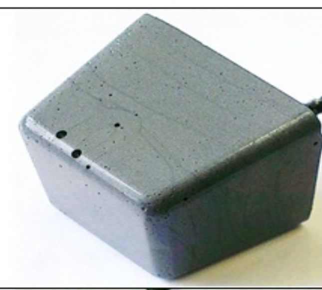
the less time toresolve the free air from the received structure.

Influence of type of the dividing greasing on the surface quality of the imprint and complexity of extraction the master-model from the obtained form

For the experiment, four plastic trapezoidal forms processed by three various dividing greasings were prepared, namely, the polish PLAK, silicone spray, silicone sealant and also the control form without greasing. The time of mixing of metallopolymeric composition is 20 min. After filling of liquid metallopolymer in the form the inserts were established for convenience of the demolding. The results are shown in Table-3.

Table-3. Results of experiment.

Type of the dividing greasing	Surface quality	Effort of the demolding	Image of the casting surface
Without greasing	The quality of the casting surface at the demolding sample without greasing is best. On the whole casting surface there is one air cavity.The surface quality is rated as good.	The demolding is possible if there are insert, significant slopes of the form of casting or the destruction of the form.	
PolishPLAK	On the casting surface the porosity is observed. The surface quality among all samples is rated as unsatisfactory.	The demoldingwas carried out without efforts.	
Silicone spray	On the edges of casting the small porosity is observed. There are 3 air cavities.The surface quality among all samples is rated as satisfactory.	The demoldingwas carried out without efforts.	
Silicone sealant	On the casting surface the wavy imprints from uneven layeringof gel dividing material are observed.The surface quality among all samples is rated as unsatisfactory.	The demoldingwas carried out withinsignificant efforts.	

Based on the results, it is possible to conclude that for obtaining the optimum surface of imprint or master-model in metallopolymeric composition the filling of liquid metallopolymer is best conducted without processing the form or master-model by the dividing composition. As application of the dividing composition causes the formation on the surface of casting of various defects, with insignificant improvement of the extraction the master-model from the metallopolymeric solidified form. In application of the liquid dividing compositions, the small spherical pores are formed on the casting surface, and in application of the dividing compositions of more viscous consistencies there is considerable difference between the geometry of casting and master-model. For convenience of the demolding or the extraction the master-model from the form it is necessary to provide the inserts in master-model, to provide necessary slopes of the form of casting, and also to take into account the thickness of

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master-model from the calculation: the thinner is the master-model, that it is easier to extract it from the solidifed metallopolymer. It is also necessary to consider possibility of destruction of master-model at the extraction it from the solidifed metallopolymer.

Influence of the application of the degassing on the porosity of the metallopolymeric

For the experiment, two plastic cylindrical forms and vacuum installation were prepared. The time of mixing of metallopolymeric composition is 20 min. After filling of liquid metallopolymer in the forms, one of the samples was placed in the vacuum chamber and its solidification was carried out in the absence of air, and the control sample cured under atmospheric pressure in the air. After the solidification of the composition, the visual control of the obtained samples was made (Figure-5 and Figure-6).

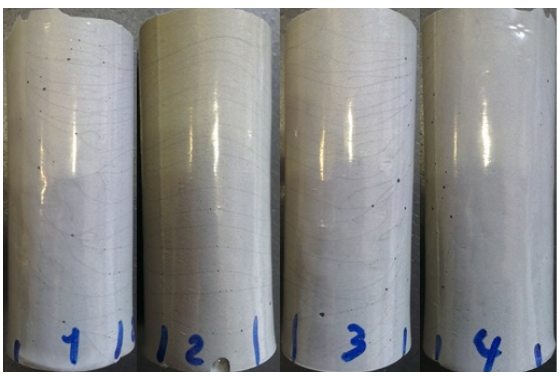

Figure-5. Sample of the solidification under atmospheric pressure in the air.

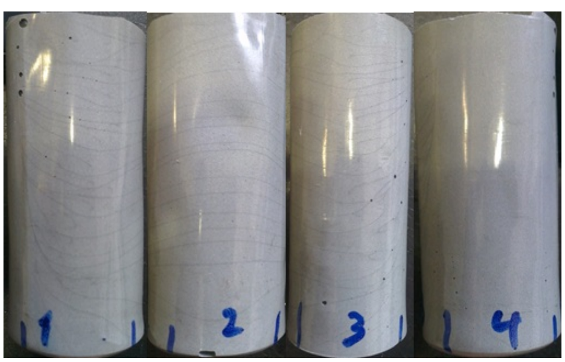

Figure-6. Sample of the solidification in the vacuum chamber.

Apparently on images of quarters of the casting surfaces, solidifed in the air and vacuum, the surface of "vacuum" casting is the cleanest and less porous. The character of the air cavities on the first quarter of "vacuum" casting (Table-3) having the big size and located in the crop, says that the air under the influence of the discharged environment is forced out from structure of metallopolymeric composition, forming the large air cavities as approaching crop.

It should be noted that the time of mixing of metallopolymeric composition was 20 minutes. During the first experiment it was found that the sufficient time of mixing of composition is 3-5 min. Increasing of the residence time of the composition in the liquid aggregate state for 15 minutes after its filling in the mold or the placement in it the master-model, will give to the air more time for replacement from the casting before its solidification, under the influence of the vacuum.

For assessment of influence of the application of the degassing on the casting quality obtained samples were exposed to layer-by-layer removal of material with face mill in the longitudinal direction with depth of removal of material 3mm (Figure-7).

Figure-7. Removal of material layer with face mill from metallopolymeric sample

Images of inside layers of the metallopolymeric samples obtained with application of the degassing and without it are shown in Figure-8 and Figure-9.

Figure-8. Cross-sections of sample of the solidification under atmospheric pressure in the air.

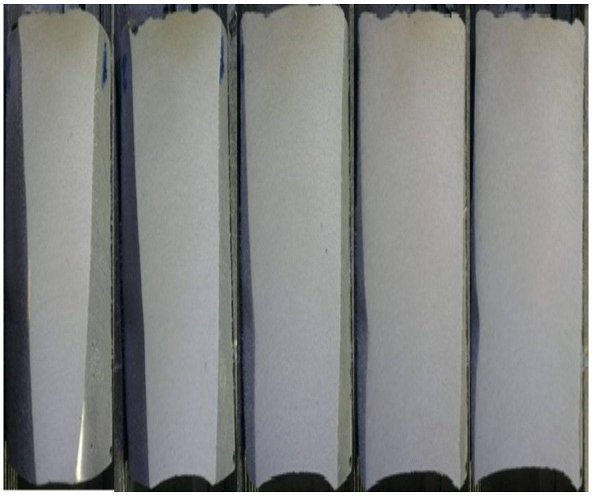

Figure-9. Cross-sections of sample of the solidificationin the vacuum chamber.

Having visually estimated the received cross-sections presented on Figure-8 and Figure-9 it is possible to conclude that the macrostructure of the sample received with application of the degassing is much better than the sample received by the solidification of metallopolymer under atmospheric pressure. The "atmospheric" sample has in the structure air cavities with the diameter of 1 to 6 mm, the "vacuum" sample has no visually detected defects of the internal structure of the sample. In figure 10 the increased images of the macrostructure of both samples received at 400-fold increase and identical illumination are submitted.

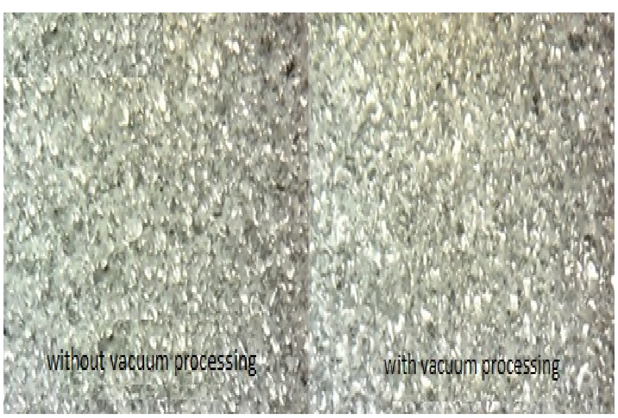

Figure-10. Macrostructure of metallopolymeric samples at 400-fold increase.

Having visually analysed the macrostructures of both samples it is possible to conclude that the image of the macrostructure of the sample received without degassing is more dark and has more quantity of black spots, that tells more roughness of surface of the "atmospheric" sample in relation to "vacuum". For more visibility increase brightness by 40% and reduce the contrast by 20% (Figure-11).

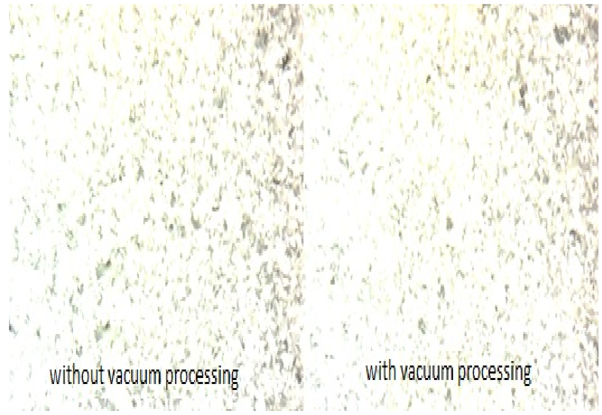

Figure-11. Macrostructure of metallopolymeric samples at 400-fold increase, brightness of + 40 %, contrast of-20%.

Heat conductivity of the metallopolymeric composition

For application of metallopolymeric composition as the material of the build-forming of the surface of the mold, heat conductivity of material has the defining value, as in the process of the molding of thermoplastics it is necessary to take away heat from the mold surface. It is obvious that material which has air in the structure and as a result is porous, will have lower heat conductivity than the material in which structure air is absent. To confirm the positive influence of the degassing on heat conductivity of metallopolymer the experiment was made.

For the experiment, two cubic samples with the side length 20mm, heating element in the form of the incandescent lamp power 75W, heat insulation, stop watch and pyrometer were prepared. By means of the heat insulating element, the samples were established at the identical distance from the heating element (Figure-12).

Figure-12. Metallopolymeric sample established in the heat insulating element.

After samples were established above the heating element under equal conditions, the lamp was turned on, and the measurement of temperature of the back side of the sample was made with frequency of 30 seconds. The results of the experiment are shown in Table-4 and Figure-13.

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Table-4. Results of experiment of measurements of samples temperature.

Heating time, t	T rev.s. VAC °C	T rev.s. ATM °C
t_0	28,9	28,9
30 sec	28,8	29,2
1 min	30	29,9
1 min30 sec	32	31,5
2 min	34,3	33,3
2 min 30 sec	37,6	35,9
3 min	40,6	38,4
3 min 30 sec	43,6	40,6
4 min	46	43,7
4 min 30 sec	49,1	45,7
5 min	51,4	48
5 min30 sec	53,8	50
6 min	56,4	51,8
6 min 30 sec	58,1	54,4
7 min	60,2	56,5
7 min 30 sec	62,5	58
8 min	64	60
8 min 30 sec	65,5	61,4
9 min	67,6	62,1
9 min 30 sec	68,8	64,9
10 min	70,9	65,9
10 min 30 sec	72,5	67
11 min	74	68,6
11 min 30 sec	75,7	70
12 min	77,2	71,5
12 min 30 sec	78,4	72
13 min	80,1	73,7
13 min 30 sec	81,1	75,3
14 min	82,2	76,1
14 min 30 sec	83,5	77,5
15 min	84,5	78,5
15 min 30 sec	85,5	79,7
16 min	86,3	80,6
16 min 30 sec	87,1	81,6

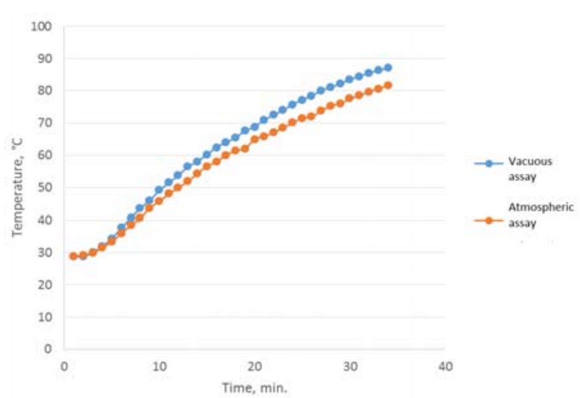

Figure-13. Heat conductivity of the metallopolymeric samples received in vacuum and under atmospheric pressure.

It is possible to conclude that the heat conductivity of the sample obtained with application of the degassing is higher than the sample obtained under atmospheric pressure. This means less content of the air in the "vacuum" sample.

CONCLUSIONS

Analyzing the results of the experiments presented above and also described in [9],it is possible to conclude that the main carrier of hereditary information in the application of the considered technology, is the air suspended in the metallopolymeric composition. Its concentration directly influences quality of the received imprint and physical-mechanical properties of the received build-forming mold. Also, it was found that application of the degassing in the manufacture of the metallopolymeric build-forming mold is the necessary condition of receiving quality equipment for molding of thermoplastics in the mold.

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