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THERMOFORMATION OF COMPOSITE SHEETS ON THE BASIS OF ABS – PLASTICS WITH HIGH SURFACE LUSTER

The possibility of application of composite sheet materials on the basis of acrylonitrile-butadien-styrene plastics (ABS-plastics) for production of details of the exterior and interior parts of road-building equipment by a method of a positive thermoformation has been investigated in the article. It was of a great interest to estimate physicomechanical properties of composite ABS- plastic formable products, to study the influence of technological parameters of a termoformation on operational properties of details. Objects of research are the multilayered sheet products received by a method of positive thermoformation. The resistance of ABS-plastics in the conditions of practical use has also been investigated.The authors have made recommendations on the use of thermoformed ABS-plastic details for manufacturing of road-building technics.

Introduction. Thermoformation is a form-changing of flat preparations (sheets or films) made of thermoplastic polymeric materials into the volumetric formed products at the increased temperatures.

The process of thermoformation consists of the following stages:

– heating of a formable material up to the temperature of high elasticity;

– formation on a special equipment for thermoformation;

– cooling in a mold to the temperature at which the configuration of the formable product gets the stable sizes;

– extraction of a finished article out from the form

Most often applied materials for thermoformation are software, OOPS, PS, the personal computer, ABS-plastic, PEVD, PEND and others [1]. The thickness of formable sheets fluctuates from 0.05 to 15.00 mm, and for the made foam materials to 60.00 mm.

Today the use thermo-formable products made of multilayered materials is considered to be perspective for manufacturing of details for automobile cabins, tractor cabins, road-building equipment. The process of thermoformation is economically effective as it doesn't demand considerable investments into equipment while manufacturing small lots of spareparts and prototypes in comparison with a molding method under pressure. The requirements to the products limit the number of plastics used for thermoformating processes. The reason or it is in the special requirements to durability, shock loading of a formable product, in resistance to ultra-violet radiation as well. The use of engineering plastics, such as polycarbonate; ABS-plastic; styrene copolymer with the acrylonitrile; copolymer of acrylic air, styrene and acrylonitrile is of a great interest.

The use of plastics with resistance to ultra-violet radiation is important for manufacturing of exterior details in automobile and road-building equipment. The application of coextruded ABS-plastic with polymethylmethacrylate (PMMA) is economically reasonable. ABS-plastic possesses high impact resistance capability, and the exterior layer of PMMA prevents aging under the influence of ultra-violet radiation and adds "mirror" shine to a surface. However, there are essential shortcomings while processing this material: unevenness of distribution of a field of temperatures during the heating of a multilayered sheet of plastics and the possible subsequent change of physical and mechanical properties of a finished article [2].

Main part. Sheets of ABS-plastic with PMMA layer on a surface from the producer – "Senoplast" Company (Austria) of the "Senosan SOLAR" brand were samples for tensile impact test, relative lengthening, impact strength on Sharpi with a cut; and multilayered shock-resistant extruded sheets of ABS-plastic of the "Senosan TW" brand of "Senoplast" Company (Austria) which have been cut out from formable details in three various places exposed to an extract as well.

However, an essential shortcoming while processing this material is unevenness of distribution of a field of temperatures during heating of a sheet of plastics in connection with composite structure of a processed material. On Fig. 1. the scheme of distribution of layers in composite sheet material ABS/PMMA of Senosan VP plastic (Austria) is represented.

Having analysed the scheme, it is possible to assume that it is expedient to heat two sides of material as it gives the chance to change the scale of temperatures both for the top sheet and for the bottom sheet. The importance of preservation of the top "mirror" layer poly-methylmethacrylate covering demands to heat the top surface of a sheet less intensively than the bottom surface. It is also necessary to take into consideration that surfaces of a sheet heat up quicker than a core, therefore the process of heating should be carried out as long as possible.

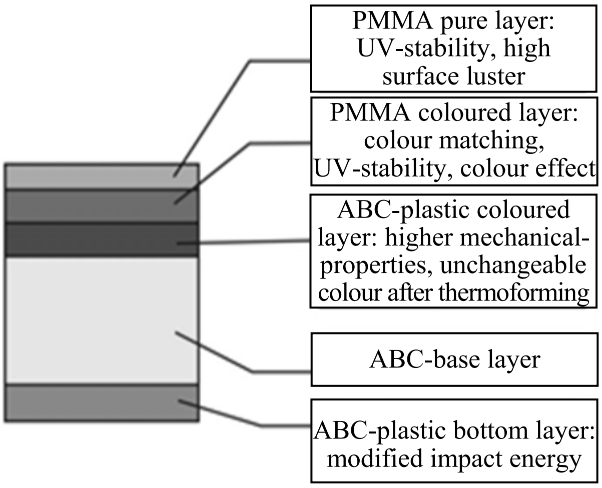

Fig. 1. Scheme of distribution of layers of composite two-layer sheet ABS/PMMA-plastics

On Fig. 2 temporary dependence of change of temperature of a surface and the core of a composite sheet during heating process is presented.

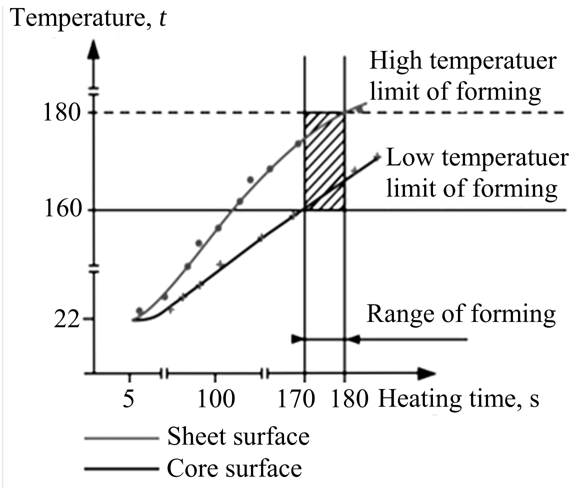

Fig. 2. Dependence of change of temperature of a surface and a core of a composite sheet in the process of heating

As the thickness of a material is a considerable factor for time determination of heating of a sheet, it should be noted that the given dependence is done for a composite coextruded sheet ABS/PMMA-plastic with thickness of 5 mm.

While heating the sheets it is necessary to take into consideration the upper and the lower temperature limits of processing of a material. When the upper temperature limit of the formation is reached – the material starts to "burn", superficial defects (bubbles, tightening), discolouring and the change of surface luster develop. If the lower temperature limit of formation isn't reached – the "cold" material is formed – it leads to high internal tension and microcracks and the subsequent decrease of physical and mechanical properties.

From the given dependences it is possible to draw a conclusion that the optimum interval of processing is, when the core temperature of the sheet is higher than the bottom temperature limit of formation, and the temperature of a surface remains below the upper temperature limit of formation of coextruded sheet ABS/PMMA-plastic.

Because of the fact that to take temperature of a core of a sheet during formation is not obviously possible, from experience of processing of sheet plastics with a gloss coating it is accepted that the temperature of a core of a sheet is equal to temperature of the bottom part of a sheet. Recommended temperatures of processing of composite coextruded ABS/PMMA-plastic are given in the Table.

Recommended temperatures of processing of composite coextruded ABS/PMMA-plastic

Material	Temperature of the top surface of a sheet, ˚C	Temperature of the bottom surface of a sheet, ˚C	Equipment temperature, ˚C
ABS/PMMA sheet plastic	165–170	175–180	70–80

In the Table above the temperatures of processing composite sheet ABS/PMMA-plastic providing preservation of high luster of a surface of the finished article that are applied in exteriors of road-building equipment are reflected. It also shoul be noted that formation was done on the equipment made of fibre-glass plastic having no roughnesses and defects on a surface.

The technique of the thermoformation developed experimentally and the results of which are presented on Fig. 2 and in the Table, was applied also for thermoformation of the composite sheet "Senosan TW" having no polymethylmethacrylate covering.

For samples under investigation tesile impact and relative lengthening at a gap tests were carried out in accordance with GOST 11262-80.

On Fig. 3 the results of measurement of durability at stretching of non-formable and formable ABS-plastic, and ABS-plastic with PMMA covering are represented. For measuring mechanical characteristics arithmetic-mean value of 5–10 tests was used (the maximum value of factor of a variation was 9 %).

From the given results we can make a conclusion that durability at stretching of the formable samples increases on the average in 1.2–1.7 times. It is explained by the reorganization of supramolecular structure of composite ABS-plastic during thermoformating processes under the influence of temperature and an orientation stretching of sheet parison.

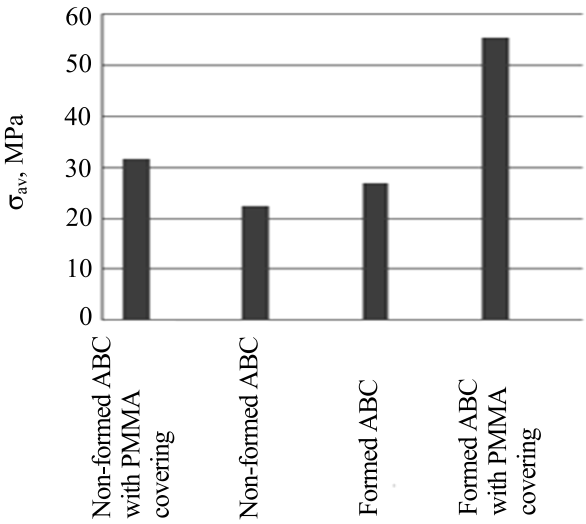

Fig. 3. Durability at stretching of non-formable and formable ABS-plastics and ABS-plastic with PMMA covering

Hardening of materials after a thermoformation is caused by relaxation process during long and uniform heating of sheet parison. The orientation tensions “fixed” in the case of extrusion of a sheet parison have time considerably to relax during the preliminary heating of a sheet, and the tension accumulated in the course of the subsequent formatiing of a parison into a product, is not significant. The small size of tension in the process of formation is proved by zero size of a thermal shrinkage that was defined in a thermocase at the temperature of 180°C.

On Fig. 4 values of impact strength on Sharpi with a cut of samples of non-formable and formable ABS-plastics, ABS-plastic with PMMA covering are given.

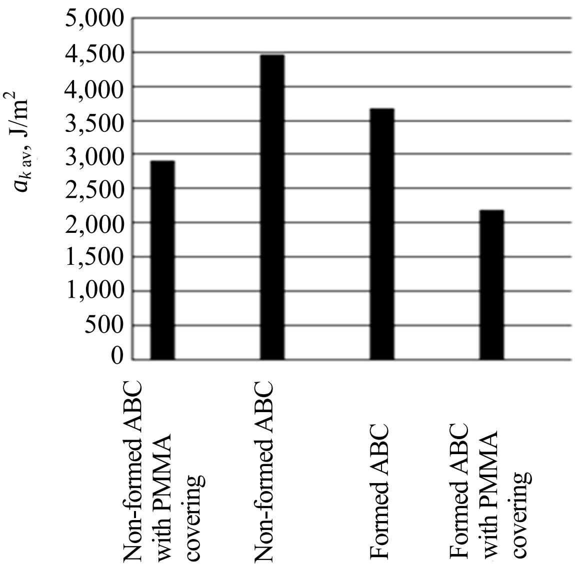

Fig. 4. The results of measuring of impact strength on Sharpi with a cut for non-formable and formable ABS-plastic and ABS- plastic with PMMA covering

From given above results it is possible to draw a conclusion that the indicator of impact strength of the formed samples decreases on the average in 1.2–1.3 times. This fact can be explained by processes of the thermooxidizing destruktsiya proceeding during formation of details, and by the orientational one-wayness of the created structure.

Thus there is no decrease of the elasticity and relaxational and deformational properties of a product. Therefore as materials under investigation will be used as facing details of cabins which are not exposed to the constant mechanical loadings, so data of impact strength on Sharpi with a cut are to considered to be quite satisfactory.

Microphotos of material structure made before and after thermoformation allowed to estimate changes in material structure, to study influence of technological parameters of thermoformation on final structure.

As can be seen from Fig. 5 and 6 a surface of multilayered coextruded ABS-plastic with PMMA covering after thermoformation becomes more regular, ordered and unidirectional.

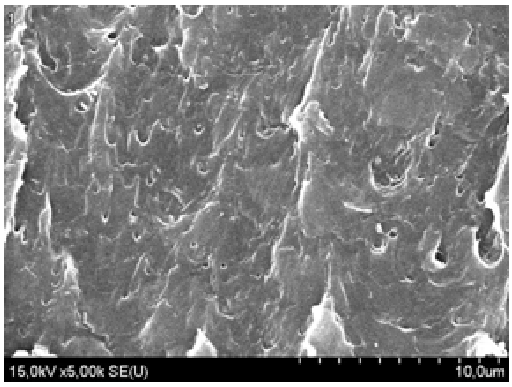

Fig. 5. A sample of non-formable ABS-plastic with PMMA covering

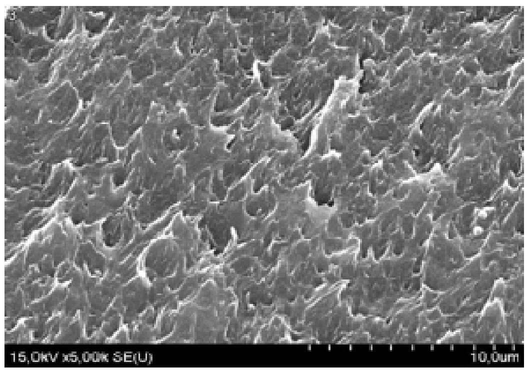

Fig. 6. A sample of formable ABS-plastic with PMMA covering

Conclusion. Nowadays the use of composite sheet plastics being processed by thermoformation is one of the major directions for development of exterior and interior details for road-building equipment and is the alternative to harmful fiberglass production and low economically effective application of metal constructions.

Samples of exterior and interior details for road-building equipment made of composite ABS-plastic sheets with PMMA covering of the Senosan SOLAR brand (resistant to ultra-violet radiation) and composite ABS-plastic sheets of the Senosan TW brand have been received in industrial conditions.

Physicomechanical characteristics of the received products were determined according to the operating standards.

The analysis of research results of composite sheet plastics testifies about the change of physicomechanical characteristics of the details which have been undergone to the thermoformation in comparison with an initial material.

In the course of processing sheet polymers are exposed to influence of shift tension, high temperatures, orientation of polymeric materials, reorganizations of supramolecular structure that leads to deformations and mechanochemical processes influencing the operational physicomechanical and technological properties of details. Besides, in the course of processing the material partially is exposed to destruction processes. The orientational and morphological changes may be caused by this process, because of the formation of other chemical groups, reduction of molecular weight, formation of branches.

The analysis of the received dependences shows that the composite sheet plastics offered to research and the formable products allow to keep physicomechanical properties of details, high shine and luster of the surface of products, to protect them from ligth- and thermal-oxidative destruction during the long period of time.

The analysis of the received results shows that:

– the influence of technological parameters of temperature and time of heating brings crucial importance for preservation of the key operational parameters of the received details;

– the increase in durability at a gap in 1.2–1.7 times of materials after thermoformation is observed, as in the case with ABS-plastic with PMMA Senosan SOLAR brand covering, so with ABS-plastic of Senosan TW brand;

– insignificant decrease in impact strength after thermoformation process doesn't carry sharp decreasing character and doesn't reduce elastic and relaxation properties of products;

– the plastic surface after thermoformation becomes more unidirectional and ordered, microphotos confirm it.

Thus, it is established that crucial importance for preservation of operational properties of positively thermoformable products made of composite ABS-plastics is brought by the technological parameters of temperature and time of heating of a sheet parison.

The ABS composite plastic with PMMA covering of the Senosan SOLAR brand is recommended as a material for external application, it is resistant to ultra-violet radiation and a thermooxidative destruction. The ABS-plastic of the Senosan TW brand is recommended to be applied for interior details of the equipment.

The assessment of physicomechanical properties of finished details has established that products are suitable for application as details of an exterior and an interior of the road-building equipment.

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