Use of polymer composites in motor vehicle electrical equipment and lighting system components

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Russian producers of motor vehicle electrical equipment and lighting system components are encountering a number of problems.

Firstly, a fair number of imported materials, often unjustifiably, are still being used and incorporated in new articles. Imported materials generally come with foreign analogues of articles. However, in this case, no account is taken of the fact that the current range of Russian polymer composites is considerably wider and of better quality than was the case 5–10 years ago. In this area we have made a qualitative leap forward. For example, the range of material grades produced by the "Poliplastik" Scientific and Production Enterprise on the basis of polyamides (Armamid) and polyolefins (Armlen) includes about 50 grades. In their service properties, these materials meet the main requirements laid down for motor and tractor electrical equipment (MTEE) specifically for Russia. Furthermore, the range of grades produced is constantly being widened and improved. For example, at "Poliplastik", a new range of composites based on polybutylene terephthalate (Armoten) is now being introduced. The example of countries of South East Asia indicates that it is economically more effective, when introducing analogues of foreign articles, to rely on your own material resources. This, in particular, is the basis of the high competitiveness of their products on the world market.

Secondly, the ecological level of production is still far behind the European standards. This level is affected significantly by the nature of the polymeric materials used and the associated production methods. Modern trends are the maximum possible reduction in the use of thermosetting plastics, especially those based on phenolic compounds, the discontinuation of the use of composites based on PVC and based on fluorine-containing polymers, reduction in the use of mechanical rubber materials by replacing them with thermoplastic elastomers, and reduction in the use of paint and varnish materials by replacing them with powder coatings or with bulk-coloured materials.

Thirdly, tightening of the requirements concerning the appropriate product certification, and concerning the compliance of the production process with the established health and safety standards, including fire safety.

It is well known that, on the Russian polymeric materials market, there is a fairly large range of materials under trade names of the Soviet era. As a rule, these now belong to nobody. To trace the origin of specific batches of these materials is fairly difficult and sometimes impossible. In view of this, "Poliplastik", to ensure the appropriate quality and liability from the very start of its activity (from 1991 onwards), adopted a civilised system based on its own registered trade names, as is the custom worldwide.

Below, taking all this into account, we will turn to the possibilities of the specific application of composite materials produced by "Poliplastik" in MTEE and lighting system components that are produced in Russia and in countries of the CIS.

An injection moulded plastic battery casing should possess excellent acid resistance, dielectric properties, and impact strength, including at low temperatures (down to −60°C), and thermal stability. These requirements are met by Armlen PP SK 50-1 material — polypropylene modified with rubber.

An injection moulded plastic generator pulley (instead of the metal or fibre plastic variants) should possess sufficiently high rigidity, dimensional accuracy, and grip...
with the belt transmission. These requirements are met by Armamid PA SM 35-1M material — mica-filled, modified nylon-6.

Generator or starter protective casings can be manufactured from oil-, petrol-, and heat-resistant Armamid PA SM 15-1 material (instead of the metal or fibre plastic variants). The given material ensures fairly high dimensional accuracy and the practical absence of warpage. Brush holders both for the generator and for the starter are best certified from high thermal stability grades: Armamid PA SV 30-2T and Armamid PA SV 30-3M. These glass-filled composites are produced with appropriate heat stabilisation on the basis of high-quality home-produced nylon 6 (PA6). If necessary, an additional increase in thermal stability can be achieved by using nylon 66 (PA66). However, this variant is of course more expensive. As is known, the Russian chemical industry has yet to introduce the production of feedstock components for PA66 (and also PA610 and PA12).

For the main articles of the traditional contact ignition system, instead of the phenolic plastic variant, use is known to be made of low-flammability glass-filled polybutylene terephthalate (to UL-94, flammability class V-0). However, to lower the manufacturing cost of some articles, especially in a contactless ignition system, where the working temperature is considerably lower, design and production engineers can turn their attention to low-flammability composites of grades Armamid PA SV 20-5AP and Armamid PP TM 15-1AP. These materials have high tracking resistance (no lower than 250 V) and high electric strength. Material based on polyamide has high oil and petrol resistance, a short-time thermal stability of at least 150˚C, and an electric strength of at least 20 kV/mm. The polypropylene-based material has high water resistance, a thermal stability of at least 125˚C, and an electric strength of at least 30 kV/mm. Both composites have low flammability class V-0 to UL-94.

To manufacture ignition units in a system with electronic control of fuel injection, use is made of casting technology, and here high adhesion characteristics of the housing material are important. They exist both in composites based on PBT and in composites based on polyamide. Other target plastic articles for use of the above grades of materials are: the housing of relays and switches; fuse, commutator, and transformer boxes; distributor cap; distributor rotor; ignition coil cap, and so on.

To manufacture the casting vessel (thermosetting resin) for the ignition coil, use is made of Armlen PP SV 30-2T glass-filled polypropylene, which, after curing, is readily removed from the article.

An important group is made up of the control and measuring instruments positioned on the instrument panel and the switches on the panel and on the steering column. For the panel and the base of the key-type switches and housing components of the instruments, use is made of composites Armlen PP SM 25-1 and Armlen PP SV 30-1. As a material of light-blue colour but non-transparent to light for the combination of instruments, it is possible to use Armlen PP TM 40-1M-504 and Armamid PA TM 15-2-504 materials. The latter variant, of course, is more thermally stable and resistant to heat distortion.

For the housing elements of mounting blocks, with requirements of increased thermal stability and low flammability, the following grades are recommended: Armamid PP SV 30-2T (with increased rigidity and thermal stability), Armamid PP SM 20-1UP (with increased elasticity), and Armamid PP TM 15-1 AP (low flammability).

For switches (key, lever, etc.), use is made of Armamid PA SV 30-1 and Armamid PA TM 15-2 materials. They have a decorative appearance and are readily subjected to hot embossing (polyethylene terephthalate (PETP) film) or cold stamping in order to apply symbols directly onto the article.

The mounting of the speedometer and tachometer, and also their drive gears, are reliably made from Armamid PA SV 30-2T material, with replacement of the more expensive PA66 KS or high-flammability polyacetal.

In the windscreen wiper, for the manufacture of the drive gear and the brush liner, Armamid PA SV 30-2T and Armamid PA SV 30-3M come highly recommended. Armamid has also successfully replaced PA66 KS and SPD (PPL). (For gears of PPL, premature failure of the teeth have previously occurred).

The drive cable of the vehicle antenna is made by extrusion from Armamid PA6-1UP, which has replaced imported PA12. In the fastening components (belts, straps, bands, braces — to tighten and fix multiwire conductors), wide use has been made of the more elastic polyamide grades Armamid PA6-2E and Armamid PA6-3E, again instead of imported PA-12, but plasticised.

To manufacture plug connectors for the electrical equipment, use is made (instead of PA66) of heat-stabilised Armamid SV 30-2T glass-filled polyamide. It ensures a long working life of articles at temperatures ranging from –60 to +150˚C, and also a high contact breaking force and electric and mechanical strength. The material is produced both in uncoloured natural blue and bulk-coloured black. Coloured connectors can be produced using colouring concentrates. To manufacture connectors of increased elasticity, use can be made of Armamid PA6-1UP. To manufacture mass plug connectors on the rotor conveyor line, use is made of talc-filled composite Armlen PP TM 25-1 both of light-grey and black colour, or of low-flammability variant Armlen PPTM 15-1AP. Polypropylene composites are cheaper and do not require drying before processing, but they provide a slightly lower contact breaking force than polyamide.

In the housings of the headlights, diffusers, lamps, roof fixtures, and other articles of the vehicle lights, wide use is made (instead of polycarbonate and the considerably
less thermally stable ABS plastic) of mineral-filled polyamides Armamid PA SM 15-2 and PA TM 15-2. In the housings of the headlights and side diffusers (and also in the face guard), general use is now made of material of light-grey colour, which ensures the appropriate decorative and scattering characteristics. However, in a number of housings for vehicle lighting system components, use is made of black material, including material with external coloration. Polyamide material has high adhesion: to surfaces vacuum metallised with aluminium; to protective surface coatings of lacquer or organosilicon compounds; to enamels; to paint and varnish materials; to sealing compositions. Without using a lacquer substrate, matt metallisation or an appearance in accordance with the surface purity class of the mould is ensured. Using a lacquer substrate or with a high surface purity class of the chrome-plated mould, mirror metallisation is ensured. Metallisation on the given material is resistant to the action of climatic factors and to salt spray. The material has the highest fungus resistance — rating 1. For small reflectors capable of working up to a temperature of 160°C, sufficiently high reflective properties are ensured by light-grey material and without the use of metallisation, provided that the mould has a high surface purity class. In turn, metallisation increases considerably the capacity of the material for light and heat loads and its dimensional stability.

It must be pointed out that the variant of manufacturing the headlight blocks with a glass assembly using an elastic liner (without a seal) and also using mechanical catches has been widely used abroad. Here, naturally, adhesion characteristics of the material are not required. For such a possible variant, materials based on polypropylene Armlen PP TM 40-1 and Armlen PP TM 40-3 (polypropylene with 40% talc in a light-grey and black variant) were developed. Materials based on polypropylene, like its foreign analogues, are of course significantly inferior to polyamide housing material as regards thermal stability and impact strength, but cheaper.

To manufacture housing articles for lamps with a thermal stability of 130°C without using any coatings or welding, use is made of mineral-filled polypropylene Armlen PP TM 25-1 and SM 25-1 both in black and in light-grey variants. Materials based on polypropylene are highly workable and require no special drying before moulding. They are more thermally stable than ABS plastics.

To manufacture a number of loaded articles (levers and supports of headlight hydrocorrectors; articles operating under repeated flexing; articles with improved strength in the cold weld zone), use can be made of Armamid PA SV 30-1ETM.

In view of the fact that, in the production of motor vehicle lighting system components, technology for the welding of the housing with glass of PC or PMMA is being used increasingly widely, an adhesive composite has been developed for these purposes, based on polypropylene Armlen PP SV 10-1 AM, as a more thermally stable (120°C) alternative to ABS plastic. Similar talc-filled composite Armlen PP TM 10-1AM is subjected to vacuum metallisation (without a lacquer substrate), ensuring a fairly high lustre.

To convert a number of elastic mechanical rubber articles to injection moulding, polyolefin (PP) thermoplastic elastomers of the Armlen TPE series have been developed, produced by dynamic vulcanisation. They can also replace PVC plastics which are ecologically unhealthy and rapidly age during service.

As can be seen from these examples, home-produced thermoplastic and elastic composites present significant scope to design and production engineers of enterprises manufacturing MTEE and lighting system components for effective selection of the necessary grades with the aim of increasing the reliability of articles, dispensing with expensive, including imported, materials, and improving the ecological level of production.