

# Usage of polymeric fuel tanks in the automotive industry

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**Abstract.** The paper investigates usage of polymeric fuel tanks in the automotive industry.

## 1. Introduction

A fuel tank in the vehicle is an important component of the fuel system in an internal combustion engine. A tank is used to store motor fuel such as petrol, diesel fuel and gas. The present-day fuel tanks can be made of different advanced materials: ferroalloys, aluminum alloys, plastics.

Steel fuel tanks are manufactured by stamping of sheet metal and welding of upper and lower parts. Steel fuel tanks use steel with high viscosity grade and ultimate strength [1]. When subjected to external influences a fuel tank is deformed due to its viscosity but remains leak-proof. The main disadvantage of steel fuel tanks is high corrodibility. The probability of water ingress into a fuel tank is great as it can find its way inside as a condensate or together with fuel and settle down at the bottom.

Aluminum fuel tanks are manufactured by stamping and welding. They are not corrodible and have lower weight than steel fuel tanks. In comparison with steel tanks aluminum fuel tanks have the following disadvantages: possible fuel leaks due to weld failure during the operation; low deformation capacity (impact resistance); presence of stress risers in a material after short-term strain higher than its strength; high cost.

Today the leading world manufacturers are in process of transition to plastic fuel tanks. Polyethylene and polypropylene fuel tanks are manufactured by rotational molding or extrusion. In comparison with steel and aluminum fuel tanks plastic tanks are not corrodible, resistant to scratches, chipping, have lower weight, require no welding, have lower cost [2-3]. The existing methods of plastic fuel tank production make it possible to manufacture components with complex geometry; use the tank mounting space efficiently; provide the maximum tank volume.

## 2. Body text

The main reason of fuel tank failures is a surface damage from blasting with abrasive particles flying off the vehicle wheels. These collided particles make the tank walls and brackets thinner. When a vehicle is moving the frame becomes distorted and fuel tank components lose their strength due to abrasive wear, so cracks are formed in fuel tanks resulting in loss of their leakproofness [4]. Damage of a fuel tank can also be caused by the quality of fuel. Diesel fuel is hygroscopic, it can absorb water from air resulting in corrosion of tank walls, which requires the expensive repairs of fuel components (high pressure fuel pump, injectors, fuel pipes) [5].



In view of this, the engineers seek to modify the design of fuel tanks and find the suitable materials. The most interesting solution is a fuel tank made of plastic.

The present day plastic fuel tanks for vehicles should meet the following requirements: operating temperature range from minus 60 °C to plus 80 °C; local and short-duration heating up to 110 °C (high temperature near the areas of more intensive sunlight, exhaust system, points of contact with the wire bundles); leakproofness at an excessive pressure up to 0.02 MPa. The design of a fuel tank shall ensure fuel sedimentation and dirt and water removal from the tank (as they are accumulated); ozone resistance; resistance to precipitation, dynamic, impact and vibration loads that occur in a moving vehicle; resistance to short-term exposure to hot detergents, diesel fuel, lubricants outside and inside the cavity; resistance to natural abrasive wear (dust, dirt); high aesthetic characteristics (the surface shall have no cracks, folds, shells, blisters, foreign inclusions and exit points of the reinforcing material nonimpregnated with resin; absence of internal flaws (layer separation, bubbles, porous structure); transportation and storage using transport plugs. The polymeric materials should meet the following requirements: no toxicity and odor; no injury hazard; flammability category G1 (Г1) (self-extinguishing [6]).

The polymeric material was selected to produce tanks. The most suitable material was found to be polyethylene. The polyethylene fuel tank was designed for trucks using the state-of-art CAD and CAE systems. Rotational molding was selected as a production method. It makes it possible to manufacture hollow large components with a volume up to 36 m<sup>3</sup>, complex components with the wall thickness than can be changed without changing the shape; to integrate metal parts by molding; manufacture several components simultaneously; to ensure no inner stress and polymer orientation for parts [7-10].

The following table shows the results of comparative laboratory tests of plastic and steel vehicle fuel tanks subjected to different types of influences.

Table. Results of comparative tests

Test description	Steel fuel tank (steel 08Yu)	Plastic fuel tank (medium-density polyethylene)
collision of the tank with the steel reservoir in the forklift (impact force and distance are similar)	complete deformation; fuel leakage; scratches on the painted surface and extensive visual damages; the tank shall be replaced immediately due to impossible further operation	deformation recovery: minor temporary deformation; lower risk of fuel leakage; the tank can be used without repair
shot through the plastic and steel fuel tank from the assault rifle with cartridges in 7.62 mm caliber at a distance of 10 m. The test was performed for the tanks filled with water to 70% of the total volume	significant leakages in the two tank walls; impossible repair and further operation; entry hole of 7.98 mm, exit hole of 25 mm.	hole only in the front wall of the tank (3.64 mm); possible temporary repair; shrinkage of the hole within several minutes after the shot and as a result leak reduction; no leakage in the rear wall of the tank
fire resistance of the fuel tank (120-second burning according to ECE34 [9])	not applied	no leak found over the whole surface of the plastic tank

The analysis of the table data revealed that plastic fuel tanks have better characteristics than steel ones. In addition, the advantages of polymeric fuel tanks include:

- easy flushing. It is necessary to ensure that running water flow through the inlet or one of the service openings on the upper surface of the fuel tank and the bottom drain hole is open;
- easy fuel level control: there is a hole for the gage rod in the upper part of the tank;
- efficient recycling of overage parts. The tank material can be reused by granulation to secondary materials for recycling;

- easy transportation.

### 3. Conclusions

Due to a variety of forms and configurations and easy installation plastic fuel tanks have established themselves in the truck market. The area of their application is continuously expanding: the manufacturers are attuned to the slightest changes in demand and offer new solutions to make the operation of products easier.

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### References

Internet resource: Faults of diesel engine fuel systems in KAMAZ vehicles. Available at: <http://xn----7sbfkccucpracijq8iofobm.xn--p1ai/> (accessed 10.10.2017)

- [1] Internet resource: Fuel tank: construction, types, operation. Available at: <https://autodromo.ru/articles/toplivnyy-bak-ustroystvo-vidy-princip-funkcionirovaniya>. (accessed 12.10.2017)
- [2] Kashapov N F, Nafikov M M, Gazetdinov M X, Nafikova M M and Nigmatzyanov A R 2016 Innovative production technology ethanol from sweet sorghum *IOP Conference Series: Materials Science and Engineering* vol 134 issue 1, 8 number 012012
- [3] Internet resource: Construction of present-day vehicle fuel tanks. Available at: <https://auto.today/bok/4303-iz-chego-sostoit-sovremennyy-toplivnyy-bak.html>. (accessed date: 11.10.2017).
- [4] Repair manual for KAMAZ 5320 and maintenance and operation manual for KAMAZ 5320, 5410, 55102, 55111, 53212, 53211, 53213, 54112, 4310, 43114, 43118, 65111, 53228, 44108, 43115, 65115, 53229, 53215, 54115 with chassis 6x4 and 6x6 (Moscow: Tretij Rim Publ) p. 286
- [5] GOST 28157-89 1989 Tests for flammability of plastic materials (Moscow: Izdatelstvo Standartov Publ.)
- [6] Internet resource: Rotational molding: new ideas]. Available at: [http://polymery.ru/letter.php?n\\_id=3046&cat\\_id=2](http://polymery.ru/letter.php?n_id=3046&cat_id=2). (accessed date: 25.10.2017)
- [7] Internet resource: Rotational molding. Available at: [http://www.rototech.it/index.php?evt\[page-displayItem\]&id=11](http://www.rototech.it/index.php?evt[page-displayItem]&id=11). (accessed date: 13.10.2017)
- [8] European Standard ECE R34 Annex 5, Fire Risks – European Economic Community Regulation – Fire safety of plastic fuel tanks for automobiles (ECE R34 Annex 5, RREG 70/221/EEC, 2000/8/EG).
- [9] Fedyaev V L, Galimov E R, Galimova N Ya, Gimranov I R and Siraev A R 2017 *Dynamics of coalescence and spreading of liquid polymeric particles during coating formation* IOP Conf. Series: Journal of Physics: Conf. Series vol 789 **012006**
- [10] Fedyaev V L, Galimov E R, Galimova N Ya, Takhaviev M S and Siraev A R 2017 *Mathematical modeling of processes occurring during deposition of sprayed particles of polymeric powder* IOP Conf. Series: Journal of Physics: Conf. Series vol 789 **012007**