UDC 665.775

PETROLEUM ROAD BITUMEN MODIFIED BY WASTE OF PETROCHEMICAL INDUSTRY

VALERIA SHIRABORDINA, MARINA RUSYAEVA, YULIYA BULAUKA
Polotsk State University, Belarus

We conducted studies on modification of petroleum bitumen with low a molecular weight polyethylene (LMPE) and residue of the heavier cut of pyrolysis gas oil (residue of PGO) of production plant «Polymir» of JSC «Naftan» to improve the quality indicators of the produced road binder. We measured physical and mechanical properties of asphalt mixture. It was found that adding of polymer- aromatic binder to the resulting asphalt concrete improves its physical and mechanical characteristics. The use of waste of petrochemical industry reduces cost of bitumen in comparison with its analogues.

Introduction. Bitumen is a very complex combination of organic compounds containing a high proportion of hydrocarbons with high carbon numbers. This family of molecules can be found in many heavy crude oils. In its simplest form bitumen manufacturing separates the lighter fractions from the residuum, the required molecules being already present in the crude oil. For other types of bitumen, for example oxidized bitumens, the only way to achieve the desired properties is to produce new molecules through chemical reactions. Several manufacturing methods are available to produce specification bitumens depending on the crude source(s) and processing capabilities available. Often a combination of processes is selected. The schematic in Figure 1 provides a compilation of refinery processes related to the production of bitumen [1–4].

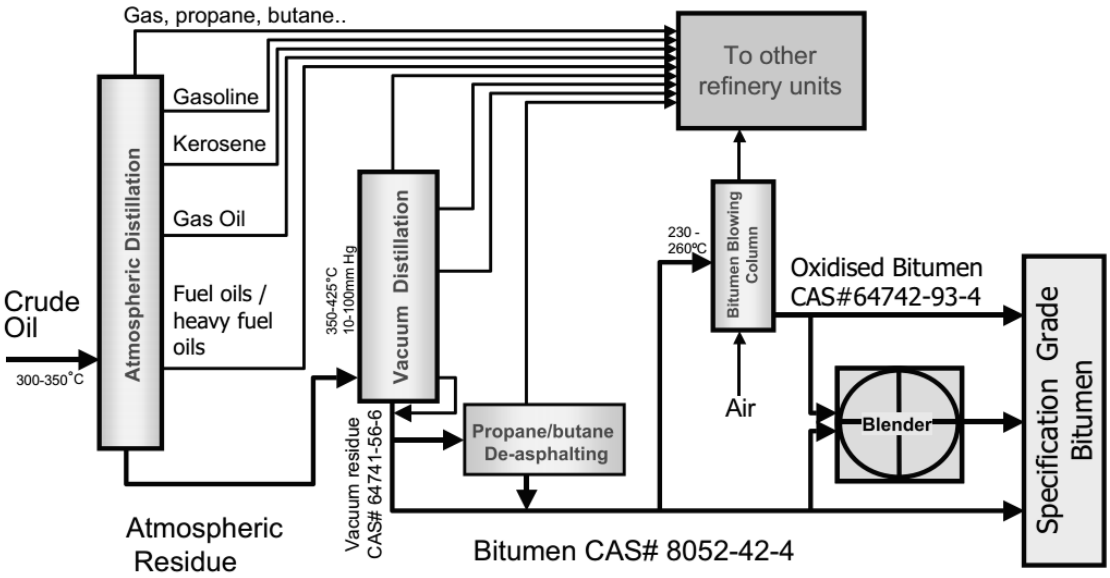

Fig. 1. Schematic diagram of bitumen manufacturing

Bitumen fume is a complex mixture having a broad boiling point range. The molecular composition can include hydrocarbons covering the range from naphtha through to long branched chain aliphatic hydrocarbons, cycloalkanes aromatics and hetero-molecules containing sulphur, oxygen, occasionally nitrogen, and low levels of polynuclear aromatic compounds (PAC), including of Polynuclear Aromatic Hydrocarbons (PAH).

The chemical characterization of bitumens is based on their separation into four broad classes of compounds – asphaltenes, saturates, cyclics and resins. The relative content of these groups of compounds varies. Examples of the typical structures of the fractions are given in figure 2 [4].

Nomenclature and grading in Europe is based on the penetration range of the product [a measure of consistency at 25°C (77°F)]. Paving bitumen specifications include EN 12591 (paving grades), EN 13924 (hard grade paving bitumens) and EN14023 (Polymer Modified Bitumens), the latter specification being bitumen products comprising bitumen plus other materials including polymers. These are based on the various existing (empirical) test methods and former national standards, which were in common use for many years.

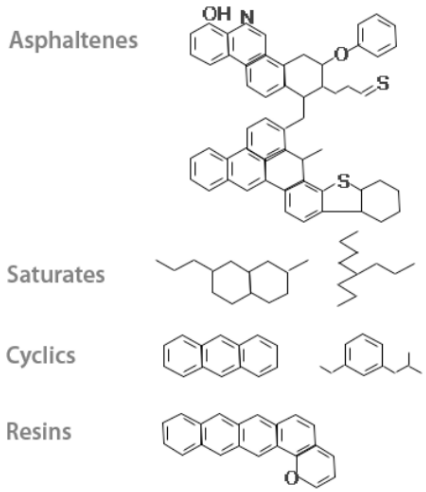

Fig. 2. Example of the broad chemical types present in bitumen

The specified properties relate to rheology (penetration, softening point, viscosity), resistance to hardening/ageing, flash point (for safety reasons) and solubility to indicate absence of contaminants. Paving grade bitumens are produced by vacuum distillation and air-rectification. Polymer modified bitumens, which are blends of bitumen with polymers and other additives, are also categorized as paving bitumens.

Methodology. For the device of pavings for low-temperature conditions of application it is necessary to increase plasticity in initial bitumen, to lower a temperature of fragility and to increase coupling with stone material at preservation up to standard of other physic and mechanical properties [5,6,7]. In this connection it is interestingly to modification of the specified properties of bitumen of low-molecular polyethylene and the pitch of heavy pitch of pyrolysis of production of the Polimir plant of JSC Naftan capable to be dissolved in bitumen.

In work used bitumen oil road, the BND 40/60 brands (Technical Conditions BY 400091131.009-2011) of production of JSC «Naftan».

Modification of bitumen was carried out by hashing of components in metal capacity at a temperature of receiving asphalt concrete of 130–160 °C within 30 min. an anchor mixer with a speed of rotation of 60 rpm.

At a research of compositions of the BND 40/60 initial bitumen and the modified knitting standard methods of definition were used:

– softening temperatures on a ring and a sphere in accordance with GOST 11506-73;

– tensile properties at + 25 °C according to GOST 11505-75;

– a penetration according to GOST 11501-78;

Results, discussion and conclusion. Results of influence of the modifying LMPE and residue of PGO additives on properties of road bitumen of brand 40/60 are presented in figures 3 and 4.

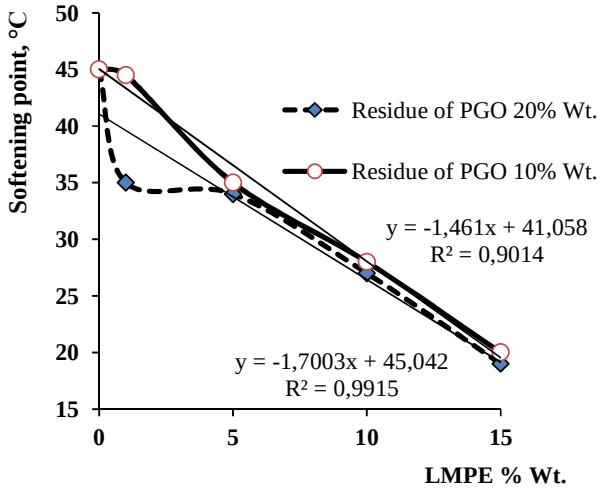

Fig. 3. Softening temperature change dependence on bitumen ring and ball concentration of LMPE and Residue of PGO

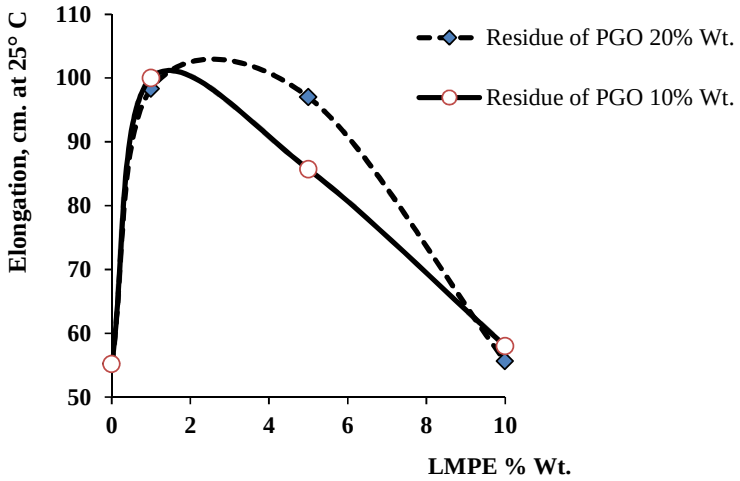

Fig. 4. Dependence of change elongation of bitumen on the ring and ball on the concentration LMPE and Residue of PGO

From the figure 3 it is visible that bitumen softening temperature linearly decreases with increase in concentration both LMPE, and Residue of PGO.

From the figure 4 it is visible that the tensile properties (ductility) of bitumen change not linearly, and passes through a maximum at concentration of LMPE 1. 5% of wt. Thus, for ensuring high plasticity of bitumen in the presence of Residue of PGO, concentration of LMPE shouldn't exceed 5% of wt.

It is established that modifying of Residue of PGO bitumen gives to sharp increase in a penetration of bitumen (decrease in hardness), for example, bituminous mix of 20% wt. Residue of PGO and 1% of wt. LMPE reduces a bitumen penetration more than twice (depth of penetration of a needle has made 99 x 0,1 mm: at 25 °C). Proceeding from the studied indicators, it will allow to receive from bitumen of brand 40/60 bitumen oil road corresponding GOST 22245-90 of brand 90/130. The modified bitumen can be applied under more low-temperature service conditions.

Introduction to bitumen of the modifying LMPE and residue of PGO additives makes the plasticizing impact on its structure [8]. Besides, use of waste of petro chemistry provides decrease in prime cost of bitumen in comparison with analogs.

REFERENCES

1. Gary, J.H. Petroleum Refining : Technology and Economics / J.H. Gary, G.E. Handwerk. – New York : Marcel Dekker, INC., 1975.
2. McKetta J.L. Petroleum Processing Handbook / J.L. McKetta, – New York : Marcel Dekker, INC., 1992.
3. Zakar, P. Bitumen / P. Zakar (American Edition) ; Chemical Publishing Company, Inc. // Library Catalogue Card Number: 73-122761. – 1971.
4. Hot Mix Asphalt Materials, Mixture Design, and Construction, / F.L. Roberts [et al.]. – National Asphalt Pavement Association Publication TB-1, 1991.
5. Improving Energy Efficiency of Bitumen Modification with Reclaimed Crumb Rubber / V. P. Belyaev [et al.] // Components of Scientific and Technological Progress. – 2013. – №1 (16). – С. 75 – 77.
6. Belyaev, V.P. On the Prospects of Integrated Solutions to Problems of Ecology and Improving the Quality of Road Surfacing / V.P. Belyaev, P.S. Belyaev, D.L. Polushkin // Перспективы науки. – 2012. – №5 (32). – С. 186–189.
7. Bitumen Modification with Recycled Polymeric Materials / V.P. Belyaev [et al.] // Глобал. науч. потенциал. – 2013. – №9 (30). – С. 29–33.
8. Павлов, А.В. Основные направления использования низкомолекулярного полиэтилена и его влияние на свойства нефтепродуктов / А.В. Павлов, А.А. Ермак // Вестник Полоцкого государственного университета. Сер. В, Прикладные науки. – 2007. – № 8. – С. 123–127.