

Republic of Iraq
Ministry of Higher Education
and Scientific Research
Al-Mustaqbal University College
Chemical Engineering and Petroleum Industries Department



Subject: Properties of Petroleum Fuels

3rd Class

Lecture one

BITUMEN

Bitumen is

- a black or brown highly viscous liquid or semisolid material that is present in most crude oils and in some natural deposits.
- Bitumen is a complex mixture of organic compounds containing up to 150 carbon atoms, mainly – aromatic, naphthenic, and aliphatic.

- Bitumen may also contain – small amounts of organic acids, bases, heterocyclic compounds nitrogen, oxygen, and sulfur.
 - Some metals are also found in bitumen.

- Bitumen may typically contain – 83 to 86 percent carbon.
 - 9 to 10 percent hydrogen.
 - 1 to 5 percent sulfur,
 - less than 1 percent each of nitrogen and oxygen, and minor amounts of metals such as vanadium and nickel.

- Bitumen is – useful anywhere where waterproofing, insulation, or chemical resistance problems are encountered.

- Bitumen is – used in the lining of water reservoirs, canals, and the upstream side of large dams to prevent water seepage and erosion.

- Bitumen is – used in diverse industries such as cable jointing compound, cold sticker compound for sticking, roofing felt over metallic surfaces, timber, battery scaling compound, for making printing inks, in automobiles for undercoating, as a base for paint and lacquers, manufacture of floor covering, and a wide variety of waterproofing and damp-proofing applications.

- Bitumen or asphalt refer to the same product.

BITUMEN COMPOSITION

- Bitumen is – a thermoplastic material:
 - It softens when heated and hardens on cooling.
 - Within a certain temperature range, bitumen is viscoelastic.
 - It exhibits the mechanical characteristics of viscous flow and elastic deformation.
- Bitumen can be considered a colloidal solution in which asphaltenes are held in suspension in a mixture of oil and resins.

Typical composition is as follows:

- Constituent Wt % (percentage of weight)
- Saturates + aromatics 50-60
- Resins 25
- Asphaltenes 20
- Saturates and aromatics are the fraction with the lowest molecular weight, ranging from 300 to 2000.
- The hydrogen-to-carbon ratio of this fraction is much higher than those of asphaltenes or resins.
- This fraction acts as the dispersion medium for asphaltenes.

Asphaltenes

- The asphaltene molecule has a core of saturated condensed aromatic rings and an aliphatic side chain.
- Heteroatoms (O, N, S, Ni, V, and others) have been found in rings.
- The asphaltene molecule is typically composed of 10 or more fused aromatic and naphthenic rings with a significant number of alkyl side chains.
- The molecular weight of asphaltene is in the range of 2000 to 5000. The higher the asphaltene percentage, the harder the bitumen.
- Asphaltene constitutes from 5 to 25 wt % of bitumen.
- When heated, at a low cracking temperature of 750°F.
- thermal cracking with coke formation occurs rapidly.

Resins

- Resins are composed of heterogeneous polar compounds with a small percentage of oxygen, nitrogen, sulfur, and metals.
- The molecular weight is typically 800 to 2000.
- Resins constitute approximately 15 to 25 percent of the weight of asphalt.
- Resins are aromatic groups with high polarity.
- Resins have a higher hydrogen-to-carbon ratio compared to those of asphaltenes.
- Resins can be considered as low molecular weight asphaltenes.

Aromatic Oils

- Aromatic oils consist mainly of carbon, hydrogen, and sulfur with a minor amount of nitrogen and sulfur.
- with a molecular weight of 500 to 900.
- These oils constitute 45 to 60 percent of the weight of bitumen.
- These compounds have mainly aromatic ring or naphthenic-aromatic nuclei with a side chain.

Saturated Oils

- Saturated oils consist mainly of long chain saturated hydrocarbons with some branched chain compounds cyclic paraffins.
- Molecular weight is in the range of 500 to 1000.
- Saturated oils constitute 5 to 20 percent of the weight of bitumen.

BITUMEN FOR PAVEMENT

- For making paving bitumen, the cut point between heavy distillate and vacuum residue is adjusted to give a residuum of the required viscosity and penetration for use in road paving.
- Both the yield and quality of paving bitumen varies widely, ranging from a few percentage points to as high as 70 percent.
- Some crude oils, generally known as bitumen crudes, yield high-quality paving bitumen simply by distillation, whereas in the case of many other crude oils, either the quality of bitumen produced is unsatisfactory or the bitumen yield is too low to be economical.
- Not all crude oils are suitable for making good road bitumen.
- If crude oil has a high wax content, its viscosity temperature characteristics may not be suitable for making road paving asphalts.

- Vacuum residue may have a high penetration and too a low viscosity at 275°F.
- For example. Arab light crude has a moderately high wax and gives vacuum residue, which has poor low-temperature properties.

TYPES OF BITUMEN

Apart from straight run bitumen, the following other types of bitumen are produced and used in the industry:

- Cutback bitumen
- Bitumen emulsion
- Polymer-modified bitumen
- Oxidized or blown bitumen

Cutback Bitumen

- Cutbacks do not require heating before spreading on the pavement.
- Cutbacks are used in many applications because the solvent reduces asphalt viscosity for use at a lower temperature.
- Cutbacks are used in road applications for priming road surfaces because they can penetrate and bind the surface layers and thus create waterproofing.
- Other road building uses are tack coats, fog seals, and slurry seals in roads and highways.

Bitumen Emulsions

- Emulsified bitumen is simply a suspension of small bitumen cement globules in water assisted by an emulsifying agent such as soap.
- Bitumen emulsions can be used in almost any application where cutback bitumens are used.
- The advantage of bitumen emulsions includes the ability to handle asphalt with minimal or no heating and the absence of significant reduction of cutter in the binder.
- Standard grades of emulsions contain approximately 60 percent bitumen by weight and 40 percent water.
- Bitumen may contain additives such as petroleum cutters and polymers.
- Disadvantages are their slow initial curing rates and higher cost.
- Emulsions effectively reduce asphalt viscosity for use at lower temperatures.
- Bitumen emulsions are used for various applications.
- For road building, emulsions are used for tack coats, fog seals, slurry seals, and bituminous surface treatment.

Bitumen Binder Modifiers

- Some bitumen binders require modifications to meet specifications.
- Modifiers can increase bitumen binder stiffness at normal service temperature while decreasing its stiffness at low temperatures to improve resistance to thermal cracking.
- There are many bitumen binder modifiers available, and the selection is done with the following objectives in mind:
 - Lower viscosity at high temperature associated with construction.
 - Higher viscosity at high temperature to reduce rutting and shoving.
 - Lower stiffness and faster relaxation to reduce thermal cracking.
 - Increased adhesion between the asphalt binder and the aggregate in the presence of moisture. This is achieved by an anti-stripping additive (0.5 percent by weight).

Polymer-Modified Bitumen

Polymer-modified bitumens are penetration-grade binders used in roads, airfields, and other high-stress applications such as road intersections with heavy traffic density and busy highways with heavy truck movement.

Examples of this type of polymers are as follows:

- Styrene-butadiene-styrene (SBS)
- Styrene-isoprene-styrene (SIS)
- Styrene-butadiene

INDUSTRIAL USES OF BITUMEN

- Roofing ,There are two basic types of bitumen roofs: a built up roof and a prepared roof. – Built-Up Roofing.

STORAGE AND HANDLING OF BITUMEN

- Bitumen is stored and maintained at elevated temperature during production and transportation to the end user.
- When handled properly, bitumen can be reheated or maintained at elevated temperatures without any adverse effect on its properties.

Bitumen Storage Tank Heating Systems

- Direct-Fired Heating. – In this method of heating, oil or gas is burned in a burner inside a tube and hot exhaust gases are circulated through a coil immersed in bitumen.
 - Cooled exhaust gases are next vented to the atmosphere through a high stack.
 - The heat input and temperature increase in tank is regulated by controlling the fuel input to the burner.
 - this method suitable only for small bitumen tanks or for mobile bitumen tanks.