Lecture 20: Properties and Testing of Petroleum Products (Contd.)

Hello and welcome to lecture number 20 of Petroleum Technology. In this lecture, we will talk about the properties and testing of various petroleum products. We have already discussed several properties of many other petroleum products. Today, let us talk about bitumen. Bitumen is the residue product coming out either from the atmospheric distillation unit or the vacuum distillation unit depending on the type of crude petroleum processed in the distillation column. Except that bitumen can also be obtained as a bottom product from various secondary processing fractionators.

All the bitumen is collected together, and primarily, bitumen is used as a paving material for road construction. It can also be used for roofing, water sealing, and more. For these applications, it's essential to determine the properties of bitumen in terms of its viscosity, stiffness, or consistency. The penetration index of bitumen is a standard test, an ASTM standard test, used to evaluate bitumen. This test serves as the basis for determining the various grades of bitumen required for different applications. Bitumen comes in different grades tailored for specific purposes, and these grades are determined through this fundamental test. The test indirectly determines high-temperature viscosity and low-temperature stiffness.

The penetration index provides a measurement of the consistency of bitumen at various temperatures, under different loads, and for varying durations of loading. This test offers insights into how the viscosity of bitumen changes for high-temperature applications and how it gains stiffness when cooled. The penetration of bituminous material represents its consistency and is expressed as the distance in tenths of a millimeter that a standard needle penetrates vertically into a bitumen specimen under specified conditions of temperature, load, and duration of loading.

The scope of the test is as follows: A sample of bituminous material is collected, into which a standard needle is penetrated using a specific apparatus called a penetrometer. This apparatus follows the ASTM standard test procedure. The test determines how deeply the needle can penetrate the bitumen. The test is conducted at various temperatures, under different loads, and with varying durations to assess how long the bitumen can withstand the load.

Straight-run bitumen grades are designated by two penetration values, such as 40, 50, 60, 80, 100, and so on. For example, a straight-run bitumen grade may have a penetration index falling within the range of 40 millimeters to 50 millimeters, indicating its grade. Another grade may have a penetration index ranging from 60 millimeters to 80 millimeters, and so forth. In this system, the softer the bitumen, the higher the penetration index. The penetration of an actual bitumen sample within any grade should fall between the specified lower and upper values. To test the penetration index, the ASTM D 506 standard method is used along with specific equipment designed for measuring the penetration index of bitumen samples.

As you can see, there is a specific needle used for this test. The needle is approximately 1 millimeter in diameter and has a length of 50 millimeters, adhering to the specified specifications. There is also a cup or container where the bitumen is poured, and a meter is used to measure the penetration depth within the bitumen. To measure penetration, a penetrometer is used, and a standard needle is applied to the sample under specified conditions. Before conducting the test, the bitumen is melted and poured into the container. Afterward, the bitumen is allowed to cool at room temperature for a certain period, typically around 30 minutes. Once the bitumen has cooled, and the upper surface is smooth within the container, the container is placed on the stand.

There is a button that needs to be pressed so that the needle can fall freely and vertically into the bitumen without any friction. It then penetrates into the bitumen, and the penetration depth is measured by observing the deflection of the meter. The meter deflects, and the penetration measurement is taken in tenths of a millimeter.

The penetration measurement can be in the range of 40 millimeters or even more precisely, down to tenths of a millimeter. The test apparatus consists of a rigid frame that holds the needle spindle in a vertical position, allowing it to slide freely without friction when the button is pressed. A dial gauge calibrated in millimeters is used to measure the penetration. The test is conducted at 25 degrees Celsius, with the total weight of the needle spindle and any added weights being 100 grams. Typically, the weight of the needle spindle is around 50 grams, but additional weights may be added to achieve finer measurements, especially when testing stiffer bitumen. These additional weights can be 50 grams or 100 grams, depending on the consistency of the bitumen.The procedure involves pressing the button for 5 seconds, which is the standard protocol. After releasing the button, the needle will move upward. This experiment is usually performed three times to obtain a reliable average value for the penetration index.

Another test for bitumen is the softening point test, which serves as an alternative to the penetration index. The softening point is defined as the temperature at which a substance, in this case, bitumen, attains a particular degree of softness under specified test conditions. The softening point test is used for designating hard bitumens and oxidized bitumens. Hard bitumens are pure bitumen obtained directly from the refinery, while oxidized bitumens are air-blown to make them stiffer. Oxidized bitumens have a higher softening point and a lower penetration index. Therefore, the softening point test is applicable to both types of bitumens.

The test for assessing the consistency of bitumen is known as the ring and ball softening point test. This test involves using two steel rings, each weighing around 3.5 grams, as well as two balls and two brass ring holders, all assembled into a structured apparatus. A thermometer is included in the setup. The entire apparatus is submerged in a beaker filled with water. If the softening point of the bitumen is below 80 degrees Celsius, the beaker contains water; if it's above 80 degrees Celsius, the beaker contains glycerol. The purpose of this test is to provide a method for determining the consistency of semisolid and bituminous materials in which the primary or major component is either bitumen or tar. In other words, this test is applicable to substances primarily consisting of heavy residue, which is bitumen, or it can be more broadly referred to as pitch—a general term.

Now, let's discuss the ring and ball test procedure, which is also an ASTM standard test. This test method involves determining the softening point of bitumen within the range of 30 degrees to 157 degrees Celsius using the ring and ball apparatus. The bitumen is immersed in distilled water if its softening point falls within the range of 30 to 80 degrees Celsius and in glycerin if the softening point is within the range of 80 to 157 degrees Celsius. The apparatus is assembled with ball centering guides and the thermometer is properly positioned. The beaker is filled with water to a depth not less than 102 millimeters and not more than 108 millimeters, adhering to the standard procedure.

The bitumen is carefully heated in an oven or on a hot plate until it becomes sufficiently fluid to pour. It should be soft enough to pour easily but not so soft that it drips down. It should maintain a standard consistency so that the rings can be filled completely with bitumen without any dripping. A fixed amount of bitumen is taken, and the rings are filled with it. The bitumen is allowed to cool naturally for the first half-hour, and if it remains soft, it is artificially cooled for another 30 minutes to solidify into a block within the rings. Afterward, steel balls are placed on the bitumen block. This entire apparatus is submerged in the beaker containing water or glycerin. The system is heated slowly at a rate of approximately 5 degrees Celsius per minute.

As the temperature increases, the bitumen becomes softer, and at a certain temperature, the two balls will sag down through the bitumen and come to rest on the lower plate of the apparatus. The temperature at which this occurs is noted. If the balls come to rest at two different times, resulting in a temperature difference of more than 1 degree Celsius, the test must be repeated. Now, let's discuss another test for a different petroleum product, namely petroleum wax. This is also a standard ASTM test known as the cone penetration of petroleum wax. Petroleum wax, which is separated from heavy petroleum products, is primarily composed of long-chain normal paraffin structures, resulting in white petroleum wax. The hardness of petroleum wax needs to be determined for various applications at different temperature points. The hardness of petroleum wax, expressed as a penetration value, serves as an indication of its suitability for a specific application. A low penetration value indicates harder wax, while a high penetration value indicates softer wax. The apparatus used for this test is similar to a penetrometer, but instead of a needle, a cone is employed. The standard steel cone used has a truncated cone shape at the bottom.

Similarly to bitumen, the wax is taken in a container, melted to a liquid state, and then cooled to a low temperature, typically around 5 degrees Celsius, and allowed to cool calmly. Afterward, a sample is taken and placed at the base of the penetrometer. Similar to the bitumen test, the cone is released by pressing it for 5 seconds. The deflection of the needle on the metering gauge allows us to determine how far the cone has penetrated into the wax. This test is conducted three times to obtain a reliable average penetration index, which indicates the consistency of the wax.

Now, let's move on to the Grease penetration test, which is another ASTM standard test. Grease is a semi-solid material produced artificially in refineries for lubrication purposes. It has various applications, and the grease penetration test is conducted to determine the stiffness of grease. If grease is excessively stiff, it may not migrate effectively to the surfaces where it needs to provide lubrication. Conversely, if the grease is too soft, it may migrate away from the surfaces, requiring lubrication.

The stiffness of grease needs to be properly determined, and this is accomplished through the grease penetration test. The penetration test begins with the grease at 25 degrees Celsius, plus or minus 1 degree, being leveled into a cup or container. The upper layer of the grease is horizontally leveled. A cone is dropped into the cup for 5 seconds using a penetrometer, creating a hole in the grease. The penetration of the cone is determined by measuring the deflection on the meter at the top of the penetrometer. The depth of the hole in tenths of a millimeter is measured, which is known as the unworked penetration or P0. If we take a pure grease that has not been used for any purpose before and determine its penetration index, that is referred to as unworked penetration or P0.The grease is then sheared using a mechanical, hand-operated device through 60 double strokes to simulate the usage of grease. This is referred to as worked grease, meaning that the grease has been used for a specific purpose, and after usage, its penetration is measured.

To simulate the worked grease mechanically, the pure grease must be sheared or worked through 60 double strokes using a machine or device. This process simulates the worked grease, and after this mechanical shearing, the cone test is performed to determine the P60 value, which stands for 60 times the double stroke. The P60 value of penetration is known as the worked penetration. Different working strokes can be used to determine the worked penetration, and the penetration index varies depending on the amount of work applied.

Now, let's move on to another test known as the copper strip corrosion test. This test assesses the active sulfur corrosion of various petroleum distillate products, including aviation gasoline, ATF, normal gasoline, lubricating oil, fuel oil, and more. The test involves using a copper strip, a thin copper plate specifically designed for this purpose. The copper strip corrosion test measures the corrosivity of hydrocarbon liquids and focuses on their ability to cause corrosion on the copper strip. No other metals, such as iron or alloys, can be used for this test; it is exclusive to copper strips.

This test is subjective and is based on the discoloration and corrosion observed on a copper strip under standard test conditions compared to a series of ASTM standards. The procedure involves taking around 30 milliliters of the liquid hydrocarbon and immersing the copper strip in it for approximately 3 hours at an elevated temperature, typically around 50 or 100 degrees Celsius, depending on the type of hydrocarbon. The temperature selection is based on the volatility of the liquid; lower temperatures are used for volatile liquids, while higher temperatures are suitable for non-volatile ones. The immersion and testing duration is usually 3 hours.

The corrosion effect on the copper strip is compared with the ASTM corrosion standards, which range from 1a to 4c. These standards provide a set of color references determined by ASTM, and the degree of corrosion observed on the copper strip needs to match these standards. Passing the copper strip corrosion test is often a prerequisite in hydrocarbon liquid product sales contracts. In other words, before a liquid petroleum product can be sold in the market, it must meet the requirements of this corrosion test.

The test involves assessing how elemental sulfur and reactive sulfur species, such as hydrogen sulfide and mercaptans, in the liquid hydrocarbon, interact with the copper test strip. If the reaction causes significant tarnishing or corrosion of the copper strip, the product fails the test. The higher the percentage of sulfur present in the hydrocarbon liquid, the more susceptible the copper strip is to corrosion, leading to test failure. Therefore, there are restrictions on the allowable sulfur content in the liquid product.

The test result is typically expressed as evidence of tarnishing or corrosion by comparing it to the ASTM color standards. This provides a quantitative measure of the degree of corrosion observed on the copper strip. In a similar vein, there is the silver strip corrosion test, where a silver strip is used instead of a copper strip. This test is primarily conducted for aviation turbine fuel to assess its corrosiveness.

The silver strip corrosion test is conducted similarly to the copper strip corrosion test, but it assesses the corrosiveness of aviation turbine fuel (ATF) toward silver. Silver is known to tarnish easily, and aviation turbine fuel must meet stringent standards. Therefore, the silver strip corrosion test is crucial for ATF.

In this test, a polished silver strip is immersed in a sample of the fuel, typically at an elevated temperature, often around 50 degrees Celsius or lower. After a specific test period, which is typically around 3 hours, the strip is removed from the sample, washed, and then evaluated for corrosion. As with the copper strip corrosion test, the results are compared to the ASTM color standard codes to assess the degree of tarnishing or corrosion. These corrosion tests are important in ensuring that aviation turbine fuel meets the required standards for use in aircraft engines, as any corrosive properties could potentially damage the engine components.

It seems like you have a passage with technical specifications and requirements related to different types of gasoline and kerosene. While the information is clear, it could benefit from some improved punctuation and formatting for better readability. Here's a revised version: Two types of gasoline are mentioned: 83-octane gasoline and 93-octane gasoline. The 83-octane gasoline is considered normal gasoline, while the 93-octane gasoline is considered premium gasoline. Visual indicators: The color of 83-octane gasoline should be orange. The color of 93-octane gasoline should be red. These colors are deliberately added to distinguish the gasoline types. Specifications for gasoline: Lead content should not exceed 0.56 grams per liter for 83-octane gasoline. Lead content should not exceed 0.8 grams per liter for 93-octane gasoline, which is the maximum allowable limit. The distillation initial boiling point should be reported for both gasoline types. The final boiling point should not exceed 215 degrees Celsius for both gasoline types, as exceeding this limit may introduce kerosene range hydrocarbons.

Reed vapor pressure at 38 degrees Celsius should not exceed 0.7 kgf per centimeter square for both gasoline types. Sulfur content should not exceed 10 ppm for both gasoline types, conforming to the BS 6 standard. Oxidation stability should be a minimum of 4 minutes for both gasoline types. Copper strip corrosion for 3 hours at 50 degrees Celsius should not be worse than number 1 according to ASTM standards. Density at 15 degrees Celsius should be reported but is not limited. Regarding kerosene, the first characteristic to report is its burning quality because it is an illuminant. The char value should not exceed 20 milligrams per kg of oil burnt. The bloom on the glass chimney should not be darker than gray after keeping it in the standard apparatus for 24 hours. Distillation characteristics should include a minimum of 20 percent recovered below 200 degrees Celsius and a final boiling point not exceeding 300 degrees Celsius. The flash point, as determined by the apparatus, should be a minimum of 35 degrees Celsius but is expected to be higher.

Diesel Fuel Specifications: For diesel fuel, there are two types: high-speed diesel (HSD) and low-speed diesel (LSD). High-Speed Diesel (HSD): The flash point should be a minimum of 38 degrees Celsius, determined in an Abel apparatus. Kinetic viscosity at 38 degrees Celsius should be between 2 and 7.5. Carbon residue should not exceed 0.2

percent, as determined in the Ramsbottom carbon residue test. The cetane number should be a minimum of 42. HSD is used in high-RPM diesel engines.

Low-Speed Diesel (LSD): Flash point should be a minimum of 66 degrees Celsius, determined in a Penske Martens closed cup apparatus. Kinetic viscosity at 38 degrees Celsius should be between 2.5 and 15.7. LSD has a thicker viscosity compared to HSD. Carbon residue should not exceed 1.5 percent, as determined in the Ramsbottom carbon residue test. The cetane number is not specified for LSD. It is used in low-speed engines. In summary, low-speed diesel is considered safer than high-speed diesel due to its higher flash point. HSD is used in high RPM engines and has specific requirements such as a minimum cetane number of 42, while LSD is used in low-speed engines, and its cetane number is not specified.

These are the references. Thank you for your attention.