Kinematic Viscosity: Rotational Viscometer

- **The absolute viscosity** is the time it takes for a fixed volume of asphalt binder to be drawn up through a capillary tube by means of vacuum.
- **The kinematic viscosity** is the time it takes for a fixed volume of asphalt binder to flow through a capillary tube by means of its weight.

- The kinematic viscosity is the absolute viscosity divided by the density of the liquid at the temperature of measurement.
- The 135° C (275° F) measurement temperature was chosen to simulate the mixing and laydown temperatures typically encountered in HMA pavement construction.

- The viscosity of asphalt binder at high manufacturing and construction temperatures is important because it can control the following:
  - **Pumpability**. The ability of the asphalt binder to be pumped between storage facilities and into the HMA manufacturing plant.
  - **Mixability**. The ability of the asphalt binder to be properly mixed with and to coat aggregate and other HMA constituents in the HMA manufacturing plant.
  - **Workability**. The ability of the resultant HMA to be placed and compacted with reasonable effort.

- The basic RV test measures the torque required to maintain a constant rotational speed (20 RPM) of a cylindrical spindle while submerged in an asphalt binder at a constant temperature.
- This torque is converted to a dynamic viscosity and displayed automatically by the RV.

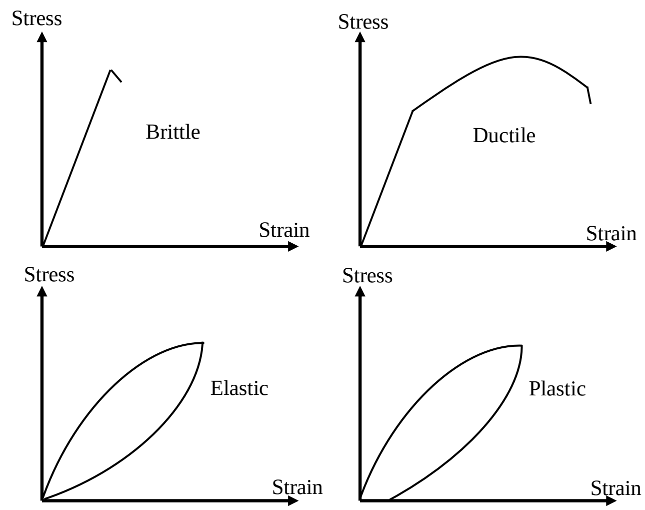
- The basic equations used to calculate viscosity from torque and speed (expressed in terms of angular speed) are:

$$\eta = \frac{\tau}{\gamma}$$

Where: η = dynamic viscosity (Pa·s), τ = shear stress (N/cm^2), γ = shear rate (sec^{-1})

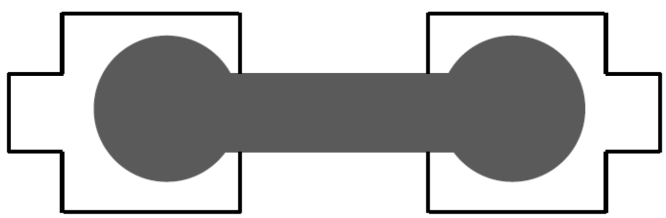
- Typically, the RV simplifies this calculation by measuring torque in percent (0 to 100), dividing it by RPM and then multiplying it by a series of constants determined by the spindle used.

Ductility Test



- Ductility is the ability to elongate before break.
- Ductility test measures asphalt binder ductility by stretching a standard-sized briquette of asphalt binder to its breaking point.

- Asphalt should have enough ductility to resist:
    - Temperature change cracking.
    - Fatigue load cracking.



- Like the penetration test, this test has limited use since it is empirical and conducted at only one temperature (25° C (77° F)).

- Standards:
    - Pulling speed: 5 cm/min.
    - Water path temperature: 25°C.
    - Specification limit ≥ 100 cm.

Rolling Thin Film Oven Test RTFOT

- This test serves two purposes:
    - To provide an aged asphalt product that can be used for further testing of physical properties.
    - To determine the mass quantity of volatiles lost from the asphalt during the test

- Rolling thin film oven test measure the effect of short-term aging due to heat and air.
    - Volatization.
      Loss of volatiles. The loss of smaller molecules from the asphalt binder, volatiles, increases asphalt viscosity.
    - Oxidization.
      Reaction with oxygen from the environment. Some samples can gain weight due to the oxidative products formed during the manufacturing and compaction.

- Mixing and compaction of asphalt at 155°C for 45 minutes is simulated by RTFOT at 163°C for 85 minutes and air exposure.

- After running RTFOT:
    - Measure the properties.
    - Compare with fresh asphalt properties.
    - Determine change percentage and calculate loss percentage in weight.
    - Subject to other rheology tests.

- Unaged asphalt binder is placed in a cylindrical jar. The oven is heated to 325°F (163°C) and rotated at 15 RPM for 85 minutes.
- The rotation continuously exposes new asphalt binder to the heat and airflow and slowly mixes each sample.

- The RTFOT aging procedure is used to simulate aging during mixing and placement, while the PAV aging procedure is used to simulate aging during in-service life.

Pressure Aging Vessel: PAV

- The Pressure Aging Vessel, PAV, provides simulated long term aged asphalt binder for physical property testing.
- Asphalt binder is exposed to heat and pressure to simulate in-service aging over a 7 to 10 year period.

- The basic PAV procedure takes RTFO aged asphalt binder samples, places them in stainless steel pans and then ages them for 20 hours in a heated vessel pressurized to 2.10 MPa.
- Samples are then stored for use in physical property tests.

- Oxidation can occur in the field during two distinct stages of a pavement's life:
    - Mixing and placement.
        - During mixing and placement, the asphalt binder is rapidly aged by volatilization and oxidation.
        - The predominate aging mechanism during this stage is the loss of volatiles resulting from elevated mixing and placement temperatures; oxidation is secondary.
    - In-service.
        - Over the life of an in-service HMA pavement, the constituent asphalt binder slowly ages as the oxygen from the surrounding environment percolates through the HMA and chemically reacts.

- The RTFO aging procedure is used to simulate aging during mixing and placement, while the PAV aging procedure is used to simulate aging during in-service life.
- Therefore, asphalt binder tests concerned with mix and placement properties are conducted on RTFO aged samples. (such as the DSR)
- While asphalt binder tests concerned with in-service performance are performed on samples first aged in the RTFO and then in the PAV. (such as the DSR, BBR and DTT)

There is no parameters measured in this procedure. The PAV is used to simulate asphalt binder aging for use in other tests associated with the performance of asphalt binder.