ASPHALT BINDER MODIFICATION 101 SERIES

How to Modify Asphalt Binder with SBS

Achieving the most optimal polymer modified binder performance starts with the right ingredients. Therefore, the choice of SBS polymer and asphalt binder is critical. Next on the list is the right production process. The production process often begins in a laboratory, where the ingredients are combined for the first time and physical properties are evaluated. This part of the Kraton 101 Series covers how to make polymer modified asphalt (PMA) in the laboratory.

Required Equipment

Before we start the blending process, let's review the required equipment.

High Shear Mill

Typically, SBS polymers are sold in a porous pellet form. This form ensures easily-handled, free-flowing material with a good density, ideal for storage and transportation. When incorporated into asphalt binder, however, the porous pellets are usually too large for a quick low shear dissolution. Sugar cubes and granules are a good analogy. It takes longer to dissolve sugar cubes in a cup of tea. To expedite the process, one may break up the cube. For that same reason, PMA production normally includes a high shear mill that cuts the pellets into small pieces, which are quickly incorporated into asphalt binder. In the lab, this process is simulated with a benchtop mill utilizing a rotor-stator cutting head.


SBS Polymer Pellets


High Shear Mill

Low Shear Blender

Once SBS pellets are cut into small pieces, the SBS and asphalt blend must be stirred. Low shear benchtop blenders with a motor-boat type propeller are an excellent laboratory-scale solution to simulate this process.


Low Shear Blender

Temperature Control Equipment

Temperature is a critical ingredient for making PMA. To make high-quality blends consistently, we must control the blend temperature within a narrow range (+/- 2°C) over the blending period. To achieve such conditions in a laboratory, it is advisable to use a system that includes a:

- heating mantle to provide a heat source to the blend;
- temperature probe that constantly measures the blend temperature; and
- control unit that measures the blend temperature and constantly adjusts the mantle heat output to maintain the target blend temperature.


Temperature Control Equipment

Required Equipment (continued)

Optional Inert Gas Source

During plant production, asphalt binder tanks are typically low in oxygen concentrations. This is not the case in laboratory conditions. The PMA is normally prepared in a metal can, where the blend surface is in contact with a constant supply of new oxygen. Oxygen is a gas that chemically reacts with asphalt to stiffen it. To better simulate the plant blending conditions - especially if the blend is prepared over a long period of time - an inert gas, such as nitrogen or argon, may be purged over the blend's surface. This displaces oxygen to prevent the blend from excessive stiffening.

Ventilation System

Due to the asphalt binder, the PMA blending produces a smell that some may find unpleasant. To maintain odor-free working conditions, it is highly advised to contain the blending process to a fume hood, a canopy or to use an "elephant trunk" fume suction device. In addition, if crosslinkers are used in the blending process, the blend may emit an elevated level of hazardous hydrogen sulfide fumes. In that case, proper ventilation is even more critical.

Personal Protective Equipment

Hot asphalt is dangerous to handle without proper protection. Therefore, proper heat resistant clothing and PPE for the task must be worn. Hot gloves or tongs must be used to safely handle the materials.

Other Items

- Metal cans to hold the blend
- Hot oven to preheat the unmodified asphalt binder
- Laboratory scale to weigh the ingredients
- Metal spatulas
- Tongue depressor
- Paper

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Blending Process

Once you have the required equipment and materials, follow the guidelines below to properly blend the asphalt for optimal performance.

1) Determine the target SBS concentration on weight basis. For example, if a 1 liter (~1 US qt) blend is made, it typically weighs 600g. If the formulation calls for 10% SBS, then the blend would consist of 60g of SBS and 540g of asphalt binder.

2) Record the weight of the metal can where the blend will be made. Measurement should be recorded to the nearest 0.1g.

3) Melt the asphalt binder at a reasonable temperature.

4) Add the appropriate asphalt binder weight to the metal can. In our example, it is 540g.

5) Place the metal can in the heating mantle and set the temperature controller to the target blend temperature. Typically, the blending temperatures range from 170°C (338°F) to 190°C (374°F). If there is no specified production temperature, 180°C (356°F) is a good choice for a laboratory evaluation. Preparation of blends over 200°C (392°F) may lead to polymer degradation and should be avoided.

6) If high shear mill is used, lower the rotor-stator head into the blend. Then agitate the blend at a low blending speed and wait for the blend to reach the target temperature.

7) Increase the mill speed to about 2,000 RPM and add polymer pellets into the blend. It may be necessary to pause high shear milling and use a metal spatula to help the mill pull pellets into the asphalt binder. The blend will emit a characteristic sound of rotor-stator cutting the pellets. Usually the pellet cutting (size reduction) lasts about 2-5 minutes.

8) Always turn off the mill before raising it!

9) Once the sound of pellet cutting stops, raise the rotor-stator head. Using a metal spatula, scrape off any uncut pellets that may be stuck to the rotor-stator head. Also, scrape off any pellets stuck to the can's walls.

10) Lower the rotor-stator head into the blend and continue high shear blending for a total of one hour. Upon completion, the blend should appear fully homogeneous with no polymer particles visible. You may use a "smear" test, where a small amount of the blend is sampled on a thick piece of paper and spread over with a wooden tongue depressor into a thin film. This makes it easy to see if there are small polymer particles left over. If there are particles left over after one hour, it usually means that some pellets got attached to the can wall or the rotor-stator and remained uncut. Another reason for leftover pellets may be related to the mill not properly cutting the pellets. In such case, an adjustment may be needed.

Smear Test

Blending Process (continued)

11) Once the blend becomes homogeneous, the rotor-stator head is removed, and the can is removed from the mantle. At this point, the blend should be weighed to account for portions that remained on the mill's head, or were used as a sample. Record the new weight of the can and its contents. Subtract the can's weight to arrive at the weight of the blend.

12) Place the blend back in the heating mantle and insert the low shear blending paddle. Set the blending speed so that the material is well agitated, but no vortex is formed on the surface.

13) If a crosslinker is used, now is the time to add it. For instance, if 0.1% elemental sulfur is used, multiply the blend weight obtained in Step 11 by 0.1% and add the resulting amount of sulfur.

14) Continue low shear blending for several hours. The blending time may vary and depends on the plant process used. It is advised to continue blending for at least 4-6 hours. When crosslinking is used, the minimum recommended blending time is 4 hours.

15) After the blending time is over, the blend is ready for sampling. It is highly advised to sample the blend immediately after it was prepared. If it needs to cooled off and reheated, it should be reheated to the blending temperature and properly agitated before sampling.

Please note:
The blending progress can be additionally monitored with a UV microscope. This method will be covered in future publications.

Preparing blends at temperatures over 200°C (392°F) may lead to polymer degradation and should be avoided.

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