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Asphalt Emulsions

INTRODUCTION

Because asphalt is a solid at normal ambient temperatures, its use in the paving of roads requires that it be heated until it becomes fluid enough for easy application to the surface of the road. As a result, the task is more costly and time consuming than it would be if the heating requirement could be eliminated.

One common solution to this problem is the use of ***asphalt emulsions***. These emulsions are uniform mixtures of very small asphalt particles in water. The major advantage is that the emulsion is fluid at normal ambient temperatures and can, therefore, be applied without any preheating. Thus, one can benefit from the convenience of handling a fluid, water-based material, while still retaining all of the binding and sealing characteristics of the original asphalt.

THE FORMULATION

Asphalt emulsions may be applied either as a sealer on existing roads or as a binder in new construction. After the water has evaporated from the emulsion, the asphalt particles must be able to form a strong ***electrostatic bond*** with the ***aggregate particles***. Because the aggregate particles are usually negatively charged, an emulsion with ***positively-charged asphalt particles*** is required. However, in some instances, the aggregate may consist of positively-charged particles, and negatively-charged asphalt particles are essential for such applications.

As with any other emulsion, three major ingredients are needed to prepare a good asphalt emulsion:

- the ***continuous phase*** (water)
- the ***internal phase*** (asphalt)
- a ***surface-active agent*** (emulsifier)

In choosing a specific formulation, the primary objective is to maximize the asphalt content of the emulsion, while minimizing the emulsifier level. Experience has shown the an upper limit of about ***65% asphalt*** can be achieved. With that high an asphalt percentage, approximately ***1.5% emulsifier*** will be required, with water making up the balance of the formulation. For lower asphalt levels, the emulsifier level may be reduced proportionally.

The selection of the optimum emulsifier is influenced by several factors. One consideration is the desired ***charge*** on the asphalt particles, as discussed above. A ***cationic emulsifier*** will yield the ***positively-charged asphalt particles*** normally preferred, but negatively-charged particles can be created by employing an anionic type of emulsifier. Also of importance is the ***speed*** with which the emulsion sets after application. Some formulations lead to an emulsion that breaks as soon as it is applied, while other formulations produce an emulsion that allows a longer working interval before the emulsion breaks. After the emulsion has broken, evaporation of the water proceeds rapidly, and the asphalt is then able to bond to the aggregate. Many of the major ***emulsifier manufacturers*** are experienced in such matters, and they can provide guidance in selecting the best emulsifier system for a particular application.

THE COLLOID MILL

Bematek **high-shear colloid mills** are ideal for providing the mechanical energy required to produce stable asphalt emulsions with particles of the desired size, while minimizing the required surfactant level. For most asphalt emulsions, it has been found that asphalt particles in the ***2-5 µm*** range usually exhibit the best performance characteristics. Asphalt particles larger than approximately 5 µm do not penetrate the aggregate well enough to provide the desired level of bonding, while asphalt particles smaller than about 2 µm penetrate the aggregate so well that larger volumes of emulsion are required for a given road surface area.

Note: *For some specialized applications, asphalt emulsions with smaller (sub-micron) or larger (10-20 µm) particles may be preferable.*

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The ease with which the ***rotor/stator gap*** of a *Bematek* colloid mill can be adjusted while the machine is in operation to precisely set any desired hydraulic shear rate, makes ***particle size control*** a simple matter. Variations in the critical final particle size due to premixing irregularities or raw material quality fluctuations can be compensated for in a matter of seconds with a simple gap setting adjustment.

A second major advantage of high-shear colloid mills is their ability to produce a stable emulsion with ***lowered surfactant levels***. This fact was mentioned earlier, but it needs to be emphasized here. If a lower energy device (such as a low-energy mixer) was used in the past, it is important that the formulation be adjusted when switching over to a colloid mill process. Also, many emulsifier manufacturers will recommend a certain usage level for their product based on the assumption that a low-energy mechanical device will be used. The high level of hydraulic shear provided by a colloid mill should be taken into account during the formulation process. There is little point in unnecessarily using more of these expensive chemicals than one actually needs.

In choosing a colloid mill for a specific application, it is essential that the proper ***materials of construction*** are used. This can only be assured through a cooperative effort between the manufacturer and the end user. Both the ***elastomeric seals*** and the ***metallic wetted parts*** must be of materials that will not corrode due to the effect of any ingredients in either the emulsion formulation or the anticipated cleaning solutions. Furthermore, the ***rotor and stator*** must be manufactured from a hard enough material to provide acceptable ***erosion resistance***. This latter concern is particularly important if a highly abrasive solids are included in the formulation. Although *Bematek's* standard materials of construction are suitable for most asphalt emulsion applications, *Bematek* colloid mills can be readily supplied in a wide range of alternative materials for extreme situations.

An additional concern is the ***processing temperature***. For optimum milling efficiency, the effective ***viscosity*** of the asphalt should be approximately ***500 cP*** or less. This may be achieved by heating the asphalt to a temperature of ***300-350°F***. Alternatively, cutting the asphalt with a small percentage of a petroleum solvent will allow the desired viscosity to be reached at a much lower processing temperature.

Finally, one must select a colloid mill with the appropriate ***rotor/stator design***. The ***capacity*** of the mill, the ***horsepower*** requirements and the final emulsion ***particle size*** are all impacted by this critical aspect of the mill's design. While some manufacturer's offer only a standard design, *Bematek* always specifies a rotor and stator that are specifically designed for the intended application. *Bematek's* decades of experience in processing asphalt emulsions means that every *Bematek* asphalt mill is equipped with the proper components for efficient and reliable operation.

THE PROCESSING SYSTEM

Having selected a properly designed colloid mill and a suitable formulation, the remainder of the ***processing system*** must be specified. There are two basic approaches to this:

- Heat the asphalt to high temperatures, such as ***450°F***, so that ambient temperature water may be used. This simplifies the design of the water phase equipment and the cooling requirements at the discharge of the colloid mill, but it places greater demands on the asphalt phase equipment.
- The second approach, which can produce smaller particle sizes, involves a trade off in the temperature levels. Both the water and asphalt phases are maintained at approximately equal temperatures in the ***200-300°F*** range.

Note: *As the latter approach involves a more complex system but yields better results, it is the primary focus of the remainder of this discussion.*

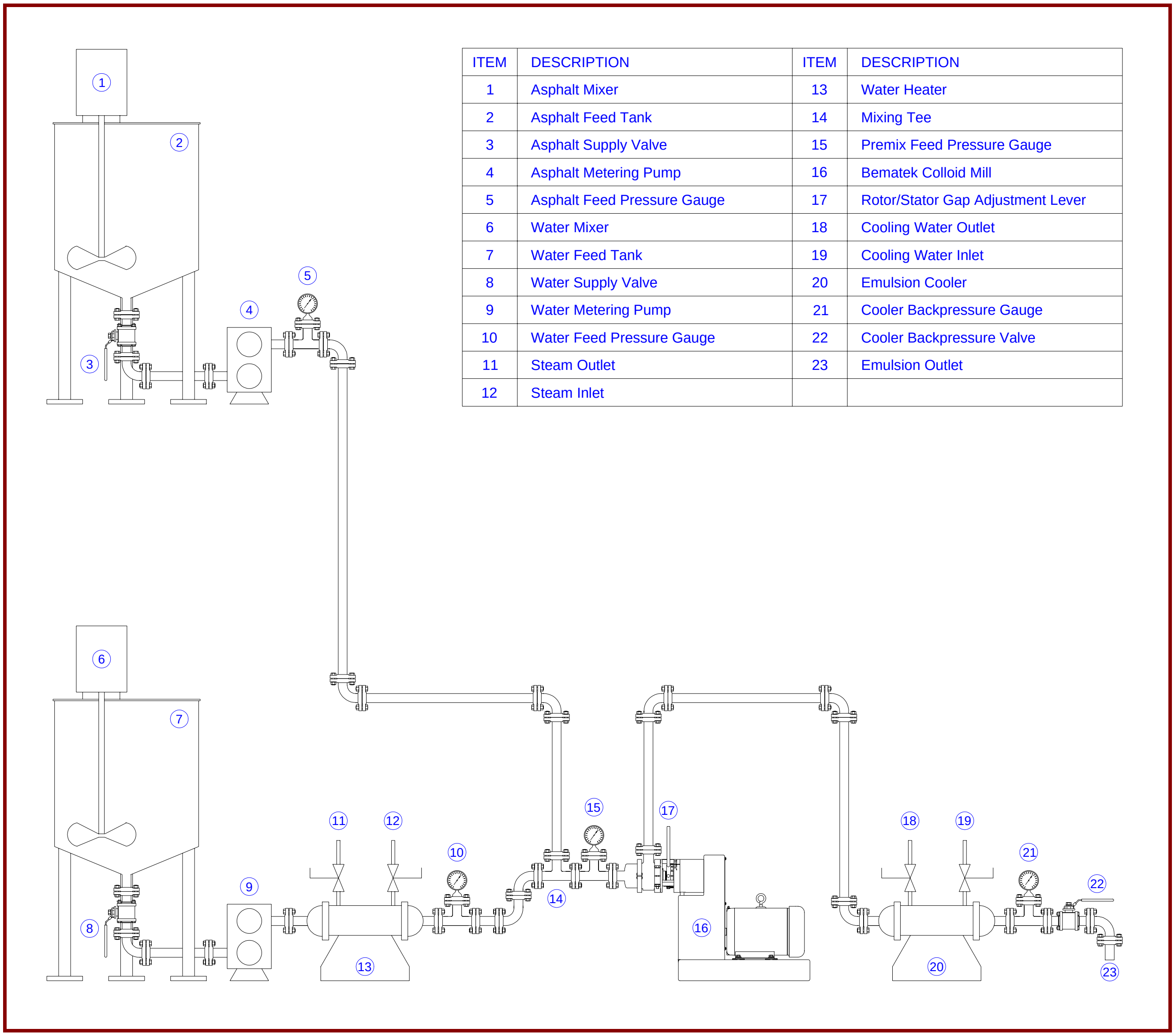
In designing a ***superheated water*** based processing system, there are two primary factors that greatly influence the choice of equipment. First, the asphalt must be maintained at a temperature sufficient to keep its viscosity at 500 cP or less until it passes through the rotor/stator gap. As a result, the water will also have to be at that temperature to ensure a good quality premix at the inlet to the colloid mill. Thus, all of the ***pipelines and valves*** in the system must be ***jacketed or traced***, as well as insulated. Also, the rotor shaft bearings of the colloid mill must be protected from excessive heat build up. A well designed colloid mill, such as *Bematek's*, incorporates a ***cooling jacket*** for this purpose.

In addition to the heating requirements on the inlet side of the colloid mill, a cooler must be installed as close as possible to the ***discharge*** from the mill. Most commonly, ***heat exchangers*** of the tube-in-shell or plate type are used for this purpose. It is absolutely critical to the quality of the finished product that the emulsion be cooled, as quickly as practical, to a point at which the asphalt has solidified. The reason for this is that molten asphalt droplets have a much greater tendency to agglomerate than solid asphalt particles. Thus, inadequate cooling will result in final particle sizes that are substantially larger than would be obtained with a properly designed heat exchanger in the system.

Another consideration in designing a plant is the choice between a ***continuous system*** or ***batch system***. In a batch system, a complete premix is prepared in a single feed tank, and the batch is then milled and collected into a storage tank. In a continuous system, the asphalt phase and the water phase are prepared separately, and they are then metered together at the inlet of the colloid mill. With this approach, production can proceed indefinitely by simply keeping adequate supplies of both phases flowing to the mill. In most instances, the continuous system is preferred for asphalt emulsions because it provides a more reproducible emulsion quality. Furthermore, the batch system requires the use of a large, sealed, pressurized vessel at the typical processing temperatures of asphalt emulsions.

A TYPICAL SYSTEM

The clearest way to describe the basic features that should be incorporated into a typical ***asphalt emulsion plant*** is to analyze a system for a hypothetical situation. Let us suppose that one wishes to use a continuous system to emulsify 50% asphalt into water at a temperature of 300°F. With an arrangement such as that shown in *Figure 200-1* below, the following steps would lead to the desired results:



ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	Asphalt Mixer	13	Water Heater
2	Asphalt Feed Tank	14	Mixing Tee
3	Asphalt Supply Valve	15	Premix Feed Pressure Gauge
4	Asphalt Metering Pump	16	Bematek Colloid Mill
5	Asphalt Feed Pressure Gauge	17	Rotor/Stator Gap Adjustment Lever
6	Water Mixer	18	Cooling Water Outlet
7	Water Feed Tank	19	Cooling Water Inlet
8	Water Supply Valve	20	Emulsion Cooler
9	Water Metering Pump	21	Cooler Backpressure Gauge
10	Water Feed Pressure Gauge	22	Cooler Backpressure Valve
11	Steam Outlet	23	Emulsion Outlet
12	Steam Inlet		

Figure 200-1: A Typical Continuous Asphalt Emulsion System

A TYPICAL SYSTEM (cont.)

1. Add a known weight of ***water*** to a jacketed feed tank, and dissolve or disperse the desired amount of all ***water-soluble surfactants and additives***. Finally, complete the aqueous phase by continuing modest agitation while heating the contents of the feed tank to about 200°F.

2. Add the ***asphalt*** to a second jacketed tank and heat the asphalt until it is completely molten at a temperature of 300°F. Be sure to allow sufficient time for this, as the asphalt is an excellent thermal insulator and it needs a lengthy time to completely melt. Mild agitation in the tank will help to distribute the heat evenly throughout the batch. Any ***oil-soluble additives*** or ***cutting solvents*** may be blended into the asphalt phase at this time.

3. After both phases have reached the desired temperatures, open the supply valve on the water tank and start the water feed pump. Adjust the steam pressure on the ***water heater*** to provide a water temperature of 300°F at the discharge of the heater.

Note: *The water feed pump, which should be a positive-displacement* ***metering pump****, must generate a pressure of at least* ***70 psi*** *pressure to prevent flashing of the water in the pipelines.*

4. After flow has been established into the discharge piping, adjust the ***cooler backpressure*** to at least 70 psi to prevent flashing in the cooler. Then, adjust the ***cooling water flow*** to provide a product discharge temperature of about 100°F. Finally, start the colloid mill and adjust the ***rotor/stator gap*** to the desired value.

5. After all pipelines and valves have reached a stable temperature of 300°F, open the supply valve on the asphalt tank and start the ***asphalt feed pump***. This pump must also be a ***positive-displacement metering pump***, and it should be set for a flow rate equal to that of the water phase metering pump in order to produce a 50% asphalt level in the finished emulsion. Furthermore, it should generate an asphalt pressure of at least 15 psi above the water pressure in order to produce a good premixing action within the mixing tee. In this case, that would mean an asphalt pressure of ***85 psi*** would be required.

Note: *Usually, the first portion of the discharged product should be discarded, because it will take a few minutes for the asphalt level in the final product to stabilize at the desired 50% level. The flow of finished asphalt emulsion may be diverted to the designated collection vessel, as soon as all system variables are within acceptable limits.*

6. After the entire batch has been processed, the system should be ***thoroughly flushed*** with a suitable cleaning solution. One approach would be to continue the flow of the water phase after the flow of the asphalt phase has been terminated. This will flush everything except the lines containing pure asphalt. Those lines may be cleaned by recirculating hot solvent through the asphalt feed pump and back into the asphalt tank.

Because the premix is formed right at the inlet to the colloid mill in a continuous system, there is no hold time to ensure that the premix quality is acceptable. Fortunately, there is a reliable technique that produces an excellent premix in this situation. The water flow is forced to make a right angle turn just ahead of the colloid mill, while the molten asphalt is injected directly into this stream through a spray nozzle. In *Figure 200-2* below, a sketch of the ***mixing tee*** that is used for this purpose is shown. In fact, the resulting premix is usually superior to that made by the batch method.

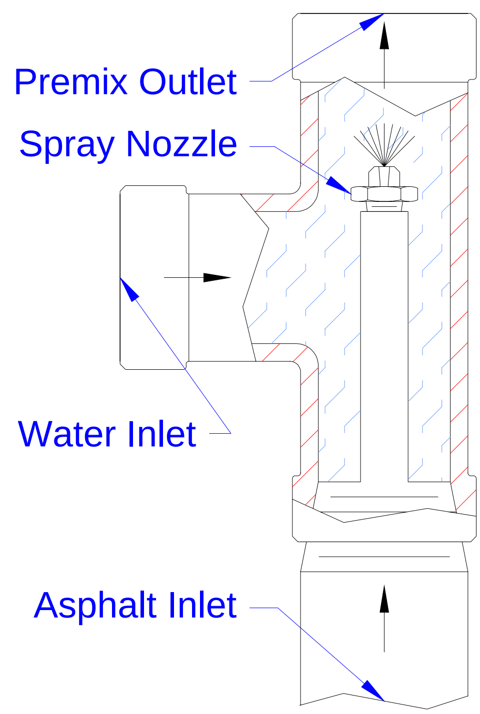


Figure 200-2: A Typical Mixing Tee

CONCLUSION

A ***high-shear colloid mill*** can readily produce fluid, high-percentage, aqueous asphalt emulsions that offer substantial benefits over the use of molten, pure asphalt. The physical characteristics of the finished emulsion can be adjusted to suit the specific requirements of any application by controlling the ***formulation*** and ***particle size*** of the emulsion. Examples of the physical properties that can be controlled through formulation and/or particle size include:

- emulsion viscosity
- asphalt particle charge
- emulsion break time
- asphalt percentage
- emulsion pH

Before closing, a common point of confusion with regard to asphalt emulsions should be clarified. If asphalt is a solid at ambient temperature, how can we talk about asphalt emulsions at this temperature? Doesn't an emulsion consist of two liquids? Technically speaking this is absolutely true. The finished product should more accurately be called an ***asphalt dispersion***, because it consists of solid asphalt particles suspended in water. However, the colloid mill does produce an ***asphalt emulsion***, since the asphalt is a fluid at that point in the process. Therefore, from the viewpoint of the equipment manufacturer, the term *"emulsion"* is appropriate for this application. Such terminology for this product has simply become commonly accepted in the industry, at any phase of the production cycle.

The ***design parameters*** required to implement a continuous-system approach to asphalt emulsion production can become quite complex, depending upon the degree of automation desired. They involve mainly the following:

- sensors
- controls
- utilities

The above components maintain all temperatures and flow rates at the correct values. Also, valves must be installed to divert the flow of each fluid to the correct location at the right time. Although the design of such a system is not a simple matter, continuous systems have been in use for many years. When properly designed, they are remarkably trouble free.

Of necessity, this discussion has only scratched the surface of asphalt emulsion technology. The milling of asphalt emulsions has slowly evolved over so many years that an enormous amount of expertise has been accumulated by specialists in this field. If additional details are desired, it is highly recommended that one or more of these experts be consulted. They may be found in such diverse disciplines as:

- colloid mill manufacturer
- emulsion technologist
- system design engineer
- surfactant manufacturer

Only by piecing together the information from all these sources, can a complete picture be formed.

- *Stephen F. Masucci* - Technical Director