EQUIPMENT FOR HOT RECYCLING

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Equipment for hot recycling can be divided into three categories -- 1) removal and sizing; 2) reprocessing; 3) laydown and compaction. Some pavements can be easily ripped full-depth and the reclaimed asphaltic material reduced to an appropriate size through a standard crushing operation. Cold milling machines can often be used to remove and size an asphalt pavement in a single operation. The reclaimed material can then be reprocessed along with additional new materials through a modified batch or dryer-drum plant to produce hot paving mixtures. Although many plant modifications have been tried, only a few are currently being used. These modifications allow plants to reprocess reclaimed asphaltic materials, producing a quality product at relatively high production rates within acceptable emission levels. Hot paving mixtures containing various percentages of reclaimed asphaltic material can be successfully used in a wide variety of applications and can be placed with standard laydown and compaction equipment.

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Removal and Sizing

Rip and Crush

Reclaimed asphaltic material is usually obtained from the mainline and/or shoulders of an existing roadway. The asphalt pavement may be removed full-depth by front-end loaders, bulldozers, or motorgraders (possibly equipped with special ripper attachments). This type of removal technique is primarily used when an existing pavement exhibits distress which can only be corrected by complete reconstruction. It may also be appropriate in cases where an existing base (or lower layer) must be replaced or reworked, where an existing roadway or detour is to be abandoned, where an existing roadway is to be realigned, or possibly where an asphalt overlay is to be stripped from an existing portland cement concrete pavement. Although it can be done one lane at a time, it is very difficult to maintain anything but low traffic volumes through a reconstruction project using this type of removal technique.

After ripping, the chunks of reclaimed asphalt are usually loaded into trucks and hauled to a central location. This material can be stockpiled for future use or it can be immediately crushed and recycled. Usually a standard crushing operation (jaw for primary and roll for secondary) is used to size the reclaimed asphaltic material prior to recycling. No attempt is made to rigidly control the overall gradation of the material; only to reduce all the chunks to an appropriate maximum size and to avoid creating excessive fines. No major equipment problems have occurred at the crusher on past projects; even on projects where the crushing was done in very hot weather.

Cold Milling

Cold milling machines may be used to remove and size an asphalt pavement in a single operation. Several equipment manufacturers (CMI, Barber-Greene, Barco, Galion, Gomaco, G.J. Payne, etc.) currently produce equipment of this type in various sizes and with varying capabilities. This type of equipment is primarily used on projects which require only partial depth removal of an existing pavement.

Figure 1. Cold milling machine.

Cold milling machines use a rotating drum with special teeth to cut a pavement to a predetermined depth and size the reclaimed asphaltic material. Single-pass cutting widths of up to 12 feet and depths of 4+ inches have been attained. The size of the milled product will vary depending on several factors -- number, type, arrangement, and condition of the cutting teeth; forward speed of the machine; depth of cut; and properties of the reclaimed material. The milled material will usually be suitable for hot recycling without further size reduction, although there may be a small percentage of oversize that will need to be screened or scalped off. There will usually be a slight increase in the aggregate fines as a result of milling. This increase has not been critical on past projects; in most cases, it has been easily offset by the additional virgin aggregate required for the hot recycling plant operation. Cold milling machines can leave an acceptable temporary riding surface, and traffic (even higher volumes) can usually be maintained provided sufficient pavement structure remains in-place. Efforts continue to be made to improve the overall productivity of these machines by developing longer lasting cutting teeth and reducing equipment downtime.

Sizing

As previously mentioned, the reclaimed asphaltic material should be reduced to an appropriate maximum size through the crushing or milling processes. Based on past projects, this appropriate maximum size appears to be in the 1 1/2- to 2-inch range. Particles of this size seem to be able to break down into their original asphalt and aggregate components when put back through a batch or dryer-drum plant modified for hot recycling. This allows thorough mixing with the additional new materials. Also, existing crushing and milling equipment can readily produce material in this size range while maintaining high production rates and without significant aggregate degradation. In most cases, specifying a maximum size less than 1 1/2 inch is unnecessary; it only increases costs and aggregate degradation. Allowing particles greater than the 2-inch maximum in a hot recycling process is very risky because they may not break down inside the plant. When this happens, the large chunks remain intact in the final mix adversely affecting laydown and performance of the pavement.

Reprocessing

Batch Plants

In a conventional batch plant operation, virgin aggregate is dried and heated in a counterflow dryer, screened into various size fractions, proportioned with hot asphalt cement, and thoroughly mixed. Several attempts have been made to recycle reclaimed asphaltic material directly through the dryer in this type of operation. These attempts have usually resulted in low production rates, excessive smoke emissions, and material buildup problems.

The only technique that has proven successful in recycling through a batch plant is the mixer heat-transfer method. In this method, virgin aggregate is superheated (450°-600°F) in the dryer and transferred to the tower by the hot elevator. The reclaimed asphaltic material, which has been previously reduced to an appropriate size and stockpiled at ambient temperature, is transferred to the weigh hopper in the mixing tower by an auxiliary conveyor system. There it is proportioned with the superheated virgin aggregate. Heat transfer occurs as the two materials are mixed in the pugmill with additional asphalt cement and/or an asphalt softening agent.

Figure 2. Batch plant modified for mixer heat-transfer method.

The mixer heat-transfer method minimizes the possibility of smoke emissions and material buildup problems by not passing the reclaimed asphaltic material through the dryer, hot elevator, and screens. There is some sacrifice of

gradation control with this process, but with the lower percentage (50% or less) of reclaimed material that is generally used there has been no problem on past projects in meeting standard gradation requirements for new mixes. Near normal production rates can usually be maintained at the plant using this technique. The percentage of reclaimed asphaltic material that can be used depends on the following factors:

1. The moisture content of the reclaimed asphaltic material.
2. The required temperature of the resultant mix.
3. The temperature to which the aggregate is heated.
4. The stockpile temperature of the reclaimed asphaltic material.

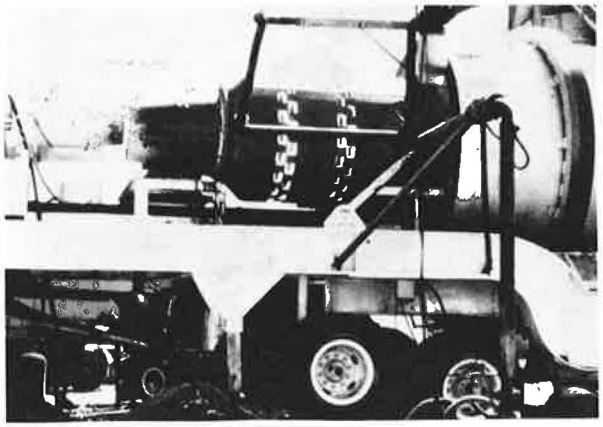
The mixer heat-transfer method was first used on a project in Maplewood, Minnesota, in 1976. Since that time, many projects have been successfully completed using the technique. These projects have generally used up to 50 percent reclaimed asphaltic material. Several plants with baghouse collectors have used the process and no major problems have occurred, but it should be noted that the exhaust gas temperature must be carefully controlled to avoid damaging the bags. The cost to modify a plant to recycle by this method is minimal and such a modification can be made on most existing batch plants in this country.

Dryer - Drum Plants

In a conventional dryer-drum operation, virgin aggregate is proportioned at the cold feed; then it is dried, heated, and mixed with hot asphalt cement in a parallel-flow dryer. Since the aggregate enters at the burner end of the drum, it is immediately exposed to very high temperatures from the flame and hot gases. Early attempts to hot recycle were made through unmodified or only slightly modified dryer-drum plants. Exposing the reclaimed asphaltic material (especially the very fine asphalt particles) to the high temperatures at the burner end of the drum produced very heavy smoke emissions. Despite the emissions problem, satisfactory mixes were produced on most of these early projects. This encouraged several governmental agencies and private companies to continue to investigate the concept of hot recycling through a dryer-drum plant. A considerable amount of effort has been made during the past several years by certain equipment manufacturers to develop modifications for drum mixers which would produce satisfactory mixes, maintain high production rates, and minimize air quality problems. The following sections briefly describe the plant modifications that have proven successful on past projects and are currently being used to hot recycle.

Pyrocone System. This system, developed by the Boeing Construction Equipment Company, controls the heat transfer rate at the burner end of the drum to prevent overheating the reclaimed asphaltic material. The system consists of a cylindrical combustion chamber with a conical heat shield ("Pyrocone") at one end. The unit is installed between the burner and the drum entrance by moving the burner assembly back on the drum frame. The flame volume is contained within the cylindrical chamber where excess air and combustion gases are mixed to produce a lower temperature, air-rich mixture. The excess air flows into the combustion chamber through slots in the chamber wall. The reclaimed asphaltic material enters the drum (usually with some percentage of virgin aggregate) by a single conveyor at the burner end. The materials are gradually heated and blended, additional asphalt cement and/or an asphalt softening are added, and mixing is completed in the remainder of the drum.

Figure 3. Pyrocone system.



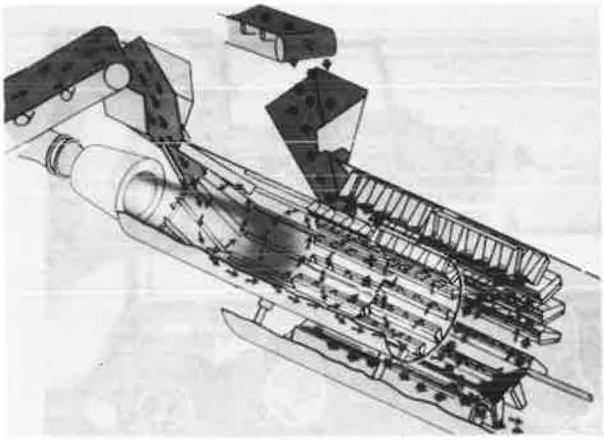
The reduced heating rates produced by this system are the result of the following three interrelated factors:

1. The heat shield ("Pyrocone") reduces direct heat radiation by interrupting the line-of-sight path between the flame volume and the material to be heated.
2. The heat energy entering the drum is more uniformly distributed over the drum cross section.
3. The temperature of the incoming gases is lowered from 2500+ degrees F. to approximately 1200 degrees F.

This system does have the capability of using 100 percent reclaimed asphaltic material, but a more reasonable maximum to expect in order to control smoke emissions is approximately 60 to 70 percent. If conventional (all virgin) mix is to be produced by a plant having this modification, the heat shield ("Pyrocone") can be readily removed.

Drum-in-a-Drum System. The "Drum-in-a-Drum" recycling system was developed by the Iowa Manufacturing Company. With this system, a convenional dryer-drum is modified by moving the burner back from the end of the main drum and inserting a smaller drum. The burner discharges into the upstream end of the smaller drum which extends coaxially into the main drum. The virgin aggregate enters at the burner end of the smaller drum and thus is in direct contact with the flame. The reclaimed asphaltic material enters through the annular space between the outer and inner drums; therefore, it is shielded from direct contact with the flame, but is heated by tumbling against the hot inner drum. The superheated virgin aggregate exits from the downstream end of the inner drum and joins the partially heated reclaimed material. The two materials are then combined with additional new asphalt cement and/or an asphalt softening agent, and the mixing continues throughout the remainder of the main drum.

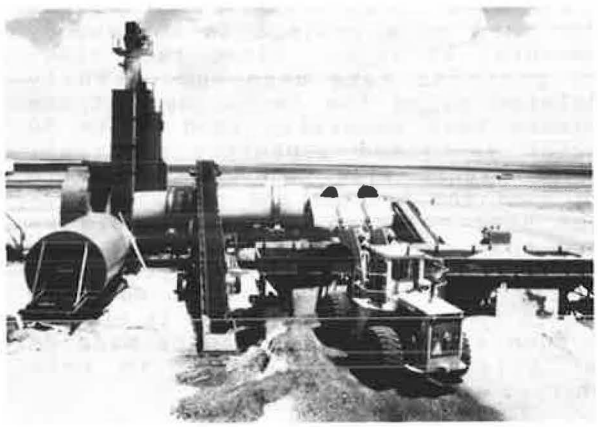
Figure 4. Drum-in-a-drum system.



This system can use a maximum of 50 to 70 percent reclaimed asphaltic material. The required plant modifications are relatively simple and inexpensive, and conventional hot mix can be produced without having to remove the inner drum.

Center-Feed System. In this type of system, virgin aggregate enters at the burner end of the drum while the reclaimed asphaltic material enters near the midpoint (behind the radiation shield that is commonly used in some plants). Flighting in the drum may be modified in order to insure maximum heat transfer to the virgin aggregate. The virgin aggregate will usually be in the 300-500 degree F. range by the time it reaches the midpoint of the drum, while the combustion gases will normally have cooled to 800-1000 degrees F. This provides sufficient heat for mixing with the reclaimed material, but usually not enough to cause overheating and resultant smoke problems. The reclaimed material enters the drum through a series of gates, chutes, or other types of openings that are covered by a metal collar extending around the drum shell. In some cases, additional cooling air may be incorporated at this entry point in order to further reduce temperatures and minimize the possibility of overheating. Additional asphalt cement and/or an asphalt softening agent are added to the combined materials and mixing is completed in the lower half of the drum. This type of system can use a maximum of approximately 60 to 70 percent reclaimed asphaltic material, and it can be readily switched to the production of conventional mixes.

Figure 5. Center-feed system.



The basic concept behind this type of recycling system was originally conceived by Mr. Robert Mendenhall of the Las Vegas Paving Corporation. Mr. Mendenhall developed a "split-feed" system in which crushed asphaltic material was divided into several size fractions and each entered the drum at different points. The coarse material entered at the burner end and the finer fractions entered away from the flame at intermediate points along the length of the drum.

The following equipment manufacturers have developed "center-feed" modifications for dryer-drum plants:

1. Barber-Greene Company ("Dual-Zone Thermodrum")
2. CMI Corporation ("Roto-Cycler")
3. Standard Havens Company ("Cone-flight")
4. Astec Industries, Inc. ("Dual Entry System")

Each of the above described systems ("Pyrocone," "Drum-in-a-Drum," and "Center-Feed") can effectively control smoke emissions while producing hot mixes containing up to 50-70 percent reclaimed asphaltic material. In order to meet current standards for particulate emissions, however, a good wet scrubber or

baghouse must be used. This is true whether the plant is producing conventional mixes or mixes containing reclaimed material.

Laydown and Compaction

Conventional equipment and procedures have been used for laying and compacting hot mixes containing various percentages of reclaimed asphaltic material. No unusual problems have been encountered on past projects and normally the mixes containing the reclaimed materials have handled the same as conventional mixes, provided the laydown temperatures have been comparable.

Figure 6. Laying mix containing reclaimed asphaltic material.

Conclusions

The necessary equipment for all phases of hot recycling is currently available. This equipment will no doubt continue to be refined and improved as various highway agencies, contractors, and equipment manufacturers gain additional experience with the recycling concepts. Also, new pieces of recycling equipment (for removing and reprocessing asphalt pavements) with expanded capabilities will probably appear in the coming years as the demand for recycling increases. It can be stated without reservation, however, that the current generation of hot recycling equipment has the capabilities to produce a quality product at competitive production rates while meeting all air quality standards.