MARTCP

**Training/
Qualification
Program**

**Hot Mix Asphalt
Plant Technician
Level I**

Aggregate Drying and Heating Systems

Page 5 -1

1

Objectives….

- Identify drying and heating principles that apply to all dryers
- Types of dryers
- Types of burners
- Identify factors that affect drying efficiency
- Ways to identify if inefficient drying is occurring

2

Dryer Requirements

- Must be capable of heating to within the specified range of any mixture...
- And measuring the aggregate temperature at the discharge chute.

Page 5B

3

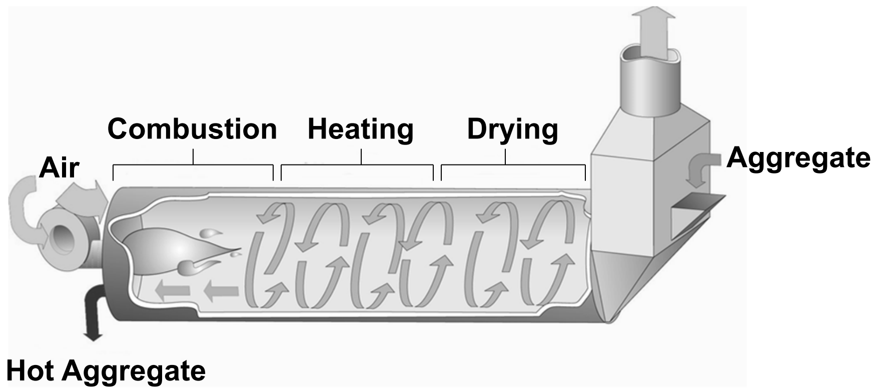
Two Types of Dryers

- Counter-flow
- Parallel-flow

Page 5B

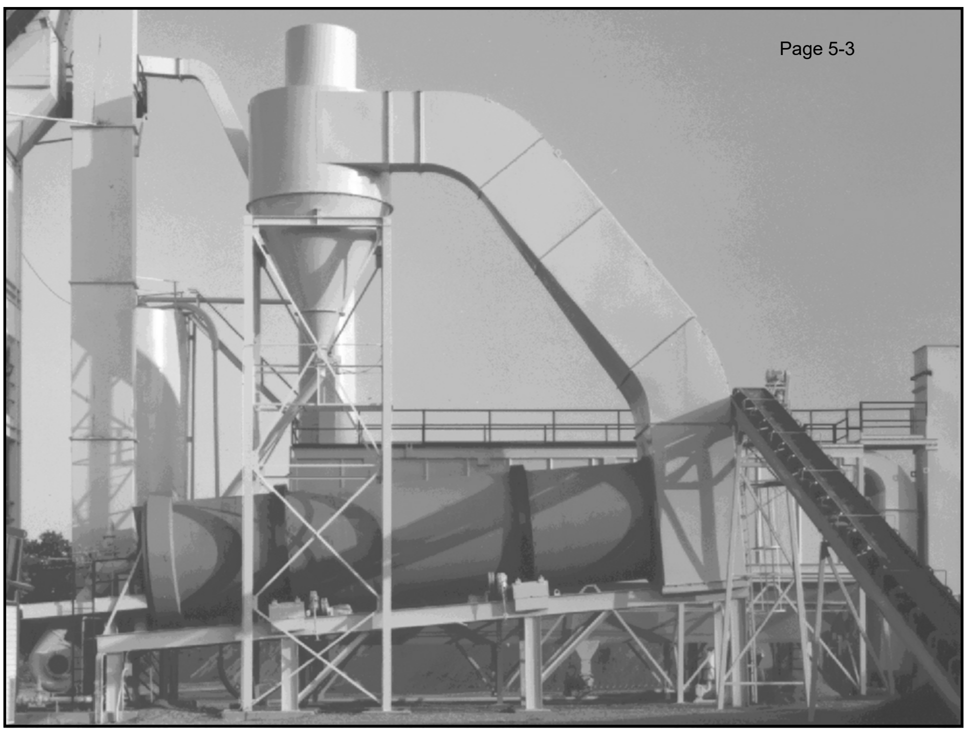
4

Typical Counter-Flow Dryer Batch Plant



Page 5-2

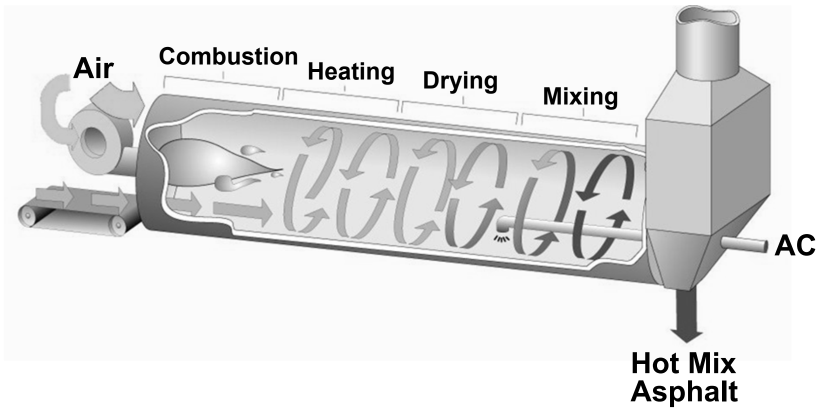
5



Page 5-3

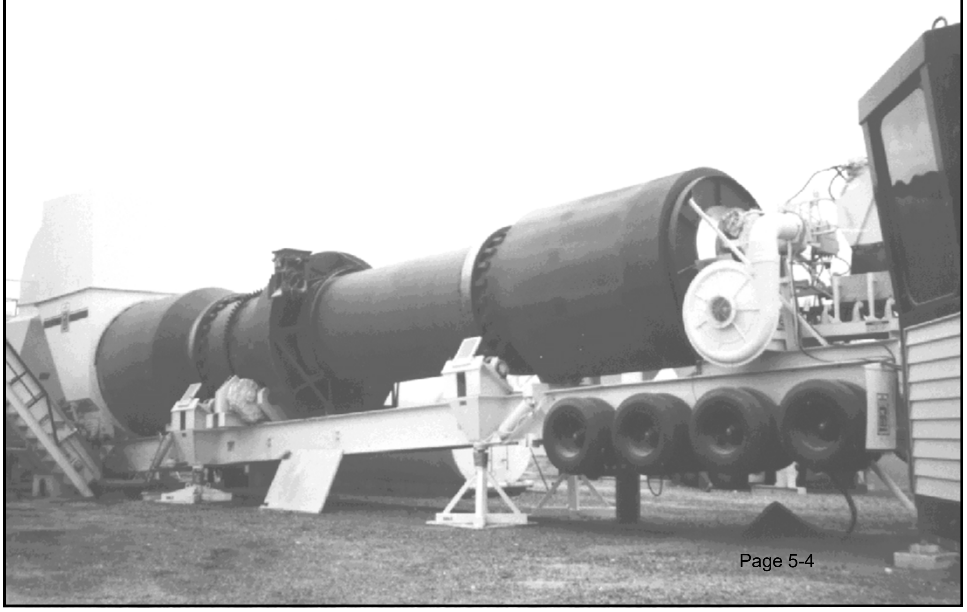
6

Typical Parallel-flow Drum-Mixer



Page 5-3

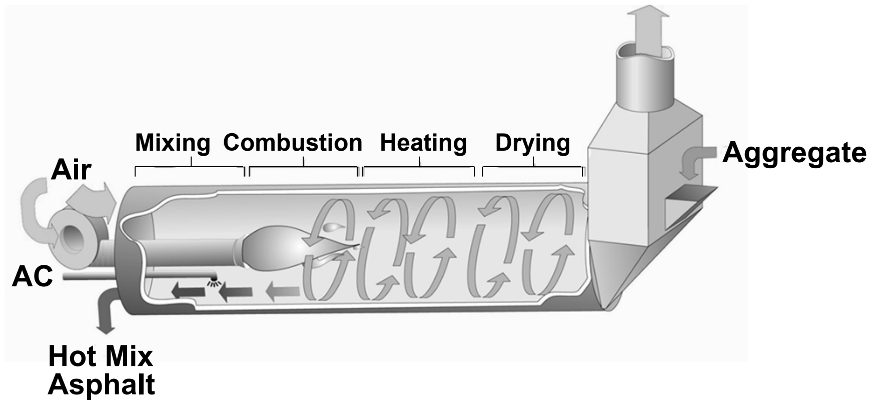
7



Page 5-4

8

Typical Counter-Flow Drum-mixer



Page 5-4

9

Counter-flow Drum Mixer

10

Functional Activities of the Dryer

✓Proper Combustion

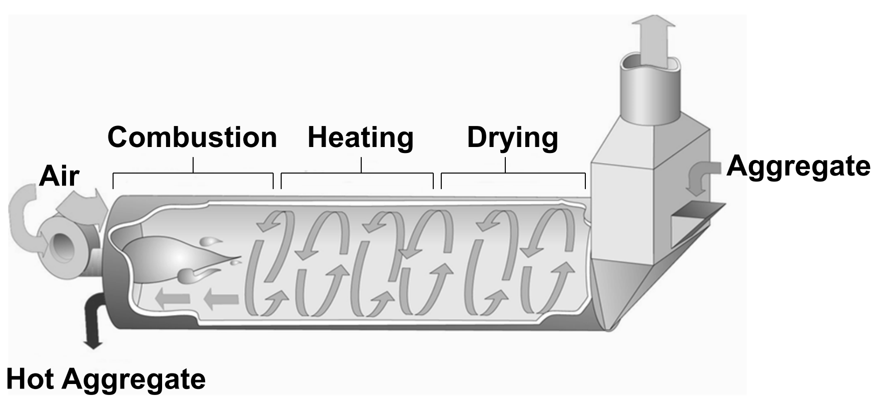
✓Drying Aggregate

✓Heating Aggregate

Page 5-5

11

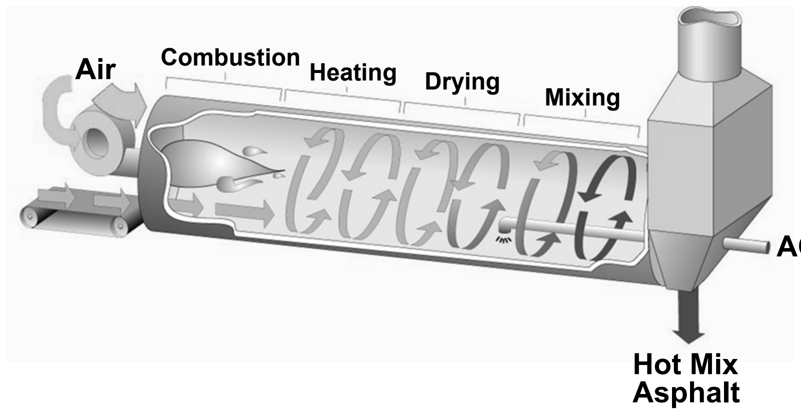
Counter-Flow Batch Plant Dryer Zones



Page 5-5

12

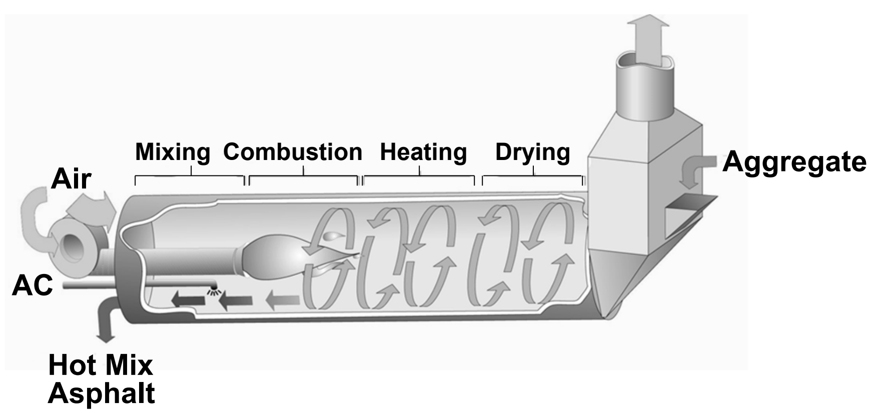
Parallel-Flow Drum-Mixer Zones



Page 5-6

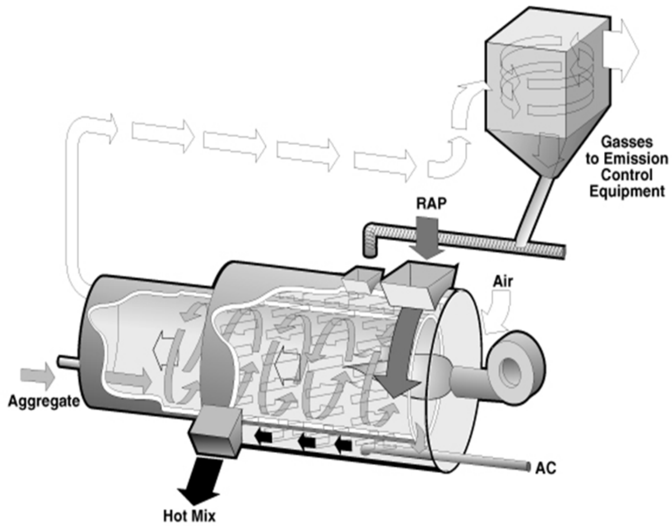
13

Counter-Flow Drum-Mixer Zones



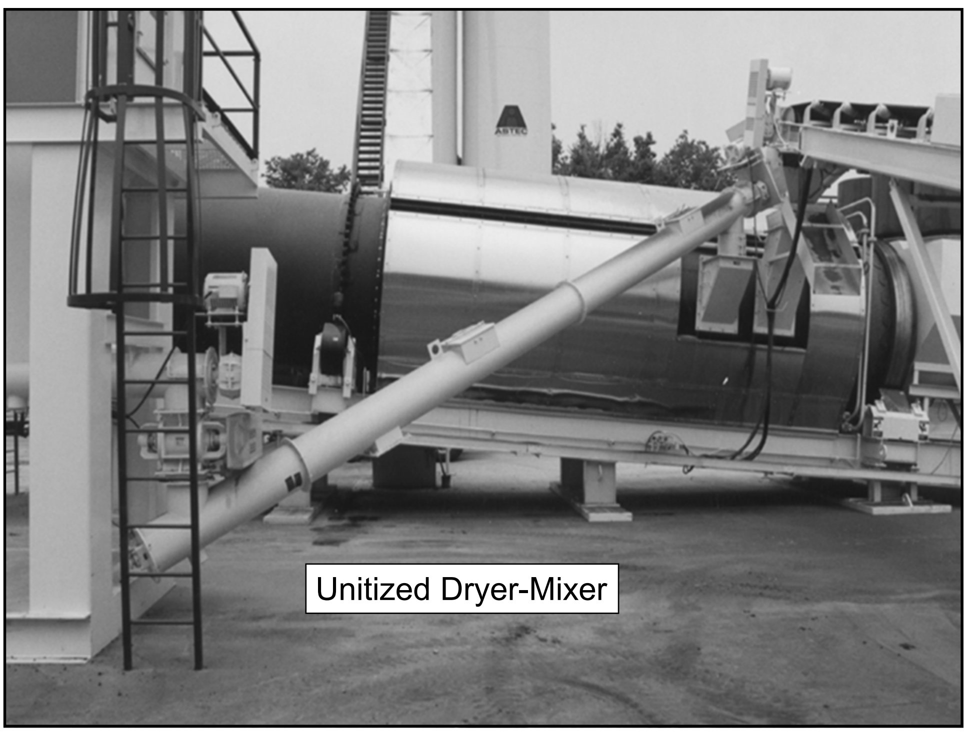
Page 5-6

14



Unitized Dryer/Mixer

15



Unitized Dryer-Mixer

16

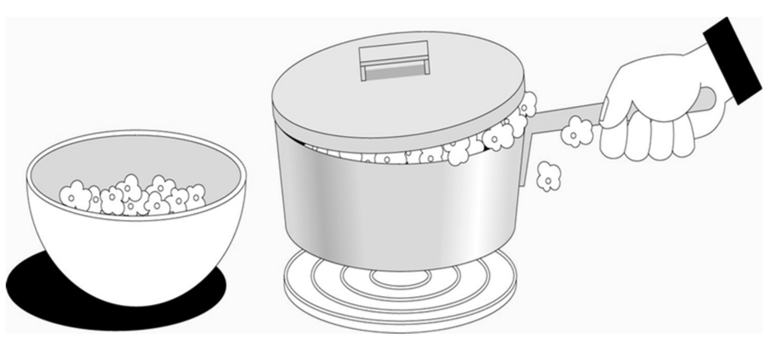
3 Types of Heat Transfer

- Conductive
- Convective
- Radiant

Page 5-6

17

Example of Conductive Heat Transfer



Page 5-7

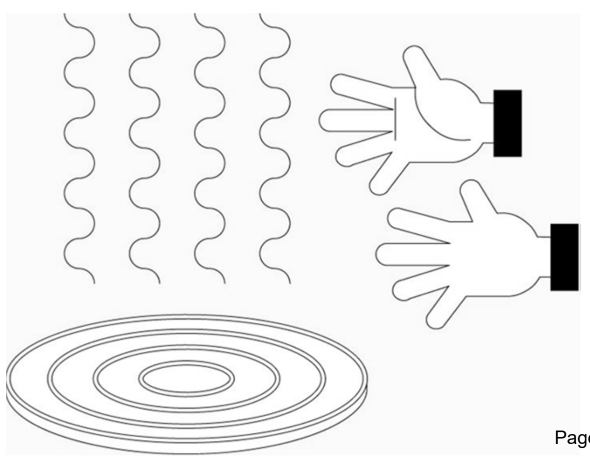
18

Example of Convective Heat Transfer

Page 5-7

19

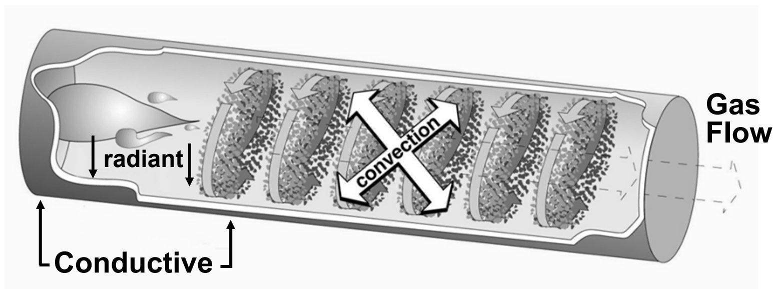
Example of Radiant Heat Transfer



Page 5-7

20

3 Types of Heat Transfer in Aggregate Dryer



Page 5-8

21

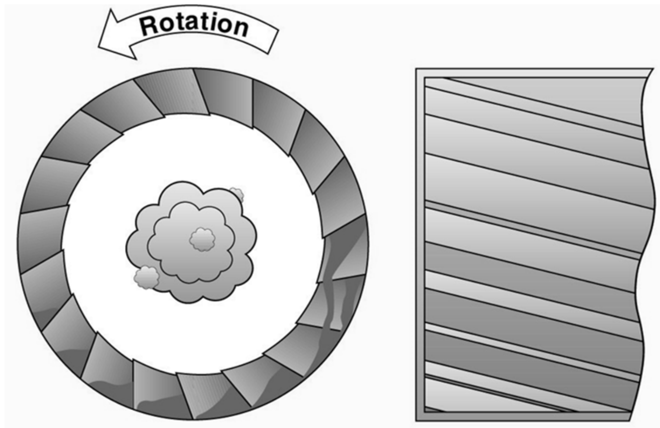
Creating Material-Free Combustion Area

1. Spiral-style flights
2. Combustion-style flights

Page 5-9

22

Spiral Flights

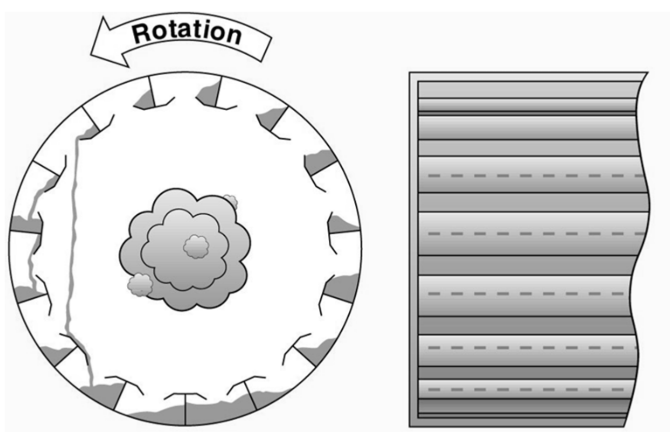


Spiral Flight

Page 5-10

23

Over Flame Combustion Flight

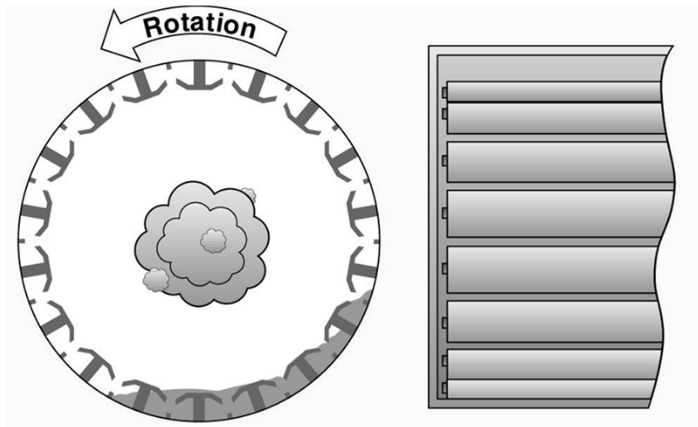


Combustion Flight
(Aggregate carries over flame)

Page 5-10

24

Under Flame Combustion Flight



Combustion Flight
(Aggregate passes under flame)

Page 5-11

25

Burners

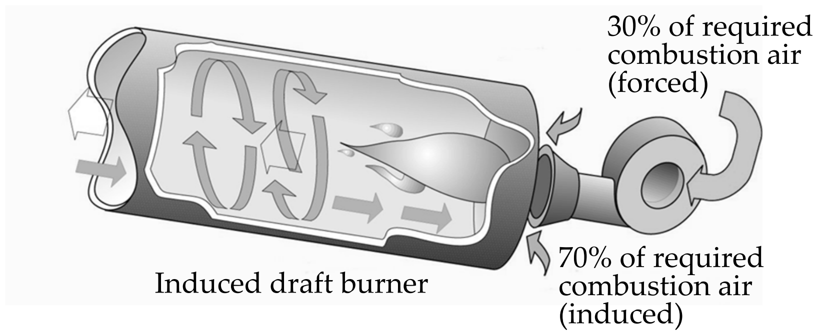
Two Types of Burners

"Induced Draft"

"Total Air"

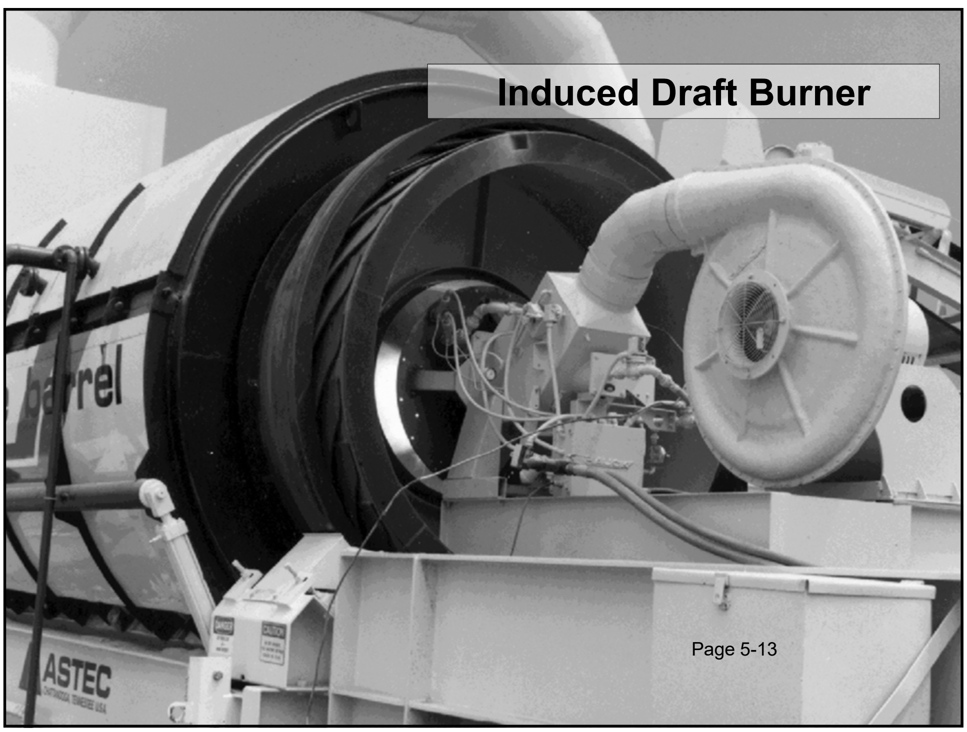
27

Induced Draft Burner



Page 5-12

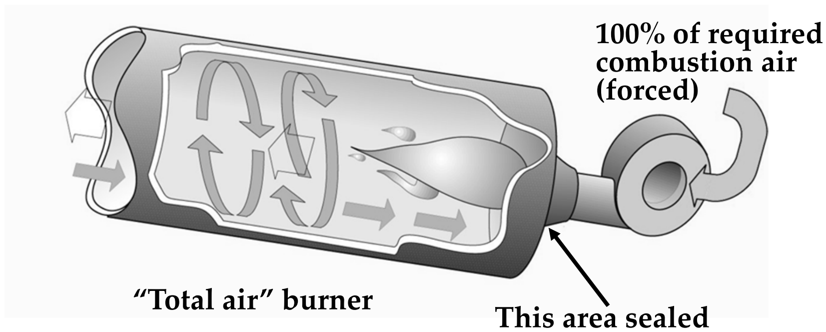
28



Page 5-13

29

Total Air Burner



Page 5-13

30

"Total Air" Burners

Advantages:

- Quieter
- Adjustable for better combustion and cleaner gaseous emissions

Disadvantages:

- Cannot see flame…must be run by instrument not sight

Page 5-13

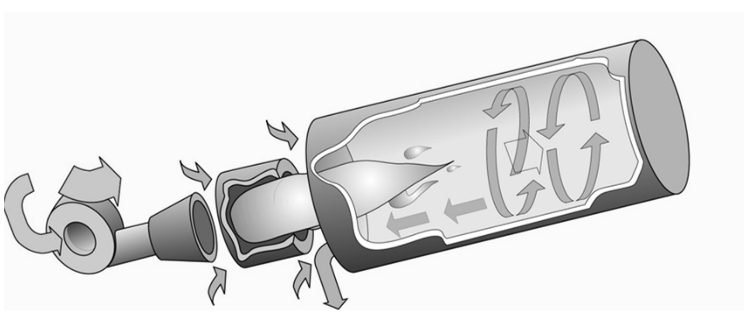
31

Total Air Burner

Page 5-14

32

Older Style Burner with Combustion Chamber



Page 5-14

33

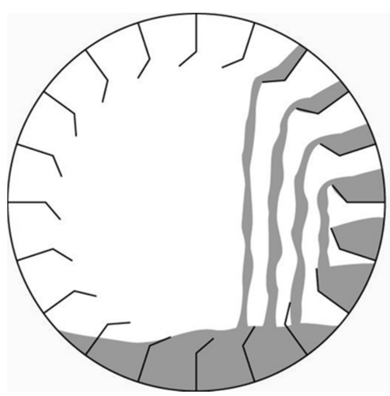
Proper Veiling of Aggregate

Proper Rotation Speed

Page 5-16

34

Insufficient Veiling

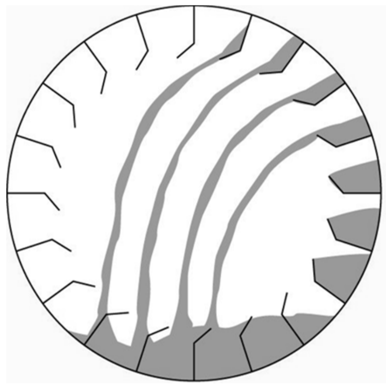


Rotation too slow, material falls short

Page 5-17

35

Overveiling

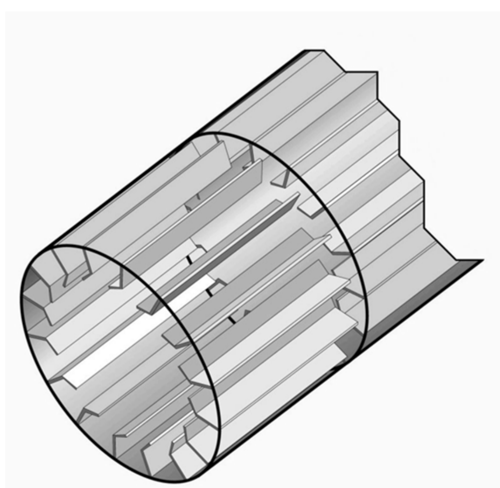


Rotation too fast, material pitches long

Page 5-17

36

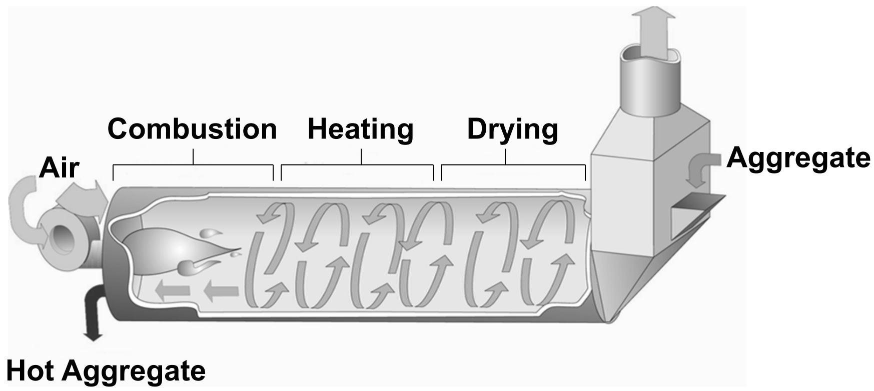
Staggered Rows of Flights



Page 5-18

37

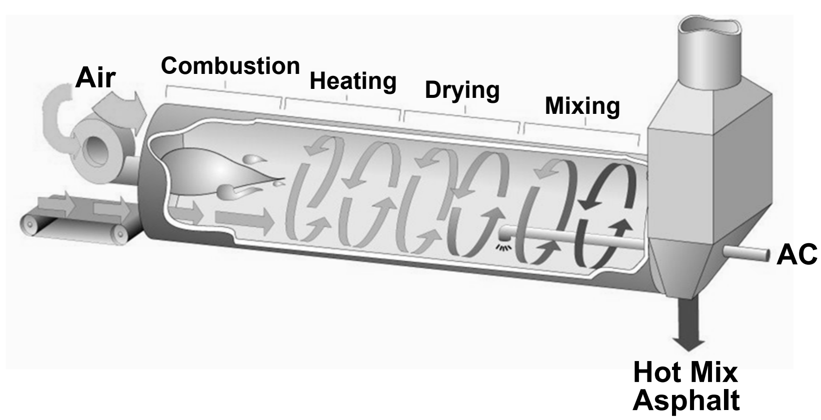
Counter-Flow Batch Plant Dryer Zones



Page 5-19

38

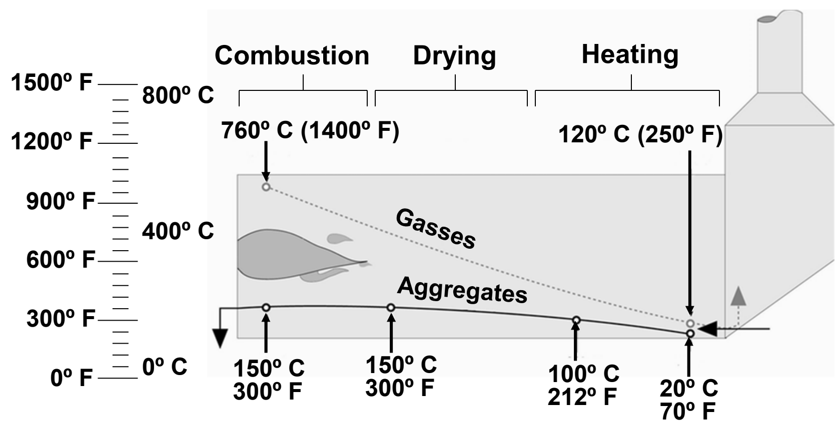
Parallel-flow Drum-mixer



Page 5-19

39

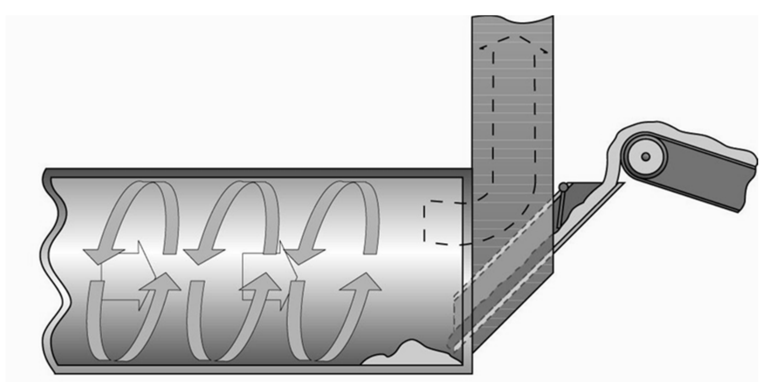
Temperature Profile of Counter-Flow Dryer



Page 5-20

40

Typical Fixed Chute Entry



Page 5-26

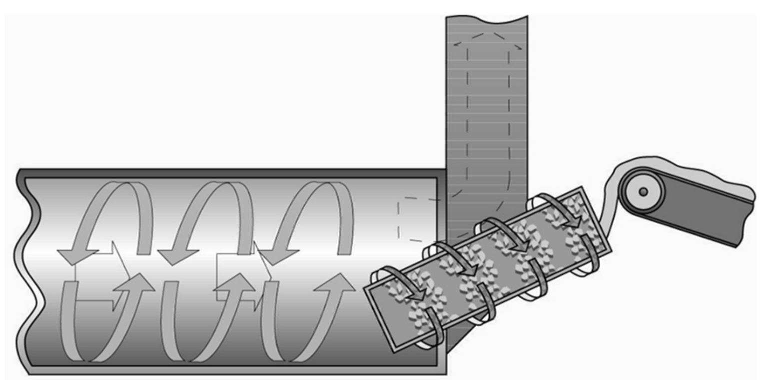
43

Fixed Chute Entry to Dryer with Vibrator on Chute

Page 5-26

44

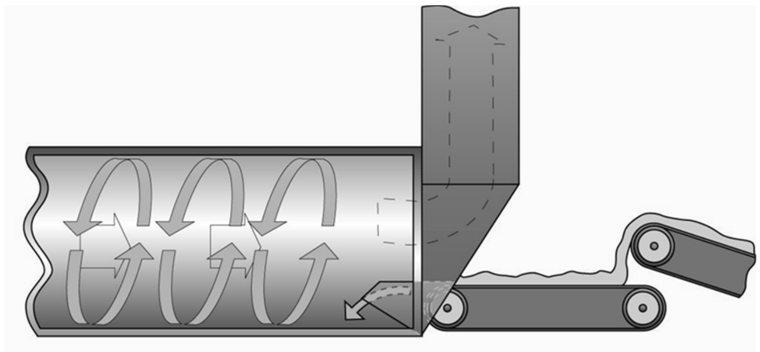
Rotating Feed Entry



Page 5-27

45

Slinger Feed Entry



Page 5-28

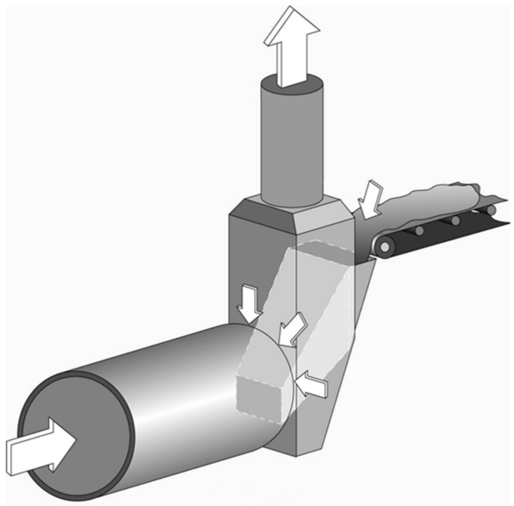
46

Slinger Feed Entry to Counter-Flow Drum-Mixer

Page 5-28

47

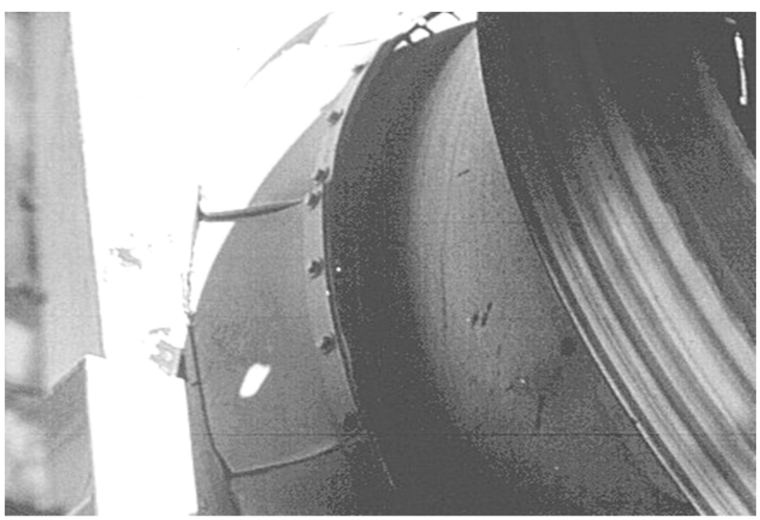
Tramp Air Being Drawn in Around Entry End of Counter-flow Dryer



Page 5-29

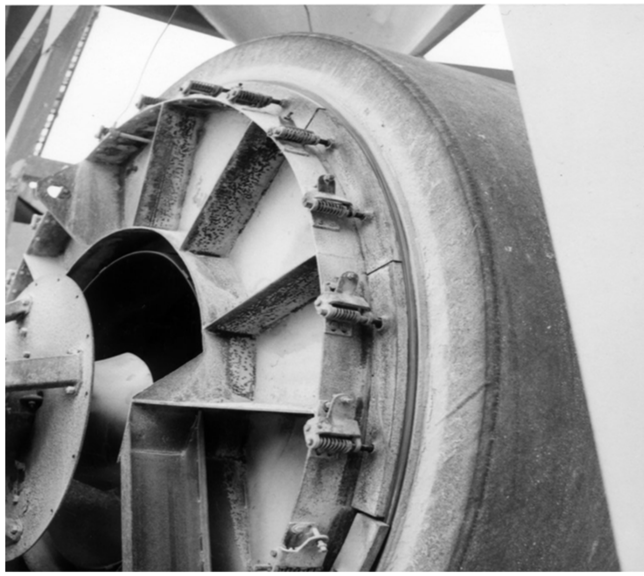
48

Belting Type Dryer Seal



49

Mechanical Type Dryer Seal



Page 5-29

50

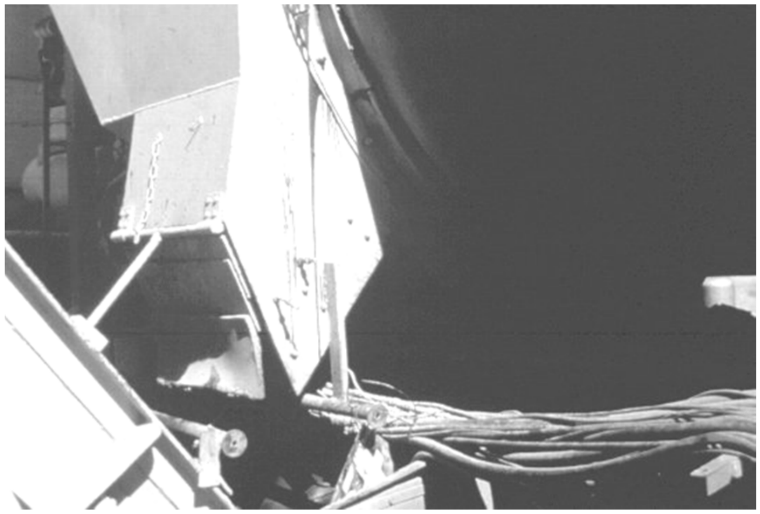
Gravity Drop Chute from Dryer

Page 5-31

51

Sweep Discharge on Drum-mixer or Dryer

Page 5-31



52

QUESTIONS

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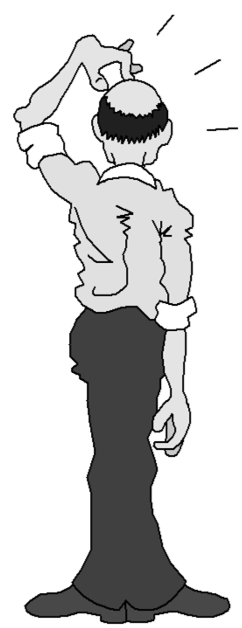

55

MODULE 5

AGGREGATE DRYING AND HEATING SYSTEMS

Glossary of Keywords

Burner	A device used on the dryer to produce the flame and hot gas stream that is used to dry the aggregate material in a hot-mix plant.
Combustion	A process of turning fuel and air into a flame and hot gas stream.
Counter-Flow	A type of dryer in which the aggregate direction moves opposite (counter) to the flow of the gas stream.
Drum-Mixer	A dryer that is used to dry aggregate and mix new liquid asphalt with the aggregate so that the final hot-mix product is produced in the dryer device.
Dryer	A device used to dry aggregate in a hot-mix facility.
Parallel-Flow	A type of dryer in which the aggregate direction moves in the same direction as (parallel to) the flow of the gas stream.

5.1 INTRODUCTION

Aggregate Drying and Heating Systems

Regardless of plant facility style, an aggregate dryer is used in the production of hot-mix. The aggregate must be dried and heated before it can be blended with new liquid asphalt to make hot-mix. The principles of aggregate drying are essentially the same, regardless of the style of plant or dryer being used. Drying principles, therefore, will be presented as a functional area, covering both batch-type facilities and drum-mix facilities.

The purpose of the aggregate dryer is to dry aggregate to <0.5 percent moisture (by weight of aggregate), and to ensure that the aggregate is heated sufficiently so that with heat losses through the rest of the facility, the end product can be produced to the desired temperature. Because temperature is very important to the effective placement and compaction of hot-mix asphalt, the efficiency and effectiveness of the dryer is of paramount importance.

An integral part of the drying function is the burner. The burner must be sized for the production rate of the dryer and be sufficient for the local moisture conditions. Production rate through the facility is generally determined by the dryer size, assuming the burner is sized properly for the dryer. Moisture, plant elevation, product temperature, and aggregate type all affect dryer performance. Typical production rates, based on these variables and burner sizing, based on required and anticipated drying rates, will be discussed later in this section.

5.2 COUNTER-FLOW AND PARALLEL-FLOW DRYERS

Dryers are primarily divided into two categories, counter-flow and parallel-flow, regardless of whether the plant facility is a drum-mix type or a batch type. "Counter-flow" as shown in figure 5.1, and "parallel-flow" refer to the direction of the gas flow relative to the aggregate flow.

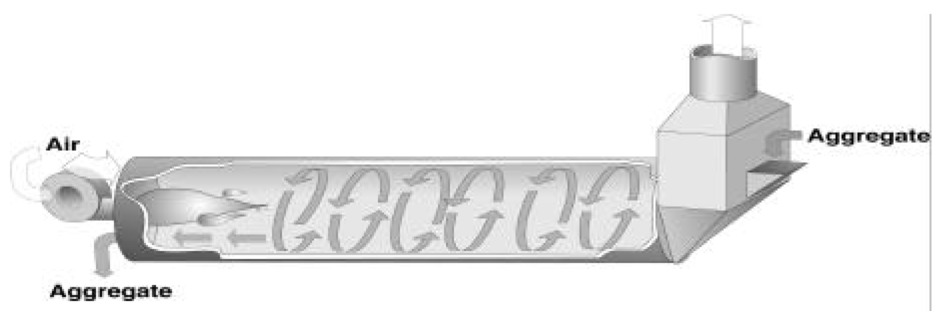

Figure 5.1 Typical counter-flow dryer.

In counter-flow dryers, which are typical of most batch-type facilities and shown in figure 5.2, the aggregate is flowing toward the burner, and the gases and products of combustion are flowing away from the burner, out of the dryer, and against the flow of the aggregate.

Figure 5.2 Counter-flow dryer on batch plant.

In parallel-flow dryers shown in figure 5.3, which are typical of most drum-mixers manufactured between the early 1970s and late 1980s, the aggregate enters the end where the burner is located and travels the same direction as the gas flow, hence the term parallel-flow.

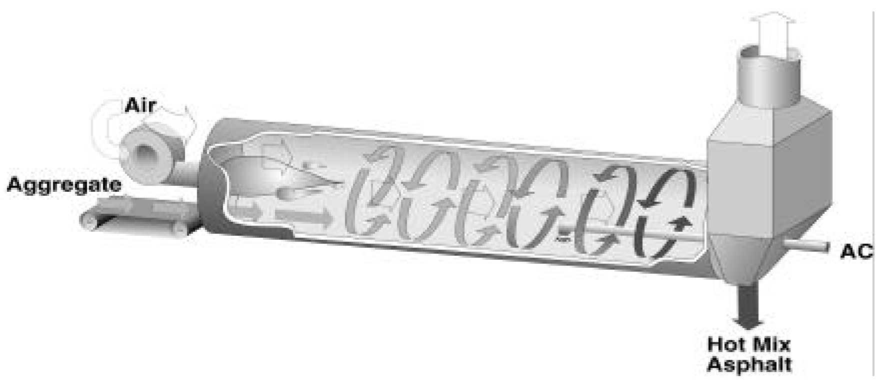

Figure 5.3 Typical parallel-flow drum-mixer.

Note that the parallel-flow drum-mixer shown in figure 5.4 typically has the new liquid asphalt being introduced near the discharge area of the dryer.

Figure 5.4 Parallel-flow drum-mixer.

In counter-flow drum-mixers shown in figure 5.5 and 5.6, which have been popular since the late 1980s, the aggregate enters as it does on a traditional counter-flow dryer, on the cold end, and travels toward the burner. The aggregates pass beyond the burner and continue toward a mixing area. The actual configuration of the burner position and mixing area depends on the manufacturer.

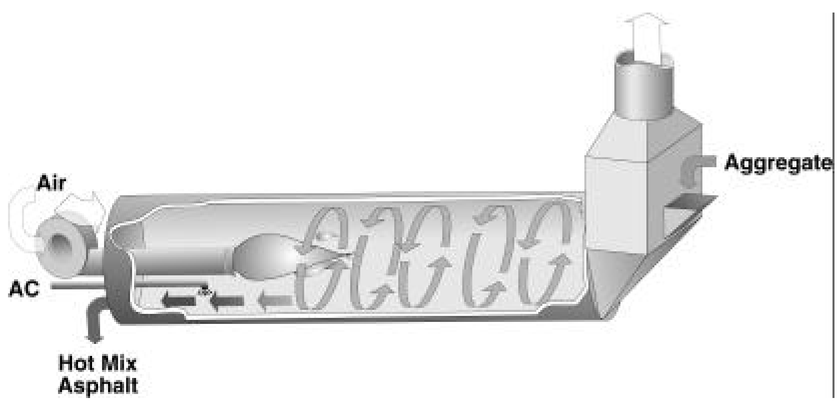

Figure 5.5 Typical counter-flow drum-mixer.

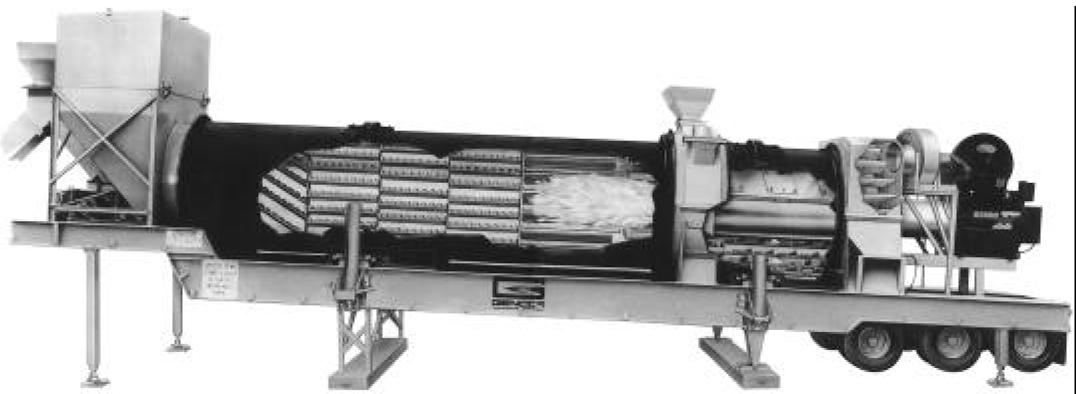

Figure 5.6 Counter-flow drum-mixer.

In counter-flow dryer-mixer facilities, the dryer is very similar to a counter-flow batch-plant dryer, but a separate continuous mixer (either pugmill-style or mixing-drum style) is used to mix the aggregate with the new liquid asphalt cement and other liquid ingredients.

5.3 HEAT TRANSFER AND DRYER ZONES

Regardless of dryer configuration, whether counter-flow or parallel-flow, the following functional activities are being performed in the dryer:

- Combustion
- Drying
- Heating

Depending on the dryer configuration, these functions happen in different places in the dryer as shown in figures 5.7, 5.8, and 5.9.

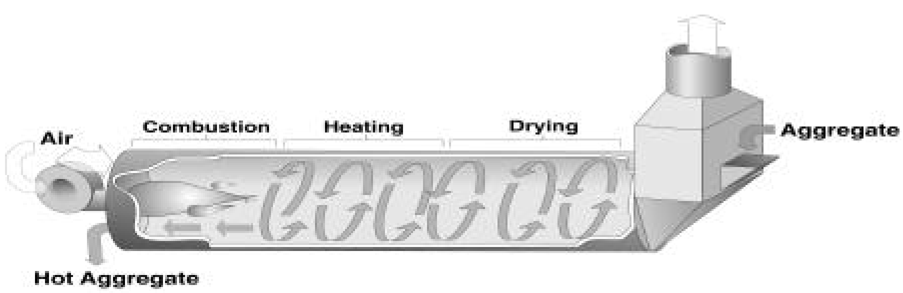

Figure 5.7 Counter-flow batch plant dryer zones.

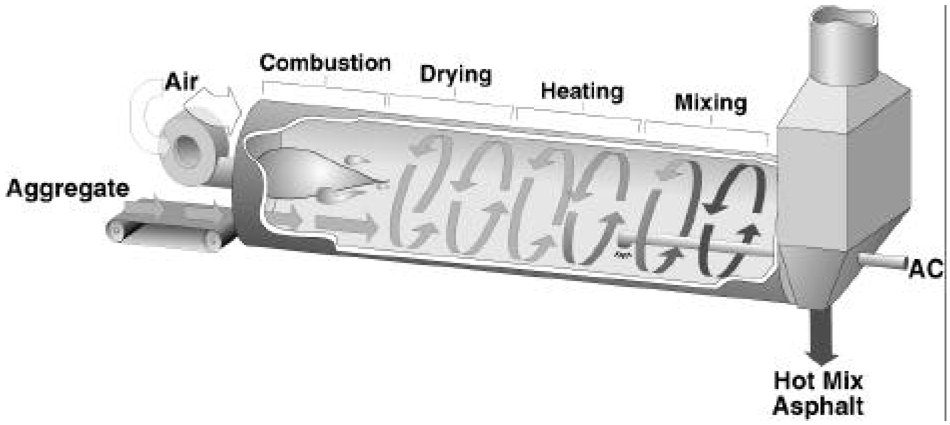

Figure 5.8 Parallel-flow drum-mixer zones.

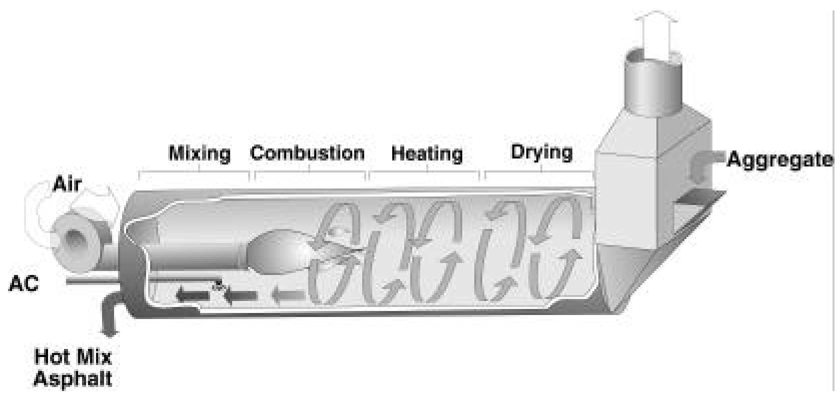

Figure 5.9 Counter-flow drum-mixer zones.

With a drum-mixer, one of the functional activities for the dryer also includes mixing the new liquid asphalt cement.

Types of Heat Transfer

Heat transfer in an aggregate dryer, whether a counter-flow configuration or parallel-flow configuration, is accomplished through:

- Conductive heat transfer.
- Convective heat transfer
- Radiant heat transfer

Understanding the different types of heat transfer is important to discussions on the different methods of heating recycled aggregates in the plant process later.

Conductive heat transfer is heat induced through contact, similar to the way pan is heated on a electric burner as shown in figure 5.10.

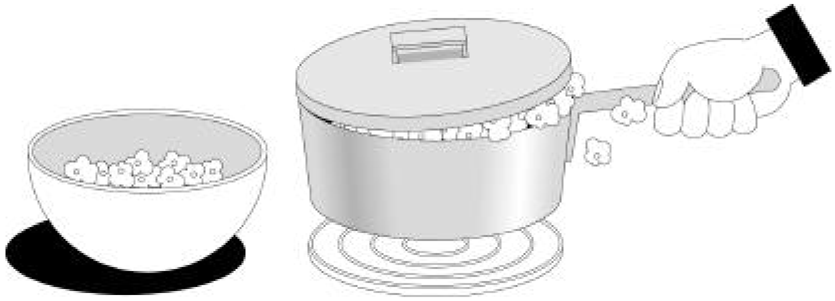

Figure 5.10 Example of conductive heat transfer.

Convective heat transfer is heat induced through gaseous transfer, similar to the heat of a hot-air popcorn popper as shown in figure 5.11.

Figure 5.11 Example of convective heat transfer.

Radiant heat transfer is reflective as shown in figure 5.12, similar to the heat from the sun or a fire.

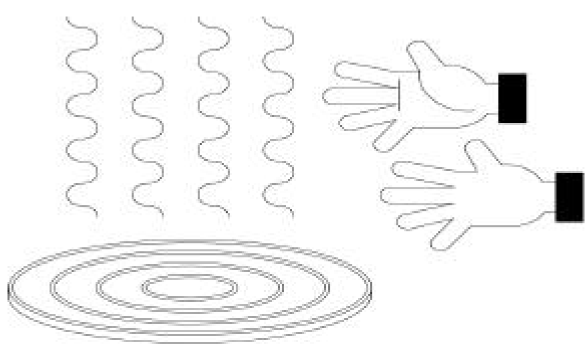

Figure 5.12 Example of radiant heat transfer.

The heating and drying of virgin aggregate in a dryer is primarily accomplished with convective heat transfer, with some radiant transfer from the flame and some conductive heat transfer from the shell and flights as shown in figure 5.13.

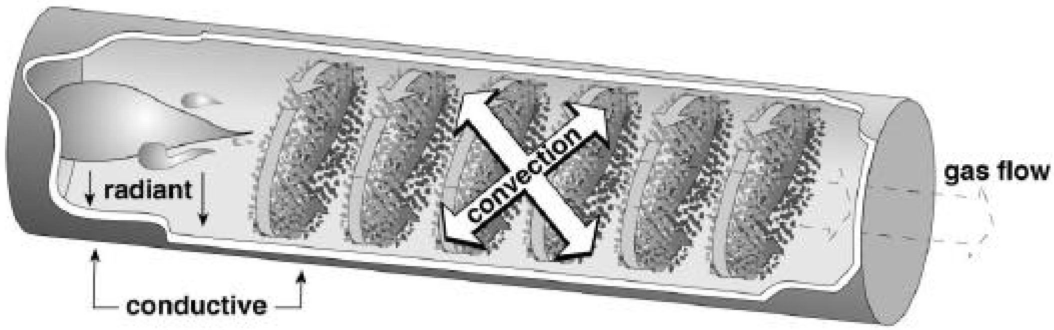

Figure 5.13 Three types of heat transfer in an aggregate dryer.

Heat Loss through the Shell

The assumption for heat loss through the shell set by dryer manufacturers, burner manufacturers, and manuals previously published on dryer efficiency is 10 percent. Heat loss can be reduced through insulation. Insulation applied is typically a ceramic blanket type covered with aluminum or galvaneal wrap. Insulation is most effective in the area of the dryer's highest temperature. It can be applied selectively to these high temperature areas or over the entire area of the dryer. Contractors who have applied dryer insulation as shown in figure 5.14, and those promoting it, generally claim a seven to 10 percent reduction in heat requirement, and thus a seven to10 percent savings in fuel.

Figure 5.14 Counter-flow dryer with insulation.

5.4 BURNER AND COMBUSTION PROCESS

All modern conventional aggregate dryers use direct-fired burners. The burner is fired directly into the dryer, and the hot gases heat the aggregate primarily by way of convective heat transfer as the gases are drawn through the dryer by the exhaust fan. This style burner has proven to be the most cost-effective for drying aggregate. This is why other heat transfer techniques, such as indirect heating, infrared heating, and electric heat have not been routinely applied in the industry.

Dryer burners are typically fitted to burn natural gas, fuel oil, or propane, although solid fuel burners (burning pulverized coal or wood/bio-mass) have been employed in recent years in small quantities. Coal- and wood-fired burners will be omitted from this discussion. For information on these types of burners and their special requirements, contact burner manufacturers (see Appendix C).

It is not unusual for burners to be fitted with a dual-fuel manifold to take advantage of lower-priced fuels or alternate fuels during peak utility consumption periods. It is important that the dryer is flighted so that no aggregate is veiled through the combustion area. The combustion area is the region in the dryer used to ensure that proper and complete combustion occurs.

If a material-free zone is not created for this combustion, then incomplete combustion will occur as the cooler aggregate material passes through the developing flame. This can create undesirable hydrocarbon emissions in the exhaust stack, can increase fuel costs by reducing fuel conversion efficiency, and in severe cases can cause hydrocarbon contamination of the aggregate. This contamination affects the ability of the aggregate to accept the asphalt binder, a problem that can negatively affect the quality of the mix.

Creating an effective material-free combustion area in the dryer is very important. Two types of flights are generally used to accomplish this:

- Spiral-style
- Combustion-style

Both the spiral-type flights and the combustion-style flights keep aggregate from veiling in the area reserved for combustion.

Spiral flights as shown in figure 5.15 direct the aggregate below the flame and combustion area by “augering” the material along the bottom of the dryer.

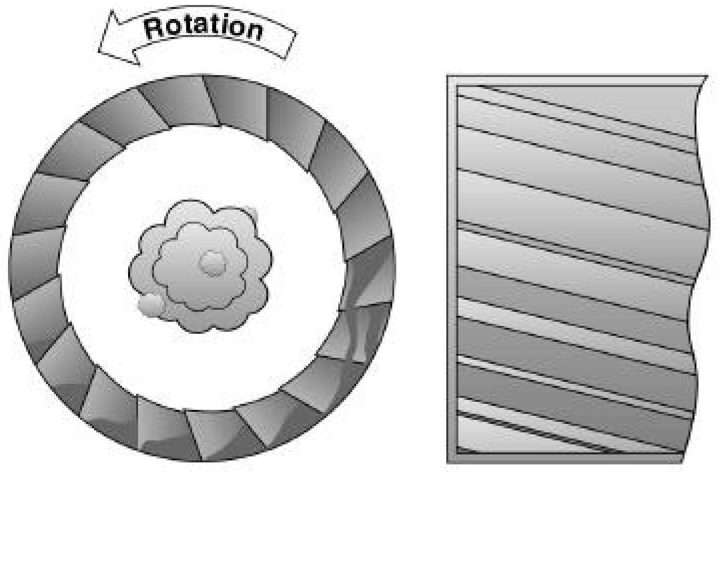

Figure 5.15 Spiral flights.

Combustion flights come in two varieties. One style of flight collects aggregate and carries it over the flame as the dryer rotates as shown in figure 5.16. The other style allows aggregate to auger below the flight along the shell of the dryer, without carrying it up and over the flame area as shown in figure 5.17. Both have a sacrificial surface that collects the radiant heat from the burner flame and helps reduce shell temperatures.

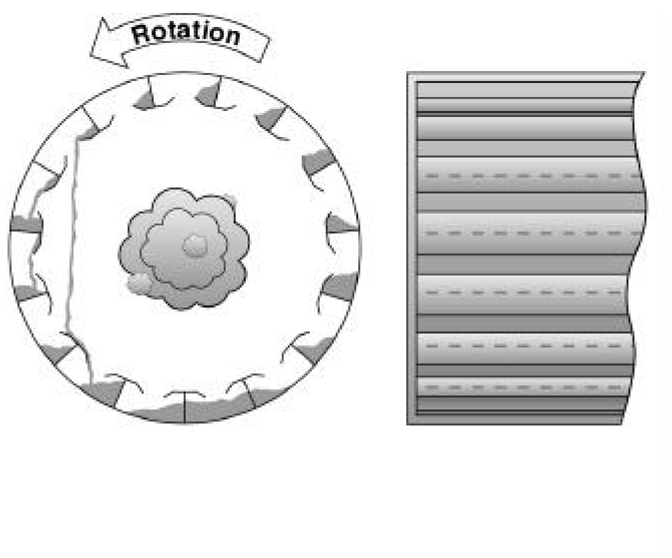

Figure 5.16 Over flame combustion flight.

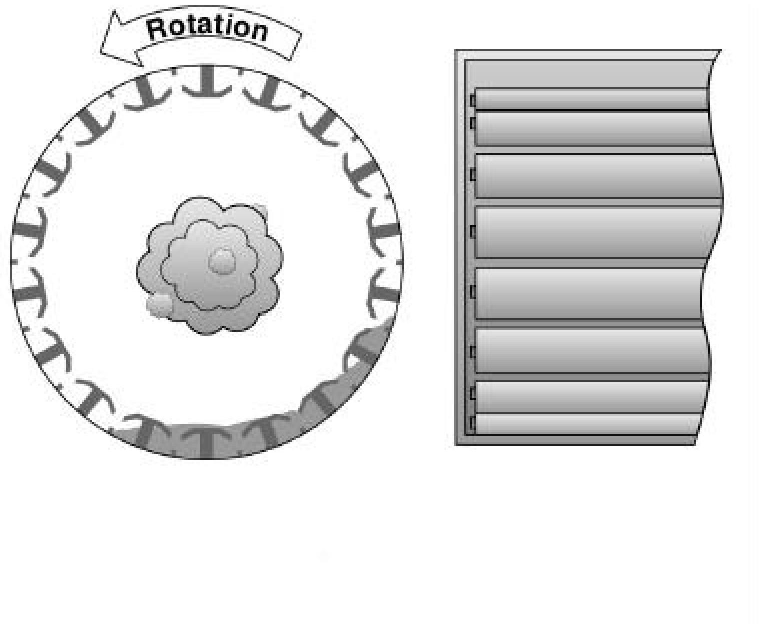

Figure 5.17   Underflame combustion flight.

The advantage of combustion-style flights is that shell temperatures are reduced, heat loss is minimized, and shell life is extended in the combustion area. Most burner manufacturers and plant consultants now recommend a combustion zone length equivalent to the diameter of the dryer for proper combustion area. This rule of thumb is intended for No. 2 diesel fuel oil and of course assumes that the dryer and burner are properly sized and the dryer is properly flighted.

Natural gas will actually take less space than this for combustion because it is easier to burn. A heavier fuel, such as heavy fuel oil or coal, will take more. The "length equivalent to the diameter" rule of thumb as shown in figure 5.18, then, is only a guideline. Actual field and fuel conditions can dictate different relationships.

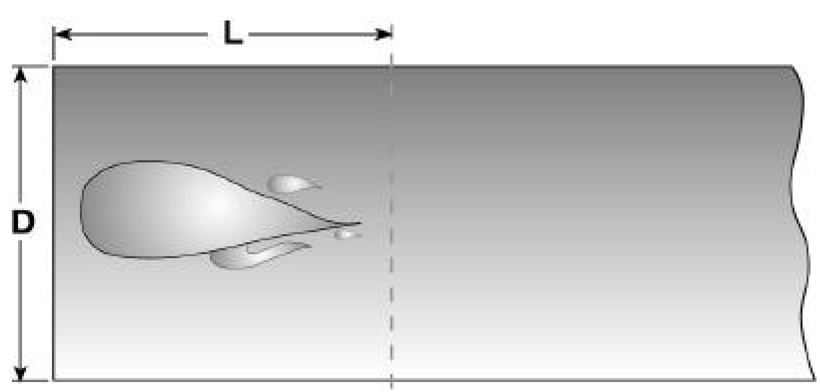

Figure 5.18 Combustion zone length equals diameter ratio.

In the combustion process hydrogen and carbon from the hydrocarbon fuels are being converted to CO_2 and HO_2 and heat is released. With proper combustion, each atom of carbon combines with two atoms of oxygen to form CO_2, and two atoms of hydrogen combine with one atom of oxygen to form H_2O. This process is shown in figure 5.19.

It is impractical to assume aggregate dryers can run under perfect conditions. That is, with the exact amount of oxygen and fuel for the combustion process. Therefore, manufacturers and industry experts assume dryers will run with somewhere between 25 percent and 50 percent excess air. The assumption one makes as to the percent of excess air the dryer will allow affects both the size required for the burner, and the theoretical production rate of the dryer.

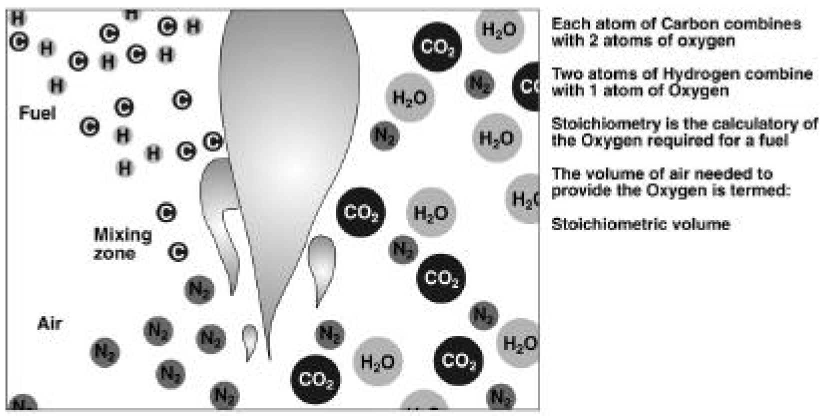

Figure 5.19 Combustion chemistry**.**

The closer an operator can run to theoretically perfect conditions, the higher the production rate possible from his facility. Air provided for this combustion process comes from the burner, the exhaust fan, or both.

Induced draft burners, as shown in figures 5.20 and 5.21, provide 25 to 30 percent of the air required for combustion with the blower fans mounted in the burner. The rest of the air is drawn through a breaching opening around the burner by the exhaust fan on the end of the dryer and emission control equipment package.

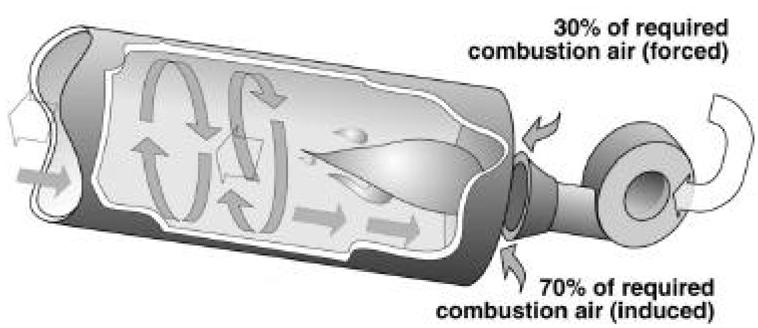

Figure 5.20 Induced draft burner.

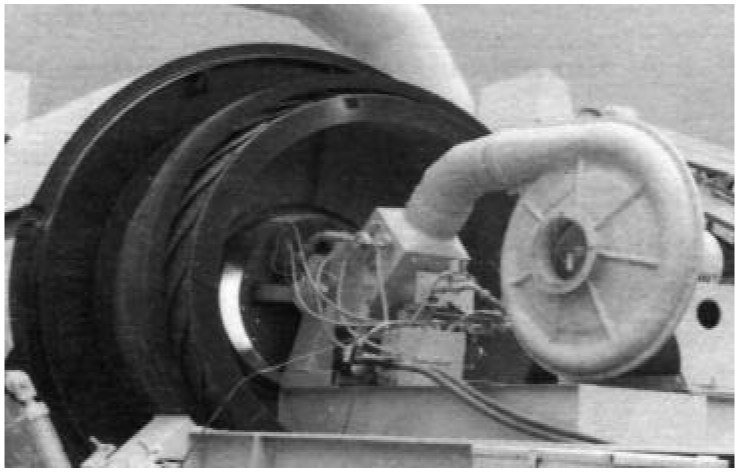

Figure 5.21 Induced draft burner.

Total air burners, as shown in figures 5.22 and 5.23, provide 100 percent of the combustion air at the burner head through a combination of primary air blowers, secondary air blowers, and tertiary air blowers, depending on the manufacturer and design of the burner. All the air for combustion is forced into the dryer at the burner head. The exhaust fan at the tail end of the dryer and emission control equipment evacuates this air which has become the process gas stream.

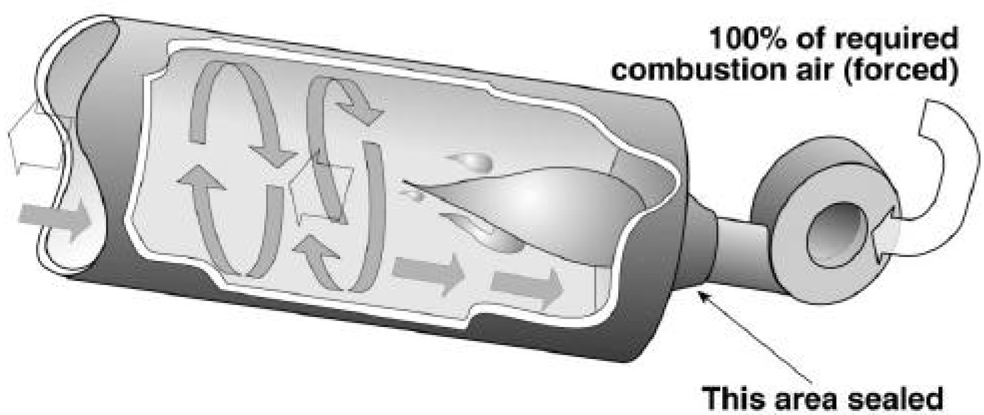

Figure 5.22 Total air burner.

Figure 5.23 Total air burner.

Older-style burners had ignition tiles and combustion chambers, as shown in figures 5.24 and 5.25, to ensure total combustion of fuel. These tiles and bricks would heat up, aiding in the atomization and combustion of the fuel.

Since the late 1970s burners have been developed in which the air pattern in the burner head causes the flame to circulate in on it, promoting efficient combustion without the aid of ignition or combustion tiles. Late-model plants have "combustion chamberless" burners as shown in figure 5.26, and many older-style dryers and drum-mixers have been retrofitted with later-model burners.

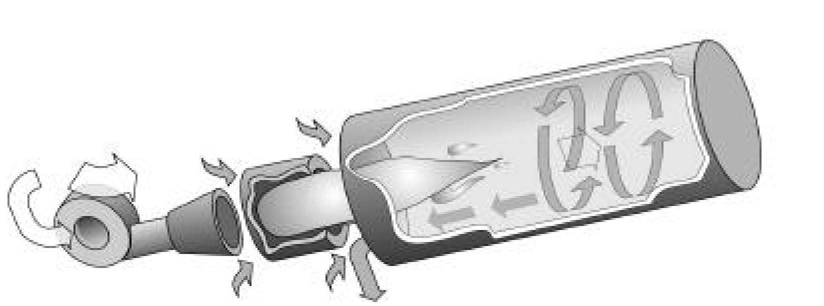

Figure 5.24 Older style burner with combustion chamber.

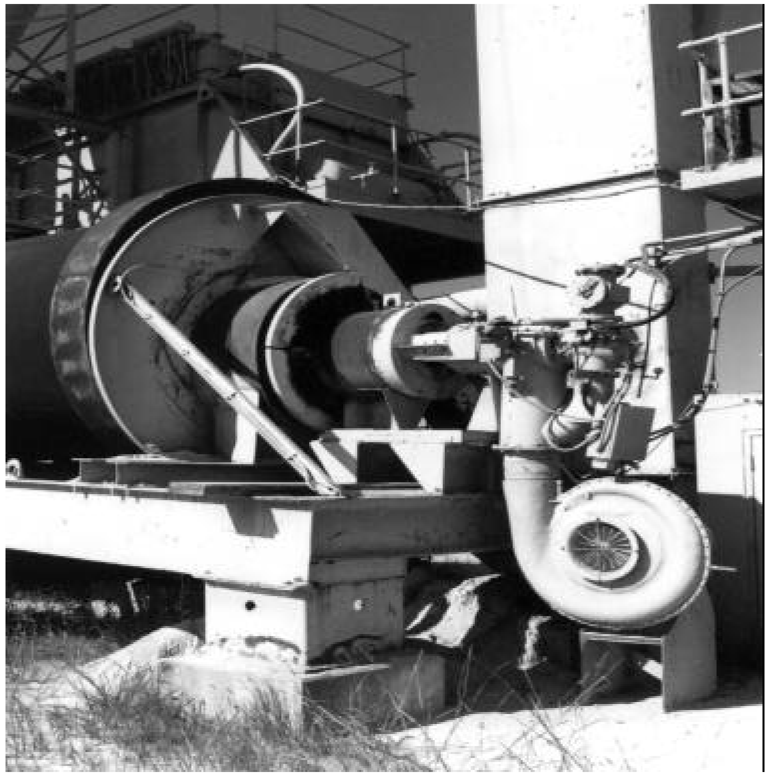

Figure 5.25 Older burner with combustion chamber.

Figure 5.26 Older dryer with new combustion chamberless burner.

5.5 DRYER FLIGHTING

Once proper combustion is assured through a combination of air flow, burner size and operation, and non-restrictive combustion zone flighting, other flights transfer the material to the process gas stream for effective (convective) heat transfer.

Flighting Styles

Manufacturers use different drying flight designs, all flights lift and drop aggregate across the cross-sectional area of the dryer as it rotates in a process called veiling. The goal is to present aggregate in a dense cross-sectional pattern so that the combustion gases encounter the aggregate as it attempts to exit the dryer. In the process, the aggregate is dried. Proper flighting inside the drier is both an art and a science and is shown in figure 5.27.

Figure 5.28 shows flights that drop or veil aggregate too soon. Too little veiling creates an open pattern in the dryer that allows the gases to take the path of least resistance and exit the dryer without encountering and drying the aggregate. If aggregate drops too soon in the cross-section of the dryer, it is difficult to dry the aggregate. If the plant operator continues to push the dryer to the rated capacity, drying costs will rise, production rates will drop, and the aggregate will not be thoroughly dried.

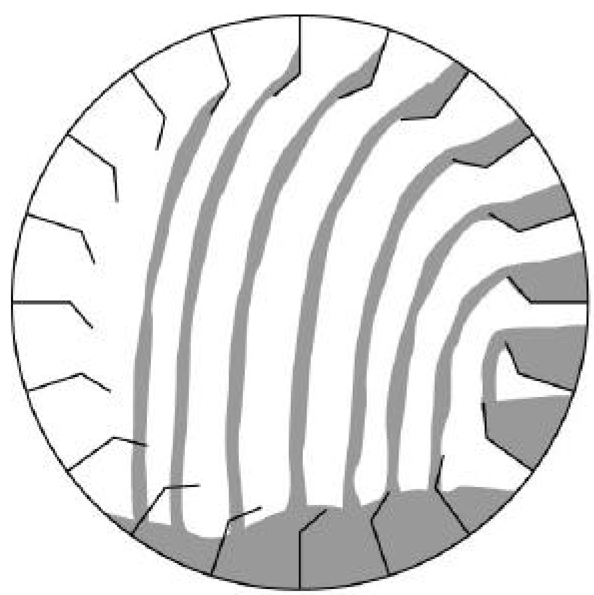

Figure 5.27 Proper veiling.

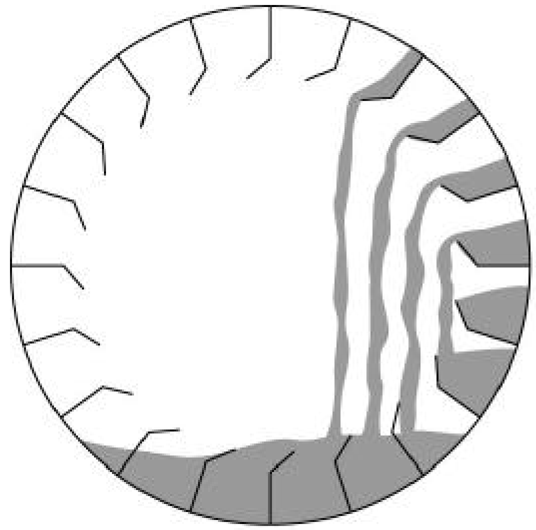

Figure 5.28 Insufficient veiling - material falls too soon.

Flights that hold aggregate too long, figure 5.29, create the same problem by "overshooting" the cross-section and dropping aggregate beyond the center of the dryer. Gases pass beside the aggregate and easily exit the dryer without encountering and drying the aggregate. If the operator pushes the dryer to the rated capacity, the drying costs will be high, the throughput will be low for properly dried aggregate, and the aggregate will not be thoroughly dried.

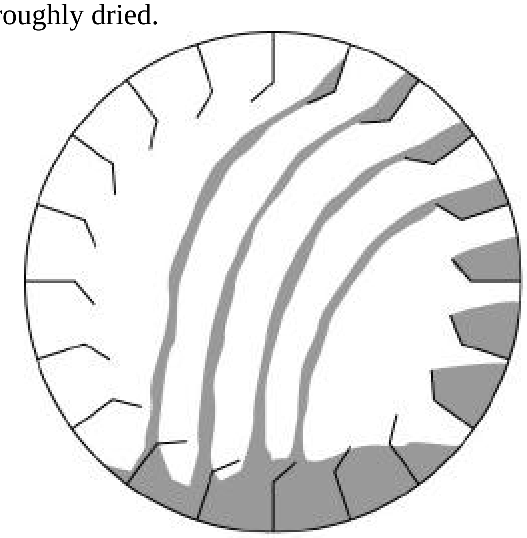

Figure 5.29 Overveiling – material pitches long.

In an attempt to maximize drying efficiency, manufacturers have developed unique styles and combinations of flights. Some are very elaborate, with different openings where aggregate can drop out at different stages as the dryer rotates. Staggering the rows of flights in a dryer, as shown in figure 5.30, is a common approach to increasing veiling efficiency, regardless of the style of drying flight employed. With staggered rows, any open spot created by one set of flights as they discharge is covered with the next set downstream as the aggregate proceeds through the dryer.

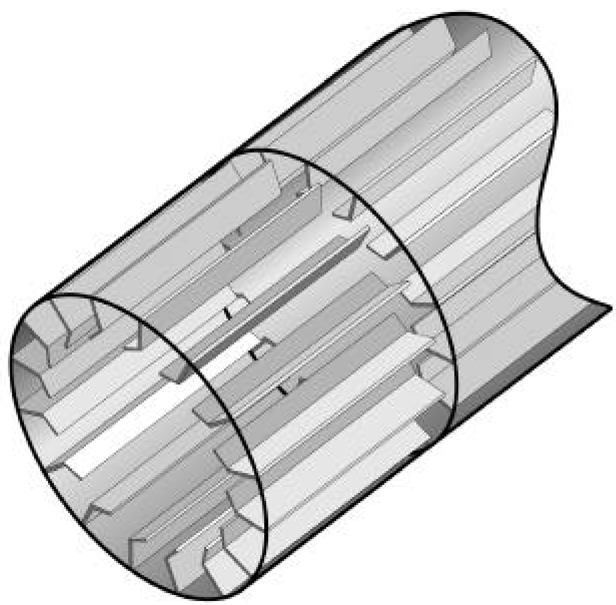

Figure 5.30 Flights in a dryer are "staggered" row to row, to improve veiling.

In a properly flighted counter-flow dryer, most of the heating of aggregate occurs in the areas shown in figure 5.31.

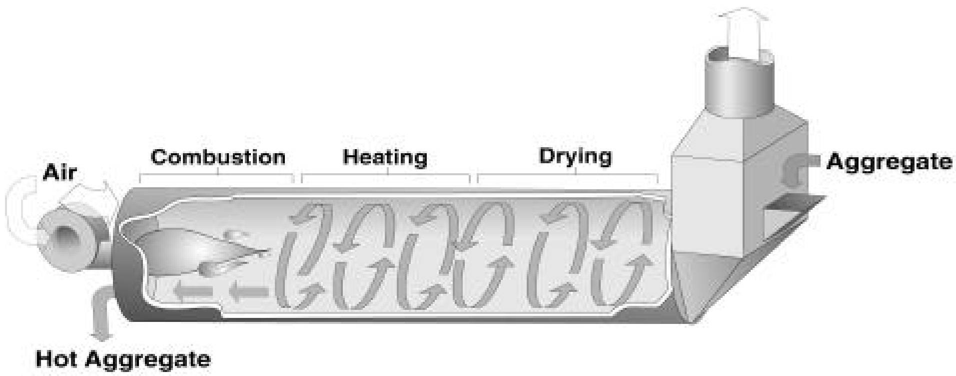

Figure 5.31 Combustion, drying and heating zones in a counter-flow dryer.

In a properly flighted parallel-flow drum-mixer or dryer, most of the heating of aggregate occurs in the areas shown in figure 5.32.

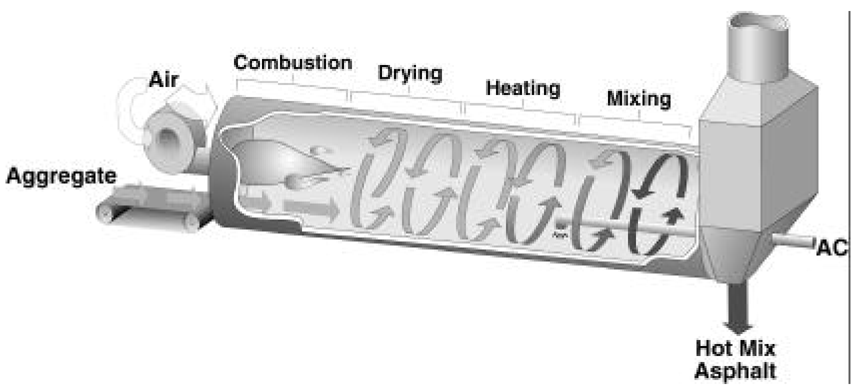

Figure 5.32 Combustion, drying, heating and mixing zones in a parallel-flow drum-mixer.

5.6 TYPICAL TEMPERATURE PROFILES

Parallel-Flow Dryers

Exit gas temperatures are an indication of flighting efficiency. Parallel-flow dryers typically have exit gas temperatures 0-30°C higher than exit product temperatures. For 150°C material, exit temperatures typically run 150-175°C. If exit gas temperatures are higher than this, it is an indication of improper flighting, and corrective actions should be taken.

It is impossible for exit gas temperatures to be lower than the product temperature in a parallel-flow dryer or drum-mixer because the gas temperature is heating the aggregate, the aggregate is flowing away from the burner, and the process gasses will always be hotter than the aggregate as shown in figure 5.33.

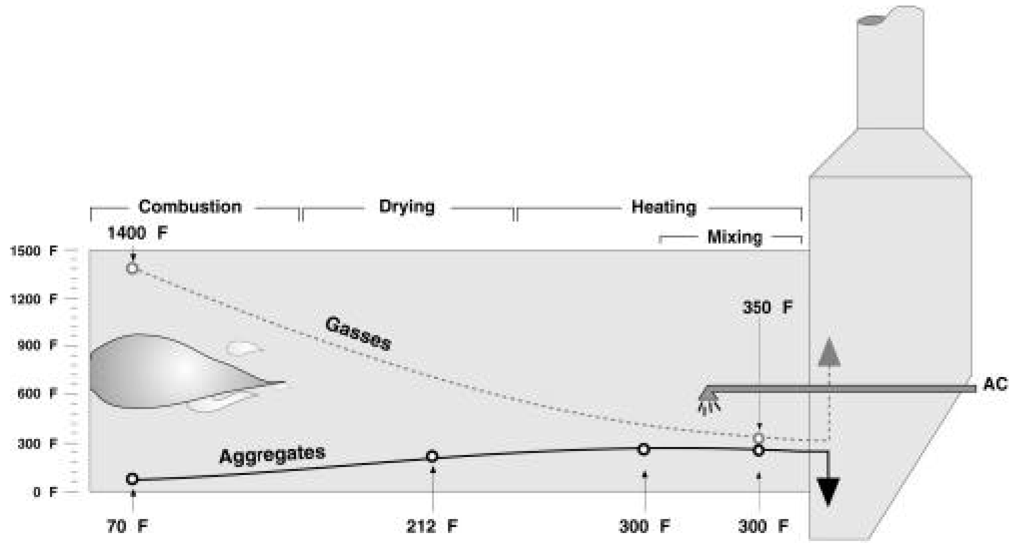

Figure 5.33 Temperature profile of parallel-flow drum mixer drying virgin aggregates.

Running the dryer at production rates substantially lower than the target design (for example, 150 tph attempted on a dryer capable of 400 tph) can lead to high temperature differentials because the dryer is flighted for a larger amount of material. A substantially smaller amount of material in the dryer does not create a dense enough veil to absorb the heat.

Counter-flow Dryers

A properly flighted counter-flow dryer has exit gas temperatures that typically run 10-24°C below the material exit temperature. Counter-flow dryers can be flighted differently than parallel-flow dryers because cooler, wet aggregate material is presented to the gas stream as it exits the dryer, and the material is moving toward the burner. Therefore, a properly flighted counter-flow dryer can take advantage of these conditions and can achieve desired product temperatures with less fuel consumption and BTU use. Counter-flow dryers with gas temperatures higher than the product temperatures could benefit from flighting adjustments to improve their efficiency.

5.7 OTHER FACTORS THAT AFFECT DRYING EFFICIENCY

There are other elements in the dynamics of an aggregate dryer that affect drying efficiency besides flighting. See figures 5.34 and 5.35.

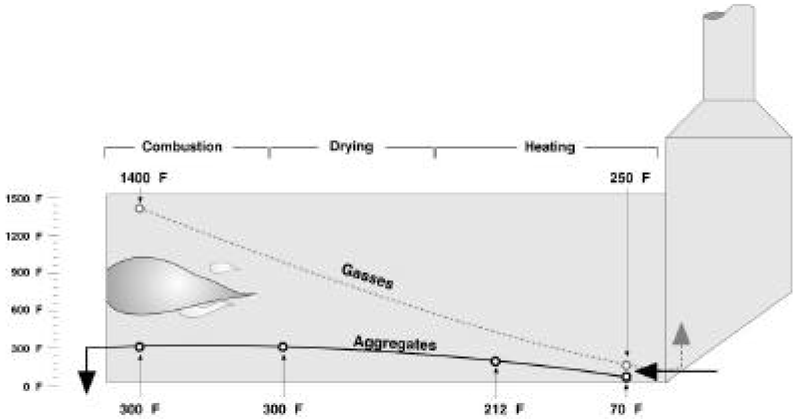

Figure 5.34 Temperature profile of counter-flow dryer drying virgin aggregates.

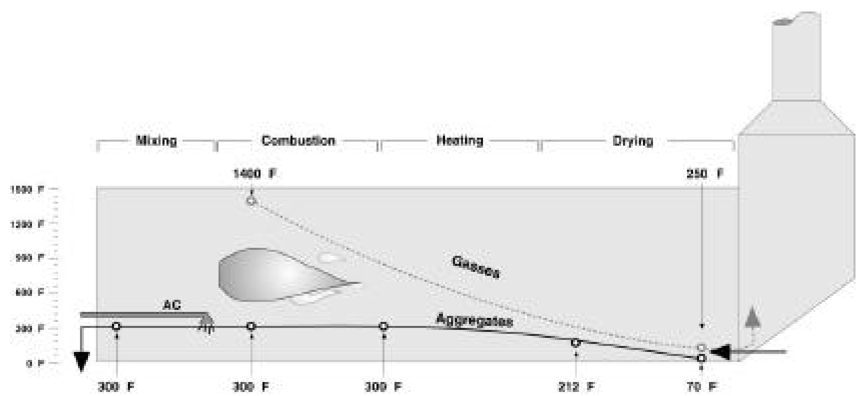

Figure 5.35 Temperature profile of counter-flow drum mixer drying virgin aggregates.

Dryer Slope

Gravity aids in moving material through the dryer as shown in figure 5.36. The greater the slope, the faster material moves through the dryer. Conversely, the lower the slope, the slower material moves through the dryer. Counter-flow dryers are typically set at 62 mm to 83 mm drop per meter of length. Parallel-flow dryers are typically set at 42 mm to 62 mm drop per meter of length. However, there are variations on this theme, and at least one manufacturer in the past designed and marketed a flat dryer, with no pitch. Material moved through the dryer solely with the aid of the flights.

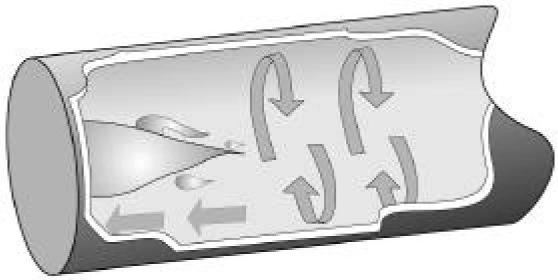

Figure 5.36 Gravity aids movement of aggregate through dryer.

Portable plants often arrive from the factory with either hydraulic adjusters or with shims that allow simplified slope adjustment as shown in figure 5.37. These features are useful in portable plants because dryer slope can be adjusted as different types of aggregates and moistures are encountered in the field.

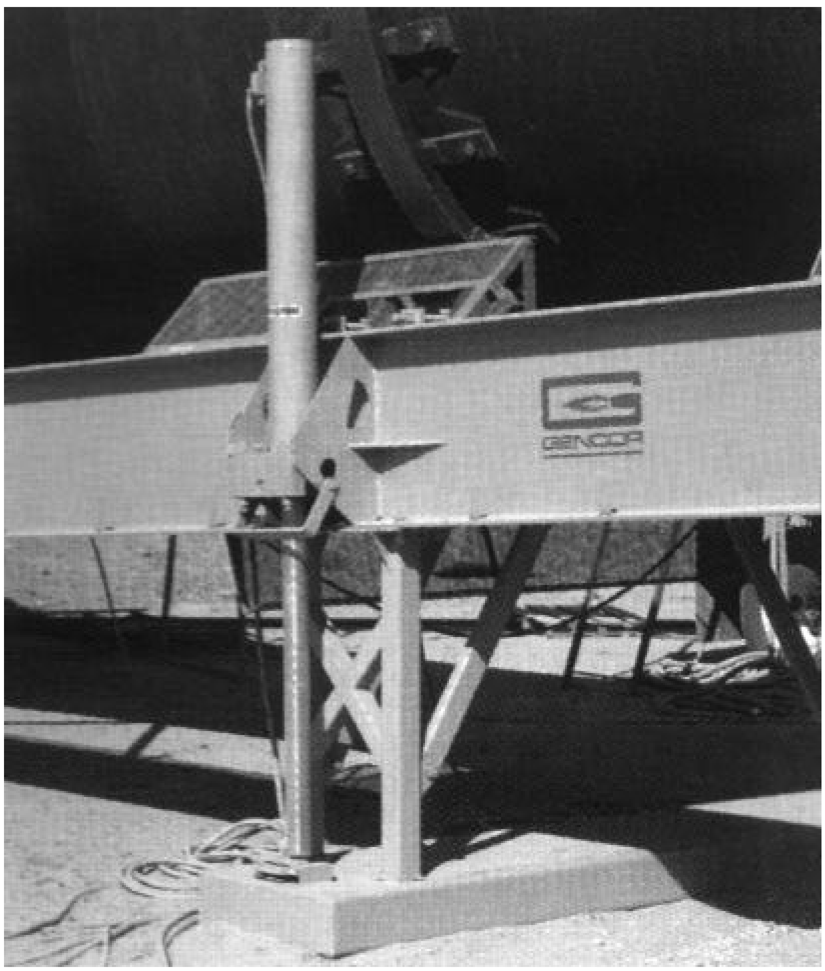

Figure 5.37 Hydraulic slope adjustment support on a portable plant.

Typically, for a given flight pattern, the lower the slope, the longer the retention time, the deeper the bed of material in the dryer, and the greater the amount of material in the dryer. Retention time in the dryer is actually a fairly complex function, dependent on the flight style and angle, the dryer slope, the dryer rotational speed, and the type of material being dried (some types of material travel through the dryer faster than others). When encountering moisture retention problems, or when gas temperatures are extremely high relative to material temperatures, dryer-slope changes can help correct the problem.

Rotational Speed

Rotational speed and the flighting pattern of a dryer are interrelated as they affect drying efficiency. For a given flight pattern, there will be an optimum rotational speed. Flights and speed should be designed to distribute the material across the entire cross-sectional area of the dryer. This will introduce the aggregate to the gas stream as efficiently as possible.

Too slow a speed will cause material to pitch "short" across the cross-section of the dryer as shown in figure 5.38.

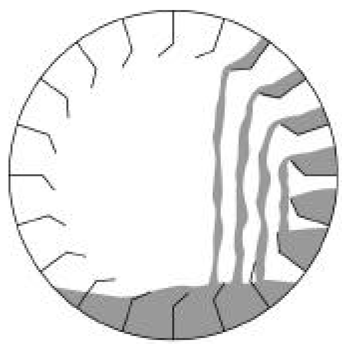

Figure 5.38 Material pitches short due to slow rotational speed.

Too fast a speed will cause material to pitch "long" across the cross-section of the dryer as shown in figure 5.39.

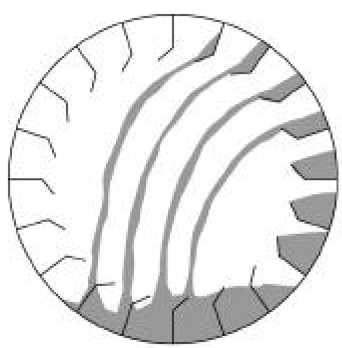

Figure 5.39 Material pitches long due to rotational speed.

Because different styles of flights release material at different points, there will be a proper speed for any given flighting pattern as shown in figure 5.40.

Figure 5.40 Proper rotational speed and balance of material across dryer-cross-section.

As explained earlier, if there are "holes in the veil," gases will pass through the hole and not encounter aggregate, since gases follow the path of least resistance. Symptoms of this are, abnormally high gas temperatures relative to product temperature, or high temperatures on one side of the exit gas breaching.

Figure 5.41 shows a simple way that dryer gas discharge can be field-tested for this condition. If gas temperatures are higher on one side of the gas discharge breaching than on the other, insufficient veiling along one side of the dryer is occurring.

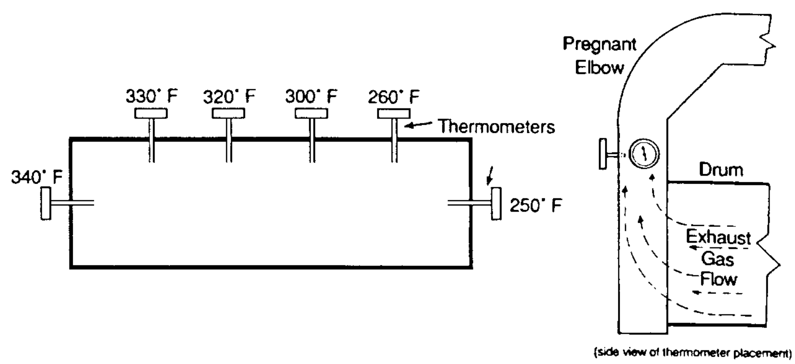

Figure 5.41 Measuring gas flow in the gas discharge ductwork provides an indication of veiling efficiency.

A remedy is not necessarily arrived at by a change in dryer rotation. Both the flight configuration and the rotation might need to be addressed. Typically, one adjusts flight pattern before changing rotational speed. Most of the time, this phenomenon can be remedied with flight pattern changes. Rotational speed changes are a last resort.

Dams

Material dams, or rings welded around the internal circumference of a dryer, create an obstacle in the dryer that material must dam up against and spill over before proceeding through the dryer.

Dams are used to increase the density of the veil, and to increase retention time and heat transfer into the material. Dams increase the density of the veil because there is additional material spilling immediately downstream of the damming point. Dams increase retention time because there is additional material retained behind the dam as shown in figure 5.42. The material must wait here and work its way through the dam before it proceeds through the dryer.

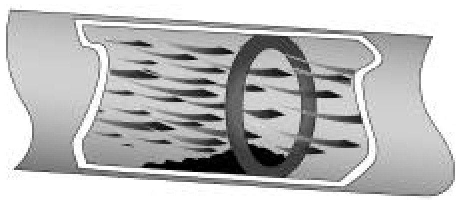

Figure 5.42 Dams increase detention time by holding material in the dryer.

There are, however, some disadvantages to dams:

- Dams increase the gas velocity through the dryer where the gas stream must go through the smaller dammed area.
- Increases in gas velocity through the dryer have certain negative effects on the efficiency of the overall operation.
- Dams can hold larger rock behind the damming ring. When a smaller rock aggregate mixture is dried, these larger tramp rocks can find their way into the dried material.

In batch plants, where aggregate sizing is done after the dryer, this last point is not a problem. In continuous flow plants, where sizing has been verified with a scalping screen prior to the dryer, the use of a dam allows the possibility of mix contamination. A 25 mm stone in a 19 mm mat is not a welcome visitor behind the paver.

Flighting, rotational speed, slope and air flow all interact in a dryer to accomplish one goal -- drying the aggregate materials as efficiently as possible. This goal which includes drying it at as high a rate of speed as possible in order to increase overall production efficiencies. Production rates are easy to monitor, but it is advisable to lab-test actual dried aggregate samples produced at actual field rates, to make sure that the dryer is meeting its goal of drying the aggregate to within one-half percent residual moisture. This can be done by treating the dried aggregate as any other aggregate sample and testing for moisture by drying it to completion in an oven.

There is no way to actually know in the field, during a production run, whether the dryer is adequately drying the aggregate materials. If the aggregate materials are not thoroughly dried, successful coating with liquid asphalt in the plant process can be difficult. Moisture running from the surge silo gates, moisture running from the tailgate of a truck, aggregate particles without binder on them at the screed, or steaming hot-mix at the paver, are all indications that changes are due in the plant process to increase the drying efficiency. If lack of moisture removal becomes a site-specific problem, modifications can typically be done to the flight configuration, slope, rpm, or the feed rate to rectify the problem.

5.8 DRYER MATERIAL ENTRY METHODS

Fixed Chute

The fixed chute as shown in figure 5.43 is very common. It consists of a slide chute into the dryer with a flop gate to keep excess air ("tramp air") from being drawn in at the chute and not through the dryer.

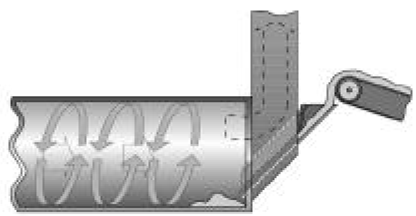

Figure 5.43 Typical fixed chute entry.

With parallel-flow drum-mixers, these chutes need to be offset so that material entering the dryer doesn’t enter the combustion zone and impede the combustion process.

A common complaint about fixed chutes is material plugging. For that reason, they are often lined with ceramic or abrasion-resistant high-molecular-weight plastic. They frequently have vibrators attached as shown in figure 5.44.

Figure 5.44 Fixed chute entry to dryer with vibrator on chute.

Rotating Chute

The rotating chute as shown in figures 5.45 and 5.46, is designed to help eliminate the plugging problem of fixed chutes, has flights installed into a rotating cylinder that help "screw" material into the feed end of the dryer.

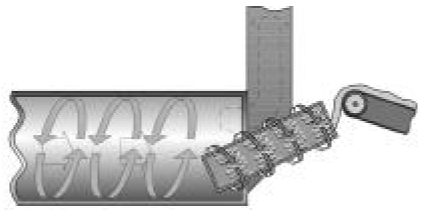

Figure 5.45 Typical rotating chute entry to dryer.

Figure 5.46 Rotating chute entry to dryer.

Slinger Feeders

Slinger feeders are becoming increasingly popular and are often found retrofitted to older dryers. A slinger feeder is a high-speed belt conveyor that "throws" material into the dryer as shown in figures 5.47 and 5.48. Because they are belt feeders, they are not prone to the plugging problems associated with chute feeders. On parallel-flow drum-mixers, where the burner is located on the feed end, they also allow material to be introduced below the burner without concern for passing material through the combustion zone.

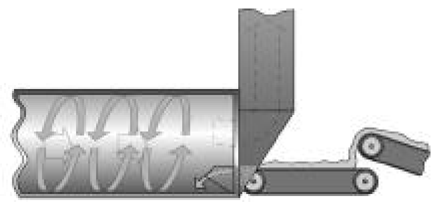

Figure 5.47 Typical slinger feed entry.

Figure 5.48 Slinger feed entry to counter-flow drum-mixer.

5.9 ENTRY BREACHING SEALS

Breaching seals are very important on counter-flow dryers, where tramp air can be drawn easily around the seal area and rob air from the drying and combustion process as shown in figure 5.49.

Seals basically fall into two categories, mechanical seals and belting-type seals shown in figures 5.50 and 5.51, respectively. Either design will work effectively to keep air from affecting the drying process.

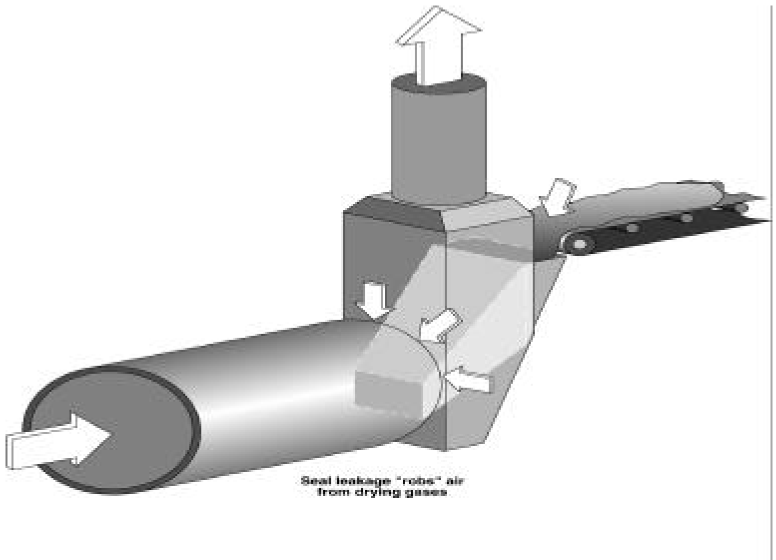

Figure 5.49 Belting type dryer seal.

Figure 5.50 Mechanical type dryer seal.

Figure 5.51 Tramp air being drawn in around entry end of counter-flow dryer.

Seals are not as important on the entry end of parallel-flow aggregate dryers because air is typically drawn in around the burner at this end of the dryer. They are advisable, however, as they ensure that all the air enters the center of the combustion zone and does not have a chance to be drawn in and around the flame envelope.

5.10 DRYER MATERIAL DISCHARGE METHODS

As with feed chutes, gravity-operated doors or flaps are installed in discharge chutes to ensure that tramp air is not drawn up through the discharge area, robbing the dryer of needed air or cooling the material as it exits the dryer.

Gravity Drop

Dried material simply drops out the bottom of the dryer as shown in figure 5.52 as it reaches the end of its journey. No sweeping paddles or flights are employed. This discharge is the simplest method, but it requires additional dryer elevation so that discharged material can reach its intended location.

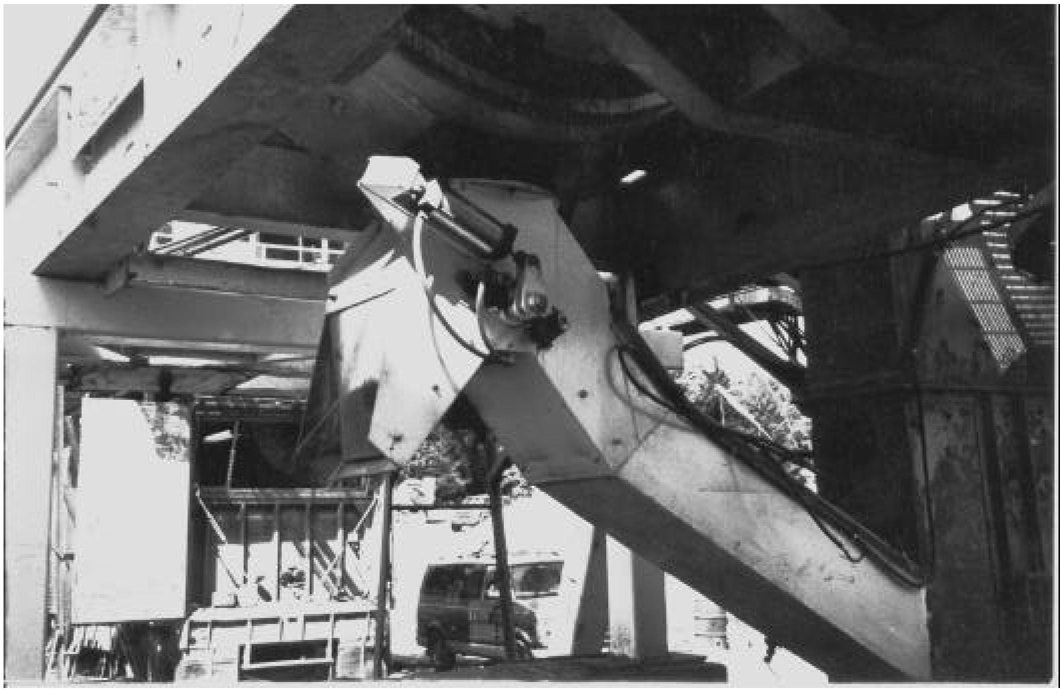

Figure 5.52 Gravity drop chute from dryer.

Side or "Sweep" Discharge

Side or "sweep" discharge chutes, as shown in figure 5.53, require paddles or flights to be added to the inside of the dryer to move material up and out for exit from the chute. They push material up and out the discharge hole, which is typically located in the four o'clock or eight o'clock position.

A side discharge chute allows the dryer to be set closer to the ground. This is particularly advantageous on portable plants, where simplifying dryer erection is advisable.

Figure 5.53 Sweep discharge on drum-mixer or dryer.

High-Lift Discharge

The high-lift discharge, as shown in figure 5.54, is typically used on counter-flow batch-plant aggregate dryers, although one manufacturer uses this design internally on its counter-flow drum-mixer to discharge material from the combustion zone into the mixing zone.

Figure 5.54 High-lift discharge on batch plant dryer.

A high-lift discharge has elevating plates fixed to the discharge end of the dryer, and the dryer lifts material up into a slide chute that deposits the material at a higher elevation than a gravity or sweep discharge does. This design is used to gain elevation at the discharge end of the dryer. A popular variation on this theme was the Barber-Greene rotary elevator, as shown in figure 5.55, which carried material up to a chute on the side of the dryer for discharge on the same axis as the dryer.

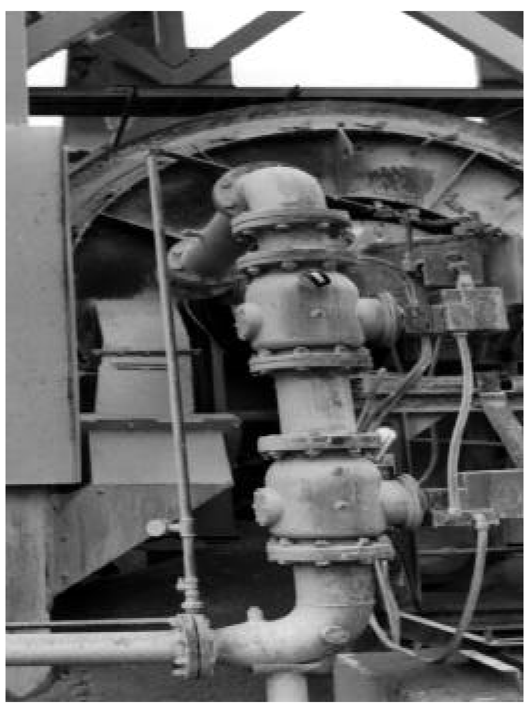

Figure 5.55 Rotary elevator discharge**.**

5.11 DISCHARGE BREACHING SEALS

As with the material entry breaching seals, discharge breaching seals are very important in designs where tramp air can be drawn easily around the seal area and rob air from the dryer and combustion process. It is important that seals are kept in proper working condition.

Breaching seals typically fall into two categories: mechanical seals and belting-type seals. Either design will work sufficiently to keep air from affecting the drying process.

Effective seals on the discharge end of the dryer are not as important on counter-flow dryers as they are on parallel-flow dryers because air is typically drawn in around the burner area anyway, as shown in figure 5.56. Although they will not affect mix quality, they are advisable because they ensure that all the air enters the center of the combustion zone and does not have a chance to escape around the flame envelope.

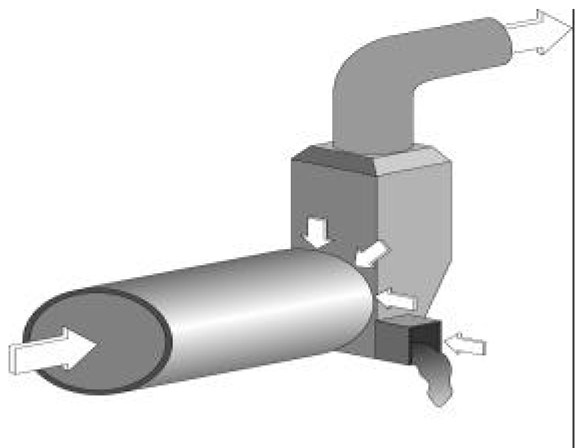

Figure 5.56 Tramp air being drawn in around parallel-flow dryer discharge area.

5.12 TWO-WAY DISCHARGE CHUTE

Air-operated, two-way discharge chutes, as shown in figure 5.57, are a common sight on most drum-mix plants.

Figure 5.57 Two-way discharge chute.

The operator can direct material by remote control to a material reject conveyor during start-up, shutdown, or mix changes. Without such equipment, good mix can be contaminated in the storage silo on start-ups and shutdowns. These two-way discharge chutes, which require additional elevation when setting up the plant, are frequently found on stationary plants and are seldom found on portable facilities. Another way to address the reject issue is with a by-pass chute in the material slat conveyor or in the silo, as shown in figure 5.58. With this device, rejected material drops from the slat conveyor or silo so that good mix is not contaminated with poor quality mix. Contractors frequently park a loader or truck below these chutes to facilitate removal of this material.

Figure 5.58 "Chop gate" or "drop gate" in slat conveyor.

5.13 REFERENCES

1. FAA Circular AC 150/5370-14, *The Hot Mix Asphalt Paving Handbook*, pp. 2:29-36, 2:65-66.

2. IS-76, *"The Uniform Burner Rating Method for Aggregate Dryers,"* National Asphalt Pavement Association, Lanham, MD.

3. IS-52, "*The Fundamental of the Operation and Maintenance of the Exhaust Gas System in a Hot-Mix Asphalt Facility*," National Asphalt Pavement Association, Lanham, MD.

4. TAS-22, "*Applying IS-52: Performance Expectations From Your Facility*," National Asphalt Pavement Association, Lanham, MD.

5. "Dryer Drum Mixer Technical Paper T-119," Astec Industries, Chattanooga, TN.