Overcoming Operating Challenges
with Warm Mix Asphalt
Presented by Dennis Hunt
Warm Mix

Step 1: Aggregate enters the drum at ambient temperature (about 70°F). Immediately, the burner flame transfers heat by radiation to the aggregate. The aggregate temperature rises rapidly to the boiling point of water (about 212°F).

Step 2: Once the aggregate reaches the boiling point of water, the heat energy of the burner flame and of the hot combustion gases heat the aggregate by boiling and evaporating the surface and internal moisture, leaving the aggregate temperature constant at about 212°F.

Step 3: After the surface moisture and most of the internal moisture are removed from the aggregate, the hot combustion gases raise the aggregate temperature to the desired discharge level. This high-efficiency system yields an exhaust gas temperature only slightly higher than that of the mix.
Early Asphalt Addition

Early asphalt addition is the key element in the patented Boeing process. By early asphalt addition we mean that the liquid asphalt is injected in the all-important boiling zone (step 2 in the aggregate heating and drying process).

What’s so important about the boiling zone? When the liquid asphalt enters the boiling zone, it interacts with the evolving steam. This interaction foams the asphalt. As the internal moisture leaves the aggregate pores, the foamed asphalt is drawn onto the surface and into the pores. This yields the superior coating for which Boeing plants are famous.
Warm Mix - Overview

- Producing warm mix will present some operational challenges to a properly tuned plant.
- Operating at lower temperatures will exacerbate deficiencies in a plant system that is not properly tuned.
Combustion
Combustion efficiency can be explained in terms of the three T’s

- **Time** - the amount of time the fuel has to combust or reside in the flame
- **Turbulence** - turbulation of the fuel, air and heat source provides for more complete combustion by keeping these components in contact with each other for a longer period of time
- **Temperature** - as the temperature difference ($\Delta T$ or Delta $T$) between the source of heat and the material being heated increases, so does the rate of heat transfer
Combustion Air

- **Primary air** - provides a percentage of the combustion air, but more importantly, controls the amount of fuel that can be burned
- **Secondary air** - improves combustion efficiency by promoting the fuel to burn completely
- **Excess air** - is supplied to the combustion process to ensure each fuel molecule is completely surrounded by sufficient combustion air
Good Combustion

PRODUCTS OF COMBUSTION FOR 1 POUND OF OIL

- Oil (100% pure fuel oil)
  1 Pound (7.5 LB / Gal.)

- Water (H₂O)
  1.18 Pounds

- Nitrogen (N₂)
  56.1% by Volume
  11.02 Pounds or 150 Cubic Feet

- Carbon Dioxide
  10.2% by Volume
  3.16 Pounds or 27.2 Cubic Feet

- Excess Air
  7.18 Pounds or 93 Cubic Feet

PLUS

EXAMPLE

At 300 TPH Production & at 5% Aggregate Moisture, exhaust system size needed would be approximately:

- 49,000 FT³ MIN

TO HANDLE

GAL HR

OR

LB HR

- 4,180 OIL

Evaporated by the dryer

35.4 FT³ Steam

LB of Water

EXAMPLE

At 300 TPH Production =

17,700 FT³ MIN

From Aggregate Only
Keys to Proper Combustion

• Properly tuned burner
• Properly sized burner
• Properly sized combustion zone
• Proper fuel viscosity
Heating Basics

- A **BTU** (British thermal unit) is the amount of heat required to raise 1 pound of water 1 degree Fahrenheit
- **Specific Heat** is the measure of the heat energy required to raise the temperature of a specific quantity of a substance by a certain amount
  - Water = 1
  - Steam = .5
  - Aggregate = .22
Heating Basics

- **Sensible heat** is heat energy that is transported by a body that has a temperature higher than its surroundings via conduction, convection, or both.

- **Latent heat** describes the amount of energy in the form of heat that is required for a material to undergo a change of phase (also known as "change of state")
  - Evaporation takes 970 BTU’s per pound
Produce Hot Mix Asphalt

- Virgin aggregate mix
  - Aggregate moisture 3%
- Mix temperature
  - 325°F
- Fuel
  - Recycled fuel oil
    - Cost per gallon $1.50
    - BTU’s per gallon 140,000
BTU’s To Make 1 Ton of Hot Mix

**Dry aggregate**

_Btu’s to heat water_

\[
2000 \text{ (lbs)} \times 1\% \text{ (moisture)} \times 1 \text{ (SH)} \times 212^\circ F \text{ (boiling point)} - 60^\circ F \text{ (ambient temperature)} = 3,040 \text{ Btu’s Sensible heat}
\]

_Btu’s for evaporation_

\[
2000 \text{ (lbs)} \times 1\% \text{ (moisture)} \times 1 \text{ (SH)} \times 970 \text{ (Latent Heat)} = 19,400 \text{ Btu’s Latent heat}
\]

_Btu’s to remove water vapor_

\[
2000 \text{ (lbs)} \times 1\% \text{ (moisture)} \times .5 \text{ (SH)} \times 325^\circ F \text{ (Mix temp)} - 212^\circ F \text{ (boiling point)} = 1,130 \text{ Btu’s Sensible heat}
\]

Total

\[
23,570 \text{ Btu’s per % Moisture}
\]

\[
23,570 \text{ Btu’s X 3 (% moisture removed)} = 70,710 \text{ Btu’s per ton}
\]

**Heat aggregate**

\[
2000 \text{ (lbs)} \times .22 \text{ (SH)} \times 325^\circ F \text{ (mix temp)} - 60^\circ F \text{ (ambient temperature)} = 116,600 \text{ Btu’s Sensible heat}
\]

**Total Btu’s**

\[
70,710 \text{ Btu’s dry aggregate} + 116,600 \text{ Btu’s heat aggregate} = 186,710 \text{ Btu’s per ton at 100% efficiency}
\]
BTU’s To Make 1 Ton of Hot Mix

Btu’s at 87.5 % efficiency

186,710 Btu’s X 1.14 = 212,849 Btu’s

Fuel usage

212,849 Btu’s per ton / 140,000 Btu’s per gallon recycled fuel oil = 1.52 gallons per ton

Fuel cost per ton

1.52 gallons per ton X $1.50 per gallon = $2.28 per ton
Hot Mix

- **ACFM 250 Deg F**: 45793
- **Virgin TPH**: 400
  - % Moisture: 3.0
- **Mix Temp**: 325
- **Burner Firing Rate**: 85.41 MMBTU'S/HR
- **RAP**:
- **Stack**: 50005 ACFM 200 Deg
- **Asphaltic Cement**: 212,849 Btu’s

**ULTRADRUM**

- **117” x 44’**
- **TPH 400**
- **Mix Temp**: 325

**Primary Collector**: 8000
Produce Warm Mix Asphalt

- Virgin aggregate mix
  - Aggregate moisture 3%
- Mix temperature
  - 250°F
- Fuel
  - Recycled fuel oil
    - Cost per gallon $1.50
    - BTU’s per gallon 140,000
BTU’s To Make 1 Ton of Warm Mix

**Dry aggregate**

_Btu’s to heat water_
2000 (lbs) X 1% (moisture) X 1 (SH) X 212°F (boiling point) - 60°F (ambient temperature) = 3,040 Btu’s Sensible heat

_Btu’s for evaporation_
2000 (lbs) X 1% (moisture) X 1 (SH) X 970 (Latent Heat) = 19,400 Btu’s Latent heat

_Btu’s to remove water vapor_
2000 (lbs) X 1% (moisture) X .5 (SH) X 250°F (Mix temp) - 212°F (boiling point) = 380 Btu’s Sensible heat

Total: 22,820 per % moisture

22,820 Btu X 3 (% moisture removed) Total: 68,460 Btu per ton

**Heat aggregate**

2000 (lbs) X .22 (SH) X 250°F (mix temp) - 60°F (ambient temperature) = 83,600 Btu’s Sensible heat

**Total Btu’s**
68,480 Btu’s dry aggregate + 83,600 Btu’s heat aggregate = 152,080 Btu’s per ton at 100% efficiency
BTU’s To Make 1 Ton of Warm Mix

**Btu’s at 87.5 % efficiency**

152,080 Btu’s X 1.14 = 173,371 Btu’s

**Fuel usage**

173,371 Btu’s per ton / 140,000 Btu’s per gallon recycled fuel oil = 1.24 gallons per ton

**Fuel cost per ton**

1.24 gallons per ton X $1.50 per gallon = $1.86 per ton
Warm Mix

ULTRADRUM

117” x 44’

TPH 400
Mix Temp 250

Oxygen 7.5

Virgin TPH
400%
% Moisture 3.0

39545 ACFM
225 Deg F

44075 ACFM
175 Deg

BAGHOUSE CLEANING AIR
8000

BAGHOUSE

Primary Collector

Burner Firing Rate
69.34 MMBTU’S/HR

Asphaltic Cement

173,371 Btu’s

Gencor Industries, Inc.
## Comparison

<table>
<thead>
<tr>
<th>Hot Mix</th>
<th>Warm Mix</th>
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<tbody>
<tr>
<td>212,849 Btu’s per ton</td>
<td>173,371 Btu’s per ton</td>
</tr>
<tr>
<td>1.52 gallons per ton</td>
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</tr>
<tr>
<td>$2.28 per ton fuel cost</td>
<td>$1.86 per ton fuel cost</td>
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18.5% drop in heating demand
$0.42 per ton drop fuel cost
Comparison

**Hot Mix**

- **Dry aggregate**
  - Btu’s to heat water: 3,040
  - Btu’s for evaporation: 19,400
  - Btu’s to remove water vapor: 1,380
  - Total: 23,570 per % moisture
    - 70,710 Btu per ton
  - Heat aggregate: 116,600
- **Total BTU’s**: 186,710 100% efficiency

**Warm Mix**

- **Dry aggregate**
  - Btu’s to heat water: 3,040
  - Btu’s for evaporation: 19,400
  - Btu’s to remove water vapor: 380
  - Total: 22,820 per % moisture
    - 68,460 Btu per ton
  - Heat aggregate: 83,600
- **Total BTU’s**: 152,080 100% efficiency
Dry and Heat Aggregate

30’ to dry and heat aggregate
Drying Aggregate/Warm mix

- To obtain the same level of drying, additional time is required for moisture to leave the aggregates
  - Flighting adjustment
  - Drum slope adjusted
  - Move heat to feed end of drum (counterflow drum)
Drum Flighting
Veil in drum
Exhaust System

- Function of the exhaust system
  - Remove combustion gases from dryer
  - Remove evaporated aggregate moisture (steam) from dryer
  - Remove / collect dust / fines from gases
  - Provide secondary air for burners
  - Pull hot gases through dryer so heat transfer can occur
Dew Point

- Temperature across baghouse must remain above dew point (170°F)
Moisture in Baghouse
Leakage Air
Leakage Air
Retained Moisture
Warm Mix Production

- Properly tuned burner
- Drying adjustments
- Flighting adjustments
- Keep baghouse above dew point
- Retained moisture
Questions?