This HADES-125 burner from Detroit Stoker is being factory test fired on fuel oil.

What You Need to Know About Burner Size and Performance

BY JIM FEESE

Editor's Note: For 2024, AsphaltPro *Magazine allows experts in the industry to share how to expand your operations to the next phase of business. Are you ready to start making your own hot-mix asphalt? Let's turn to some professionals who have equipment, services, software and tenure to help you expand efficiently to mix design, production, hauling and more. This month's installment from Detroit Stoker Company delves into the mechanics of sizing the aggregate dryer properly for your intended HMA production plant.*

Properly sizing your aggregate dryer burner for optimum plant production should be a straightforward exercise; however, in many cases the burner is sized for significantly more than typical plant operating practices or even production capability. This can lead to multiple performance-related issues, reduce both burner and overall dryer efficiency, and reduce equipment lifespan.

Let us first explore why or how a burner gets over-sized. This typically happens one of two ways. One, an existing burner gets moved from one plant to another by the owner or via a used equipment sale. Although the plant may only require a 100 MBtu/hr burner, the next larger size (or two) may be the only unit available on the used equipment market and/or from a different plant in the owner's fleet and that burner gets applied to the system. Second, when purchasing a new burner, the customer tends to "over-spec" the burner such that it is sized for the maximum tonnage rate the plant could ever produce in addition to very high maximum material moisture percentages.

Revisit the article "Mix-and-Match Asphalt Plants" by Malcolm Swanson in the December 2023 issue for a deep dive.

Let's look at a simple example. A customer is purchasing a new 400 TPH counterflow drum mix dryer with the following specifications:

Dryer Output (TPH)	400
Virgin Material Moisture (%)	5
RAP (%)	30
RAP Moisture (%)	3
Material Mix Temperature (°F)	310
Flue Gas Temperature at Stack (°F)	250
Asphalt Cement (%)	5
Heat Losses, from Drum/Ductwork (%)	5
Total Burner Heat Input Required (MBtu/hr)	91.1
Specific Fuel Consumption (Btu/ton HMA)	227,810

The above example yields a required heat input of 91.1 MBtu/hr with a specific fuel consumption of 227,810 Btu/ton of material. Because the nearest available burner is rated at 100 MBtu/hr, the customer wishes to go up a size for "safety" reasons and selects a 125 MBtu/hr rated burner.

Now let's look at typical plant operation. The plant runs on average at 250 TPH production with 3% moisture in the virgin material. The heat balance now looks like this:

Dryer Output (TPH)	250
Virgin Material Moisture (%)	3
RAP (%)	30
RAP Moisture (%)	3
Material Mix Temperature (°F)	310
Flue Gas Temperature at Stack (°F)	250
Asphalt Cement (%)	5
Heat Losses, from Drum/Ductwork (%)	5
Total Burner Heat Input Required (MBtu/hr)	47.5
Specific Fuel Consumption (Btu/ton HMA)	189,881

In this example, we now have a burner that typically fires at 38% (47.5/125 x 100) of its rated capacity. We'll see why this is a big deal as we look at burner design.

A burner is a fixed orifice (both air passages and gas passages are of set design or dimensions), which is sized for at least the maximum rated capacity of the unit (plus some safety factor to ensure the burner does not blow-out or the flame lift off at or near the maximum capacity). This means with the above 38% output a few things are happening. The airflow and fuel flow are now exiting the burner at approximately a third of the maximum design velocity.

The burner's function is to stabilize the flame and to properly and thoroughly mix the air and fuel to ensure complete combustion. In a rotary dryer, that combustion must be completed as quickly as possible in the limited combustion zone length. You may recall from high school physics:

$$KE = \frac{1}{2} M \times V^2$$

$$(\text{Kinetic Energy} = \frac{1}{2} \text{Mass} \times \text{Velocity}^2)$$

Assuming a Detroit® HADES burner (each burner make and model will result in different values, but the overall reduction in KE will be the same), the HADES-100 burner is designed for a peak KE at maximum firing rate of:

$$KE_{design} = 5{,}586 \text{ ft-lbs/s}$$

Note: this is technically "rate of change of Kinetic Energy" or "power."

The HADES-125 example burner selected (for "safety" sizing purposes) is being fired at 47.5 MBtu/hr at 250 TPH production rate or:

$$KE_{actual} = 315 \text{ ft-lbs/sec}$$

(assuming we could fire at the same 25% excess air level)

The over-sized 125 MBtu/hr rated burner is now firing at approximately 6% of the optimum discharge energy design point. This has a significant impact on air/fuel mixing, emissions and ultimately dryer performance.

The burner almost certainly must now operate at significantly higher excess air levels to get some of that lost air/gas mixing (kinetic energy) back. So instead of firing at optimum design point of say 25% excess air, we now must tune the burner for say 50, 60% excess air or more at this lower load (and larger size burner) to get sufficient air/gas mixing to ensure complete combustion—minimum Carbon Monoxide (CO) emissions.

Assuming 60% excess air, the overall loss in combustion efficiency due to heating up this additional airflow results in fuel consumption increase of 2.3%. Further, even with the additional excess air to drive mixing, it still often leads to additional CO emissions as the added excess air quenches the flame. Excessive CO emissions often coincide with unburnt fuel, which means HydroCarbons (HC) out the stack, which are typically not measured by most portable combustion analyzers. An increase in CO emissions alone of 200 ppm (CO has a higher heating value of 321 Btu/scf) will result in 52,240 Btu/hr of lost fuel (not accounting for additional HC losses).

The above simplified example demonstrates how over-sizing the burner can easily cost a plant 3% or more in additional fuel costs per ton of asphalt. Additional potential problems include:

- Tuning the burner to meet more stringent NOx and CO emissions requirements or permit limits can be substantially more difficult if not impossible to achieve. Decreasing CO emissions through tuning will typically increase NOx and vice-versa.
- Material temperature can fluctuate widely as small percentage changes in burner output cause relatively large changes in fuel flow as only a small band of the actual burner output range is being utilized.
- If a burner fires at very low output (and correspondingly excess air is not high enough to drive the air/fuel mixing process) it is common to find burner front end over-heating damage. Warped and/or overheated burner parts can be costly and time consuming to replace and will decrease burner combustion efficiency and performance as the deterioration worsens.
- Combustion flight damage could also occur resulting in costly and more frequent flight replacements.
- Additional performance related issues with balance of plant equipment operation can occur depending on drum, baghouse and exhaust fan sizing to name a few.

A corollary to burner sizing is air/fuel ratio control. The burner control system must be able to keep the air/fuel ratio optimized at all firing rates or burner efficiency will suffer for the same reasons cited above. Linkage-less control with direct coupled fuel flow valve/actuators and direct coupled air dampers/actuators or better yet, air flow control via variable frequency drive (VFD) is the best solution when properly integrated with a PLC based combustion control. The PLC control is designed to provide a tuning curve to enable optimal adjustment of the air/fuel ratio at all firing rates.

Note there are a lot of assumptions involved in this simplified example not the least of which is material moisture, percentage of RAP in the mixture as well as overall RAP moisture, etc. These are especially important considerations when sizing the proper burner. The burner manufacturer should be consulted early in the burner specification stage to ensure the plant needs are being properly met with a correctly sized burner for peak operating efficiency.

While over-sizing the burner may seem to be the right decision for future big jobs or anticipated growth, it can be a costly one, perhaps avoided by better plant operations including silo storage and truck load out to the job site, etc. Properly sizing the burner from the start can pay for itself in fuel efficiency gains in relatively short order. AP

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