Many of the problems associated with process burners are related to the burner tips. In fact, some say there may not be two process heaters in the world that have identical burner designs: While the burner bodies may be the same, the tips are custom designed for the specific application. Each burner normally has multiple fuel tips, and each tip usually has multiple holes (sometimes called ports). The number, size and angle of the holes in each tip are carefully selected to give the desired flame characteristics (flame length, for instance) and burner performance (to minimize NOx emissions, for example). Therefore, tips design, installation and maintenance are critical to ensuring proper burner operation.

One way the burners’ firing rates can be determined is by using individual fuel flowmeters. However, this is usually prohibitively expensive in plants that have many process heaters and where each heater has multiple burners. Instead, the most common method used to determine the firing rate of individual process burners is with fuel capacity curves — graphs of firing rate vs. fuel pressure.

Fuel capacity curves are generated specifically for a given burner design and fuel composition. In many cases, because multiple fuel compositions are used, multiple curves are needed for each particular process heater. The curves are generated based on three factors:

- The number of tips used in the burner.
- The sizes of the holes in each tip.
- The flow coefficient for each tip.

The total fuel flow to a heater is usually measured with a flowmeter. Because all of the burners in a heater typically are designed to fire at the same rate, the firing rate of an individual burner can be calculated by dividing the total firing rate of the heater by the number of burners. The actual measured fuel pressure required to produce a given firing rate then can be compared to the predicted fuel pressure for that firing rate from the fuel capacity curve. Assuming that the correct burners tips are installed in the burners:

- If the actual fuel pressure is higher than that predicted by the capacity curves, the tips likely are plugged.
- If the measured fuel pressure is lower than predicted, the holes in the tips likely are larger than designed. This can occur if they have been eroded or corroded from contaminants in the fuel, or from repeated cleaning.

Because they are typically exposed directly to the heat in the heaters, fuel tips often are made of a higher temperature metal alloy. High temperature alloy tips are required in preheated air applications.

**Figure 1.** The plugged tips in these burners are noticeable during operation. Refinery fuel gases often contain contaminants that can plug burner tips. Also, coking due to high tip temperatures and pipe scale can plug the small holes in burner tips.
and if significant amounts of hydrogen are present in the fuel. The purpose of the alloy is to reduce metal scaling.

Many of today's low NOx burners have the tips located outside the refractory tile that is used, in part, to protect the metal components inside the burner. The tips are outside the tile to help stage the fuel into the airstream to minimize NOx emissions. However, this location exposes them to higher temperatures. Under normal conditions, this is not a problem because the tips are cooled by the high-velocity fuel gases flowing through them. Under some circumstances, however — very low firing rates, or when burners are turned off while the heater is still hot, for example — the higher temperatures can be a problem. Overheating the burner tips can cause the carbon in the fuel to thermally crack, giving rise to coking inside the tips, which leads to plugging of the holes.

**Common Burner Tip Problems**

Many problems can occur with burner tips that have not been properly designed, installed and maintained. Common issues include:

- Flame impingement on the process tubes.
- Flame-to-flame interaction.
- High pollution emissions.
- Improper heat transfer.
- Unstable flames such as flame pulsations, which are sometimes referred to as huffing.
- Difficulty lighting burners.

Figure 1 shows burners in operating process heaters where some of the tips are partially or fully plugged. Process burners typically use refinery gases as the fuel combusted in the burners. These gases often consist of many different components such as methane, propane and hydrogen. Refinery fuel gases also often contain contaminants such as liquid fuel droplets or amines that can plug the small holes in burner tips. Also, as previously mentioned, coking due to high tip temperatures can cause plugging. Pipe scale also can plug the small holes in burner tips.

Figure 2 shows some examples of plugged tips found in operating process heaters. An industry best practice is to add some type of filtration such as strainers or coalescing type filters in front of the burners to remove particulates that could plug the burners. Another method is to use stainless steel piping from the fuel filter to the burners to prevent pipe scale from plugging burner tips. Without filtration, dirty fuels and rusty piping can necessitate more frequent burner tip cleaning.

**Proper Installation**

Burner tip installation is critical to proper burner performance. Vendor drawings give specific dimensions on how to properly locate and orientate the fuel tips. This includes which direction the tips should point and the elevation of the tips within the burner. These details may vary among burner designs even for the same basic models. This means it is critical for plant personnel to use the drawings when installing burner tips. Failure to do so could result in problems such as difficult light-off, flame instability and flame impingement on the process tubes.

Another common installation problem is installing the wrong tips. Figure 3 shows common burner tip bodies can have different drilling patterns, so users should consult the burner’s engineering drawings to identify the correct tip when replacing them.
common burner tip bodies that have different drilling patterns. Sometimes, plant maintenance personnel keep all of the same burner tip bodies in a common storage bin. Past burner problems have sometimes been traced back to installation of the wrong tips, re-emphasizing the need to use a drawing to identify the correct tip.

**Tip Maintenance**

Proper tip maintenance is critical to burner and heater operation. Depending on the contaminants present in the fuel and the efficiency of the fuel filtration system (if one exists), fuel tips may need to be cleaned at regular intervals. For instance, they may be cleaned on a certain time schedule (e.g., quarterly), when the measured fuel pressure is higher than the design pressure for a given firing rate, or when the burners appear to have operational problems usually associated with plugged tips.

It is important that all tips in a particular burner are cleaned at the same time, and also that all burners in a given process heater are cleaned at the same time. Although some ports may be more plugged than others, it is highly likely that all of the tips will have at least some fouling. Cleaning only some of the tips usually results in more fuel flow to those tips and less to the tips that were not cleaned. This can produce asymmetrical flames that often lead to operational problems.

Another important aspect of burner tip maintenance is using the correct procedure to clean the tips. The first step is to get the proper size drill bits used to make the ports in the tips as specified on the burner drawing. Before removing the tips, be sure you have the required personal protective equipment (PPE) and that the tips have been cooled in a water bath. If the tips are removed from the risers while they are still hot, the threads can be damaged.

The bits then should be inserted into the burner holes and turned by hand to clean out any contaminants that may be plugged the holes (figure 4). Under no circumstances should a power drill motor be used to clean the holes as this could enlarge the holes, change the shape of the holes (for example, from round to elliptical), or change the angle of the holes. Using high-pressure air or steam to clean plugged holes may not be effective at removing coke if it is hardened.

If the next larger size drill bit can be inserted into a tip port, then the tip should be replaced. Enlarged holes can flow significantly more fuel than they are designed for, which can adversely affect burner operation. It also means the fuel capacity curves would no longer be valid for the burner with the enlarged holes, making it more difficult to determine the burner’s firing rate.

Always use a high temperature anti-seize thread compound when reinstalling the tips on the risers to make it easier to remove them in the future. Also, be careful not to overtighten the tips on the risers because this could damage the tips and change the tip elevation in the burner.

In conclusion, burner tips play a critical role in process burner and heater operation. They must be properly designed, installed and maintained to ensure burners perform as specified. Drawings should be used to make sure the right tips are installed correctly in a given burner. Fuel filtration should be used unless the fuel is known to be clean such as with purchased natural gas. Plugged tips should be manually cleaned with the drill bit sizes specified on the drawings, and tips with enlarged holes should be replaced. Failure to properly install and maintain the correct tips in a burner can lead to many problems that can be potentially dangerous and costly to a plant. PH

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