Question 63: What type of facilities have you used to cool hot vacuum residue going to storage to avoid plugging problems and facilitate reprocessing?

WATTS (LyondellBasell Industries)

I am going to focus on the system we have and also some of the issues we have experienced. The majority of our resid that is produced off the crude unit vacuum towers is sent through the hot resid system straight to the cokers. We have two crude unit trains. We process 120,000 to 140,000 barrels per day of crude on each unit. We have two cokers. Each coker has four drums. One coker can process up to 40,000 barrels per day of resid on a four-drum operation. The other can process 60,000 barrels per day of resid on a four-drum operation.

Our cold resid system is where we send excess resid, but we also maintain that system during normal operation. So, what we do is take uncut resid at about 400°F+ and add cutter. A base cutter for us is heavy cycle oil from the FCC. That is typically the only place we send it. Then we make up, as needed, with distillate-range material. The majority of the time it is LCO from the FCC. Basically, we target a maximum tank temperature. We have a temperature limit of 210°F, so we try to keep it around 200°F. When we are stacking a lot of resid, we can hit a viscosity spec. We have found that we need to add about 30 to 40% cutter to hit that spec.

We have three main modes of operation. The first is typically the mode in which we operate. I call it ‘resid system balanced’. Basically, this is where the coker is pacing the cold resid. So typically, we are sending 6,000 to 10,000 barrels per day to tank and pulling that equivalent amount back to the cokers.

We have what I call ‘resid stacking mode’. With the current system, we can stack up to 30,000 barrels per day of resid with a minimum of 30% cutter. That leaves about 21,000 barrels per day of resid you can stack.

The last mode, which we do not do very frequently, I call ‘resid pull’. Typically, this occurs after a short outage of the cokers. After the outage, we will pull back resid that was stacked. Occasionally, the economics support going out and purchasing resid, but the way our refinery operates is that we are typically close to limits on the cokers when both crude units are at full rates because the resid yield is typically above 30%.

The last piece I want to talk about is basically how we minimize the potential for resid line plugging; basically, it is managing the temperature. As I said, we have limits on what we can send to the tank, but we operate in a relatively tight window. We try to keep the temperature above 190°F. Basically, we have added in the orders for the console operators that one time per shift, they need to heat up the cold systems. So, they do that about twice per day. Resid, as I am sure a lot of you are aware, is hard to meter. So basically, what we have done, based on operating experience, is set minimum valve output limits where we are all alarmed if the resid rate gets too low. That is based on historical information. So, for us, the biggest challenge for managing the hot and cold resid system is during major upsets when we lose production of our main cutter source and significant coking capacity. This is typically where one or more of the cokers go to a two-drum operation. That is where we are most likely to have issues with plugging in the sections of the hot or cold systems.

In fact, back in 2010, we had a refinery-wide emergency shutdown. We actually plugged up the hot system between one of the crude units and the cokers. It took a lot of money and time to unplug that system. Last year, we also plugged up a small part of the cold system. The highest risk for us is when we have a major refinery outage because multiple assets or operating teams have to communicate with each other to make sure we get cutter in the lines.

PRICE (Fluor Corporation)

I want to second what Ed said: The challenge of storing hot resid is very difficult, although folks who make asphalt and store it have more chances to do this than others.

To overcome the difficulty in storing hot resid, many refiners in Southern California will use box coolers, diversion air coolers, or a tempered water bath. Normal cooling water cannot be used because it will cause extreme fouling on the water side, as well as plugging on the hydrocarbon side. The diversion air coolers incorporate special design features to ensure that the approach to pour point is adequate to prevent plugging on the hydrocarbon side. On an emergency basis, quenching with cold gas oil product is about the best option you have.

EBERHARD LUCKE (CH2M Hill)

I do not know if you mentioned this; but if you did, I apologize for making you repeat it. When you process cold vacuum residue in the coker unit, because of heat integration and the amount of cutter stock you need, do you have a limit, such as a percentage of total fresh feed, up to which you can process?

WATTS (LyondellBasell Industries)

A typical operation is where I would, say, pull less than 10,000 barrels per day out of 90,000 barrels. I know that we pulled quite a bit more than that in the past – up to 20,000 barrels, or somewhere in that range – out of 90,000; so, a little over 20%.

JAMES DOHERTY (LyondellBasell Industries)

To add to the point and answer the question, I work on the cokers with Ed. We would hit that limit. Sometimes, right before we got to that limit, we would see increased foaming on the cokers. That would limit our pullback instead of a heat limit.

WATTS (LyondellBasell)

I want to comment on what Maureen mentioned. I did not really add detail to how we cool off our resid. We add cutter. We have cooling water exchanges on the crude units. But a couple of years ago, we installed a temporary cooling system just before we sent the resid to the tank. We actually cool off the resid with glycol. That is a much better system, in terms of reducing exchanger fouling. It allowed us to reduce our cutter significantly and also to stack more resid. With that system, we were able to stack as much as 40,000 barrels per day of resid. Without that system in place, we were limited to somewhere around 20,000 barrels per day.

VILAS LONAKADI (Amec Foster Wheeler)

In most cases, vacuum residue is cooled with the incoming feed to a crude unit or other streams that require heating. Other facilities employed are the use of steam generator or tempered water system. Viscosity, and pour point of vacuum residue, along with the design temperature of the storage tanks, tracing of the product rundown line, type of heating facilities for storage tanks, and storage duration should all be taken into consideration when deciding the storage temperature and design of the associated facilities.

EDWIN WATTS (LyondellBasell Houston Refining)

There are several different system designs that are used to manage excess resid produced off the crude units. Our excess resid is mixed with a cutter stock and cooled to about 200°F using cooling water exchangers prior to going to storage tanks. The cutter is a combination of FCCU heavy cycle oil and distillate range material. The resid is either sold or pulled back to the cokers as feed. It is important to maintain adequate flow, temperature, and cutter to prevent the system from plugging up.

MAUREEN PRICE (FLUOR)

Ideally, hot vacuum residue is cooled through the preheat train to about 400°F before being sent to a storage tank that is designed for this hot temperature and in accordance with the codes and standards which can present a challenge. To overcome the design challenges of storage at (or near 400°F), a box cooler, diversion air coolers, or a tempered water bath can be used. The use of normal cooling water is not recommended (due to the risk of extreme fouling on the water side AND plugging on the hydrocarbon side). Diversion air coolers incorporate special design features to ensure that the approach to pour point is adequate to prevent plugging on the hydrocarbon side. For emergency rundown, the hot vacuum residue can be quenched with cold gas oil product to be sent to a storage tank for reprocessing.

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