
Question 86: The reformer's feed properties can be affected when the refinery is maximizing refinery diesel yield. How do these changes to reformer feed affect performance with respect to C5+ yield, hydrogen production, cycle length, and economics?

NEWTON (Roddey Engineering Services, Inc.)

As everyone knows, we're not here to discuss how to make more gasoline; we're here at the conference to learn how to make more diesel, so I just hope you people in here... But whenever you start to talk about maximizing diesel yield from most refineries, what you're going to talk about is shifting the heavy end of the reformer feed to the diesel stream and so you lower your endpoint to the reformer.

This has three different effects on the reformer. First of all, the heavier reformer feed normally is easier to reform. When you lower the endpoint of the feed going to the reformer, directionally, you're going to have to raise your inlet temperatures to the reactors to have higher activation energy because you're going to have components that aren't as easy to reform.

Though when you cut the heavy end of the reformer feed to the diesel, you'll lower your space velocity, which will offset that a little bit. But directionally, as you lower the endpoint of the other reformer feed, your C5+ yield will go down and your hydrogen production will also go down. There will be a little offset due to the fact that the space velocity is low, but the good point is that you increase your cycle length. So for all those years when we were struggling to make your six-month or your year cycle and you were worried about your reformer not making it, it's pretty easy to make it.

As far as economics go, economics vary from refinery to refinery. In the past, we've had P&P discussion on how to operate a reformer well. We could all sit up here and give what makes economic sense for the reformer, but that's not necessarily going to be what's good for the overall refinery picture right now. So your two main constraints are going to be hydrogen demand and octane. If what we talked about with the Isom and ethanol blending doesn't really strain a reformer for octane, then what will be the hydrogen needed to run your other units? The other constraint is going to be your turnaround schedules; i.e., your hydrotreater. The only other thing that may constrain you is dependent upon how much of the reformer feed you send to the diesel pool. A question we'll discuss later is: What is the minimal space velocity for a reformer? If you cut out so much of the feed that you're towards the minimal space velocity requirement for your reformer, that may be a constraint; though, it's not likely.

ZMICH (UOP LLC)

I would like to provide a few comments based on UOP's experience. Some of the Canadian refineries that I'm used to, and have been historically following in the past, do this as a Gasoline Processes Gasoline Processes Effects of Lower End Point • C5+ yield • Hydrogen production – There may be a little offset if the LHSV is lowered • Cycle length (semi-regen) normal practice during the winter months. They'll shift some of the cut to the diesel production and lighten up the endpoint on the feed to the reforming unit. If I premise this saying that we're looking at a full boiling range feed to start with, then I agree with what Michael said in that as you shift the material to the diesel, which means lowering the

end boiling point of the naphtha into the reforming unit. Lowering the endpoint concentrates the lower molecular weight material—C6, C7 paraffins, maybe C8 paraffins. As you go down in molecular weight, those are the materials that are more difficult to convert to an aromatic—the objective in reforming anyway—and less selective. Half of the C8s, for example, go to an aromatic and roughly 25% of the hexane material will go to an aromatic.

As we drop the endpoint, then, recognizing that the selectivity is worse, the reformate production and hydrogen production are going to go down at constant octane, research octane number. The coke rate will go down, which will result in a longer cycle length. And, there will be what I call a shift in the optimal octane barrel relationship. Sometimes when we look at trying to help refineries optimize their production of the reforming unit, we'll look at an octane barrel versus octane graph. There will be an apparent shift in that relationship as we change the endpoint.

QUINTANA (Valero Energy Corporation)

Regarding the comments from both Michael and Joe about lower hydrogen yield with lower naphtha distillate cut-point, we contend that somewhat depends on the initial boiling point of the naphtha. We agree that if the naphtha feed includes the full C6 fraction, then indeed your hydrogen yield will go down because you have a greater proportion of the C6 fraction in the feed and you tend to hydrocrack a fair amount of that fraction, which consumes the hydrogen.

Gasoline Processes Gasoline Processes Reforming unit feed properties • Shift to diesel means lower end boiling point (EP) naphtha to reformer • Lower mol wt hydrocarbons more difficult to convert • Feed EP ? reformate ? H₂ yield at constant RON • Feed EP ? catalyst coke rate ? longer cycle • Feed EP means shift in optimal RON-BBL relationship

However, if you have a feed that's primarily C7+ fraction, as we have at one of our California refineries, we find that reducing endpoint actually can increase hydrogen yield because you are making the feed a bit leaner with less aromatics in the feed and more paraffins. As you convert those paraffins to aromatics, you produce incrementally more hydrogen. With the C6 fraction, you're just getting a larger contribution of the hydrocracking that erodes that hydrogen potential. Given a C7+ fraction, you're able to capture some of that, so you can actually get a mild improvement in the hydrogen yield.

SONI OYEKAN (Marathon Oil Company)

This question appears to be directed more towards semi-regen-type operations. I think one of the difficulties we find with the CCR-type operations is if you're running a reasonably low octane and you start cutting your feed deeply to satisfy diesel, you start not making enough coke. And if you don't make enough coke, then you start having very unsteady state regenerator operations, which leads to some inefficiency in how you run the CCR and also impacts your economics as well.

KAISER (Delek Refining Ltd.)

Yes, we've certainly found that to be the case at our CCR operations. And in fact, we'll put the regenerator in hot shutdown quite often and let it sit there—let the catalyst sit in the reactor, and let it build up some coke. Then, we'll start the circulation back up, run it through some regeneration cycles until all the catalyst is cleaned up, and then we'll shut it back down again. Periodically, we're also still doing high plat octane runs for premium blending. We'll fill up our tank. That's a good time to run a decent circulation to keep the regenerator in good health and the catalyst moving around. But for the majority of the time, our regenerator is down and we're operating essentially as a fixed-bed unit.

NEWTON (Roddey Engineering Services, Inc.)

Yes, we've had some people who have talked about cutting the hydrogen-to-oil ratio way back to increase coke make. We caution that before you start making drastic changes like that and going outside of normal operations, you should talk to your catalyst provider or your technology supplier before you start. You might be thinking, Well, I'm just going to make more coke by cutting the recycle gas back, but you don't want to do that without really thinking through it.

QUINTANA (Valero Energy Corporation)

We have one of our refineries in California that operates in that same mode. As California changed its gasoline specifications over time, we basically chopped off the back end of the feed and chopped off the front end of the feed as well. So we ended up having about a 220°F to 320°F boiling range feed. We were making about only 20% of the original designed amount of coke. Our philosophy is actually to keep circulating the catalyst, let it build to about 3.5% coke and then start operating the regenerator. We will regenerate the inventory, shut down the regenerator, and continue to circulate until coke builds again. It's typical to see some sort of cyclic impact on the yields when you do that, but we find that it gives us a much better control of the product quality with this approach.

NEWTON (Roddey Engineering Services, Inc.)

Is there anyone who is buying naphtha to supplement their own feed to help make up the reformer for their CCR or if there is any available that you know of?

KAISER (Delek Refining Ltd.)

We actually have, from time to time, purchased reformer feed; not specifically to generate coke or to keep velocity up in the reformer or the feed rate up in the reformer, but just because it was opportunistic.

METKA (Sunoco, Inc.)

Historically, we have purchased naphtha, but the economics right now aren't really supporting running the reformers up to those levels.

SONI OYEKAN (Marathon Oil Company)

Just a follow-up question for Javier: You indicated that in the refinery in California, Valero keeps the catalyst circulating. So that means you're not conducting the burn, but it allows you to move the catalyst until you determine where the coke level is and then kick in or restart the burn.

QUINTANA (Valero Energy Corporation)

That's correct, yes.

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