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What constitutes a real-time application?

I recently heard computer programs, mainly of the simulation variety, described as working in real time in service of the unit operators, inferring product properties and other unmeasured constraints minute-by-minute. I have heard this story from a number of different people, about predicting crude unit product properties, reformer octane and coke make, FCC product yields and properties, and numerous other units. Hang on, I would say, what do you mean by that? The simulation requires manual input of the unit feed and surely the operator would not have the ability to keep your program up-to-date minute-by-minute. Well, comes the answer, it is real time because it reads the unit control handles, and while it does not give relevant results all the time, it does work correctly at the moment when unit feed is specified. In fact it works so well that we are looking to put it in closed-loop service.

That is not real time my friends, and that is not inferential calculation. It is a useful offline tool that may be activated from time-to-time, inputting whatever is known about the unit feed and obtaining an estimate of the unit performance at that moment. When you let such programs run minute-by-minute, and you store the results into an historian, you create not information but misleading clutter. Consider keeping the result of such simulations in a database similar to what the lab is using to store information. The result is not continuous and it has a time stamp, showing that it is valid only at the time indicated.

Estimating feed properties. One of the most difficult problems in any refinery is to correctly identify the feed properties of any unit. Bookkeeping of oil movement activities to estimate unit feed tank properties has been tried for decades, but this problem is yet to be solved. In addition to the incomplete knowledge of what comes into the tanks, the degree of mixing in large tanks is unpredictable. To calibrate crude unit simulation, the simulation industry companies have resorted to detailed lab analyses of all products, and, from those analyses, mathematically synthesized the crude oil feed properties. They no longer attempt to estimate feed properties from crude receipts. When a reformer simulation needs to be calibrated, they test the feed for boiling curve and paraffin, naphthene and aromatic (PNA) content. To calibrate FCC simulation they go through a very extensive feed testing procedure, measuring con carbon, refractive index, boiling curve, metals, sulfur, nitrogen and other impurities. Why do they go through the trouble of such elaborate feed testing programs? It is because precise unit feed information is simply not available.

I would argue that such "real-time" simulations cannot become a tool in service of operators. If the operator has to type several numbers into the computer, one of those numbers might be wrong and then the simulation results would be erroneous. More correctly, those programs service process engineers, who understand that the unit feed data being input is incomplete, but they can still go through valid comparisons and "what if" studies.

Can we somehow modify such offline simulation to infer the unit feed properties? I am not saying it is always possible, but suggesting that to qualify as a real-time tool we ought to demand that the simulation give valid results all the time, not only at the instance that someone types data into it. If inverting the simulation to identify unit feed is not possible, then perhaps partial inversion is possible, and perhaps a few more measurements or an on-stream analyzer would help.

Let me give examples of feed identification by a simulation. I have a program that identifies the true boiling point (TBP) curve of the crude being fed to the crude unit (CDU). That identification is possible because there are strong relations between TBP and crude column measurements. I use this program to infer product distillation properties minute-by-minute. However, when the requirement is to infer cold properties, I do not have enough information. Cold properties are a function not only of the distillation curve, but also the Watson *K* factor (*Kw* = cubic root of boiling point divided by density), and there are normally no measurements on CDUs to help identify *Kw*. To overcome this problem, it would be necessary to install a density analyzer on the kero or diesel products.

Using a density analyzer. I also use a density analyzer on reformer feed to help identify the reformer PNA content. Reformer unit normal measurements are not enough, but aided by the additional density reading they are able to identify the feed. Knowledge of the feed PNA content minute-by-minute permits continuous calculation of reformate octane and catalyst fouling rate. That is a real-time inferential program. If I could not invert this simulation (with the help of density readings), and had to wait for occasional PNA input as measured by the lab, that would only qualify as an offline program.

But be careful when you specify many and complex analyzers. An FCC simulation relied on a number of analyzers: refractive index, sulfur and others. The simulation was not bad technically, but was plagued by analyzer reliability problems and never got off the ground.

The moral of this story is: If you have a simulation that requires lab analyses and manual inputs to work properly, don't say that it is a real-time tool. You will disappoint the users and tarnish your reputation. If you can invert this simulation with the help of one or two simple analyzers, go ahead and you will quadruple the value of your tool. HP

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