ChE views and opinions

Test to Measure the Ability of ChE Seniors In the Practical Application Of ChE Principles

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The following test was first given to our plant design students. It was meant to be part of a routine test toward the end of the semester in the practical application of ChE principles to the layout of a typical process flowsheet. When I reviewed the answers to the problem, it was very discouraging to have to accept the fact that our students had made so very many unexpected mistakes. It caused me to wonder how ChE seniors in other schools compared with ours in the practical application of chemical engineering principles. It occurred to me to ask other schools to give this same test, if their professors would cooperate.

Copies of the same test were submitted to several schools having ChE departments in hopes of making comparisons of our students with theirs. The professors were promised that I would not use school names or student names, if the test scores were analyzed and published. Thus, no effort is made to compare schools or individual students in this publication. The test presented below was given to the schools that agreed to the proposal.

OPEN BOOK PORTION OF TEST

Complete the process flowsheet that has been started having been given the following data: Compound A has physical properties comparable to isobutane. Compound B has properties comparable to hexane. The compound B is unsaturated but when combined with A and hydrogen over a nickel complex catalyst, a saturated compound AB is formed with traces of methane and about 2% tar based on total weight of A + B fed. Reactions may be represented:

A(4 moles) + B(1 mole)→ AB unsaturated + A(excess)
AB unsaturated + H_2(4 moles)→
AB saturated + 3 moles H_2 + 2% tar

The tar boils at about 450°F and 35 to 40 psia.

The reaction is exothermic having about 100,000 Btu/lb mole of AB formed. Compound AB has properties equivalent to decane.

Assume impurities in the hydrogen should not build up above 10% before being bled off and there is a constant supply of make up hydrogen available as well as A + B.

Assume product AB is to be 95% or greater purity. Show approximate temperatures, pressures and approximate compositions directly on vessels on the flowsheet you complete. Take advantage of utilities produced where possible. Reflux ratios on tower or towers may be taken as 1/1.

Approximately 100 students took the test, including all schools. The names of schools and names of students are not given to avoid embarassing any schools or students. The test results are summarized below.

This was given as an open book test and equilibrium data or other needed data were available.

SUMMARY OF ANSWERS

1. **23% of the students used a pump to take the 25 psia gas from the holder and charge to the reactor at 700 psia.**
2. **Of those that used compressors to move the gas from**

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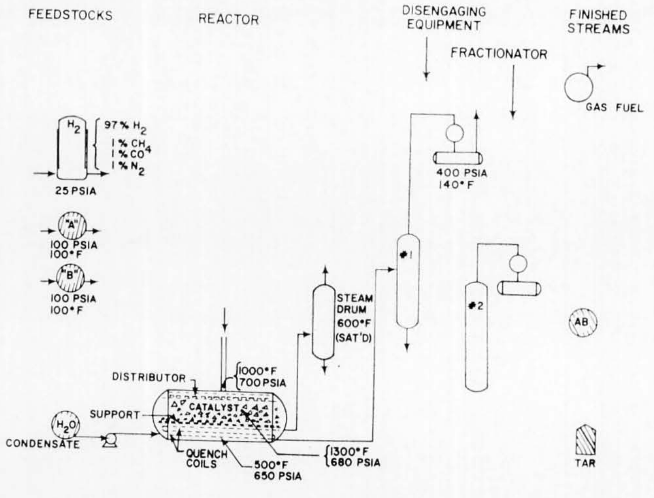

Process Flowsheet.

25 psia to 700 psia, 69% failed to use a knockout drum ahead of the compressor.

3. 24% of the students used compressors to take liquid "A" at 100 psia and discharge to reactor at 700 psia. (Note: Equilibrium temperature and pressure relationships of "A" and "B" could have been consulted, if in doubt, as to being a liquid or a gas.)
4. 36% of the students used no pump to take liquid "A" at 100 psia to reactor at 700 psia.
5. 28% of the students used compressors for moving liquid "B" at 20 psia to reactor at 700 psia.
6. 26% took liquid "B" at 20 psia directly to reactor at 700 psia without any power mover.
7. 20% used no preheater of any type to go from the vessels as indicated to reactor at 1000°F.
8. 12% vaporized liquids then compressed to 700 psia with a compressor.
9. 46% preheated with 600°F steam only to reach 1000°F feed temperature entering the reactor.
10. 80% failed to recycle steam condensate to reactor.
11. 68% showed no recycle H_2 from flash vessel to reactor.
12. 82% showed no recycle of product "A".
13. Of those that did recycle hydrogen, only 10% took advantage of the pressure of gas off the flash vessel and returned it to one of the higher pressure stages of the compressor.
14. 80% failed to quote any temperature or pressure whatever as requested on the first tower.
15. 60% failed to show any reflux for tower #1.
16. 40% failed to take bottoms from tower #1 to tower #2.
17. 30% failed to use any reflux on tower #2.
18. Of those that had correct feed to the tower #2, 60% failed to select pressure and corresponding temperature correctly on reflux drum to #2.
19. 80% failed to give proper temperature and pressure for top of tower #2.
20. 42% failed to provide a reboiler of any type for tower #2.
21. 70% failed to use correct transfer equipment for tower #2 products where correct feed to tower was used.
22. 60% failed to place any type product coolers on product lines to storage vessels.
23. 90% failed to show any temperature or pressures recommended for storage vessels.
24. Only three students took into consideration that it would be better to store the tar at elevated temperature.
25. Only about 10% of the students established the correct design basis for the feed to the reactor—the moles H_2 should be in the ratio 9 moles per 1 mole of the sum of the inerts—10% inerts in the total Hydrogen feed.
26. Obviously, with the knowledge of the simple mistakes made as mentioned, it would be too much to expect them to know how to process the #1 column overhead in a manner to obtain the proper recycle compositions. Some students did select the correct type reboilers and similar considerations.

TEACHING OUR STUDENTS TO THINK

There were many other mistakes, too numerous to mention collectively, but it was extremely revealing just how little our students have learned to think. It was not a surprise to learn that many would make mistakes on several of the above items, but the percentage that made these type mistakes and the grade point average (based on quality point averages in engineering courses) of some of the students that made mistakes was alarming. Professors will likely be surprised to learn their students will not do any better if they give this or a similar examination. It is believed other professors will have just as big a disappointment in the results as those of us that cooperated on this test, especially if they will not drill them on these specific type problems prior to giving the test.

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My analysis of the results reveals a very serious weakness on our part as professors in teaching our students to think. It has uncovered a weakness in our teaching procedures or curriculum that I think is in need of correcting, if at all possible. Just where and how to undertake to do this, in the best possible manner, is the so-called "$64 question". Some of this weakness at our school may have started when we dropped the teaching of inorganic and organic technology. Any courses where flowsheets of various processes were rather thoroughly discussed emphasizing reasons for the various pieces of equipment, operating conditions, catalyst, etc., served to help the students apply engineering principles.

PROCESS FLOWSHEET DISCUSSION

TWO OR THREE PROCESS flowsheets involving various types of equipment are discussed in my plant design course. Then the students are required to lay out a process flowsheet. Apparently, they are able to find their particular process flowsheets illustrated fairly completely in the literature, but they do not receive enough practice in thinking out the reasons why all the specific equipment is used. There are many items that the students should have thoroughly fixed in their minds before they undertake a course in plant design. Some of these items are:

- **Pumps are used to move liquids and compressors are only used to move gases.**
- **It costs a great deal more to elevate the pressure to some higher pressure by a compressor than it does a like weight of liquid by a pump.**
- **One does not vaporize material and then use a compressor to elevate it to some higher compression level if it can be elevated to the higher compression level first by a pump, then heated to the desired conditions to convert it to a vapor.**
- **One does not heat something to a higher temperature than the heating medium being used.**
- **Compounds having lower boiling points go out the top of an ordinary fractionator and the higher boiling compounds go out the bottom.**
- **All ordinary fractionating towers have a lower temperature and pressure at the top than at the bottom.**
- **All ordinary fractionating columns must have reflux and reboilers.**

These and many other statements that could be listed should be fixed in the students' minds before starting plant design.

I have tried to analyze why this weakness exists with our present day students. Just about all graduates of 20 to 30 years ago were required to take courses in organic and inorganic technology. In those courses taught to me, process flowsheets were discussed thoroughly in class and students were required to give reasons why the type of equipment used was needed; why specific operating conditions were best, based on kinetic and thermodynamic relationships; the likely poisons for catalyst, considering the chemical reactions that were likely to occur, etc. These courses have been dropped as required courses and in many curricula are not even offered. At least, I think those courses taught me to think and learn to apply fundamental chemical engineering principles. This causes me to wonder if we have not made a mistake in eliminating these courses. The other possibility is to utilize flowsheets in teaching some of the fundamental chemical engineering principles in such courses as mass and energy balances, unit operations, mass transfer phenomena, thermodynamics, kinetics, and plant design.

NOT ENOUGH PRACTICAL APPLICATION

IT HAS BEEN OBSERVED that the students are keen at memorizing fundamental principles, laws, rules, and derivations of equations, but when asked questions where these are to be used or could be applied to think out an answer or a solution, the students seem to fail to recognize the source of help. There appears to be too much emphasis placed on derivations of equations, theorems, etc., and not enough practical application. Perhaps the lack of industrial experience of faculty members or the tendency of faculty members to teach undergraduates like they were taught graduate courses, where derivations of equations were stressed, may have something to do with the weakness of students in the application of engineering principles.

At any rate, this test has convinced me that our ChE curricula have one serious weakness in the fact that so many of our graduates cannot do a better job of applying chemical engineering principles. □

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