ChE views and opinions

THE CHANGING ROLE OF THE CHEMICAL ENGINEER*

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CHEMICAL ENGINEERING TO ME is a peculiarly American institution. I was first reminded of this many years ago when I was studying in Switzerland. I observed that there were no chemical engineering textbooks by European authors. Walker, Lewis and McAdams, and Badger and McCabe were the standard references, and they were available only in English. Also, at that time there were as yet no departments of chemical engineering in the European universities as we had already known them in this country for many years.

In recent years, as I have had occasion to become somewhat familiar with the chemical industry in Europe, I have been struck with the different role of the chemical engineer over there as compared to this country. For example, I find it interesting that the heads of several of the leading engineering firms engaged in the design of chemical plants in Europe are not engineers but chemists. Likewise, I have observed that, at least in the German chemical industry, people with chemical engineering backgrounds are not found in positions of high authority—much in contrast to the situation in this country. I recall two or three years ago that the president of one of the largest chemical companies in Europe was quoted in *C. & E. News* as saying that he did not hold chemical engineers in very high esteem. He said that he could get more done with one chemist and two technicians than he could with one chemist and one chemical engineer.

I have concluded that chemical engineering in the United States is a more prestigious profession than elsewhere and that we, perhaps better than others, have learned the value of bridging the gap between chemistry on one hand, and engineering on the other, for the benefit of the chemical industry.

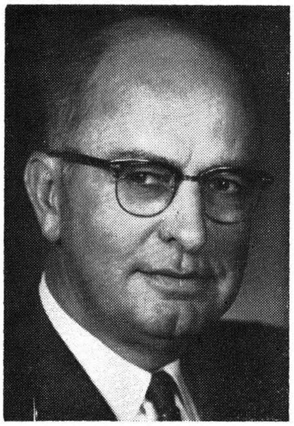
Certainly the chemical engineer has played a vital role in the American chemical industry for many years. I propose to talk about how I think that role is being changed by what is going on in the industry and by forces outside the industry which impinge on the profession.

CHANGES IN THE CHEMICAL INDUSTRY

THE CHEMICAL INDUSTRY has always been a changing industry, which makes it an interesting place to work, but it seems that the rate of change is now faster than ever before. In fact, it is probably changing at a rate faster than any other high technology industry with the exception of electronics. The industry has become large-volume, investment-sensitive, highly-competitive and more prone to rapid obsolescence. Competition to a large degree is the result of high profit margins of a few years ago which attracted newcomers to the industry, especially the oil companies who forward integrated into petrochemical products. We suffer from overcapacity at times, and profit margins are not what they used to be. The year '72, it should be noted, was the best year for some time and '73 to date looks even better. Further progress will depend heavily upon the performance of the chemical engineer and, as I will attempt to show, the engineer will be more important than ever.

The role of research in the chemical industry is changing. There has been considerable discussion in the literature about how our industry's research is not as productive as it once was. This is a highly debatable point and, of course, depends upon definitions of productivity. In any event it is certainly true that research is more competitive than ever, partly because there are more highly capable research organizations around than there were a few years ago. It is be-

*Presented to Delaware Valley Section AIChE, April 11, 1973.



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coming more difficult to come up with a new product on which a completely exclusive patent position can be obtained and with which we can proceed, with less than optimum technology to exploit the market with a comfortable margin. Then too, the nature of research is changing in the chemical industry. It is moving in the direction of support for existing products or variations of them. There are fewer examples in recent years of a chemical company researching itself into large, completely new proprietary areas in the manner, say, of nylon, which is probably the all-time classic.

We have certainly learned that invention and discovery cannot be bought merely by massive application of dollars and platoons of Ph.D.'s. Nevertheless, the rewards for good research, in my view, are as great as ever. It is just a tougher game than it used to be.

As a consequence of the foregoing considerations, it seems to me that the competitive position of a chemical company in the future is likely to depend less on patent positions and more on technology. I am certainly not underrating the value of a good patent position; I am saying that such a position is harder to get nowadays. Also for many important products of our industry, basic patents have expired.

To me this state of affairs means that the engineer, especially the chemical engineer, has a more important role to play.

LARGER SCALE OF OPERATION

AS THE INDUSTRY BECOMES more competitive and as more products approach commodity status, scale of operation becomes increasingly important. Exploiting this advantage of scale to a large extent depends upon the chemical engineer. We continue to build larger and larger single-line plants, for example, in methanol, polyvinyl acetate, textile fibers, DMT, etc. and I see the trend continuing. Scale-up factors seem to be getting larger each year, calling for increasing sophistication on the part of the chemical engineer. Our engineers recently extrapolated a very complex process form a 1 lb-per-hour mini-plant to a 150MM lb-per-year commercial plant. After a certain number of headaches, the plant is now operating at capacity. A great deal of time and money was saved by this approach as compared to carrying the product through a pilot plant. I should point out that this particular case involved an intermediate for internal use, so that market development was not involved.

The development and design of large single-line plants inherently require superior engineering. Continuity is critical; the malfunction of a single piece of equipment can shut down millions of dollars of investment. Since plant utility or time on line is so important and is the multiple of the individual utilities of a large number of equipment items, highly sophisticated techniques have been developed to predict during the design stage overall plant utility for various equipment configurations and to select the arrangement giving the best trade-off between down-time and investment.

In addition to our scale of operation getting larger, our processes are becoming more complex. This increasing complexity augmuents the need for better, more sophisticated engineering. The chemical engineer must not only comprehend basic relationships but very complicated interactions as well. This situation is particularly evident in process control which, in many of our processes, ex-

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ceeds the ability of human operators to handle directly. As a consequence, the industry is moving to computer control which is developing rapidly and has already attained an astounding level of development. Process control has become a profession in its own right. The use of computers requires more quantitative knowledge of the effects of process variables and their interactions than was previously necessary. The chemical engineer must provide this knowledge and it takes an especially good engineer to do it adequately.

As our technology becomes increasingly complex, more specialized knowledge in-depth is required for optimization of plant design. The chemical engineer is becoming more dependent on other engineering specialties. Our modern chemical plants are developed and designed by teams of engineering specialists.

There are, it seems to me, some important consequences of increased specialization and the growing importance of technology vs. patent position. Specialization is possible only in a fairly large engineering organization. Certainly outside assistance can and should be brought in when appropriate but this can present problems when we are dealing with proprietary technology. Technology can best be kept proprietary if the engineering is done in-house. Hence it seems to me that a competitive advantage in some types of large-scale chemical manufacture will accrue to those companies large enough to support their own specialized engineering organization. This does not necessarily apply to the manufacture of true commodity chemicals where the technology can be readily purchased, along with turn-key plants supplied by highly competent contractors.

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ENVIRONMENTAL AND ENERGY CRISES

PREVIOUSLY, I REFERRED TO forces outside the chemical industry which impinge on the practice of chemical engineering. One of the most potent of these is the drive to clean up the environment. In the chemical industry much of this task falls in the domain of the chemical engineer. There are certainly thousands of chemical engineers engaged in finding ways of cleaning up existing effluents to streams and rivers and exhausts to the atmosphere from existing plants. In some cases, they have been able to do this on a breakeven or a profit basis by recovery of valuable materials, recycling, etc. But this is getting more difficult all the time and, as regulations have become tighter, engineers are endeavoring to come up with solutions imposing the least economic penalty on the operation. Many ingenious solutions to many difficult problems have already been found. At the same time there are cases where there is simply no way out and the operation must be closed. As you are aware, the stated goal of existing legislation is zero stream pollution by 1983. Strictly interpreted, of course, this means that industrial effluents by then must be composed of nothing but pure water. Now we as chemical engineers know that such a goal is impossible without limitless supply of energy for free, and even then we would transfer much of the environmental problem to the solids waste and air pollution areas. It is not my purpose to discuss the wisdom of existing environmental legislation. I know that some legislators fully realize that absolute zero pollution is unattainable. But (politics aside) they feel that setting such a goal will push us to the limit of technical feasibility and perhaps inspire us to do things we didn't think possible.

In addition to the impact on the chemical engineer of the task of cleaning up existing operations, environmental considerations are strongly affecting his activities in the design and the development of new processes. He must now take environmental problems into account every step of the way. The process development is not finished until environmental problems have been satisfactorily dealt with, and obviously his choice of processes is greatly affected.

Another outside force which will have an increasingly profound effect on the chemical industry, and hence the chemical engineer, is the energy shortage. This shortage is already with us and will be getting far worse. The problems of the environment and the energy shortage are closely related and eventually priorities will have to be set—just how and by whom is not clear. Unfortunately, in our free society these kinds of problems tend to be neglected until a crisis develops. We have been hearing about the environmental crisis

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for sometime. Now the energy crisis is getting the attention of the public. There appears to be a growing awareness that the two crises cannot be solved independently. Environmental regulations have forced the substitution of oil and gas, already in short supply, for coal, which we have in abundance. Furthermore, present and future auto emissions controls are resulting in much less efficient automobile engines. This in turn means greater demand for oil. Environmental concerns have blocked exploitation of Alaskan oil as well as drastically slowed up adoption of nuclear power plants. We will be forced to import larger amounts of crude oil from the Middle East which will result in untenable foreign trade deficits.

All of this has a great bearing on the chemical industry, not only in regard to energy to run our industry but, of even greater importance, on the cost and availability of hydrocarbon feed stocks upon which the industry basically depends and for which there are no substitutes.

The energy shortage is already having considerable influence on how we do our chemical engineering. Energy consumption is becoming a much more important factor in process development and design. Increasing attention is being given to heat and energy recovery in the design of new plants. We used to install energy recovery systems if they showed a return on investment at current energy costs. Now we feel that energy recovery should be installed on a breakeven basis since costs can go only one way and that is up. Rising energy costs are also making it appropriate to restudy existing plants for opportunities for energy conservation. We are already doing this, and what we have found in several instances is that in order to make *significant* savings in energy, we must make *significant* changes in our processes. This poses a real challenge to the ingenuity of our chemical engineers.

COMPUTERS IN THE PROFESSION

I PREVIOUSLY MENTIONED computers for process control. No discussion of changes in the practice of chemical engineering, or engineering in general for that matter, would be complete without a few words about the effect of computers and computer systems on the profession. The computer has certainly increased engineering productivity many-fold and has enabled us to solve problems that we couldn't tackle previously. We have become so accustomed to the power of the computer that it is hard to visualize how we would function without it. It has removed much of the old drudgery from our work. I can remember hours and hours of slide rule work until I was bleary-eyed making a trial-and-error plate-to-plate distillation calculation; then to find that I had made some stupid mathematical error early in the calculation.

I am impressed with the impact that the computer is having on the design function. Our engineers have available to them well over a hundred programs of various size and complexity, covering just about all phases of design activity. Computer-balanced flow sheets are becoming standard for most major projects. Computer-made piping diagrams are becoming commonplace. Here again computers are relieving the engineers of drudgery. More important, they are providing him with greater flexibility and unprecedented speed to optimize designs.

One area where we should be able to use computers to a larger extent is in energy conservation. There are computer programs to make overall plant steam and water balances, but I get the impression that they are not used very much and that they are cumbersome and expensive. It seems to me that we have more opportunities in this field. The computer's influence on our work has already been revolutionary and the process is still going on.

Now, I have dwelt on the use of computers to a large extent, and in most instances I have commented on some interrelationship between the computer and the engineer. The computer is not lessening the role of the chemical engineer. Far from it; it is upgrading his role.

CONCLUSION

I have tried to suggest from my point of view how changes within the chemical industry and an increasing number of outside forces are changing the role of the chemical engineer. The need for chemical engineers with the basic ability to define and solve problems is greater than ever. Today's chemical engineer has a lot more knowledge and resources to draw on; but his problems are becoming a lot more difficult too. Change and challenge have always made chemical engineering interesting. It looks as though it is going to continue that way. □