THE CHEMICAL ENGINEER AND MATERIALS PROCESSING

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Before getting on with subject given in the title, it is well to say something about engineers in general before dealing with the chemical engineers in particular.

Engineers deal with things and people as they are related to things. Granted an engineer deals with ideas also, but nowhere to the extent of say, a researcher. Things are difficult enough, but people are even more complex. Because of this large intermeshing with people the engineer becomes involved in broad non-technical generalizations which definitely deal with philosophy. Therefore, considerable of what I shall say will deal with philosophical aspects of an engineer's work, which are as important, in my mind, as the more commonly accepted technical aspects.

Frequently an engineer must listen carefully to the lowest man on the totem pole to get clues toward the solution of problems. At the other end of the spectrum he has to sell his solution to his superiors, who may or may not be technically trained. If his supervisors are technical by training his selling is perhaps a bit less difficult, but he still must sell his solution. In the latter instance of a technically trained superior, it is my experience that he thinks more as a manager than engineer per se, and this is as it should be. The engineer should realize that all his solutions will not be accepted, because upon comparison to many other things that management has on mind his solution is not important. Just because of this it can be helpful to be selective in choice of problems, both from the standpoint of relative importance to the whole endeavor, as well as to available resources. The question can be put to me "Were you always aware of this?" The answer is in the negative and it can be said that osmosis is a slow process. But then learning people is a slow process.

Having said something about an engineer in general we shall deal with our subject the chemical engineer. At first glance it is sound to say he has to do with engineering aspects of chemical manufacture, for example sulfuric acid. Most people would not consider titanium dioxide pigment manufacturing as a chemical business but it is just as much so as petro-chemicals. Thus, a chemical engineer is a person who in school has had much formal chemistry, more than other engineers, has quite a grasp for fluid heat flow and has a good knowledge of a wide variety of unit processes.

As an illustration of what has just been said I should like to mention a particular session on metallurgical education, held a number of years ago at a national AIME meeting. Some of the professors wanted suggestions how to improve or strengthen the teaching of process metallurgy. Dr. O. Ralston, at that time head of Metallurgy Branch of the Bureau of Mines, and now retired, gave an answer that did not sit well. He stated that after many years of experimenting he found that it is best to teach chemical engineers some metallurgy and turn them loose than to try to teach metallurgist (physical for most part) unit processes. At the mentioned meeting a number of persons, including myself, voiced the same opinion as Dr. Ralston.

The chemical engineer, like all engineers has problems to solve, without creating too many in the process. Before getting into the matter of problem solving it is desirable to again talk about people. First there is the matter of receptiveness. When collecting opinions of description of events it is important to remember that you may have to ask your question a number of times and in different ways. This is necessary so that the other person understands your question and repetition causes the other person to think more actively. This can be construed as a form of harassment and the approach should be used only in the most important cases. A second version of receptiveness is when an associate or subordinate is trying to come through. The first time around you may not take to the idea discussed. This can be a result of poor presentation by the other person or lack of attentiveness on your part. Repetition by the other party may at times bring out good ideas because of your improved attentiveness or because of a better presentation by the other party. The same reasoning applies to one's superiors.

In general problems are related with new processes for old or new products. Then we have trouble shooting or fire fighting. In between there may be very time consuming problems having to do with causes and corrective measures for product variations.

Before solutions are sought it is important to know what the problem is. I shall give examples later to show that at times a problem appears on the scene because of a lack of meeting of minds on a specification and details of testing procedures contained therein.

In school we are taught to study literature before embarking on solutions. I agree with this concept. Having established the nature of the problem one finds that people are pained by the notion that they should struggle with the other chap's work before starting active work themselves. This may shock those of you in teaching, however, this is par for engineers a few years out of school. The few that do search the literature before suggesting solutions overdo it at times. For example, since messrs. X and Y wrote an article or book they must be right in all they say, a form of author worship. If this were the case there would be less need for most research. The difficulty is that publications are too frequently read and too infrequently studied.

Assuming that the literature and other background information has been studied we turn to suggested solutions. A typical case is where A makes a suggestion and B knocks it down as unworkable. Does B feel that A's suggestion is technically unsound or uneconomical or both? One never knows unless one inquires. The best approach is to confine the first discussions to technical evaluation of suggestions and then to evaluate the many aspects. To carry both at the same time creates friction, and is often a waste of time.

In any discussion of solutions to a problem it is nice to recognize precedence, provided this does not lead to a continued status quo. At times there is much more than meets the eye about a process. This is particularly true for a minor product that has been made for years without much complaint from customers. The rub is when a customer wants a lot of the stuff, made to a spelled out specification and a much lower price. This involves some sort of changes. The particular case is difficult, in that the process is not well understood, in that Joe and Mike have made the stuff for years without the benefit of a written or up-to-date operating procedure. They know how to make it at present scale, the engineers do not know, but must know before they make scale-up changes. This takes us back to the process of careful interrogation. This must be done most carefully because Joe and Mike have their guards up. Did they do something wrong and are you trying to eliminate their jobs. Gentlemen, this is a real problem to my mind.

The solution that chemical engineers come out with can require considerable effort by supporting research people. Sometimes the projected effort can be made brief by reasoning. After discussion with the research group the projected process should be understood. If we now assume that we have a stack of reports answering most of your questions we can make calculations just as if we actually had the reports. On infrequent occasions this approach will show that the suggested solution does not have merit. It is important to mention that some people have a mental block unless they have reams of data.

If the solution involves purchase of new equipment that you have not had experience with and cannot benefit from the experience of acquaintances in other plants, put in large safety factors. Most equipment manufacturers are carried away by their enthusiasm. Therefore, literature per se is usually very troublesome. To narrow the gray area, telephone calls or visits and conferences are very much in order. I well recall the time we decided to replace an old and tired jaw crusher. Literature from seven manufacturers was studied. Many words were printed by all of them, but not a word about type of bearings or nature of jaws. Phone calls revealed that only one distributor could answer the critical question. One wonders, how as a nation we can compete with other countries if this example is not a rare one.

What one runs into in the processing field can best be illustrated by random examples that I have been exposed to. This does not mean that I have been directly associated with each experience, for some of them have been called to my attention by friends in other plants A few examples are as follows:

a) A specification on a powdered material gave a distribution of particle sizes with a part being "not more than 15% thru a 325 mesh". The customer got 65% thru a 325 mesh screen which was difficult to understand in that we wet washed on this one sieve and he dry screened only. Exchange of samples used for testing yielded the same results. There were letters and there were telephone calls and finally a meeting of four people - two from each side. After about a half a day it became clear that our super assumed assumption about ASTM standards were not valid. We assumed that the sample was ro-tapped for 15 min. per standard, but no, the customer used 30 min. In any event, when both labs used either time they checked. What is grain size?

b) Again dealing with particle size and philosophy I remember well a case of milled rutile that was a bit finer than specified. Since it went into a weld rod coating we saw no harm and shipped the product. Customer rejected product. At first this appeared harsh. Finally it turned out he had a case. A rather dark substance like rutile will have a progressively lighter shade as particle size is reduced. The customer agreed that the welding characteristics would not be impaired but were uncertain about a welder in the field, who sometimes makes up his mind he has a different rod and he will manage to prove it does not work. So you are technically right, but are you going to suggest to a foreman in that field that he prove to the welder you are right?

c) Take the case of an operating procedure that stated "Pump A into tank M then pump B from tank N into tank M and heat to boil and agitate". In some instances this type of instruction may be valid, but in case of precipitation of hydrates it is not. The time to boil, and type of agitation must be spelled out. Again if you want the same results today as yesterday you had better make your instruction at least concise enough to have assurance that your desire is met. If you do this much you have an easier time of tracing trouble when it arises.

d) There is the case of a frit manufacturer who decided that it would be less expensive to have the vendor calcine borax ($Na_2B_2O_7.10H_2O$), since about half is water and save on freight. Then too it seemed to make sense since he would have to supply BTU's to remove water in his fritting furnace if the vendor did not. The dehydrated product did not produce good frit. After much to-do one lad woke up and realized that things were not the same as they had been. So dehydrated material was moistened with proper amount of water and satisfactory frit was produced. The assumption made was that at the frit making temperature, (say 1300°C), the water could not be part of the melt. A very plausible notion but not a valid one.

e) Another example of the role of water in high temperature reactions is preparation of titanium diboride by reacting titanium dioxide, carbon and boric acid. At 1600/1800°C very nearly theoretical product is obtained. When anhydrous boron trioxide is used a very poor product is obtained.

f) A customer requested a fair quantity of a zirconium soap dissolved in mineral spirits. To do the job safely meant that operations had to be placed in an explosion proof building, etc. Since the quantity was not large the cost came out fairly high. Whereupon one staff member suggested we make a solid soap and let the custome dissolve it in solvent. This drastically reduced cost not only because a special building was not needed but also because a given size kettle can produce more pounds per hour. All of which demonstrate that requests are not unalterable, as we are lead to believe at times.

g) Zirconium metal, which by laboratory tests is superb in concentrated boiling hydrochloric acid,was made into a valve that failed after three weeks service at room temperature. In this instance reagent acid was used for laboratory testing while service was with commercial acid that had a few hundredths of a percent of sulfates and iron.

h) In another instance a product we make was off specification on small amounts of iron. After much discussion it became clear that despite changes our raw materials should be analyzed. It turned out that our supplier of hydrochloric acid was not adhering to the specification. This is a particularly knotty area in that cost is added in analysis of raw materials, yet you have to have a cross check even though the vendor is supposedly adhering to a specification.

In the process of closing this delivery I would like to add one final word of caution. This has to do with the biggest curse of all - the concept of an average - it should be outlawed in engineering certainly.