ChE *learning in industry*

This column provides examples of cases in which students have gained knowledge, insight, and experience in the practice of chemical engineering while in an industrial setting. Summer interns and coop assignments typify such experiences; however, reports of more unusual cases are also welcome. Description of analytical tools used and the skills developed during the project should be emphasized. These examples should stimulate innovative approaches to bring real world tools and experiences back to campus for integration into the curriculum. Please submit manuscripts to Professor W. J. Koros, Chemical Engineering Department, University of Texas, Austin, Texas 78712.

CREATE A SUCCESSFUL SUMMER ENGINEERING PROJECT

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Many of us had experience either as summer engineers during our university experience or as engineering mentors to others during a summer assignment. While there is no doubt that a summer engineer can benefit by gaining experience in an industrial setting, the summer assignment can also benefit the industrial firm, provided that adequate preparation, planning, and common sense are demonstrated on the part of the sponsoring or mentoring engineer. The following areas should be considered.

Project Selection

- A good concept to use in selecting a project is, "I'd like to . . ., but my boss, duties, etc., do not allow me to." To some extent, a summer project can be an opportunity to explore a concept or an assignment that you believe can be valuable, but which you cannot find the resources to study personally. Don't be afraid to gamble on an idea if it seems to have potential. The enthusiasm you have for a project will be reflected in the enthusiasm of the summer engineer.

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- Be sure that the selected project makes obvious business sense so it will be well supported not only by management but also by your co-workers.
- If necessary, tailor the project to fit the abilities of the summer employee. It should not be easy, but neither should it be overwhelming. Carefully consider the intern's experience and educational level. Try to match both the skills and the interests of the intern.
- Finally, have a backup project available "just in case."

Preparation

This can be the key to avoiding frustration since the summer engineer may have only ten weeks to complete the project.

- Before the summer engineer arrives, prepare a 1-2 page summary of the project. Include sources of background information (people, reports, etc.), the project objectives, the available resources, and a suggested starting approach.
- Have a workplace ready and the necessary tools for the job assembled (*e.g.,* safety equipment, lab space and equipment, telephone, personal computer, e-mail account)

so the employee won't waste valuable time waiting to get started. Ask yourself, "What would I need in order to start work immediately?" Don't wait for the summer engineer to arrive to begin gathering things together, or (even worse) don't expect the engineer to find everything without help.

- Discuss the project with your co-workers and enlist their support before the summer engineer arrives. Make arrangements for any necessary hands-on training, and consider scheduling pertinent meetings.
- Since we are often out of the office on business or vacation, be sure to make arrangements for a co-worker to be a surrogate sponsor during any absences.

Project Implementation

Implementation will follow naturally if the sponsor's project selection, planning, and preparation have been adequate. The project implementation has two phases:

Initial Phase • During the first two to three weeks, the student will settle into the new surroundings, will become familiar with the necessary background information, and will start "doing something." During this time the sponsor should be especially tuned both to the scope of the project and to the student's abilities. Does the summer engineer understand what is expected? Is the project too hard or too easy? Are adequate resources available? Does the project still look workable? Are there any other concerns? The answers can be found by spending time with the student and watching how he or she approaches the problem. Don't panic if progress is slow at this point, but be ready to implement a backup project if it appears that the current project is neither suitable nor workable.

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Progress Phase • During the ensuing weeks the summer engineer should be making steady progress toward project completion. As a sponsor, you should be ready to give advice and aid in overcoming any resource or bureaucratic obstacles that might be encountered, and you should be encouraging even when the student's approach differs from your own. After all, an inquiring mind has been hired, not just a pair of hands! But don't neglect your responsibility to manage the project if the approach is unreasonable. Periodically sit down with the summer engineer and formally review the results to date. Confirm that a notebook is being adequately kept and reiterate that a written report will be expected by the end of the summer.

Wrap-Up

The wrap-up should occur during the final two weeks of the assignment, and in some ways it can be the most challenging period. A well-written report is essential for both the summer engineer and for the employer. For the intern, it provides a tangible measure of accomplishment and a valuable educational experience. For the employer it documents the work and the conclusions which have been reached. It also represents the 'product that the company has purchased.' Without a complete and well-written report, the summer's efforts can easily become lost when the time comes to build on the work completed by the summer intern. Often the sponsor will need to do some prodding and editing to be sure that the report is complete.

Finally, don't neglect showing the summer engineer your appreciation for the work accomplished before he or she returns to school.

CASE HISTORY

DEVELOPING A CORRELATION FOR PARTICLE SIZE VS. MIXER PARAMETERS FOR A DOUBLE PLANETARY MIXER

► Background

The DuPont-Merck Pharmaceutical Company (DMPC) has embarked on the development of a novel polymeric substance for a medically related application. The polymer is produced by the addition-controlled reaction of a low viscosity monomer solution to a premix of a second monomer in a viscous (100,000 cp.) premix. The final product of the reaction is an insoluble polymer in the form of a solvent swollen polymeric mass composed of discrete polymer particles with the look and consistency of mashed potatoes. The control of the discrete polymer particle size is an important consideration for the purification process following the reaction step. To provide adequate mixing during this reaction process, a 'double planetary' mixer-reactor (also called 'change-can mixer[1]) is used.

The DMPC engineers and chemists have been challenged to aggressively move the process for this polymer into commercial scale equipment. This product had been produced in a 1-liter lab unit and in two different styles of 150-liter reactors, one US based (see Figure 1, next page) and one

European based (Figure 2) in vendor trials. The selected manufacturing site had an existing 500-liter reactor of a third configuration (Figure 3). Due to time constraints and the lack of published criteria for the scale-up of these reactors, the suitability of these reactors was determined by full-scale tests. The test process conditions were selected to insure bracketing the product requirements.

Based on the above experiences, a strong intuitive understanding of the reaction process had been developed. Test data logs and retainer samples were accumulated. The data had never been fully analyzed, however, nor had a quantitative relationship been developed between the polymer particle size, the reactor type, and the conditions.

▶ Project Assignment

The challenges posed to the summer engineer were:

1. Learn to use a Malvern laser light scattering instrument to measure the particle size of the products from the reactor tests on a consistent basis. This instrument measures the diffraction pattern of a suspension of particles and transforms the information into particle size distribution data. Find the most suitable liquid media for dispersing the particles for the Malvern measurement.

2. Develop an empirical scaling relationship between particle size, reactor mixer geometry, and reaction conditions. This entails consolidating, on a common basis, the mass of data available from the various reactor tests.

3. Confirm any correlations developed by using the 1-liter lab reactor.

While this may seem to be an overly ambitious project for a ten-week summer assignment, the summer engineer had just completed his BSChE degree with excellent grades, had significant prior summer work experience, and was headed to graduate school.

▶ Preparatory Work

The sponsoring engineer had drafted a one-page letter outlining the proposed assignment. Lab space was located with a functional lab reactor and a personal computer with the necessary software. Arrangements for training on the Malvern were made, and copies of reports from the various reactor tests were made available. A meeting with a mixing consultant was held to insure that the appropriate parameters would be included in the work. This meeting was scheduled prior to the arrival of the summer engineer in order to minimize the time required for him to get organized.

▶ Project Results

The summer engineer's assignment revealed the following results.

1. A liquid medium in which the raw polymer reaction mass would disperse was found, and retainer samples were analyzed for particle size distribution on the Malvern.

2. The summer engineer adopted a reaction monitoring scheme that was under development by one of the process chemists. This scheme was used to follow the reaction and to assign when the particle size was "fixed" during the reaction process. Armed with this information, it was then possible to characterize the reactor conditions (temperature and

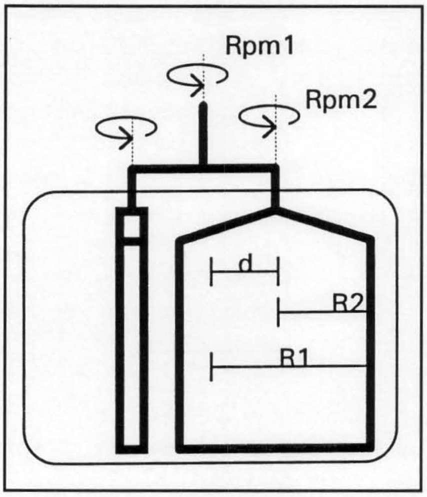

Figure 1. Reactor Mfg. 'R'

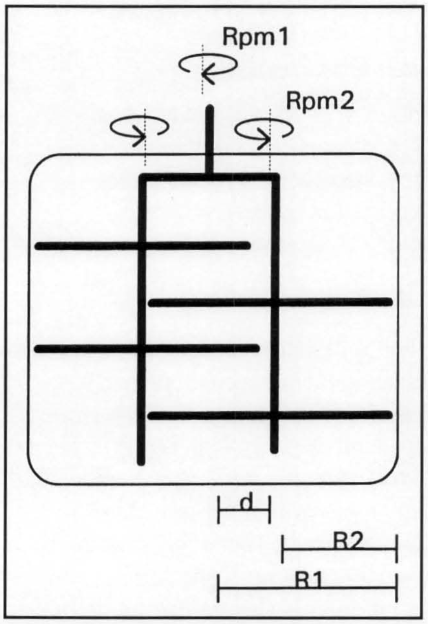

Figure 2. Reactor Mfg. 'D'

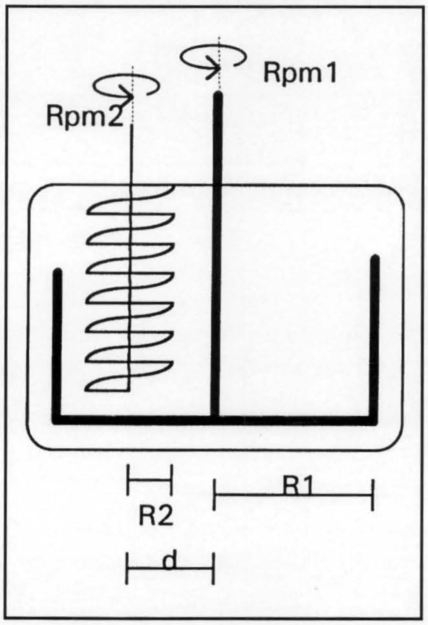

Figure 3. Plant Reactor Type 'L'

mixer speed) for each of the reactor tests at which the particle size was fixed.

3. Considerable effort was spent analyzing all data collected in the various reactor tests, understanding the reactors' different geometric configurations, and then developing plots of parameters. (This was accomplished using Excel 4.0 spreadsheet.)

4. Several lab runs were made in the 1-liter reactor to fill in gaps in the data. A correlation was developed for particle size and mixer speed and geometry (see Figure 4).

The summer student's starting point for the correlation developed in Figure 4 was based on data reported in Oldshue[2] that showed a relationship between average particle size and impeller speed for liquid-liquid emulsions. As would be expected, the average particle size decreases with increasing impeller speed. Log-log plots of average particle size vs. impeller speed for the data developed for our mixer/reactors resulted in a series of parallel lines for each reactor size and manufacturer. The goal was to develop a correlation which could unify the data for all of the reactors evaluated.

A published analysis[3] of dispersion in mixing vessels where the power number and geometry for mixing vessels are similar leads to the following partly empirical, partly mechanistic relationship:

$$\frac{D_p}{D} \approx \left(N_{We}\right)^{-3/5}$$

where

$N_{We} = N^2 D^3 \rho_c / \sigma$ (Weber number)

D_p = particle diameter
D = mixer impeller diameter
ρ_c = density of the continuous phase
σ = surface tension

It should be noted that the referenced analysis was for dispersion in mixing vessels and not a reacting system that forms insoluble (solid) polymeric particles in a thick, pasty reaction mass. While data for ρ_c / σ was not available for the reacting system under study, it was not required for the correlation as other product considerations necessitated that the reaction recipe remain constant and the reactor temperature profile be fixed. Hence, there should be little variation in ρ_c / σ between all of the reactor runs, and it was assumed to be constant. Thus, it might be expected that

$$\frac{D_p}{D} \approx \left(N^2 D^3\right)^a$$

Armed with this knowledge, the relationship presented in Figure 4 was developed. The sizes of the reactors used in this study were 1 liter (lab), 150 liters (pilot plant), and 500 liters (small commercial unit). The correlation's fit is more than adequate to guide our future scale-up efforts.

5. Finally, a comprehensive report was prepared to document the above results.

This project allowed both the summer engineer and the company to profit. The summer engineer not only received a stipend for his work but also gained additional work experience. DMPC benefited by gaining a more rigorous understanding of the reaction conditions required for the scale-up of an important process parameter.

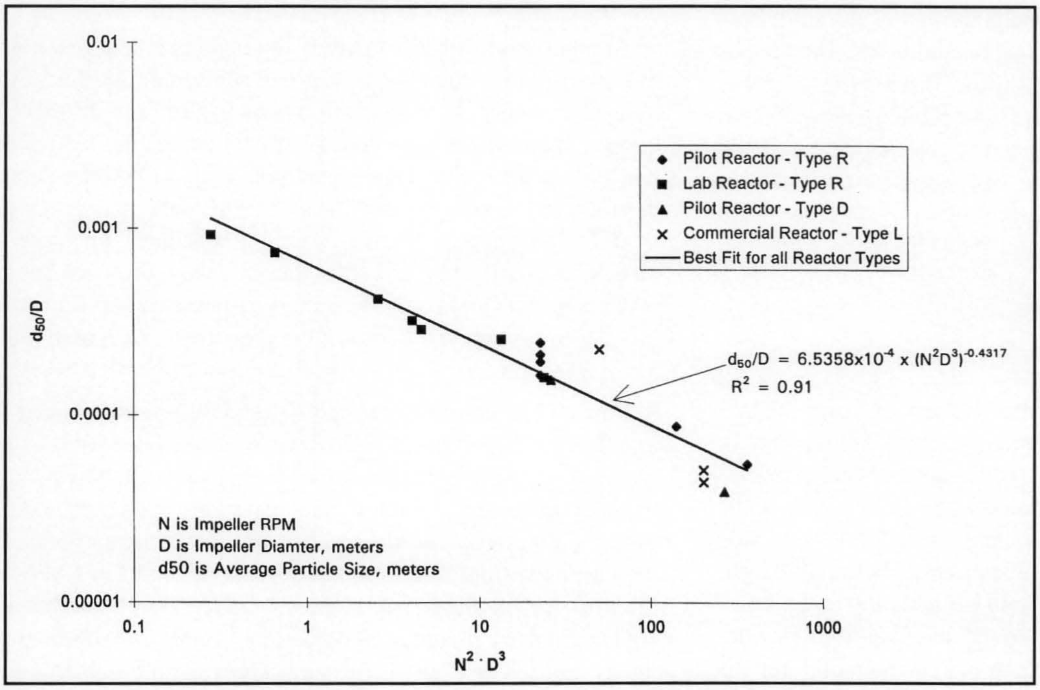

Figure 4. *d50/D vs. N^2D^3*

ACKNOWLEDGMENT

I would like to acknowledge the work of Martin Chandler who was the summer engineer for the case history discussed in this paper and who developed the data in the figures.

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