# Introducing Chemical Engineering to Freshman Through Measurement Oriented Studies in the Unit Operations Laboratory

by

Deran Hanesian, Angelo Perna
New Jersey Institute of Technology

The Fundamentals of Engineering Design Program was instituted at NJIT to bring senior level experience into the freshman year. The course replaced the old Engineering Graphics (2 credit hours) with a series of modules in various disciplines. The Mechanical Engineering module ran for all 14 weeks of the semester. The Civil, Electrical and Chemical Engineering modules, however, ran for seven weeks in length. Students were required to complete two modules in addition to the Mechanical Engineering module.

Class size was kept small and was about 15 - 18 students. More students would not be effective since a maximum of 5 -6 groups of three students each were involved in the experiementation. Each section was assigned a teaching assistant to aid in the effort and each laboratory had two assistants and the instructor. This aspect of the course is very important since the freshmen need much individual attention. In addition, a course manual was prepared which included two parts. The first part on the theory of measurements, definitions, basic concepts, units, dimensions, standards, conversions, dimensional analysis, correlations, linearization, statistical analysis, and written and oral communication, provided the students with the necessary background. The second part was a detailed explanation of the various experiments that the student groups performed.

In the seven weeks of the Chemical Engineering module, students were exposed to the senior chemical engineering laboratory; the unit operations experiments.

In the first sessions, measurement concepts were discussed and the related calculations were taught. Correlations of data in graphical and tabular form were stressed including dimensionless numbers and extraction of key constants from slopes and intercepts by linearization techniques. Statistical methods including regression and analysis and correlation coefficients were stressed. Students were then exposed to the experiments.

Later, we alternately exposed the students to the concepts and the experiments. Concepts were taught relating to their specific hands-on experience, and this approach appeared to be more satisfactory. It enhanced student interest and learning.

Chemical Engineering concepts in flow measurement, pressure drop in pipes, pressure drop in packed towers, pressure drop in fluidized beds and efflux time from tanks were introduced to students ranging from eleventh grade in high school to college sophomores. Integrated throughout the course the important aspects of Pollution Prevention are stressed.

The new Fundamentals of Engineering Design course using the Chemical Engineering Unit Operations Laboratory was first introduced in the summer of 1994 to a group of high quality eleventh graders for advanced college freshman credit. In the Fall of 1994, this course was taught for the first time to a group of freshmen and sophomores at NJIT.

The first practical experience for all groups was the calibrations of a rotometer by the direct weight method. Students were required to plot the flow rate versus rotometer reading. In addition, they compared their measurements to the vendor specification, correlated the results by linear regression analysis developing the equation of the correlation, and finally calculated a correlation coefficient. The theory of statistical analysis was explained as they developed their results. Figure 1 shows a typical student result from the written report.

In addition to calibration of the rotometer, students then performed a study of

- Pressure drop in pipes, fittings, and pressure drop and recovery in a venturi meter

- Pressure drop and bed height in a fluidized bed

- Pressure drop in packed towers and

- Efflux time from tanks.

For pressure drop in pipes and fittings, the emphasis was on the correlation of the friction factor versus Reynolds number. A typical result is shown in Figure 2. For pressure drop and recovery in a venturi meter, results are shown in Figure 3 and Tables 1 and 2. Students compared their results to published values.

In a study of pressure drop in a fluidized bed, the students measured bed height and pressure drop versus the superficial velocity and they determined the velocity at minimum fluidization. A typical result is shown in Figure 4.

In a study of packed towers students measured pressure drop in a 6-inch diameter packed tower which contained about five feet of 0.5-inch Raschig rings. Pressure drop in dry packing was measured first and the measured slope was compared to an accepted slope of 1.8. Next, pressure drop was measured at various liquid rates and loading and flooding points were determined. Typical results are shown in Figure 5.

In a study of efflux time from tanks students studied the time required to empty a tank with different lengths and diameters of pipe attached. Their results were compared to theoretical correlations. Typical results are shown in Figures 6 and 7.

Throughout the course, teamwork was emphasized as students worked in groups of three. Pollution prevention concepts and consciousness of pollution prevention were developed throughout their experience. The course ended with a written report on the studies by each group and an oral presentation by each group.

Student response was very enthusiastic and the laboratory measurement aspect of the course was enjoyed the most. The team approach to studies was also enjoyed. Least enjoyable appeared to be the oral presentations. The faculty also learned that it is better to have students actively make the necessary measurements followed by the appropriate calculations as a team rather than lecture to them as a group about concepts and methods and then allow them to enter the laboratory to make measurements.

Conclusions:

The conclusions made are:

1. Overall, the students were enthusiastic about a measurements laboratory.

2. The team approach was accepted and beneficial.

3. Hands-on laboratory experience was enjoyed most.

4. Least enjoyable appeared to be making oral presentations about their results.

5. Students need to be taught about the basics at this level since almost everthing is new.

6. Student acceptance of the course is highly instructor related.

7. Instructors must be patient, persevering, sympathetic and understanding.
8. Instructors should build confidence instead of destroying student confidence.

9. The best instructors in the department must be assigned to this course for success.

10. The biggest complaint -
"It's too much work."

FIGURE 1

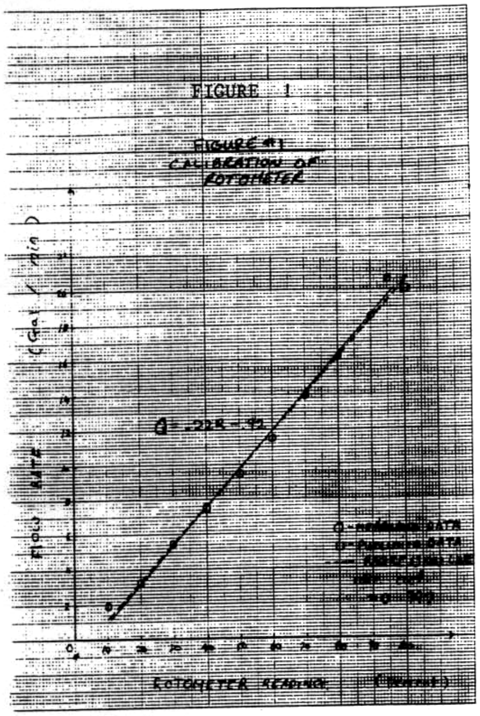



FIGURE 2

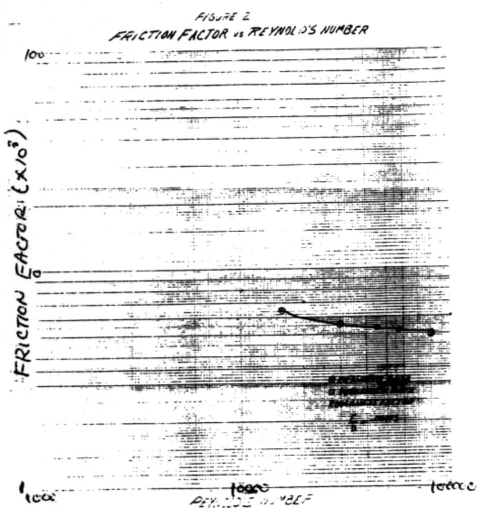



FIGURE 3

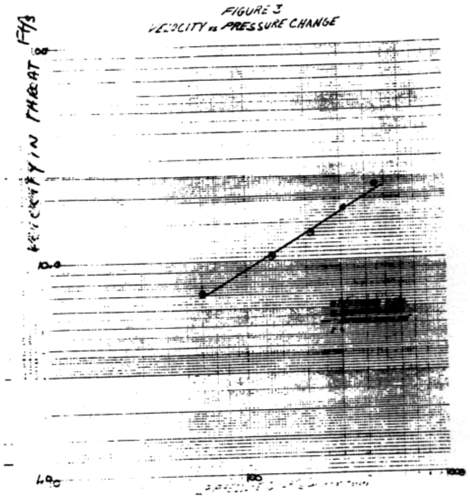



TABLE 1

**PER CENT RECOVERY OF VENTURI METER**

**TABLE 4**

| RUN | PRESSURE DROP Inch Fluid (P1-P2) | PRESSURE DROP Lbf/Ft | RECOVERY Inch Fluid (P1-P3) | RECOVERY Lbf Ft | (P1-P3) (P1-P2) |
|---|---|---|---|---|---|
| 1 | 14.40 | 56.07 | 2.00 | 7.79 | 0.14 |
| 2 | 30.00 | 116.81 | 3.60 | 14.02 | 0.12 |
| 3 | 3.20 | 210.16 | 0.40 | 26.48 | 0.13 |
| 4 | 4.80 | 315.24 | 3.60 | 39.72 | 0.13 |
| 5 | 7.00 | 459.52 | 3.80 | 59.96 | 0.12 |
| | | | | AVERAGE= | 0.125 |
| | | | | PUBLISHED | 0.1 0 |

TABLE 2

**CALCULATED Cv**

**TABLE 5**

| RUN | Cv | |
|---|---|---|
| 1 | 0.92 | |
| 2 | 0.93 | |
| 3 | 0.92 | |
| 4 | 0.91 | |
| 5 | 0.99 | |
| | AVERAGE= | 0.93 |
| | PUBLISHED= | 0.98 |

FIGURE 4

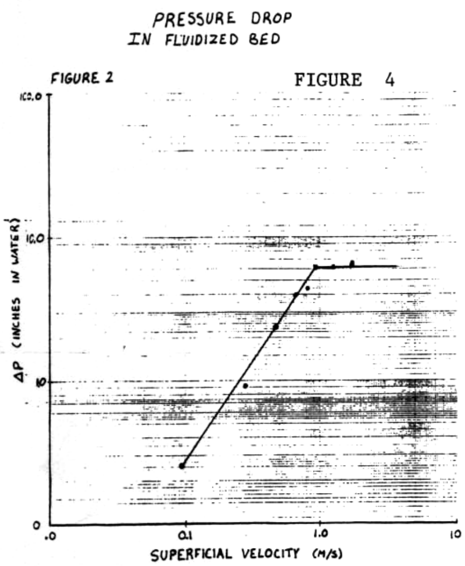



FIGURE 5

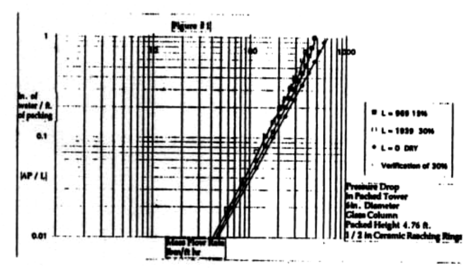



FIGURE 6

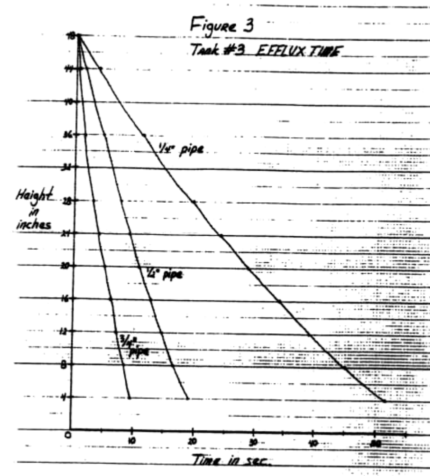
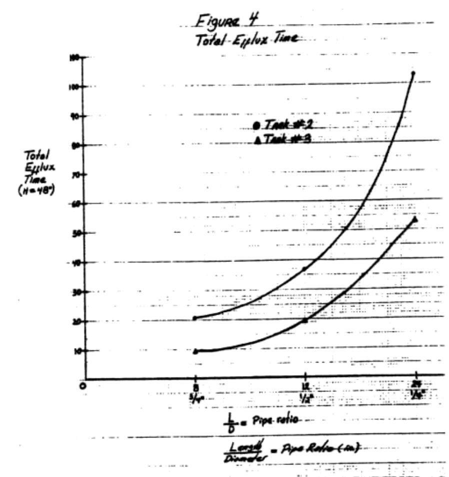



FIGURE 7



**DERAN HANESIAN**

Deran Hanesian served as chairman of the Dept. Chem. Eng., Chem., and Env. Sci. from 1975-88 and is Professor of Chem. Eng. He came to NJIT in 1963. He received a bachelor of Chem. Eng. in 1952 and a Ph.D. in Chem. Eng. in 1961, both from Cornell Univ. Dr. Hanesian worked for Dupont from 1952-57 and 1960-63. He taught at the Algerian Petroleum Inst., Yerevan Poly. Inst., Armenia as a Fulbright Scholar, the Univ. of Edinburgh, Scotland, and Rutgers, the State Univ. of NJ. He was the recipient of the Robert Van Houten Award for Teaching Excellence in 1977 at NJIT, the ASEE, Midlantic AT&T Foundation Award for Excellence in Instruction in Eng. in 1986, the John Fluke Award, ASEE, 1994, and the Outstanding Tenured Faculty Award, NJIT.

**ANGELO J. PERNA**

Angelo J. Perna received his B.S. ChE degree from Clemson University in 1957 and his M.S. degree from there in 1962. He received his Ph.D. from the University of Connecticut in 1967. He worked as a production and development engineer with Union Carbide Nuclear Company in Oak Ridge, TN, and taught at VPI, and the University of Connecticut. He is currently Professor of Chemical Engineering, Chemistry and Environmental Engineering at New Jersey Institute of Technology.