# UNIT TWO
# RESEARCH AND DEVELOPMENT

## *Special Terms*

**Laboratory:** A place especially equipped for experimentation, testing, and/or analysis in a particular field of science or technology.

**Flowmeter:** An instrument used for measuring the flow of fluids (liquids or gases). Many different types are available.

**Hopper:** A container, usually funnel-shaped, for storing and delivering powdered or granular material. It is filled from the top, and the bottom is often equipped with a device for delivering measured quantities of the material.

**Steam Jacket:** A shell fashioned around a tank or other vessel. Steam is introduced into the space between the vessel and the shell, thereby heating the vessel and its contents.

**Batch Process:** A way of manufacturing chemical products. Measured quantities of materials are carried through a series of operations, step-by-step, to produce the final product.

**Continuous Process:** A way of manufacturing chemical products in large quantities. Raw materials are fed continuously into one end of the processing plant, flow through various operations, and emerge as the desired product. Continuous processes may run for months or years without stopping.

**Proportioning Pump:** A device usually consisting of several interconnected pumps. They are designed so that their outputs are adjustable, thereby permitting the ratios of materials discharged to be changed.

**<u>Heat Exchanger</u>:** A device for heating or cooling fluids. Steam is usually used for heating and cold water for cooling.

**<u>Pilot Plant</u>:** A miniature plant used for experimentation.

**<u>Shift Work</u>:** A way of staffing a plant or laboratory continuously for long periods of time. The workers are divided into groups; each group works at a different time.

**<u>Group Leader</u>:** The person in charge of a group of people. In experimental work, the leader is usually an engineer or scientist.

**<u>Progress Report</u>:** A description of the work of a group of researchers. Generally, a progress report is written each month.

## *Vocabulary Practice*

1. What is done in a *laboratory?*
2. For what purpose is a *flowmeter* used?
3. What is a *hopper?* What kinds of devices are often used at the bottoms of hoppers?
4. Describe a *steam jacket.*
5. What is a *batch process?*
6. What is a *continuous process?*
7. Describe a *proportioning pump.*
8. What does a *heat exchanger* do? What is usually used in it for heating? For cooling?
9. What is a *pilot plant?*
10. Describe *shift work.*
11. What is a *group leader?*
12. What is a *progress report?* How is it usually presented?

### *Research and Development*

The chemical process industries spend more money on research and development than do most other industries. As a result, we now use many kinds of products unheard of a few years ago. Countless items in our daily lives are different from those our parents used, because of this innovation. Much of our clothing is now made of synthetic fibers instead of natural materials such as wool or cotton. The toys our children play with are often made of plastics that replace wood or metal. And many of us drink instant coffee rather than brewing the beverage from ground coffee beans.

These kinds of products have come about through research and development I research ***laboratories***. These laboratories are usually staffed by chemists who do their experimentation in the usual laboratory glassware. For example, when two materials must be mixed together, the chemist may do it with a glass rod or by merely shaking the container. The mixture can be heated by placing the container over a small gas burner or cooled by setting it in cold water. But many of the things that seem so easy in the laboratory are much harder to do in the plant. Even making the same product in the same way, but on a larger scale, presents many problems.

Let us look at a very simple process as the chemist does it and as it might be done in a chemical process plant. He or she (many chemists are women) takes a bottle of Chemical A from a shelf and pours the required quantity into a glass measure. The chemical is dumped into a flask and a second liquid, Chemical B, is measured and added in the same way. Chemical C, a powder, is weighed on a small laboratory scale and added to the two liquids. The chemist mixes the chemicals together by shaking the flask and heats the mixture over a small gas flame, with constant shaking. Finally, the mixture is rapidly cooled by placing the flask into a container of crushed ice. The chemist may have made a total quantity of a half-liter or less of product.

Now consider the same process carried out in a plant in batches of a thousand gallons. (Most chemical plants in English-speaking countries still use the old units such as pounds, feet, and gallons.). Instead of a glass flask, the container will be a thousand-

*Photo Courtesy Du Pont*

Many of the products we use every day began in a research laboratory like this one.

gallon metal tank. Chemical A will not be in a bottle on a shelf – it will be in a storage tank. The proper amount of Chemical A will be added by pumping it from the storage tank through a ***flowmeter*** into the processing tank. Flowmeters usually show flow in gallons per minute, so five-hundred gallons might be added at fifty gal/min for ten minutes. Chemical B will be pumped from its storage tank in the same way. (The operator will probably pump both liquids into the processing tank at the same time unless there is a danger in mixing them this way.). Adding Chemical C – the powder – is not as easy. If only a small amount is needed, it might be weighed into a container and dumped by hand into a mixture. If larger quantities are required, Chemical C will probably be stored in a ***hopper*** over the processing tank; the hopper will have some sort of measuring (usually weighing) device to ensure adding the proper amount.

Mixing a thousand-gallon tank cannot be done with a glass rod so the engineers will have provided a mechanical mixer, something like a ship's propeller, driven by an electric motor. The tank will probably be heated by steam supplied to a ***steam jacket*** surrounding the tank. The mixture in the tank is stirred throughout the heating period to make sure it is heated uniformly. To cool the mixture, the steam will be shut off and cold water pumped into the jacket. Water cannot be cooled below 32 oF (0 oC) without turning to ice, but colder temperatures can be achieved by using a solution of salt water called brine. Finally, the mixture will have to be pumped into another tank for storage or the next stage of the process.

What has just been described is an example of a ***batch process*** in which a given amount of chemicals is processed in some way to yield a quantity of product. Batch processes are commonly used when relatively small quantities of materials and handled and particularly common when the materials are expensive. For example, batch processes are very often employed in the manufacture of drugs, dyes, and foods.

Another widely used way of handling materials is the ***continuous process*** in which materials are constantly fed into one end of the equipment and finished product comes continuously out of the other end. All petroleum refining, for example, is done by continuous processes. In a refinery, crude petroleum is pumped into one end of the plant and a continuous stream of gasoline, kerosene, and fuel oil pours out of the other end. Let us look at the simple process we have been describing (mixing quantities of Chemicals A, B, and C, heating, and cooling) and see how it might be done as a continuous process.

The two liquid chemicals are pumped by a ***proportioning pump*** into a small mixing tank, where Chemical C is continuously added by a solids feeding device. The mixed chemicals are continuously drawn off the bottom of the mixer and passed through a ***heat exchanger*** where they are steam heated. They then pass into

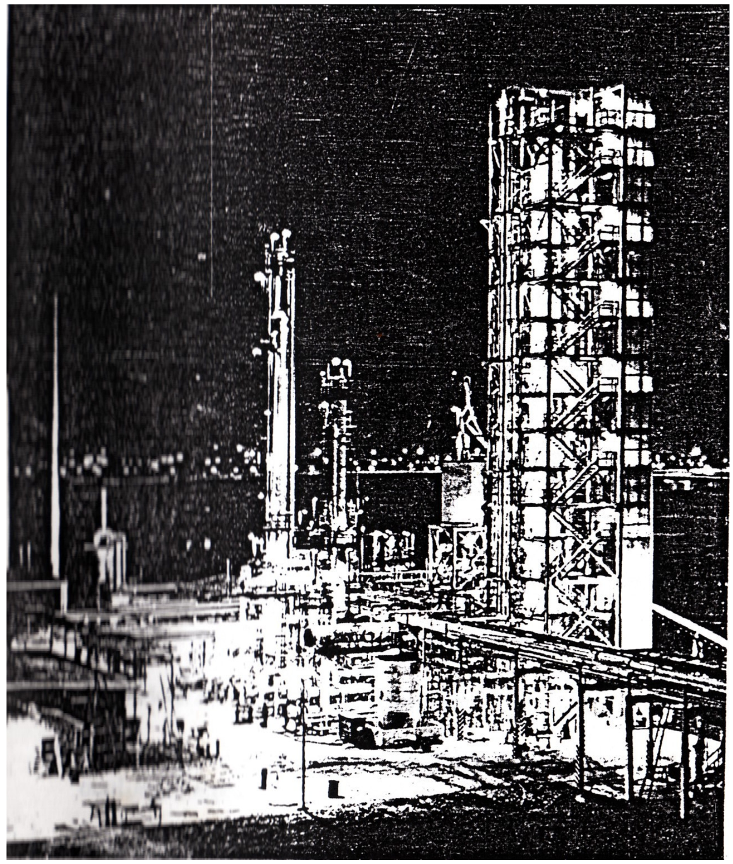

*Photo Courtesy National Coal Association*

This large scale pilot plant tests a process for making substitute natural gas from coal.

another heat exchanger where they are chilled by cold water or brine. The products flow out of the end of the cold heat exchanger.

Because chemical plant equipment is so different from that used in the laboratory, one of the major jobs of R&D engineers is to decide what kinds of equipment must be used to carry out a commercial chemical process. They also determine the sizes of equipment needed – how big must the pumps be, how much power must the mixer have? Before designing the full-sized plant, the R&D engineer usually constructs a ***pilot plant*** – actually a small model of the final plant, containing small versions of the equipment. Pilot plants are particularly useful when designing continuous process plants which are so different from the research laboratory. (It is usually impossible to run a continuous process in the standard laboratory glassware available to the chemist.).

A continuous process pilot plant will usually run twenty-four hours a day with three or four groups of operators and engineers, each group working for eight hours. This is called ***shift work***, and each group is called a shift. Most often, shifts work from 8 a.m. to 4 p.m., 4 p.m. to midnight, and midnight to 8 a.m. A fourth shift is needed if the plant is to run during weekends, although many pilot plants shut down at that time. Usually there is a ***group leader*** in charge of each shift. The group leader may be a chemical engineer, a chemist, or a specially trained operator. This arrangement makes pilot plant experimentation unattractive to many chemical engineers who prefer to work during the day and leave the evening and night shifts to specially trained operators. However, a pilot plant is often so complicated that engineers are required on all shifts.

Since the basic purpose of the pilot plant is to gather information, there are frequent changes of flowrates, pressures, and temperatures. R&D engineers are always looking for that combination of conditions that will enable them to produce the maximum amount of product at the minimum price. As information is gathered, it is passed along to the company's management. This may be done by memoranda and telephone calls but in most companies, once a month, the R&D engineers write all they have learned during the past month in a ***progress report***. These become their main record of accomplishment. The purpose of R&D is to gather information; since a company's management judges R&D engineers by the reports they submit, a great deal of work goes into the reports' preparation. When the research and development project is completed, information in the various progress reports is consolidated into a final report that details everything learned during the research. This final report is invaluable to the process design engineers who will design the full-scale plant.

There is one thing about R&D that many engineers find frustrating: a project is seldom finished. As with all research, there are always more ideas than time or manpower. Eventually, the work must end, even if the best possible design has not been reached.

Otherwise, no process would ever get into full-scale production. The decision to end a project is usually made by the head of the research laboratories in consultation with the executives of the company.

### *Discussion*

1. What kind of work is done in a laboratory?
2. What kind of specialists usually do laboratory work?
3. Of what material is most laboratory equipment made?
4. How might a laboratory chemist mix materials?
5. What could a chemist use for heating and cooling chemicals in the laboratory?
6. What kinds of equipment might a chemical engineer design for mixing large quantities of materials? What might he use to measure these materials?
7. What is the device engineers use to heat tanks of materials?
8. What is a solution of salt in water called?
9. How does a batch process differ from a continuous process?
10. What kind of equipment is used for the continuous heating or cooling of streams of chemical materials?
11. What kind of equipment might a chemical engineer use for experimenting on a continuous process? Why doesn’t a chemist usually run continuous process in the laboratory?
12. Why is shift work necessary in running a pilot plant?
13. What are the usual time periods for each shift?
14. Why is pilot plant work unattractive to some engineers?
15. What do chemical engineers look for when running a pilot plant?

16. How do R&D engineers pass o information to a company's management?

17. Who usually decides when a research project should be ended?

## *Review*

A. List as many kinds of things as you can think of that are now made of plastics but were formerly made of natural materials.

B. Employees in the chemical process industries often have to work in shifts. What are some other kinds of jobs that require shift work?

C. Complete the following sentences with an appropriate word or phrase.

   1. Ideas for new products are generally developed in a ________________________________________.

   2. A person experimenting in a laboratory is likely to be a _______________________.

   3. A chemical engineer uses a ___________________________ to measure large amounts of liquids.

   4. A ____________________ is used for storing and delivering powdered or granular materials.

   5. A process plant mixer may look something like a ship's ______________________.

   6. A __________________________ is often used to heat materials in a tank.

   7. Batch processes are often used to process materials that are ______________________________.

8. Quantities of materials may be added in fixed ratios to a process by using a ____________________________.

9. A _____________________ is employed for continuous heating or cooling of materials.

10. A ______________________ is a miniature plant used for experimentation.

11. A _____________________________ plant will generally operate twenty-four hours a day.

12. People who operate continuous process plants generally do _______________ work.

13. ______________ shifts are usually needed if a plant is to work on weekends.

14. The basic purpose of a pilot plant is to ________________ ________________________________________.

15. Engineers write __________________________ to inform management of their findings.

16. Progress reports are important because __________________ _____________________________________________________.