UNIT FOUR
PLANT OPERATION

Special Terms

Foreman: A specially trained worker selected, because of work skills and leadership abilities, to supervise other workers.

Plant Efficiency: A comparison between the amount of product made in a plant and the cost of making it. The more efficient a plant is, the lower the cost of making a given quantity of product.

Plant Throughput: The amount of product manufactured in a particular length of time. A plant's throughput, or output, is usually given as tons/day or tons/yr.

Startup: The process by which a plant begins operations. The initial startup – the first time operation is attempted – may take months before all the equipment and the control system are working satisfactorily.

Shutdown: The process by which plant operation is stopped. Pieces of equipment must be stopped in a particular order, and sometimes in special ways, to avoid problems.

Column: A tall, narrow, closed vessel used for a particular purpose. It may have a height eight or ten times its diameter, and may be 100 feet (30 meters) tall, making it a striking feature of a process plant.

Reactor: A vessel (usually closed) in which a chemical reaction takes place. Reactors which work under high pressures – pressure vessels – are usually equipped for heating or cooling their contents.

Purging: The process of clearing liquids or gases out of pipelines and equipment. Flammable or dangerous materials are usually purged by displacing them with a safe material.

Instrument Tuning: The process of adjusting instruments that automatically control a plant's operation.

Lost-time Accident: A mishap that requires a worker to be away from the job for a day or more. Records of plant safety are usually based on the number of lost-time accidents.

Quality Control: The process of assuring that a plant's products have the required physical and chemical characteristics. The qualities checked may include such things as purity, strength, and color.

Rotating Shifts: A form of shift work in which each group of workers is changed at regular intervals from day work to evening work to night work.

Insulation: A material that provides a barrier to the passage of heat. It is used to keep hot things hot and cold things cold. Insulation contributes to plant safety by preventing contact with dangerously hot surfaces.

Vocabulary Practice

1. What is a *foreman*? On what basis are they usually selected?
2. What is *plant efficiency*? How is it usually calculated?
3. How is *plant throughput* determined?
4. What is meant by *startup*? What may be special about the first one?
5. What is *shutdown*?
6. Describe a *column*.
7. What is a *reactor*? What is it equipped to do?
8. What is meant by *purging*? How is equipment purged?

9. What is meant by *instrument tuning*?
10. What is a *lost-time accident*? Why is it recorded?
11. What is *quality control*? What may it check?
12. What are *rotating shifts*?
13. What is *insulation*? How does it contribute to safety?

Plant Operation

The function of the chemical engineer involved in plant operation is to see that the plant manufactures product. This sounds simple but includes a great many details. The engineer's two big responsibilities are the plant itself and the people who run it. The operation engineer is in charge of plant maintenance which is a continuing job in any chemical process plant, large or small. He or she is also responsible for having trained personnel on hand for plant operation. Since plant production often varies with the country's economy and sales of the plant's products, the size of the work force must also vary. Personnel are hired and laid off at various times. Sometimes workers can be recalled but often they have taken other jobs and new people must be hired and trained. In addition, personnel are discharged, quit, or retire, and some are sick or injured. Many CPI plants are unionized so operations engineers must be skilled in dealing with unions, both in day-to-day matters and in bargaining when union contracts expire.

The plant operation engineer is also responsible for the selection and training of ***foremen***. A foreman (who may be a man or woman) is a specially trained person who is in charge of a group of workers. The plant operation engineer is always on the lookout for skillful workers with leadership qualities. A foreman is part of the plant's management personnel and may advance to higher levels of management.

An ongoing occupation of plant operation engineers is that of increasing the ***efficiency*** and ***throughput*** of their plants. Efficiency of plant operation is generally defined as producing product of the

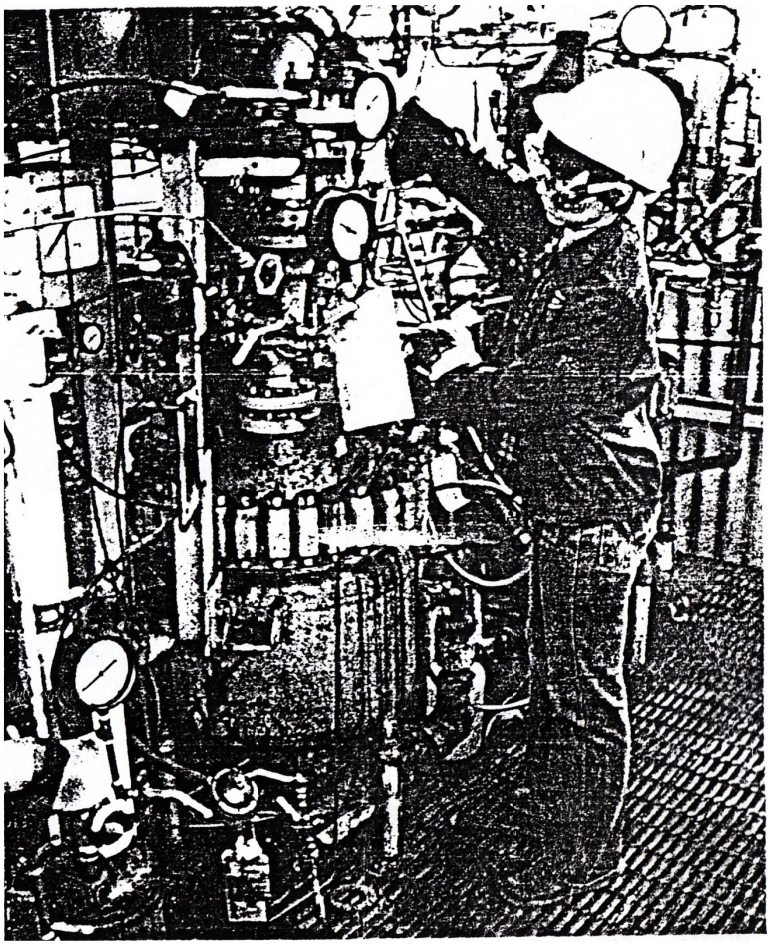


Photo Courtesy Dow Chemical

An engineer in a chemical plant takes a reading on a reactor.

required quality at the lowest possible cost. Sometimes, if there is a shortage of the product made by the plant, it may be important to increase the throughput even at increased cost. Hence, plant managers frequently experiment to find ways of increasing both efficiency and throughput. In theory, every process plant should always operate at the maximum efficiency possible, consistent with the required throughput.

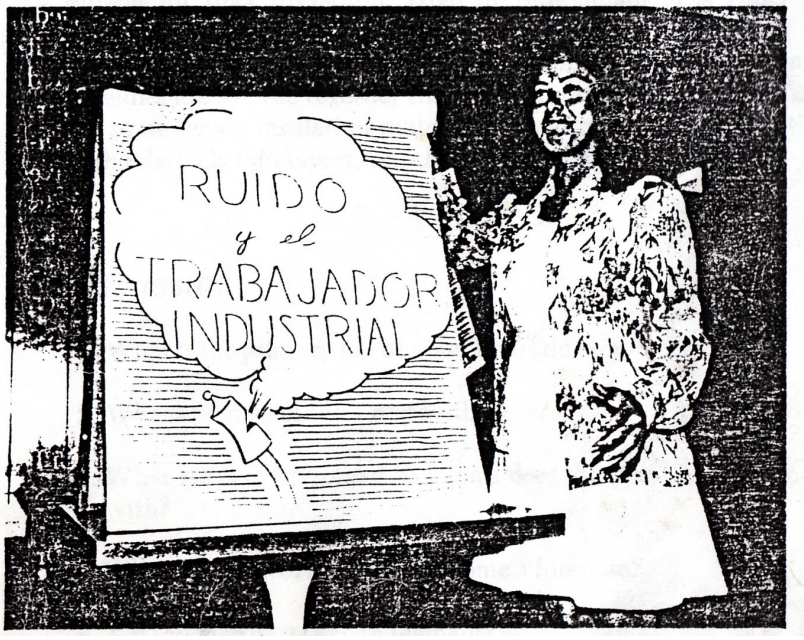
Most large chemical process plants operate continuously; while the plant is running there is often little for plant personnel to do. Problems occur when some piece of equipment operates improperly or breaks down. But there two occasions when plant personnel are always very busy: ***startup*** and ***shutdown***. At the beginning of startup nothing is operating, so valves must be opened in the proper sequence to start the flow of materials; steam and cooling water must be started as required; ***columns*** and ***reactors*** must be brought to their proper operating temperatures. Some plants may take as much as a day before operating normally. Shutdown takes less time but also requires continuous attention from all plant personnel. This is particularly true of emergency shutdowns caused by equipment failures or by accidents such as fire and explosion. During shutdown it is often necessary to clear liquids or gases out of pipelines and equipment, particularly if they are flammable or corrosive. This is usually accomplished by displacing the dangerous material with a safer one – a process known as ***purging***.

Perhaps the most laborious job in any plant is the very first startup. Inevitably, equipment is found to be detective or improperly installed. Pipe joints leak, pumps are improperly wired, and valves are jammed so they cannot be opened or closed. Often it takes several months of steady work before everything is corrected and the plant can run as it was designed to. Much of the work during an initial startup is devoted to what is known as ***instrument tuning***. Most instruments used to make a plant run automatically have several adjustment knobs that must be set properly for the devices to work. These adjustments interact with each other – that is, changing one will change the action of the others. This means considerable trial and error before all are brought to the proper position.

Although chemical process plants use many dangerous materials, their accident rates are quite low as compared to other industries. Perhaps it is because the plants handle dangerous materials that everyone tends to be extremely conscious of safety. CPI plants generally carry on extensive safety campaign. In many areas of a plant everyone, including management personnel and visitors, is required to wear a safety helmet (usually called a hard

Photos Courtesy Dow Chemical

Safety is a primary concern of the chemical process industries. Above, laboratory animals used for testing the presence of air pollutants and below, a safety meeting held for Spanish-speaking workers at a Dow Chemical plant in Texas.



hat), or safety goggles, or both. Special safety showers and eyewash stations are provided to furnish emergency aid to any worker sprayed by a dangerous chemical. If poisonous gases are used, gas masks are kept available. Every plant keeps bandages, burn dressing, and first-aid equipment readily available. Since many of the materials used in the CPI are highly flammable, there is always danger of fire. Smaller plants have fire-alarm boxes connected to the local fire department; large plants often have their own fire departments.

One way to determine the safety record of a plant over a period of time is to calculate the number of ***lost-time accidents*** – those serious enough for the one injured to be unable to work for a day or more. Many plants have large signs at the plant entrance indicating the number of days since the last lost-time accident.

Another plant responsibility is that of ***quality control***. Every product of the CPI must meet certain specifications before it is sold. Enforcing these is the job of the quality control laboratory and its personnel. They check raw materials bought by the plant to determine if they are of the proper grade and check samples of product at specified times to see if the quality is being maintained. Quality control personnel usually report only to the plant manager – not to other production supervisors – so that their standards and judgment cannot be influenced by production personnel.

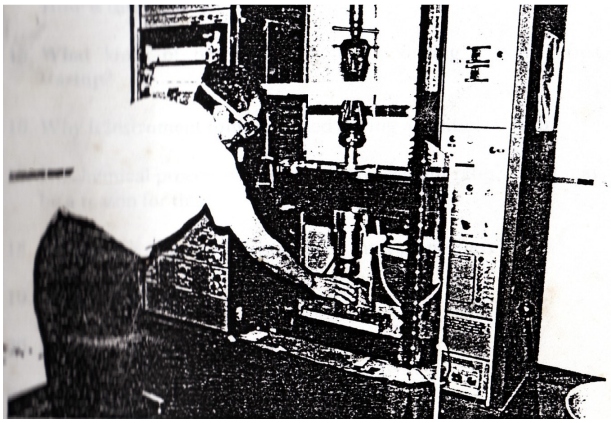


Photo Courtesy Dow Chemical

The flexural strength of a cured resin is tested as part of quality control.

Since continuous process plants are generally staffed by four shifts, there must be four workers available for each production job. Consequently a plant's workforce is much larger than can be seen – only a quarter of the workers are in the plant at any one time. Most workers prefer the day shift, so the evening and night shifts are compensated by higher rates of pay. But shifts are usually changed every few weeks so that each worker has an equal share of the desirable and undesirable conditions; this is known as ***rotating shifts***. Scheduling the four shifts can be very complicated and take up a considerable part of the operations engineer's time.

There are still some parts of the world where energy is comparatively cheap, but in most places it is a considerable part of the cost of producing chemical products. Energy conservation has become a major way of decreasing costs in most process plants. Hot pipes and equipment have always been insulated because they would otherwise be safety hazard, but the modern trend is to use much more ***insulation*** in order to conserve heat. Chemical reactors frequently operate at high temperatures so they are prime candidates for thick insulation. High pressure steam lines also need heavy layers of insulation. In older plants it may be difficult to use as much insulation as is now desirable because the equipment and pipelines are so close together that there is insufficient room. There are some newer insulation materials that provide good protection with relatively thin layers, but they are expensive.

Discussion

1. What is the primary job of plant operation engineers?
2. What are some of their responsibilities?
3. What kinds of personnel problems does the plant engineer deal with?
4. What kind of worker might become a foreman?
5. Are foremen parts of management?

6. When is it desirable to increase plant throughput even at lower efficiency?

7. Is a plant always operated at its highest efficiency?

8. What are the most frequent causes of operating problems in process plants?

9. When are plant personnel busiest?

10. What must be done during a plant startup?

11. What things must be done during a plant shutdown?

12. What are some types of process plant equipment brought up to operating temperature during a startup?

13. What may cause an emergency shutdown?

14. Why do pipelines and equipment sometimes have to be purged? How is this done?

15. What kinds of problems may occur during a plant's first startup?

16. Why is instrument tuning needed during an initial startup?

17. Do chemical process plants have high accident rates? What may be a reason for this?

18. What kinds of safety equipment do most plants have?

19. How do CPI plants fight fire?

20. Discuss lost-time accidents.

21. What is the purpose of quality control?

22. To whom do quality control personnel usually report? Why?

23. Usually, few people can be seen working in a process plant. Explain why the actual work force is much larger.

24. What is the purpose of having rotating shifts in a plant?

25. What are the two main reasons for using insulation?

26. Why is it difficult to use enough insulation in many older plants?

Review

A. The last three units have discussed the role of the chemical engineer in research development, process design, and plant operations. Discuss the area of work that interests you the most and explain why.

B. From your experience in chemical plants, discuss the ways in which engineers ensure safety.

C. Complete the following sentences with the proper word or phrase.

1. The initial _____ is the first time a plant is operated.
2. A _____ is a tall, narrow vessel.
3. Chemical reactions take place in a _____, usually under high pressure.
4. Stopping a plant requires orderly _____ procedures.
5. _____ is used to conserve heat energy.
6. A _____ supervises a group of workers in a plant.

7. The _____ laboratory is used to make sure that the plant's product meets specifications.

8. One reason for putting _____ on equipment is to protect workers against burns.

9. A _____ results in a day or more out of work.

10. _____ is the relationship between the amount of product made by a plant and the cost of making it.

11. If more product is needed, engineers must increase the plant's _____.

12. Adjusting control instruments to give optimum results is called _____.

13. If someone works during the day for a week, during the evening for another week, and at night for the third week, he or she is on a _____.