PRACTICAL MANUAL
OF
CHEMICAL PLANT EQUIPMENT

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by
ROBERT G. SCHMIDT, P. E.
Columbia Nitrogen Corporation
Augusta, Georgia

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Preface

This complete manual of commonly used chemical plant equipment has been written for the chemist, engineer, operator, or mechanic entering the chemical industry. The manual is designed to explain the principles of operation; advantages and disadvantages of the different types of equipment; terminology used in the industry; and some of the important basic operating theories and practices.

When first viewed, most chemical plants are a confusing maze of pipe, valves, pumps, columns, tanks, and other equipment that appear to be impossible to understand. The language commonly used by the "old hands" is also very confusing to the new man. The purpose of this manual is to provide knowledge of the commonly used equipment and terminology so that the new man can be relieved of much of his initial mental confusion. He can thus devote his efforts to the study of the special equipment used and grasp the overall idea or sequence of operating steps so necessary to an understanding of the particular plant and the job to be accomplished.

March 1967

ROBERT G. SCHMIDT

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1. SOLIDS—STORAGE AND HANDLING

GENERAL

It is still quite common to find solids being received, stored, and handled in bags or fiber drums. For large quantities of solids, however, the hopper car, some type of conveyor, and bins or silos are more economical. In many places in the process, the solids might be present with sufficient liquid as a slurry that can be pumped. (Generally less than 25 percent solids by weight can be pumped successfully.) This section of the manual will deal with solids where there is insufficient liquid present to use a pump.

CONVEYORS

Air Conveyor

The air conveyor has become extremely popular and it can be used on almost all but wet sticky materials, although some breakage will occur in the material being conveyed.

There are four general types:

A *suction* or negative system sucks the material up, much as does a vacuum cleaner; this system is used especially where material must be picked up from a number of points and deposited at one or more points. Only one operation can be performed at a time.

The *pressure* or positive system moves the material by direct pressure created by a blower located ahead of the intake of material. This system is used where there is one intake place and several delivery points.

The third system is a combination of the two, shown in Figure 1:1. Note that the blower can suck the material from the hopper car to the storage bin and can also blow the material from the bottom discharge of the silo to another point.

The fourth system, called *fluidizing*, is accomplished by mixing

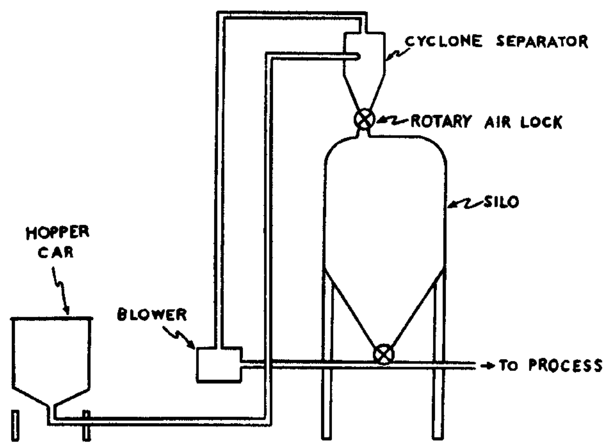

Fig. 1:1. Combination suction and pressure air conveying system.

each particle in a thin envelope of air. This system moves a great deal of material with a minimum of air and minimum of degradation or breakage. For example, 20 to 30 standard cubic feet per minute (SCFM) of air moves about 1,000 lb. an hour through a one-inch pipe. Actually, the quantity of air would depend upon the length, number of bends, nature of material being conveyed, and height to which it is to be conveyed.

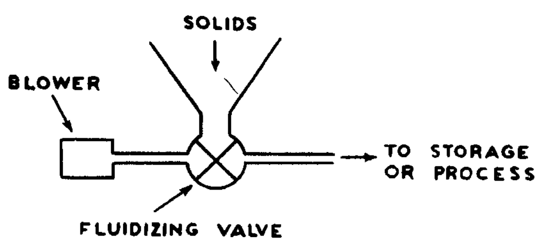

Fig. 1:2. Fluidizing type air-conveying system.

Figure 1:2 is a simplified diagram of the fluidizing portion of a fluidizing system. The blower supplies air to a rotary air-lock valve. The rotating blades can regulate the rate of solids being fed into the system, mix the solids and air, and take them over to the discharge pipe. A fluidizing valve is needed at each point of pickup of solids.

As with the other air conveyors, the pipe discharges into a cyclone separator and through a rotary air-lock as shown in Figure 1:3. The cyclone separator is a vessel or piece of pipe of large diameter and the conveying pipe discharges into the cyclone in a tangential way to give the air and solids a circular motion. The air then rises at a slow velocity because of the large diameter of the cyclone, thus allowing the solids to drop down into the rotary air-lock. The rotary air-lock lets the solids drop into the silo or bin and keeps the air from entering.

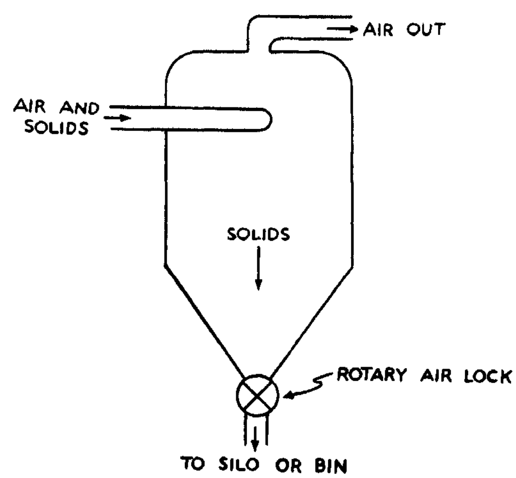

Fig. 1:3. Cyclone separator.

As a cyclone is not 100 percent efficient, the air will contain about one percent of the solids fed into it originally. This air is frequently taken to a second cyclone, bag filter, or other type of collector or scrubber to recover these solids.

Belt Conveyor

One of the most economical types of conveyor is the belt conveyor; however, their use is limited to reasonably level straight runs. The angle at which a belt conveyor may be run depends upon the material to be conveyed.

Vibrating Conveyor

In the vibrating conveyor the solids lie in a trough, which is vibrated in such a way as to make the particles move along in short jumps. It is not good for wet sticky materials and is generally used only for short, straight, horizontal, or downhill runs. A spiral, elevating, vibrating conveyor is available but it is rather expensive.

Zipper Conveyor

A zipper conveyor moves with the solids as a belt conveyor does, but it has the advantage of being able to elevate material and change direction. The maintenance costs are relatively high compared with other types and fine rubber particles gradually created by wear could cause contamination of certain materials.

En Masse Conveyor

The *en masse* conveyor consists of a chain holding a succession, of solid paddles, or vanes, often called *flights*, that move with the material being conveyed. It is so called because it is designed to run completely filled, and the chain, the flight of paddles, and the solids move together. In a newer type, called a *modified flight*, the vanes or paddles are not solid, but have a large slot in each. This type uses less power and is less noisy than the other form, but it can carry only solids that can interlock with one another—nothing that might fall through the openings.

The major advantages of *en masse* conveyors, with both solid and modified flights, are that they can operate under positive pressure, they can elevate solids, and they can change direction. They are, however, generally a little more expensive than other types of conveyor.

Screw Conveyor

This well-known screw type of conveyor is satisfactory for most materials but it is generally noisy and limited to straight short runs.

Bucket Elevators

The bucket elevator is used where elevation of the solids is the only requirement. There are three major types:

1) A *centrifugal discharge elevator*, which must operate at a relatively high speed.
2) The *continuous bucket elevator* in which, at the discharge point, each bucket drops its content on the sloping bottom of the bucket below, deflecting the solids into a discharge chute.
3) The *positive discharge elevator* in which the chain passes over the upper sprocket and then passes two snub sprockets so that the bucket is turned through more than 180 degrees.

A major problem of bucket elevators is the slow rate of movement of solids and the relatively large height needed at the loading and discharge ends of the conveyor.

Feeders

Where it is necessary to supply solids to a process at a controlled rate, a *volumetric* feeder (which delivers a certain volume of solids), or a *gravimetric* feeder (which delivers solids by weight) is used.

Most of the conveyors previously listed can serve for volumetric feeding. A rotary valve, sometimes called a *star feeder* is an economical model to use and is shown in Figure 1 : 4.

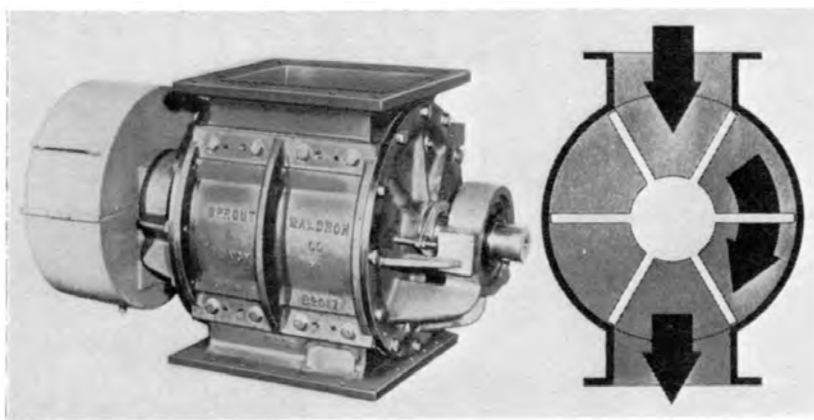

Fig. 1:4. Typical star feeder. (*Sprout Waldron*).

Gravimetric feeders are used where the rate of flow by weight must be accurately controlled. Generally, these consist of a belt moving over a weighing scale and the speed of the belt, or the amount of solids fed to the belt, is adjusted to obtain the desired weight of solids delivered.

DRYING

The most economical method of removing liquids from solids is by mechanical means, such as the use of filters and centrifuges. These mechanical methods generally leave from 2% to 50% liquid with the solids, which must be removed by some type of dryer.

Flash Dryer

The flash dryer is one of the most popular dryers where a powdered product is desired. As it employs air-conveying and short residence time it is not too satisfactory for large crystals or where breakage is to be avoided. Some of the variations are the *air-stream flash dryer*, *the cage mill,* and the *recycle.* Figure 1 : 5 shows an air-stream type in which a relatively dry material is to be fed to the flash dryer and breakage of the product is to be minimized.

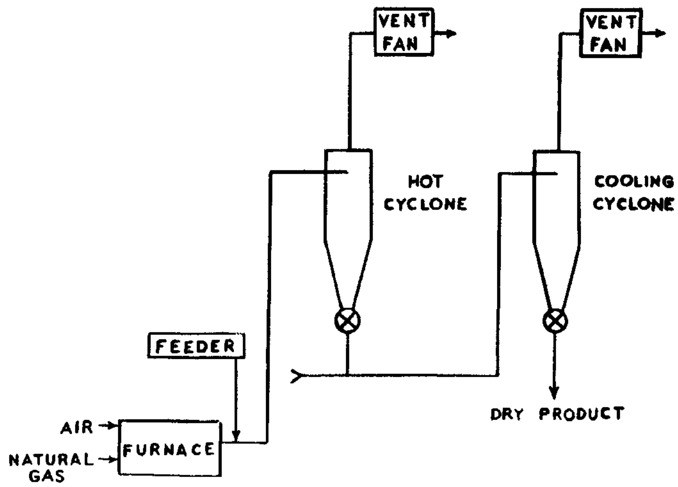

Fig. 1:5. Air-stream type of flash dryer.

Air and natural gas are burned in a furnace to provide hot air around 1300 degrees F. Air could also be blown over steam coils but the higher the temperature of the air, the more efficient the system. A feeder, such as a screw-feeder, supplies the wet product at a uniform rate. The product is carried by the stream of warm air up to the hot cyclone and may be at a temperature around 300 degrees F (more, or less, as desired). If the product is then to be cooled, it may be passed into a cyclone system shown in Figure 1 : 6, where cool air is mixed with the hot product.

If the final product is to be very fine or in powdered form, a cage mill can be added. The cage mill consists of rods fastened to a rotating disc which break up the particles of product. Other types of mills are also used—for example, an *impulse mill.*

If the product is wet enough to be like paste, a recycle system can be added in which a percentage of the dry product from the hot cyclone is mixed in a paddle-blade mixer with the incoming wet material. A complete system using a cage mill, a recycle, and a cooling cyclone is shown in Figure 1 : 6.

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