

Design and Construction of Food Processing Operations

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Process Description

A first step in developing a new food product for retail sale is to define the process required to make the product. In many cases the product has already been produced on a small scale and the entrepreneur is wanting to scale up the process to allow production of larger quantities. A useful tool in this instance is the development of a Process Flow Diagram (PFD). The PFD shows the desired production rate and the raw materials (ingredients) required at each stage of the process. The required equipment is shown schematically on the diagram which is very useful to engineers in estimating costs and selecting and sizing equipment for the process.

Pilot Plant Testing

The second step is to troubleshoot problems that may exist in scaling up the process. This requires test runs on key equipment in a pilot plant laboratory. Depending on the process and desired level of production, scaling up may be quite difficult as illustrated by the following example. In small-scale production, a bowl is used with a simple “fan blade” impeller for mixing. In the large-scale operation, a larger tank and impeller will obviously be required. However, what operating parameters should the scaled-up operation be based on?

Let us assume that the ideal mixing speed and time has been determined through trial and error experimentation at the small scale. The question is, which parameter should be kept constant in moving to a larger scale: (1) the mixer speed (rpm), (2) the power to volume ratio, (3) the bulk fluid movement, (4) the tip speed, or (5) the Reynolds number? If one of these parameters is held constant for the scale up, then the magnitude of the others will be changed considerably. The speed of the impeller tip influences the amount of



shear exerted on the product and will affect the texture, pumpability and stability as will the amount of power or work exerted on the product. The bulk fluid movement in combination with the other factors will influence the degree of mixing. Experimental runs are required to determine the optimum parameter to scale-up and to determine whether the equipment design should be modified. These experimental tests are typically performed in some type of pilot plant facility. Some equipment vendors will assist in determining the required equipment sizes and features and may even offer testing, free of charge, in hopes that you will purchase their equipment.

Facility, Equipment Layout and Process Control

If the processing line is to be housed in a new facility, then the layout of that building can be designed in conjunction with the processing line. Electrical power requirements from the processing equipment need to be estimated and power outlets need to be located. If the building already exists, the layout of the processing line should be tailored to fit within that facility. Once the layout is finalized, the piping routes can be determined. The required flow rate and the pressure drop that will be associated with the piping configuration can be used to determine the required piping and pump sizes. Sensors for measurement of pressure and temperature, etc. need to be specified as well as any process control instrumentation. The type of process will determine the number of controls that are needed.

In a batch process, a small amount of product undergoes the entire process in a step-by-step manner. This type of process has a lot of flexibility and generally involves less automation and more manual labor. A continuous process is more efficient. Ingredients are continually added and the product is continually produced and packaged. Process control is generally required and alarms should be used to indicate any part of the process that is not working correctly.

When processing affects the safety of the product, care must be taken to prevent cross-contamination of finished product and raw materials. For instance, if a product is heated to reduce the number of microorganisms and comes in contact with unheated materials, it becomes contaminated and unsafe. The layout of the process should be such that the risk of cross-contamination is minimized. Incoming materials and finished product should be on opposite ends of the facility and separated by walls or air curtains when possible. The HVAC (heating, ventilation and air conditioning) system should be designed so that the highest air pressure is in the finished product area. This reduces the risk of cross-contamination by air-borne particles.

Additional Requirements for Sanitary Design

Exposed piping and crosswalks should not be run over unenclosed tanks or conveyors with unpackaged product. Equipment should be located to permit easy cleaning. For example, equipment should be at least 6" off the floor, 18" from the ceiling and 36" from the wall and other equipment. Walls should be free of ledges. However, if ledges are present, they should be slanted at 60 degrees. Floors should be sloped to drains at a slope of 1/4" per foot. All food contact surfaces need to be nontoxic, nonabsorbent, and corrosion resistant. Gear boxes, motors and bearings need to be located outside of the product zone in the event of a leak. Welded joints of food-contact equipment need to be continuous-welded, flush and ground smooth.