4. Mixing

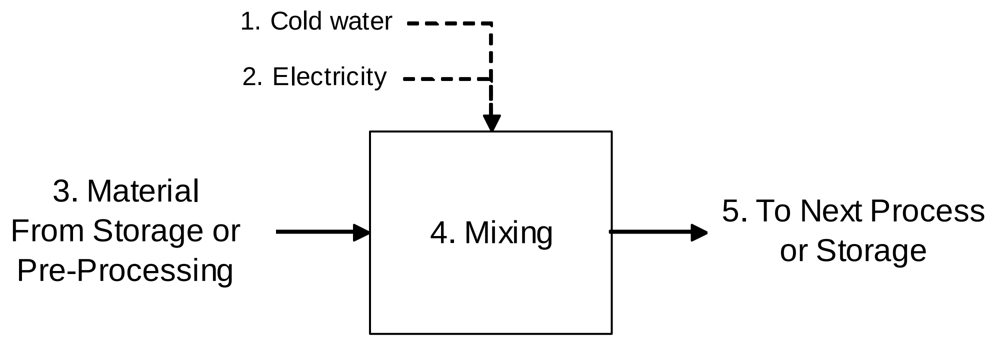

Figure 4.1 – Mixing system diagram

MIXING SYSTEM OVERVIEW (REFER TO FIGURE 4.1 ABOVE)
Mixing is probably the most universally used process in the food processing industry. It can involve solids, liquids, or gases, or any combination of the three. The ultimate goal may be to completely mix the ingredients to obtain a homogenous mix, such as in many cake mixes, or to mix suspended ingredients, such as in many salad dressings.

In general, the conversion of ingredients will result in a final mixture that is one of the following:

- a liquid
- a dry powder
- a thick paste

Proper flow of material in the mixer is important to ensure the quality of the end product. Insufficient flow throughout the container causes pockets of unprocessed or incompletely processed materials that will settle to the bottom or float on top of the mixture. Also, insufficient flow can burn some of the mixture if heat is not dissipated properly; overshear of sensitive ingredients is another possibility.

Liquid mixers that use some sort of propeller or paddle are very common. To provide adequate flow, the rotor is often offset or some sort of baffling is used.

Ribbon blenders using twin-screws, and double-cone mixers are commonly used with dry powders. They provide vigorous intermixing of the ingredients.

Thick pastes are mixed by heavy equipment that often uses contra-rotation to shear the mixture. In some cases, this process can generate a significant amount of heat. To avoid damaging the product, mixing vessels may be wrapped in cooling jackets.

The amount of energy consumed may not be directly related to the degree of mixing that takes place because many foods change in viscosity as they are mixed. In some cases, such as the high-speed mixing of flour dough, the longer the mixture is worked, the greater the energy required to operate the mixer. This is due to the fact that flour components oxidize when mixed in air, requiring greater shearing forces and, therefore, more power to operate the mixer. However, in other cases shear forces decrease as the product is mixed, such as in making ketchup.

Mixing is easiest when components are of similar density and used in roughly equal proportions. When proportions vary greatly, like mixing a small amount of vitamins into cereal, it is usually best to mix the product in stages.

ENERGY EFFICIENCY

Electric motors are commonly used to provide the energy input for mixers. Energy consumption can be quite high, especially when mixing thick pastes that tend to revert to their original shape, like flour dough. It is possible to expend large amounts of energy without doing much mixing. With well-designed equipment, however, energy consumed does correlate to the degree of mixing taking place. This relationship can be determined through experimentation, and in some instances consumption of electricity is closely monitored and used to determine when sufficient mixing has occurred.

As mentioned, mixing thick pastes can generate significant heat. To avoid damaging the product, cold water is sometimes circulated through a jacket around the mixing bowl to remove excess heat.

Some ingredients and mixtures require temperature monitoring and control. For example, some liquids stored in bulk will be pumped through heated lines to maintain the proper viscosity for reliable delivery and mixing. A common method for warming the lines is to pump warmed water through a jacketed line; the temperature in the water jacket is monitored and controlled to maintain the needed viscosity of the liquid ingredient.

WEIGHING

Frequently, ingredients need to be weighed before they are mixed. Increasingly, this part of the process is being done automatically on continuous feed lines. Electric motors, a series of electronically controlled devices, and a conveyor/auger system work together to accurately weigh ingredients, delivering precise amounts into the mix when required. These systems generally do not consume large amounts of energy.

BEST PRACTICES

Electric motors are the primary source of energy used to power mixers. The size of the motor should be directly related to the load required by the mixer. Avoid over or under sizing. When a mixer is used for ingredients that have significantly different load requirements, consider motor speed controls.

For best practices on size selection, speed controls, and maintenance of electric motors, refer to the Appendix: Motors and Pump/Fans.

The noise generated by some mixers may be intense. In these cases, the best practice is to either isolate the mixer or use excellent ear protection.

PRODUCTIVITY FACTORS

In recent years, food processors have been pressured to increase the output or "flow" throughout the entire operation. As manufacturers take steps to reduce waste, they realize that what seems like a small, insignificant improvement in isolation amounts to a very profitable savings when extrapolated over an entire year.

In order to convert an increase in flow at a particular point in the system into profit dollars, that "local" improvement must result in an actual increase in the output of product that is immediately used to fill customer orders. In other words, there will *not* be an increase in profits if the increased flow at this point in the system just means the product waits longer in another queue or sits in a warehouse. The term commonly used today to describe a resource that limits the output of the system is "bottleneck." If mixing is the most restrictive bottleneck in the system, the following factors should be considered to increase flow and, therefore, profits (over and above the financial gains from reduced energy costs). Note that lack of orders may be the true "bottleneck" of the system. Increasing output of product that will not sell, i.e., overproducing, is a major waste!

- Mixing time—Better-designed equipment that provides the required flow and shear in a shorter amount of time will increase productivity by making it possible to run more batches every day.
- Discharge time—The ability to empty the contents faster adds capacity for more batches every day.
- Clean-up time —Factors that shorten clean-up time (e.g., discharge completeness and surface finish) add capacity for more batches and reduce the likelihood of cross-contamination between batches.
- Variable speed drives—The ability to change the speed of the mixer allows more intense mixing at high speeds, while still being able to run lower speeds for other ingredients[11].

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[11] Ross Online: http://www.ribbonblenders.com/operation.asp.

RESOURCES

Printed Material

Singh, R.P. and Heldman, D.R., Introduction to Food Engineering, Academic Press, 3rd ed., 2001.

Wulfinghoff, D.R., Energy Efficiency Manual, Energy Institute, MD, 1999.

On-Line Tools

Earle, R.L., Unit Operations in Food Processing: http://www.nzifst.org.nz/unitoperations/index.htm

Energy Manager Training: http://www.energymanagertraining.com/new_index.php

Online Chemical Engineering Information, Pinch Technology: Basics for Beginners: www.cheresources.com/pinchtech1.shtml.

Singh, Paul, Teaching Resources: Animation: http://www.rpaulsingh.com/animated%20figures/animationlist.htm

Organizations

Association of Energy Engineers: www.aeecenter.org

International Energy Agency: www.iea.org

Iowa Energy Center: www.energy.iastate.edu

Iowa State University Industrial Assessment Center (IAC): (515) 294-3080 or www.me.iastate.edu/iac