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Beer Brewing Revisited

Now that we have reviewed most of the basic topics in chemical engineering, let us go back and review the beer flow sheet that we discussed earlier (see Figure 19.1).

First, we have numerous raw materials that enter this process, and the unique aspect to most of them is that they are "natural" in the classical sense. This means that their composition, in the broadest sense of the word, will vary with time, weather, and how they are grown and harvested. But on the other end of this process is desired a constantly unvarying output of a beer whose taste and quality is expected to be the same by its loyal drinkers. This means that the process control embedded in each of the process unit operations must be able to respond to a constantly changing raw material input. Quite a challenge!

What's involved in accomplishing this from a chemical engineering standpoint? Since we know that the raw materials will be constantly changing, we need some way to measure the compositions and adjust the downstream unit operations so that the beer flavor is unchanged. What would we measure? The chemical composition to the extent possible. Particle size and particle size distribution may be important. Bulk and true density would affect the recipe and the size of the batch and percentage volume used in the various tank "reactors." The particle size distribution, both due to the incoming materials and how this is affected by initial grinding and other processing, will affect the reaction rate, so the brew master will make adjustments as necessary. The brew master may not know the fundamentals of reaction kinetics, but it is understood based on experience how these changes will affect the recipe, and the process control system will be adjusted accordingly.

And what is adjusted? What process variables and analysis can link the composition of the process stream as it goes through the process, to the final taste/composition? All the intermediate steps need to be adjusted as well. What temperature, pressure, and vessel reaction times and compositions need to be adjusted? Do changes in the intermediate compositions change viscosity

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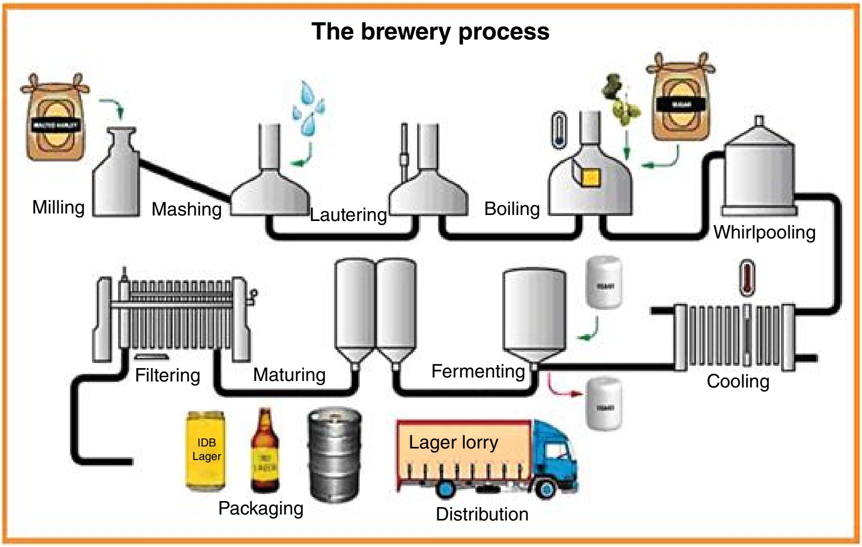

Figure 19.1 The brewing process. Source: https://chem409.wikispaces.com/brewing+process. Used under http://www.creativecommons.org/licenses/by-sa/3.0. © Wikipedia.

and density? If so, how do these changes affect the performance of the heat exchangers? The agitation systems?

Fermentation is a chemical reaction that produces ethanol (C_2H_5OH). Is the reaction rate versus particle size and composition known or only in the head of the brew master? Is the reaction rate as a function of temperature known? The activation energy? How is the residence time in the various downstream vessels determined?

We see heat exchangers in use to drop the temperature after the primary brewing step. How would we decide what kind of heat exchangers? Which fluid would be put on the shell side? Tube side? How do the fluid properties change as a function of the brewing recipe and raw materials? What might foul the exchanger? How would we clean it? The fact that this is a product consumed by people affects this decision. What happens when (not if!) the exchanger leaks? Water into ethanol? Ethanol into water? Diluted beer might be less of a problem than ethanol (which has a biological oxygen demand if released into a public waterway). We at least need to think about it.

Filtering of the process stream is required. What affects this rate and the type of filter media chosen? Should constant pressure or rate be the preferred process? Is vacuum filtration a logical option? Why or why not? What is done with the filter residue? Any environmental issues in this decision? Does it have use as a by-product or agricultural feed? What kinds of filters have been considered? Should this unit operation be revisited? If there is a market for this material, is further processing necessary to change dryness, particle size, or particle size distribution?

Since there is the possibility of biological activity at the end of the process, most beers are pasteurized prior to shipping and inventoried. Destroying residual bacteria is again a chemical process. Many breweries use what is known as "high temperature–short time" pasteurization. If the beer is held at a high temperature or at a more moderate temperature for a long time, the ethanol (its primary ingredient) can also degrade into off-flavor ingredients such as aldehydes and ketones. The kinetic rate curve for this process must be understood so that this last process, necessary to ensure no biological contamination, can be controlled. Coors is a brand name in the beer business. It makes, as a major point of its advertising, that it is "cold brewed." It is also shipped in refrigerated trucks (a significant cost). This type of process does not pasteurize the beer. If kept below a certain temperature, the biological activity is minimized, and if this low temperature is maintained throughout the supply chain, this cold "flavor" can be maintained.

Making beer is a chemical process and has all the same issues of concern, design, and control that make any complicated chemical with a four syllable name.