MIXING MECHANICS

Peter Holman

Determining your powder's temperature rise during mixing

High temperatures during batch powder mixing can harm your mixture. Some materials will degrade. Others will become sticky, impairing their flowability. For these reasons, it's important to know how to determine your material's actual temperature rise during mixing. When you know that, you'll be able to adjust mixing time and other factors to mix safely and efficiently.

Two factors increase the temperature of the powder being mixed: the amount of energy being applied for the mixing and the mixing cycle time. Often users forget about the first when determining the second. Yet you must take both into account.

The total energy applied to the mixing

Determining the amount of energy, or BTUs, applied during mixing is somewhat complex. You must consider the particle flow and the shear applied to the particles. Therefore, if you use a revolving V-type or ribbon mixer, for example, you must consider the flow energy amount, and if your mixer has choppers to break up material, you must consider the choppers' energy input as well.

You can figure out the total energy input with a few simple calculations. First, determine the total horsepower of all motors on your mixer. This includes the main motor and any auxiliary motors, such as for choppers. To determine the total number of BTUs your powder must absorb, multiply the total horsepower by the mixing time, and multiply this total by 2,545 (the number of BTUs for every horsepower per hour).

Keep in mind that just because the motor nameplate says "25 horsepower" doesn't mean that 25 horsepower is being drawn and put into the powder. You must *measure* the horsepower. Do this by measuring the amperage and voltage and then multiplying them to get the number of watts. Then convert the watts to horsepower by dividing by 746. If you use a three-phase motor, multiply the watts by 1.732 (the square root of 3) instead.

Don't use the voltage stated on the motor or the line voltage as stated by the electric company, because when a motor is running the actual voltage will drop. Measure the voltage during motor operation — this is the voltage you must use in your calculation.

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An easier approach is to use a wattmeter. This instrument measures both the amperes and the voltage automatically and calculates the watts for you.

You must also take efficiency into account. Evaluate this by operating the empty mixer with all motors running at operating speed and measuring the horsepower. Then subtract this horsepower from the horsepower recorded during the actual mixing process. For example, if a mixer pulls 5 horsepower during actual mixing and 2 horsepower when the mixer is empty, the actual mixing horsepower will be 5 minus 2, or 3 horsepower. Use this horsepower in your calculation. If you're mixing for 30 minutes, then the amount of heat added to your powder will be 3 horsepower times 0.5 hour times 2,545 BTU, for a total of 3,817 BTUs.

Be aware that not all the BTUs go into the powder. Some heat up the metal in the mixer. The first batch may be slightly cooler than the following batches because the mixer may reach an equilibrium temperature after the first batch. But this is something too complex to be calculated easily, and the effect on your powder is negligible.

Actual temperature rise

Once you know the BTUs going into the mixture, you can predict your powder's temperature rise during mixing. The actual temperature rise is determined by the number of BTUs added, the number of pounds of powder being mixed, and the powder's heat capacity. (You can obtain your powder's heat capacity from the powder manufacturer.) Use this equation:

$$\Delta T = \frac{Q}{M \times C_p}$$

where ΔT is the temperature rise in degrees Fahrenheit, Q is the BTU/h put in by the mixer, M is the pounds of powder being mixed, and C_p is the powder's heat capacity (BTU/lb/ºF).

For the same amount of energy input, the greater the amount of powder mixed, the lower the temperature rise for powders with the same heat capacity. For the same amount of powder being mixed, the powder with a lower heat capacity will have a higher temperature rise than a powder with a higher heat capacity.

Knowing the actual temperature rise during your mixing cycle will help you determine how much powder you can mix and for how long before the temperature becomes high enough to damage the powder or create flow problems. **PBE**

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