Curing Temperature

Today's industrial mass production would not be possible without the use of baked coatings. Drying times (baking times) varying between a few minutes to half an hour are common in the production process. Today's finishes must meet very high mechanical and appearance QC requirements, including

- Optimum adhesion
- Sufficient elasticity in case of deformation through mechanical stress
- Long-term weather stability, e.g. corrosion resistance
- Gloss and color stability
- Optimum hardness

Optimum curing is the prerequisite for achieving these specifications. The properties and the exact temperature distribution of the oven must be known in order to avoid rejects and ensure consistent quality. Poor curing can lead to failure:

- Insufficient adhesion to the substrate
- Insufficient elasticity to resist mechanical stress
- Insufficient surface hardness
- Premature aging, brittleness and chipping, leading to rust and corrosion
- Discoloration and loss of gloss

Any of these damages can be costly to repair.
The traditional range of baked coating systems has changed considerably with the introduction of environmentally friendly systems. The following types of paint technologies are being used:

- Conventional, solvent borne systems with 50% to 60% organic solvents
- High-solids with 10% to 30% solvents
- Water-borne paint systems
- Powder coatings, 100% solids and 0% solvents

Thermoset coatings (acrylic, polyester, epoxy or alkyd resins) are established finishes for industrial applications. The right catalysts and amount of heat initiate the crosslinking process among the various components. The result is a compact paint system consisting of polymers, resins, binders and pigments, which is to be chemically resistant and long-lasting.
Paint properties largely depend on cross-linking quality. Today's binders are very sensitive to insufficient crosslinking.

Insufficient cross-linking causes

- Soft films with low hardness
- Poor or no chemical resistance
- Poor weather resistance (UV, SO2 etc.)
- Increased gloss
- Lower haze values

Insufficient cross-linking can also result in

- Better adhesion
- Better flexibility
- Better intercoat adhesion

Over-cross-linking causes

- Increased hardness
- Less flexibility
- Less gloss
- Higher haze values
- Poor adhesion or intercoat adhesion
- Improved solvent resistance

- Yellowing or discoloring
- Less outdoor resistance, especially when subjected to UV radiation

In order to determine the optimal cross-linking parameters of a system, a series of tests must be carried out at different baking temperatures. Minimum and maximum baking temperatures determine the limits of an optimal curing process. In this process, time and temperature can vary. The reaction speed changes with the temperature, but in a nonlinear manner. The heat-up speed is another key factor for solvent based and aqueous systems. If the heat-up speed is very high the solvent evaporates too quickly and pinholes may occur causing poor appearance.
The example shows three different theoretical temperature profiles with identical curing. Slight temperature changes have a big impact on the curing time. In the production process the temperature profile will rarely be so simple, since material thickness is never constant and oven temperatures vary due to external influences