Ramp and Soak Applications

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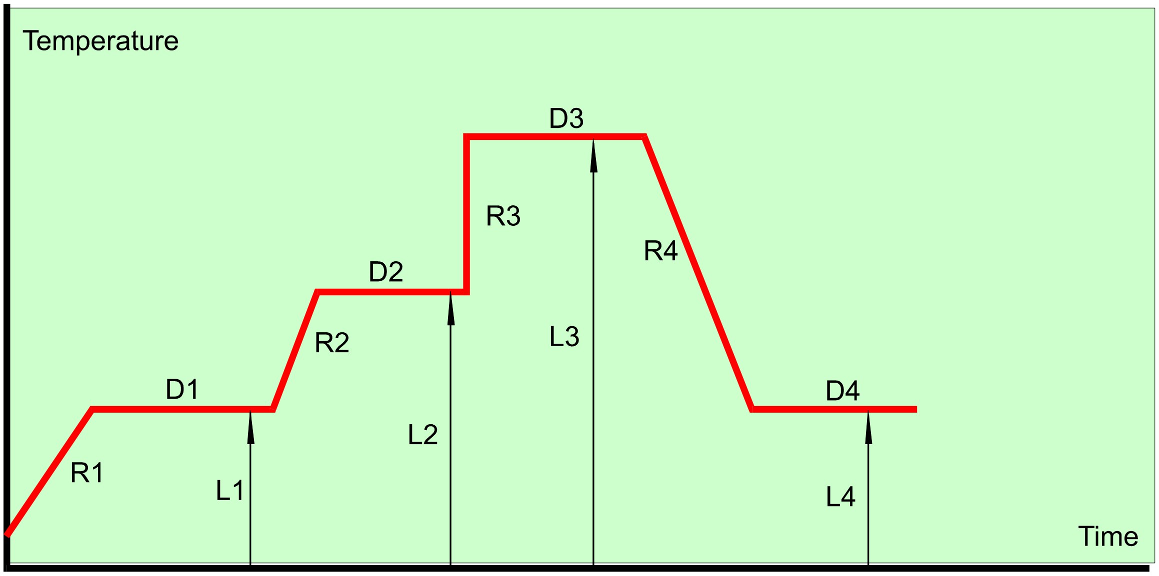

Fig 1 Ramp and Soak Program

A newly built 50 zone rubber-curing oven during start up suffered severe distortion and buckling of the metal work. A major cause of this was the differential expansion of the metal due to the sudden application of full power to the electric heaters and the consequent severe rate of rise of temperature. Two solutions came to mind;

Solution 1. Limit the start up power.

The discrete controllers had a power limit feature built in. Here was a way to bring each zone up more slowly by setting the power limit to some percentage of full power. This is often an acceptable, cheap solution, provided that later, you reset the power limit high enough to achieve the full working temperature.

However in a multi-zone system this method is unlikely to ensure that all zone temperatures will track each other.

Solution 2. Substitute new program/controllers.

Expensive but not necessary because luckily the controllers, while not the program type, had a simple ramp-to-set-point feature built in and it was easy to wake it up and put it to work. Here you set the target temperature and the degrees per minute ramp rate. On start up, all zone set points find and start at the current temperature, usually room temperature, then ramp up to the target temperature at the rate selected. Because the ramp is accurately controlled, the temperatures stay together, minimizing differential thermal expansion between zones.

The above case is a very simple use of ramping. It is unusual in that the equipment benefits, not the work. It could be that more equipment than we ever suspect would provide longer life and less maintenance, given this kind of relief from thermal shock and cycling on start up.

Typical of the products needing ramp and soak control are glass, ceramic and heavy metal parts. A slow ramp will minimize the risk of distortion or cracking due to differential thermal expansion within the work. It will also help to avoid temperature overshoot as the ramp stops and becomes a fixed temperature for a specified dwell time, sometimes called the soak segment. At this stage the dwell time is set long enough to ensure that the parts attain a uniform temperature throughout and maintain it long enough to complete that stage of the processing.

You may need sensors on or inside the work to ensure that the actual material is receiving the required temperature and time processing. A chart recorder or the data acquisition part of an integrated multi-zone control package would monitor these.

A program/controller is a controller and set point generator in one unit. The set point can ramp, step or hold at one value. A typical program is shown in Fig 1.
Here the set point takes off up ramp 1 (R1), holds at level 1 (L1) for a dwell-time (D1) and so on until the time/temperature program is completed. The controller makes the process temperature follow the set point.
There is a wide range of controllers on the market. Some come packaged in a 48mm square case, the user interface being 3 push buttons and 2 digital displays.
The range goes up through to multi-zone models with more user controls and a graphic panel showing the program (like Fig 1) plus digital displays and annotations.

Controller manufacturers have applied much thought and ingenuity to meeting the needs of heat processors across different industries. Major advances continue in control and communication techniques and in configuring controllers to handle the wide range of inputs, sensors, engineering units and final control elements.

- The available number of segments can go from a single ramp as in the opening case, up to typically 80 ramp/soak pairs. By using a number of straight-line segments you can make a good approximation to a curve as a set point program.
- A program can be made to execute once only or repeat a number of times or repeat continuously.
- The number of available stored programs can go from one to typically 50. This enables you to make quick changes from one setup to another and to recall previously used programs.
- You can string two or more stored programs together if you want a larger number of segments than the maximum of one program.
- You can configure the program END to hold at the last dwell temperature, to reset to your choice of set point or to your choice of fixed power.
- As the set point ramps, the temperature may lag behind. If the deviation exceeds a preset value from set point (called HOLDBACK) the program can automatically be put on hold until the temperature returns to within that setting. This is used for example to guarantee that the soak segment does not begin timing until the rising temperature is acceptably close to the required soak temperature.
- A number of internal relays or logic outputs can be configured to operate at fixed temperatures or deviations from set point. Alternatively they can be configured as EVENT outputs to operate as the program ends or enters one or more particular segments. These outputs enable alarms and peripheral equipment to be operated according to the requirements of the process.
- Logic inputs are available, actuated by external signals or contact closures. Here you can initiate such functions as: RUN, HOLD, RESET to a fixed set point, SKIP the remainder of a segment, CHANGE to a new program, SELF-TUNE and ADAPTIVE-TUNE. An analog dc retransmission signal is an option. This can represent such values as process temperature, output power, set point or deviation from set point. The set point retransmission signal from a master controller can command slave controllers on other zones in a multi-zone process to follow the same program. Another option is a digital signal which can retransmit but with absolute transmission accuracy.

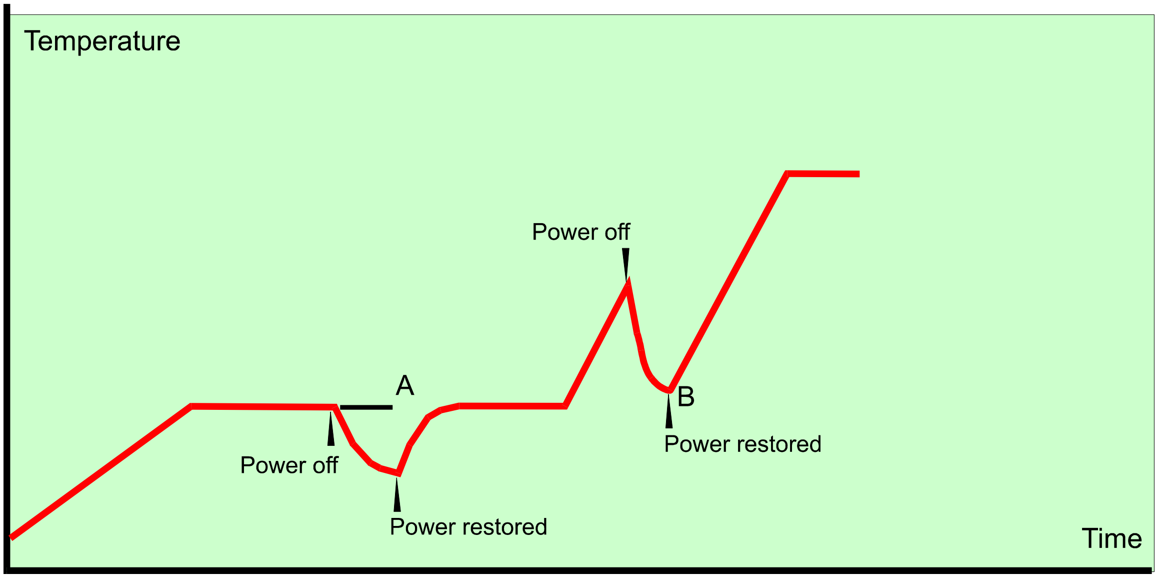

Fig 2 Power Recovery Strategies

- <u>Recovery from Power Interruption</u>

Upon restoration of power after interruption, the program's memory is maintained and it will be ready to continue. The process however will have cooled by an amount dependent on interruption time. You now have three choices any one of which can be called up automatically:
1. Abandon the program and reset to a fixed set point or to some preset power level.
You might do this if you have lost too much heat to guarantee proper completion of the program.
2. Make the program continue from the last set point before power-off (A on Fig 2) For a prolonged power failure you have to judge the effect on the work, of losing some temperature and having it jerked back to the last set point.
3. Move the set point to match the current temperature (point B on Fig 2) and continue the program. Fig 2 shows such a recovery from interruption of a ramp segment. This mode of recovery from within a dwell segment gives a ramped return to the program, starting from current temperature.