Interesting Case Study on Temperature Measurement & Control of a Heat Treatment Furnace

Problem

We have a heat treatment furnace with two different zones. Each zone has a thermocouple and a temperature controller to control the electric heaters for that zone. The temperatures for these two zones are set at different values – 900°C for the first zone and 1020°C for the second zone. We find that we are unable to get the temperature as set in spite of several trials. The furnace is always loaded fully. The temperature in zone one shoots up above 900°C. Please advise about options to get the desired results.

Observations

The data provided by the customer and also the answers to some questions asked to the customer, as well as the visit to the actual workplace revealed some interesting facts.

1. The furnace is electrically heated with three-phase configuration of heaters. For zones one and two, there are two different heater banks. These are controlled in on/ off fashion by a master contactor for each, which in turn is connected to the respective temperature controllers.

2. The thermal insulation of the furnace, especially at the charging and discharging doors, was inspected and found to be inadequate. This was corrected. To begin with, the thermocouples were checked for their calibration and found to be all right. Then the compensating cables were checked for their characteristics and polarity which were also found to the within limits. However, it was noticed that the thermocouples were connected with incorrect polarity to the compensating cables at the connector heads. These were corrected. This gave incorrect temperatures, but to a small value at about 10 to 20°C depending on the actual temperatures inside the furnace and the ambient temperature outside the furnace. This variation would not have affected the set value of the temperature.

3. As the first step, the furnace was put on with full load and at the working temperature of 1000°C. Flexible mineral insulated thermocouples were inserted inside the furnace and the temperature profile was examined at different locations inside the furnace. These thermocouples were connected to an inadequate indicator. The furnace had two thermocouples – one for each zone. Their temperatures and temperatures as shown by these flexible thermocouples were analysed. It was noticed that temperatures of zone one and zone two as shown by the thermocouples were within 10-15°C of the actual job temperature. A better reading for such furnace was not possible. The thermocouples always show the temperature at the tip where they are inserted inside the furnace. On further examination, it was found that the thermocouple of zone two was inserted too close to the heater and it was reading a little more. The thermocouple location was slightly changed and the reading was better, i.e. within 10°C of the job temperature.

4. Then, it was found that the set temperature was achieved for both zones, but in zone one, temperature was shooting up more than the set value. Actually, the heater was put off by the temperature controller at the set value, but the heat capacity and the heating from zone two was heating the job. So, even though the controller was off, either the furnace was on in zone two and the job was getting heated to 1020°C or the furnace was off in zone two, but as the job was already hot in that area, it heated in turn zone can also. So the temperature also shot up more than 900°C there. Since the temperature controller cannot act like a ‘refrigerator’, it cannot reduce the temperature; it can at best just put off the heaters.

Solutions

The solution was as follows:

1. The zone one and zone two temperature controllers were set at 900°C. Naturally, the furnace at both zones was operating at temperature 900°C within tolerance. Then the temperature controller of zone two was set at ascending values such as 920, 940, 980 etc. and the effect on zone one was observed. The data conclusively confirmed that the excess heart given to zone two at temperatures above about 1000°C made effect on zone one temperature.

2. The temperature controller of type on/ off at zone two is not suitable, but a PID controller has to be used. A PID controller controls the heater on duration proportionately depending on the set value and the actual temperature. Ideally, a PID controller and thyristor driver unit to control current in the heaters should be installed. But as the PID controller with timed action (which controls time of heater) worked well, this ideal system was not necessary. It also saved cost of additional electronic thyristor unit.

Results

The customer was requested to run the furnace and give feedback. Happily, the feedback was satisfactory and the cost of simple PID controller was paid back in no time.

Foundrymen, please contact NCTS at iifncts@pn3.vsnl.net.in for solutions to your technical problems.

- Please give your feedback about the NCTS Helpline on above address.

Reference book:

Indian Foundry Journal
Vol. 51, No. 6
June, 2005