Excess Air Burners for Batch Furnaces

Introduction

For batch furnaces, excess air burners provide more rapid heat-up time and very uniform heating compared to conventional burners. A batch furnace heated with a conventional burner becomes uneven in temperature during the soaking period of the cycle. This is actually the critical part of the heating process, and it occurs at a period of lowest fuel input. Normally, burners are at low fire and there are not enough products of combustion in the furnace to maintain a positive furnace pressure. Because of this, cold air infiltrates the furnace setting at the doors, sand seals, etc. and causes cold areas. In addition to this, the burners are simply reduced from large, hot fires to small, hot fires. These small, hot fires tend to localize temperature in the burner area during the soak period. Because there is a lack of furnace pressure, the hot gases will generally travel directly to the flues with the result that hot gas flow is stratified.

These are all well-known arguments for the excess air burner which maintains approximately the same hot gas flow during the soak as during the heating part of the cycle. The gas input only is reduced and the burner, in effect, becomes a small air heater.

Rules of Thumb

The calculations we make to establish burner input on an excess air job are more often made on the basis of uniformity than heat required to load. We always compare the load requirements with the uniformity requirement as a check, but greater input is required to achieve uniformity. The important fact is that every 36° F difference between our burner flame temperature and furnace temperature results in one available Btu for work per standard cubic foot of air flow through the burner. Different applications have different uniformity requirements, and even though every customer wants his furnace ±10°F during the soak, most times this is not necessary.

You pay a certain penalty for these very fine degrees of uniformity, and you should not shoot for them unless your understanding of the application tells you that you should.

Our experience has indicated that a 50°F difference between burner gas temperature and furnace temperature will give ±10°F in the furnace. This type of uniformity is hardly attainable by any other method, including recirculating fans. However, you use a lot of combustion air and a lot of burner. Normally, we would set a furnace up for a 100°F difference and still produce an excellent heat treatment. If we use a 108°F difference, we would have a three Btu per cfh available heat in this system during the soak period. The size of the furnace and its construction is a known factor so heat loses through the furnace structure itself can be calculated. If we take this figure and divide it by three Btu, we will arrive at the cfh we must have at the burner.

Burner Placement

We have also established from experience that, in the case of a furnace over- and under-fired, one burner per foot of furnace length does an excellent job. In other words, a furnace eight feet long would have about eight burners on it, four firing under and four firing over.

Since we have determined the cfh of air we need for the furnace based on available heat during the soak, we can divide this figure by the right number of burners and be in a position to make a recommendation. Furnace flues should be located at the work level to force hot gases down to that level on their way out of the furnace. Flues should be evenly spaced down the length of the furnace. We know that the more flues we use, the better our distribution will be. In general, one flue per vertical buckstay space is what we like to see. Some furnaces cannot be under- and over-fired because of the nature of the load. For example, on some car bottom furnaces we use only half the number of burners as above and flue at the top of the car. You cannot get the uniformity discussed above by this means, but you will certainly do much better than you can by any other method.

We have found on furnaces four feet wide or less that there is an advantage in firing all the under-fired burners from one side and all the over-fired burners from the other. This approach promotes a rolling action of the hot gases in the furnace and has a considerable effect on uniformity. When you get to a five foot width, this is no longer the case, and for that reason we always evenly divide the over and under burners on each side of furnaces five feet and wider.

Control Zones

It has been our experience that batch furnaces should be either one-zone control or three-zone control (or more), but that two-zone control has always been very bad since the cold, or door, end of the furnace demands more heat than the hot, or closed, end, and at the middle of the load there is a non-uniform temperature band where the two zones meet. In this situation the customer unsuccessfully tries to make correction by manually adjusting the burners in that area, and you have a disgruntled customer.

However, you have to use judgment and common sense in recommending zones because every zone requires an expensive controller. If you were to just stress relieve welds in a furnace up to ten or twelve feet long, one zone would do it nicely. Many other jobs are more critical than this, and starting at about 25 feet in length, you should consider the possibility of a three-zone furnace. Three zones are usually ample for furnaces as long as 22 to 25 feet. Generally speaking, we use a door end zone and a rear end zone which are considerably shorter than the center zone. This is probably obvious because the effect of the cold door and the hot rear wall can be compensated for in not more than six or seven feet on large furnaces and the remainder can be treated as a uniform heat requirement from one end to the other.

Temperature Control

We have used various types of temperature control all the way from proportioning recording controllers downward. It is our feeling that the instrument companies have grossly over-sold and over-engineered their control systems. When the control is left up to us, we generally use a millivoltmeter proportioning controller for every zone and a multi-point strip chart recorder if the customer wants a record of the heat treat cycle.

Sample Calculation

Problem: Size an excess air combustion system for a car bottom furnace six ft. wide x eight ft. high x 25 ft. long operating at 1100° F to 1300° F, over- and under-fired.

1. **No. of Burners:** Rule of thumb says 25 burners. However, we have six four-foot spaces between buckstays, so use 24 burners.

2. **Burner Size:** Customer says ± 25° F in load is satisfactory. We will work on flame-to-furnace difference of 100°F, or about three Btu/scfh flow available heat during soak.

   Total furnace wall surface is 796 sq.ft. Heat loss through wall is 250 Btu/sq.ft./hr. Total loss is 200,000 Btu/hr.

   200,000/3 = 66,600 cfh/24 burners = 2770 cfh/burner.

   Use 24 #63 TA burners set for 275,000 Btu/hr. maximum.

3. **Control Zones:** Use two end zones seven ft. long each, center zone eleven ft. long.