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Heat Recovery System for Glass Melting Furnace

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HEAT RECOVERY SYSTEM FOR GLASS MELTING FURNACE

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Abstract

The installation and operating of a 100 ton per day glass melting furnace by Flat River Glass Company to make specialty bottles provided an excellent opportunity for recovery of waste heat. The furnace operates at 2300°F, and four feeders to bottle making machines operate at 2100°F. The 120,000 s.f. packaging area is next to the furnace bay, and it is heated solely by reclaimed heat from the melting furnace bay.

There are two systems that are used to transfer this waste heat from the furnace area to the packaging area. The first of these systems is a water loop. Water is circulated above the molten glass feeders and refiner section of the furnace. This hot water is piped out in the packaging area and through six (6) fan coil units. These fan coil units are located down the center of the packaging area. The water also goes through a coil located in the air recovery system. In the summertime the water is circulated around a sand storage silo to preheat incoming sand.

The second system that recovers heat from the melting furnace area is a series of ducts to capture hot air. This ductwork is placed above the crown of the furnace. Also heat reclaim hoods are placed above each feeder and the refiner section of the furnace. Hot air from all of the hoods is drawn through a filter section to clean sand and dust from it. The hot air from the hoods is delivered to the 42" diameter main ductwork by 24" diameter ducts. Each of the 42" diameter ducts are open above the refiner section and molten glass feeders. Additional heat is recovered by this open ductwork. Main 42" diameter ductwork then delivers the recovered hot air to each side of the packaging area. Four 1 h.p. supply air fans are located here and supply plastic tubes with 10,000 cfm each. Distribution of heated air along the sides of the packaging area is done with flexible plastic tubes that have holes in the bottoms of them, so high velocity air is delivered to the packaging area.

This system has worked well during the last winter. Certain adjustments have to be made to the louvers in the building structure during the heating season. Some redesign of ductwork will occur before next winter so that even more heat can be recovered.

Flat River Glass is a good example of how waste process heat can be transferred from one area to another and put to good use.

1. INTRODUCTION

The use of waste process heat is one area of energy conservation that has long been ignored. A glass melting curance is an ideal source of enormous amounts of very clean waste heat. This heat comes from many areas of the glass furnace. The first of these areas is the recuperator that preheats combustion air with exhaust gases. The second area of waste heat is the crossover section between the recuperator and the glass melting tank. The third area of waste heat is the crown of the glass melting tank. Overhead hoods were built to pick up heat from each of these areas. One fact should be noted about the operation of this glass melting furnace: it has cooling air being blown on the exterior of refractory material constantly. This is to cool the refractory material so holes are not melted in it by the glass. Also the structural steel that supports the refractory has cooling air blowing on it. The fourth area of waste heat is the refiner, which is a section that the glass flows into from the glass melting tank. A fifth area of waste heat is the four feeders that feed molten glass to the bottle making machines. Some heat will be picked up by the air system from the glass metering heads and from the glass blank as it drops down to the molding line. A sixth source of heat is the holding furnaces that keep the cermaic metering plugs up to temperature constantly. This source of waste heat is collected and redistributed by an air recovery system. The air system is the primary recovery system and the water loop system is the secondary recovery system. The water loop system is used to preheat sand in a storage bin in the summertime and when the outdoor temperature is above 60°F. To my knowledge of all the glass and metal melting industries in Union Electric's service area, this is the only one to utilize waste heat.

2. HOW MUCH HEAT IS AVAILABLE

The furance is rated at 100 tons per day of glass production. This rate is about 4.2 tons per hour. This furnace operation is a continuous process. Typical inputs of Natural Gas are near 7000 cubic feet per ton, or 7.9MM Btu/ton. The actual heat content of glass produced is 1.9MM Btu/ton. Therefore, the furnace efficiency is 24%, and this is a good indication that a great deal of waste heat is available. The furnace is currently being operated at near 70 tons per day or 2.9 tons per hour. The firing rate for gas would be 2.9 tons/hour times 7.9MM Btu/ton or 22.9MM Btu/hour. The losses from this firing rate would be (1 - .24) times 22.9MM Btu/hour or 17MM Btu/hour that can be reclaimed. It should be noted that electric booster heaters are used in the bottom of the glass melting tank but the efficiency of these heaters is very good (93%), and most of this heat goes into the product.

3. HOW MUCH HEAT IS NEEDED TO HEAT THE PACKAGING AREA

A calculated heat loss for the packing area is 3,970,000 Btu/hour at an outside design temperature of -5°F and an indoor temperature of 70°F. This heat loss was based on no wall insulation and a three (3) inch batt insulation in the roof. Skylights are insulated panels and do provide excellent lighting on sunny days. The real variable in this calculation is how much infiltration occurs. The ridge vent is closed during the wintertime as are the side louver panels that provide summertime ventilation. However, there will be leakage and some air infiltration from an adjacent unheated storage area. An infiltration rate of 0.25 volume per hour was assumed for the heat loss calculation. This is 21,300 cfm of outside unheated air.

Actual inside temperature reading during last winter's severe weather was 55°F. Based on this temperature and supply air temperature of 145°F at 40,000 cfm supply air the quantity of delivered heat by the air system was 3,960,000 Btu/hour. This agrees very well with the calculated heat loss, so 0.25 volumes of infiltration must not be too much in error.

An estimation of the quantity of gas saved is 74,000 therms per year for heating the packaging area. The cost of this gas would be about $15,000.

4. DESCRIPTION OF AIR HEAT RECOVERY SYSTEM

Figure 1 gives a line diagram with notes showing details on where the heated air is recovered. The waste heat is initially recovered from above the furnace crown by ducted hoods. The area over the crown of the furnace has heavy refractory material and, therefore, is fairly well insulated. The next area of heat recovery is the refiner section of the furnace. There is a great deal of heat recovered from this area due to open area above the refiner. The four feeders to the bottle molding machines also provide a great deal of heat. These feeders have ducted hoods above them.

The open ends of the 42" primary ductwork terminates above this area of the furnace. Part of the waste heat that is not recovered by the various hoods will be recovered by this primary ductwork. Naturally, not all of the heat will be recovered and that heat that is lost goes out the ridge vent. One possible improvement would be to move the open end of the 42" ductwork twenty feet closer to the furnace so heat from the furnace structure cooling air could be recovered.

Heat is also recovered from two holding furnaces that operate continuously. These holding furnaces keep ceramic metering plugs up to temperature (about 2100°F) so quick replacement can be made. The final source of heat is a hot water coil that is in the ductwork just ahead of the filter and a fan. The coil is in the water loop recovery system and in theory will add additional heat to the air recovery system. The fan is rated at 15,000 cfm and is 5 h.p. Its job is to overcome the static pressure drop of the filter and coil. Also it will draw air through the various hoods and associated ductwork. The filter's function is to remove any sand and dust that may be captured by the air. Air from this part of the air heat recovery system is connected to the 42" ductwork by 24" ducts.

Each of these ducts has 7500 cfm of air flowing in them. The balance of the air (13,000 cfm) is flowing in the 42" ductwork. This air is picked up above the refiner section and molten glass feeders. Air temperature at this point in the system is 190°F. The ductwork goes through the wall that separates the furnace-molding machines area from the packaging area. Each duct delivers 20,000 cfm to two fans of 10,000 each. These fans force the air down each 375 ft. side of the building through flexible plastic tubes with holes in the bottom of them. Supply air is discharged at a high velocity so destratific action occurs in the packaging area. One of these ducts takes care of half of each side of the building. Discharge air temperature is 145°F. Control of temperatures in the packaging area is achieved first by thermostats that control the fans on the fan coil units. The second mode of control is to turn off inline fans, either one set or both sets. This causes the reclaimed hot air to flow back through the 42" ductwork and out the ridge vent in the furnace bay.

5. WATER LOOP HEAT RECOVERY SYSTEM

Figure 2 shows a one line diagram of the water loop heat recovery system. Black iron pipe is used to circulate water around to the various areas of heat recovery. Heat is recovered from two principal areas. The first is a coil that is located in a hood above the refiner section of the furnace. The second area is two pipes that are above each of the four feeders. Again the pipes are located below the hoods that pick up heat for the air system. Placement of the pipes along the feeders for maximum heat recovery is critical. Figure 3 shows a cross section of the feeders with pipe placement. Pipes were placed so that they would be at the point of maximum temperature in the plume of waste heat air. The need to fire gas along the length of the feeder is to maintain the molten glass at the proper temperature for molding. Water is circulated at a rate of 150 gpm by a 15 h.p. pump. Water temperature was anticipated to be 260°F.

The three areas that heat is given up in the system are: the hot water coil in the air handler ductwork, the fan coil units located in the packaging area, and the batch tank preheater. The fan coil units are sized so that the smallest unit is near the furnace-packaging wall. These units have their fans operated by an in-space thermostat for temperature control. At an outside air temperature of 60°F the water goes to preheat the sand going into the furnace. Water flow control is achieved by a three-way modulating valve.

6. CONCLUSIONS

Waste heat can be recovered and put to good productive use. In this case, waste heat was of high temperature and readily available in large quantities. There were other sources of waste heat, but due to low temperatures the savings in energy didn't justify the cost of equipment. The system was very simple by design, and failure or maintenance work on it did not effect glass production. Since this heat recovery system was of unique design, there were problems with it. Some portions of it worked well, while others didn't. However, when inventive engineers are involved in energy related problems, there are many workable solutions that can be obtained.

BIOGRAPHY

Milton J. Murry is a Project Engineer in the Special Projects Division, Customer Service, at Union Electric. Part of his job assignment is in the field of energy conservation in industry. He earned a Bachelor of Science degree in Electrical Engineering from Missouri School of Mines and Metallurgy in 1964. He has taken graduate courses in Electrical Engineering from the University of Missouri - Rolla. He is a registered Professional Engineer in the state of Missouri.

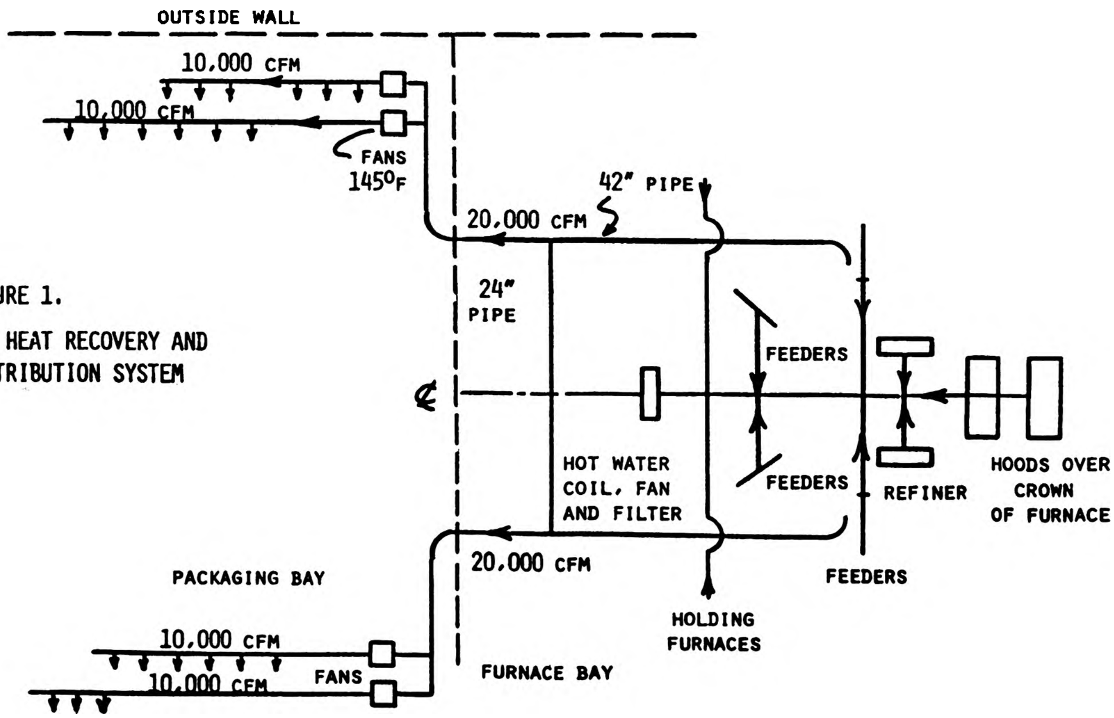

FIGURE 1.

AIR HEAT RECOVERY AND DISTRIBUTION SYSTEM

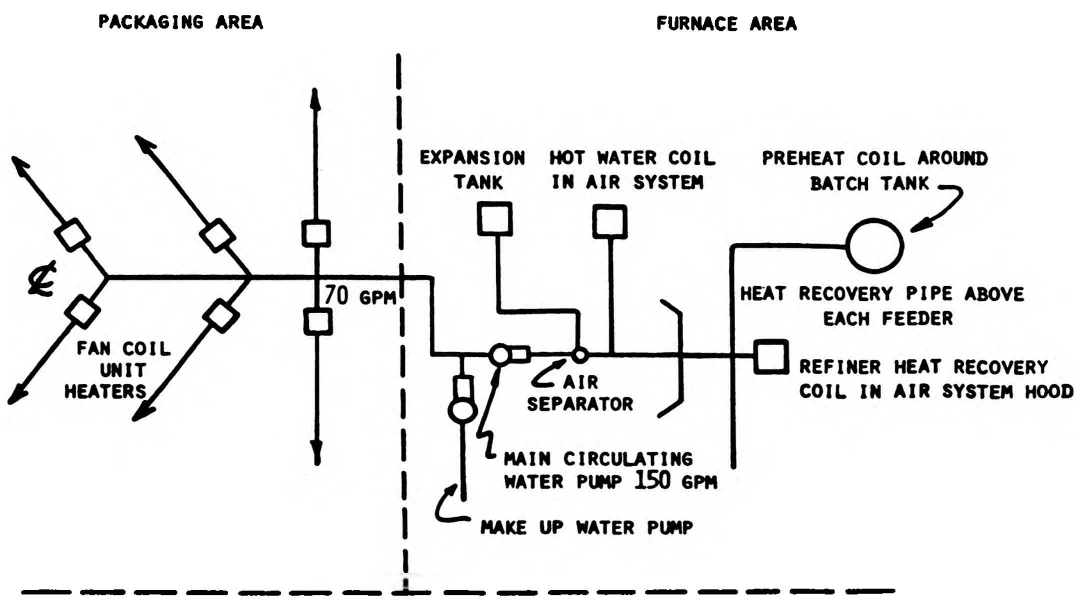

FIGURE 2. WATER LOOP HEAT RECOVERY SYSTEM

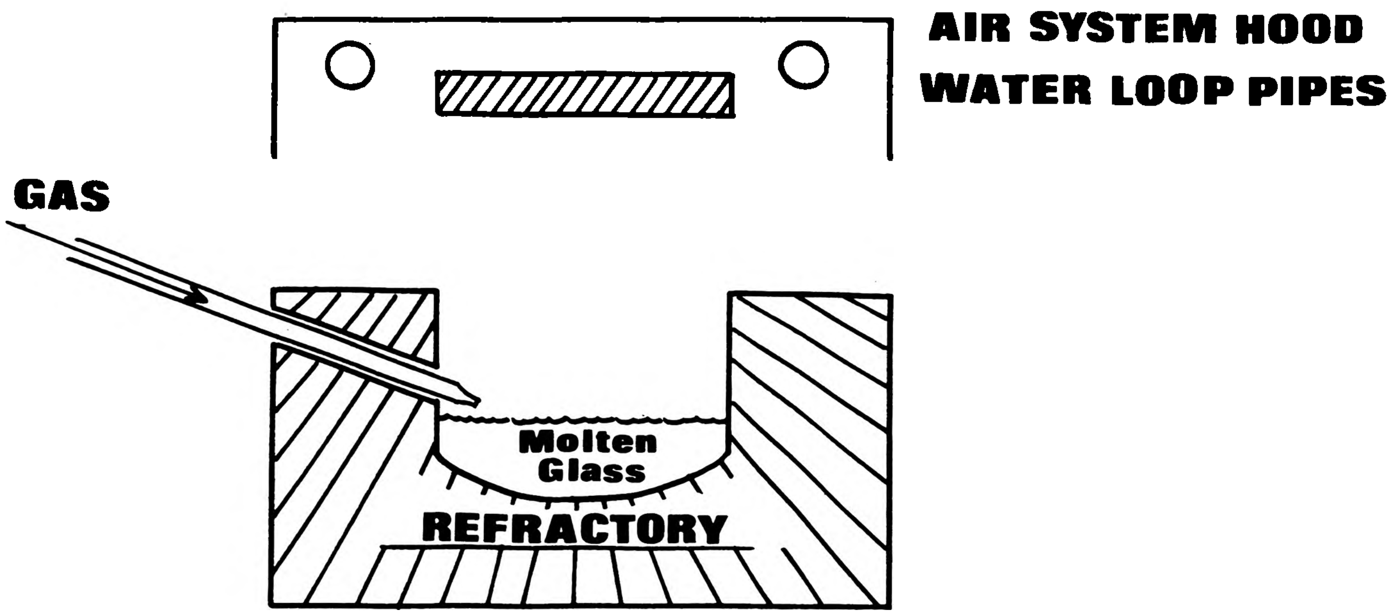

FIGURE 3 WATER LOOP PIPE REPLACEMENT