Application Bulletin

Glass Tanks

Introduction

Operators of glass tanks are facing significant operating cost increases due to constantly-increasing fuel costs. Increasing world demand for energy, political instability in energy-producing countries, and likely changes in domestic tax policy has caused commodities analysts to forecast that energy costs will continue to increase throughout this decade. High temperature processing efficiencies can be gained by employing the latest burner or controller technologies or by using insulation to its fullest advantage. EMISSHIELD® high emissivity coatings[1] present an opportunity to gain additional energy savings.

What is EMISSHIELD®?

EMISSHIELD® is a family of high emissivity ceramic coatings manufactured by Wessex, Inc. based on patented technology licensed from NASA. This latest NASA emissivity technology was developed for the next generation of space vehicles intended to replace the existing shuttle fleet when retired in 2010 (Figure 1).

Figure 1 - X-33 Orbiter

Wessex combined their own patented binder systems with the NASA technology to produce high emissivity coatings that will strongly adhere to dense refractories, insulating fire brick, refractory ceramic fiber, and most metals. Coating glass tank refractories with EMISSHIELD® will provide more even heating, increased productivity, longer refractory life, and fuel savings.

How Does EMISSHIELD® Work?

EMISSHIELD® is not an insulator. It is not a barrier to the conduction of thermal energy through a furnace wall. Insulating refractories are generally placed behind dense refractories at the cold face of refractory linings. While this reduces heat loss from a furnace, the amount of heat stored in the refractory is increased and the refractory materials must withstand higher mean temperatures. Because the working lining acts as a heat sink, valuable process energy is absorbed by the refractories and lost by conduction to the cold face of the lining. Additional convective energy held by the furnace combustion gases is lost up the flue (Figure 2).

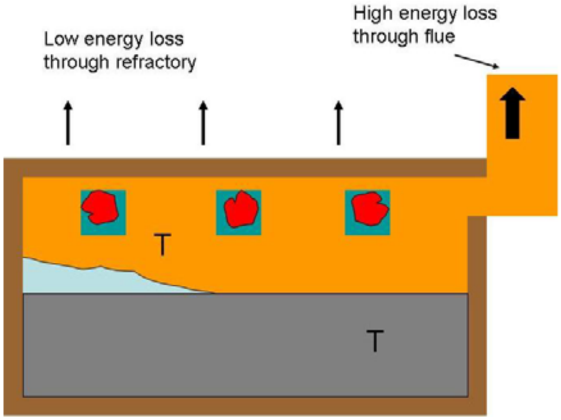

Figure 2 – Glass tank with insulated refractory superstructure and crown showing heat loss through the refractory and great heat loss up the flue.

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[1] US Patent 6,921,431, Other Patents Pending

When EMISSHIELD® is applied to the hot face of the furnace refractory in the superstructure and crown, radiant and convective energy from the burners and hot furnace gases are absorbed at the surface of the coating and re-radiated to the cooler glass batch (Figure 3).

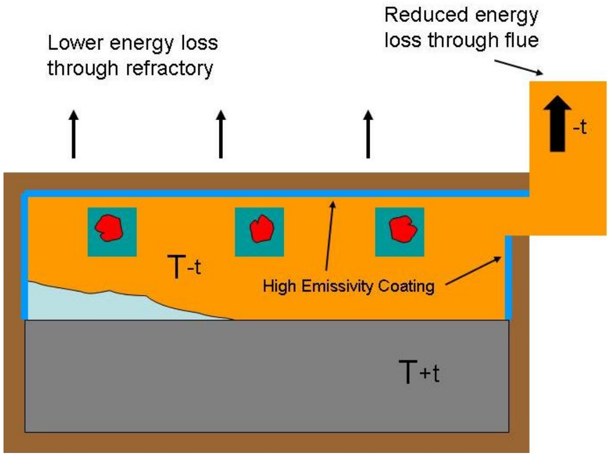

Figure 3 - EMISSHIELD®-coated superstructure and crown results in lower heat loss through the refractories and significantly reduced heat loss up the flue. As a result, more energy is available to heat the glass.

For EMISSHIELD® to be effective, the temperature of the coating surface must be greater than the temperature of the glass, which is always the case whether the glass batch is being melted or whether the molten glass is being refined. The amount of heat re-radiated from EMISSHIELD® is predicted by the following equation:

$$Q = E_w \cdot \sigma \cdot (T_C^4 - T_L^4)$$

Where: Q = re-radiated energy absorbed by the furnace load
E_w = emissivity of the coating
σ = Stefan-Boltzmann constant
T_C = coating temperature
T_L = load (glass) temperature

Since the temperature of the coating and the temperature of the glass are raised to the fourth power, it is apparent that EMISSHIELD® absorbs and re-radiates the most energy when the temperature difference between the coating and the load is the greatest. Therefore, the greatest opportunities for energy savings are when a cold furnace is being commissioned and in the area where materials and cullet are being melted during operation. The application of EMISSHIELD® above the melt line increases the radiative component of heating glass at the expense of the convective component. The coating absorbs convective heat from the hot gases and re-radiates this energy to the glass. The result is less energy being lost up the flue and more energy being used to heat the glass.

Application of EMISSHIELD® in Glass Tanks

Unlike the use of insulating materials that have predictable performance characteristics under steady state conditions, the benefits of using EMISSHIELD® depend greatly upon tank design and operating parameters. Uncoated refractories have emissivities, E_w, in the range of 0.4-0.6 at glass melting temperatures. The application of EMISSHIELD® to the refractory increases the emissivity of the refractory to about 0.9. This means that about 90% of the energy absorbed by the coating is re-radiated to the cooler glass.

Referring to the equation in the previous column, it is easy to see that by increasing the E_w of the refractory, the heat absorbed by the glass, Q, will increase significantly. This may not be desirable where over-heating can change the viscosity of the glass and alter the entire production process, so something else in the equation must be reduced to compensate for the increase of E_w, to maintain a constant Q. The factor that must be reduced is the temperature of the coating and the furnace gases, and this is achieved by reducing the total energy input to the furnace. Of course, as total energy is reduced, fuel savings are gained.

After an EMISSHIELD® coating is applied (Figure 4), the combustion products of firing, carbon dioxide and water vapor, do not absorb all wavelengths of the continuous blackbody spectrum emitted from the coating. The complete spectrum, however, is absorbed by the glass. The result of this is that the temperature difference between the glass and the hotter atmosphere is not as great as before the coating

Figure 4 – Spraying EMISSHIELD® on the silica crown and silica and zircon breastwalls of an gas/oxygen-fired textile fiber furnace.

was applied. It is essential, therefore, that the melting process be controlled by the temperature and behavior of the glass batch rather than the temperature of the furnace atmosphere. While critical furnace parameters should always be monitored, the operation of the burners should be affected by management of the furnace load.

A key parameter for determining appropriate burner settings is the location of the point where the glass batch and cullet are 100% melted. If historic burner settings are used after the coating is applied, the glass will be hotter and the 100% melt surface (free of batch logs) will be closer to the doghouse than normal. The burners and any heating elements within the glass must be turned down until the 100% melt surface returns to its pre-coating location.

The key glass temperature control point is the entrance to the throat. Adjusting burner output so that the glass temperature equals the pre-coating temperature will insure that drawing and forming processes beyond the throat will not be affected by the use of the coating.

After coating the breastwalls and crown of a glass tank, the furnace and crown behavior during heat-up will be different than that experienced before the application of EMISSHIELD®. Early in the heat-up process, the hearth refractories or solidified glass in the hearth will be the low temperature load that will absorb the energy radiated from the coated superstructure and crown. At this point in the heat-up schedule the difference in temperature between the coating and the hearth will be a maximum. Very little heat will be conducted through the coating and absorbed by the refractories, so the degree of crown rise typically experienced in uncoated furnaces is not likely to occur. As the hearth and its contents get hotter, the delta T between the coating and the furnace load decreases and the crown will start rising.

When cullet is introduced into an empty furnace, the delta T will increase and the crown will drop, somewhat. The crown will begin rising again as the cullet heats and eventually melts. A drop and rise cycle will again occur as cold glass batch is introduced. The crown will stabilize when production stabilizes and at that point it can be sealed.

Newly-sprayed tanks with frozen glass in the hearth will also exhibit little heating of the crown early in the heat-up schedule. As the glass heats and finally melts, the delta T will decrease and the crown will rise. Another drop-and-rise cycle can be expected when the glass batch is introduced. Again, the crown should not be sealed until production stabilizes. Furnaces with silica crowns will show less movement with raw material introduction above the quartz inversion temperature.

Expected Results When Using EMISSHIELD®

The application of EMISSHIELD® high emissivity coatings to glass tanks increases the radiative component and reduces the convective component of heating glass. Less energy is lost through the refractories above the glass line and significantly less energy is carried up the flue by exhaust gases.

Depending upon the size of the tank and the way it is operated, fuel savings of 4% to 10% can be expected.

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