BG HitCoat®

# When Common Sense May Fail

If somebody told you that if you paint the inside of your melting or heating furnace green in order to achieve 8% energy savings and to accelerate the melting process or heating of the charge by a few percent, you would probably stop listening to them immediately and throw them out. You might be surprised that the results of a research have proved this person right. Let's take a look at heat transfer and loss at temperatures above 500 $^{o}$C/930F.

The higher the temperature in the furnace, the more radiation takes place during the heat transfer – that is more electromagnetic radiation in the infrared band. The radiation prevails at temperatures above 750 $^{o}$C/1,380, as it increases with the biquadrate of the absolute temperature. An important role is played by so called emissivity, which is the capability to absorb and emit heat. An ideal in terms of physics is a so called "black body", of which emissivity is 1, i.e. 100%. It is therefore capable of absorbing and emitting all heat.

Materials used in furnace and refractory construction have significantly lower emissivity. The emissivity of linings ranges from 0.35 (for fibre insulation) up to 0.45 and 0.55 (for ganister, fireclay, corundum, SiC). Steel water-cooled unscaled walls initially have app. 0.6 but it drops after a short period of operation down to 0.4. The higher the temperature of the surface, the lower the emissivity of common construction materials. In practice this means that the wall and the roof of the furnace emits less then 50% of the input heat into the charge. Where does the remaining heat go? – It goes through the lining into the furnace housing and into the surroundings or into the cooling water, if the roof and the metal wall are cooled. A small portion of the heat goes to the chimney or exhaust pipe or through the furnace atmosphere.

We shall now explain how heat is transferred by radiation in gases. Solid bodies absorb and emit heat continuously, which means at all wavelengths, but that is not the case with gases. With gases this process takes place in narrow so called "absorption" bands. That's why we talk about absorption bands of certain wavelengths of water vapour, $CO_2$, nitrogen etc. The water vapour for instance (which is a common product of burning natural gas) has the most significant absorption bands at about two, three and six micrometers. Wavelengths between these absorption bands are so called "free slots". In free slots a respective gas is completely transparent to thermal radiation depending on chemical composition of the gas.

Now here we finally get to that green coating we mentioned at the beginning – that's our ceramic BG HitCoat®. Its emissivity is as high as 0.95 – which is close to the ideal black body - even at high temperatures. Unlike with steel or fireclay, the emissivity of the high-emissivity coating does not significantly decrease with increasing temperature. A spray coating of 100 up to 150 micrometers / 4 up to 6 mils is sufficient in order to stop heating the furnace atmosphere or taking the heat away through the lining and 95% of all heat will return to the charge. This can be easily verified because metallurgical processes are usually fairly short. The coating absorbs the heat of the gas emitted at the wavelengths of respective absorption bands and it radiates it back continuously in the whole spectrum. So only a small amount of the heat returns to the gas and the majority of it heats the charge.

►On an electric arc furnace with water-cooled tube roof, the heating (input/output) of the cooling water dropped from the original 5 to 8 °C to 1 up to 2 °C (from the original 41 to 46F newly to 34 to 36F) after application of the high emissivity coating. The melting time was by 3 minutes shorter. Upon the removal the roof turned back from the red hot state to its darker colour much faster than before the application of the coating. The caught slag did not survive this shock and fell off, whereas before it continued to build up.

►The temperature of the steel housing of the furnace with a fireclay lining of 600mm/2ft thickness dropped by 17 °C/31F after HitCoat had been applied.

►Temperature of combustion gases in the furnace chimney dropped by 26oC/47F after HitCoat had been applied.

**Conclusion:**

BG HitCoat® is not a mirror that would return all radiation back at the same wavelength at which it received it. It is neither thermal insulation that would reduce the carrying off the heat from the furnace through the lining or a cooled wall. Considering the small thickness this would be impossible. BG HitCoat® is based on the principle of a body with almost perfect emissivity at exactly those wavelengths and temperatures that are most efficient. The coating absorbs the majority of the radiant (but also convective) heat from the hot atmosphere or an electric arc and radiates almost all of it back at different wavelengths in order not to heat the combustion gases but to heat the charge. Surprisingly enough the surface temperature of the lining does not rise but on the contrary – it drops, which makes the service life longer. It is a quantum effect with which our common sense may fail us; this effect seems absolutely illogical. Nevertheless, the practice shows that it works and we would be happy to pay you a give you a demonstration in your plant. Apart from energy savings, BG HitCoat® brings another bonus to you - the increased service life of your equipment, which is also interesting in terms of savings. The return on investment is usually extremely fast.

P.S. Those of you who rely on calculations may simply replace the variables in the following formula which defines the facts mentioned above:

$$Q_e = E_w \cdot \sigma \cdot (T_w^4 - T_c^4),$$

where

$Q_e$ = radiated thermal flow $[W \cdot m^{-2}]$

$E_w$= emissivity of the wall or coating [dimensionless]

$\sigma$= Stefan-Boltzmann constant $[5{,}670400 \cdot 10^{-8}\ W \cdot m^{-2} \cdot K^{-4}]$

$T_w$= surface temperature of the wall [K]

$T_c$= charge temperature [K]

**BG SYS HT s.r.o.**

**ENGINEERING ● HIGH-TECH IMPLEMENTATIONS**

CZ 530 03 PARDUBICE, HOLUBOVA 389, TEL.: 466-264-565

WWW.BGSYSHT.EU BGSYSHT@ BGSYSHT.CZ