THE ADVANTAGES OF

Soot Deposition on Copper Mould

The rich combustion of acetylene is widely used to generate the coating for the wheel and the band molds of the continuous casting machines for copper wire rod production. The incomplete combustion of this gas enables the molds to be covered by the resulting thick smoke which adheres to the surfaces as carbon, known as soot.

Acetylene is normally blended with combustion air to enhance flame propagation. The air to gas ratio may vary greatly from user to user, according to practice, burner design, position, gas composition, etc. However, results are not always as good as they should be and, even in the more experienced environments, are difficult to control and repeat.

The critical issues are as follows:

>> The flame is difficult to be accurately directed and it is subject to be distorted by the surrounding turbulences.
>> The burner tips frequently clog as soot sticks and builds up around the nozzles. Frequent cleanings are required to prevent build-ups from eventually falling into the casting cavity, thereby inducing inclusions.
>> The resulting soot layer is made of amorphous carbon which retains humidity due to its higher hydrogen levels.
>> When contacting high temperature metal, amorphous carbon cracks up and pops off, unevenly, leaving uncoated areas on the molds.
>> Being a poor conductor, the layer needs to be consistently removed to grant the necessary cooling during the entire production period.

It’s no wonder that bar quality can be easily compromised by the issues mentioned above. Uneven, patchy soot originates bar cracks, hot-spots, porosity, as well as unstable rolling temperatures, not to mention carbon related inclusions.

Over the years tremendous efforts have been made to improve soot control in order to reach higher rod quality and performance standards by casting a flawless bar. In fact, copper rod quality requirements continue to be more and more demanding.

More recent studies and tests indicate that oxygen may be a better substitute for conventional air in the combustion mixture. Although the ratio remains rich, pure oxygen develops a hotter, shorter flame which could bring a few advantages in soot control. The sizable benefits are:

>> The flame is stronger; it propagates more efficiently and it’s less affected by nearby turbulences. Therefore, it’s easier to properly direct the flame in order to correctly coat the mold surfaces. Soot can be applied only where needed, with minimal fuel waste.
>> Burner tips remain much cleaner and tip clogging no longer occurs. Smoke evolution is very limited.

SOOTING WITH OXYGEN

>> Higher flame temperature induces the generation of graphitic carbon containing less hydrogen. The soot, therefore, has much less humidity which is promptly dissolved by the wheel temperature before it reaches the pouring area.
>> Because of its nature, graphitic carbon is not affected by molten metal temperature. Therefore, the soot layer remains thin and smooth across and along the molds. As a result, cast bar temperature stability, as well as bar surface quality, will benefit.
>> Graphite is a good conductor; it enhances heat extraction and may eliminate macro-porosity. Soot removal requires less intensity.
>> Once optimized, the graphitic layer remains homogenous and stable in time thereby yielding much longer quality castings.
>> The improved soot distribution and the better heat transfer may considerably extend the overall wheel life, as well as band operation time.
>> Cooling water is less polluted due to the lower amounts of loose carbon being generated and therefore it remains much cleaner.

Due to the above mentioned advantages, it is possible to protect the copper ring and the steel band by the formation of a smooth, consistent, graphitic film which also enables the optimal heat transfer necessary for the proper grain formation in a sound, defect-free, cast bar.

Bar temperature is more controllable and, more importantly, remains steady, thereby permitting smooth rolling into a geometrically correct rod. The symmetrical bar structure will also ensure ideal rolling deformation, enhancing the mechanical properties of the copper rod.

Progressive, homogenous cooling allows the evolution of molten metal gases, thereby reducing porosity while virtually eliminating hollow bar formation. Furthermore, soot-related bar surface defects, like hot-spots or cracks, are almost reduced to zero. Thanks to the superior and more uniform coating, the thermal stress to the expensive casting ring is contained and therefore the formation of cracks is delayed and minimized, thereby allowing far more tonnage. Band life is also extended and becomes more predictable for the same reasons as mentioned above. A good soot layer also makes the system, to a limited extent, more tolerant of cathode impurities.

Although the advantages are considerable, the transition from air to oxygen combustion is quite simple and requires only minor investments. Specially designed burners and holders are required, as well as specific flow-meters for oxygen. A liquid oxygen tank may become advisable. Individually controllable, high-pressure water-jet soot strippers will be required for the wheel and the band in order to properly maintain the correct soot film thickness, which should be in the 50 to 100 µm range.

To generate the bright black layer, the oxygen flow should normally be set to about half that of the acetylene. However, final adjustments relative to flow rates and positioning of the burners may be required based upon each unique local lay-out and environment. Operators easily become familiar with the acetylene/oxygen technique and are no longer discouraged by poor results.

Most important, however, is that set-ups and operations always be carried out with maximum attention and care. Repeatability, as usual, is a key factor.

The relatively simple replacement of the combustion air with oxygen grants improved bar quality, wheel and band life, as well as operational conditions. The additional oxygen cost will pale in comparison to the savings that result from these improvements.

Continuus-Properzi will be glad to provide full service and support for the implementation of an acetylene/oxygen combustion system. *by Andrea Peviani*

Soot Deposition on Steel Belt