Cooling of hot briquetted iron

Production of direct reduced iron (DRI) has increased significantly over the last few decades as new and innovative uses in the form of pellets and hot briquetted iron (HBI) in steel production came into being. Unlike hot DRI, HBI is transported cold and the technology of cooling is of great importance for briquette quality and for operational reasons. Aumund Fördertechnik provides such technology.

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Since the 1970s, the use of direct reduced iron (DRI) as a raw material for steel production has increased significantly, as illustrated in Figure 1. From 2003, the data also illustrates the mix between cold direct reduced iron (CDRI), hot briquetted iron (HBI) and hot direct reduced iron (HDR). The capacity available for operation in 2012 was in the region of 86.7 Mt/yr, and with a further 21.1 Mt/yr under construction, this makes a capacity of more than 100 Mt/yr.

With its Fe content of 91.94% and a very low portion of undesired companion elements compared with other feedstock materials, DRI has become a premium raw material, both for the production of hot metal in the blast furnace, as well as steel production in the BOF and EAF.

Currently, there are a number of DRI technologies in use or under development, including shaft furnaces, retort processes, rotary kiln processes, rotary hearth processes and fluidised bed reactors (see Figure 2). The latest installations of MIDREX shaft furnaces have an annual capacity of 2 Mt/yr, but among the non-shaft furnace technologies the capacity usually is much lower with, for instance, individual fluidised bed facilities having a design capacity in the region of 1.5 Mt/yr. The gas-based technologies currently dominate the market, but the next generations which use coal as an energy source are under
development, and for which there are very interesting developments for the production of synthesis gases and gasification of coal/coke from other metallurgical processes.

After direct reduction there are basically two options (see Figure 3):

- Direct use of hot DRI/HBI for steelmaking, e.g., hot charging into on-site EAF
- Cooling of HBI for later use on-site or for external sale

For storage and/or transport on trucks and ships DRI is usually hot briquetted immediately after the reduction process. This provides considerable decrease in the surface accessible for re-oxidation and an increase in density up to 5t/m³ (from 3.2t/m³ for DRI).

**COOLING OF HBI**

After briquetting, the material must be cooled from about 750°C to about 80°C to allow safe intra-plant transport and storage, a process that normally takes place in a water bath either on a vibratory feeder or on a conveyor. The inner residual heat suffices to dry the briquettes after the cooling process, however, this method leads to the cooling devices being subjected to excessive wear. Moreover, due to the ‘Leidenfrost effect’—a phenomenon in which a liquid produces an insulating vapour layer which keeps that liquid from boiling rapidly—the efficiency of this cooling method is very low. The high material temperatures may also cause water-gas reactions in the cooling bath.

Furthermore, large temperature differences within the briquettes caused by the quenching process result in cracks, spalling and breakage, and undesired chemical and physical reactions result, all of which reduce the product quality.

Operating disadvantages of the traditional approach may be summarised as:

- Insufficient cooling capacity
- High cost of water treatment
- Extensive maintenance of the vibrating feeder or conveyor
- Frequent exchange of the belts at the subsequent belt conveyor

**THE AUMUND COOLING CONVEYOR**

In devising a better system, the challenge was to combine the positive attributes of a material transport system, without any relative movement of the material to the machine, with the advantages of cooling HBI with water. The amount of water had to be drastically reduced, as a metallic plate conveyor is not able to handle liquids. Furthermore, as a major cooling effect occurs at the transition from liquid to gaseous state, we designed a
system that uses only the amount of water that is exactly required for this transition. This requires various calculations to determine the useful range of water quantity for treatment under different scenarios, but by using several sensors at relevant points we have at each stage an exact knowledge of the temperature of the material and can control the related water flow.

The result is a smart mist spraying system that is precisely adjusted to the material and its properties. At some installations the amount of water could be reduced to only 10% of the amount used in more conventional HBI cooling systems. This makes this cooling method attractive for regions of limited water supply or which can be generated only with a great effort. In addition, the costs are reduced for the water system, cleaning, filtering and pumping with this approach.

Because there are no major temperature differences within the individual briquettes, this avoids cracking or spalling and any undesired chemical and physical reactions. The water vapour produced with this cooling method also provides an inert atmosphere which avoids a re-oxidation of the material. Figure 4 shows a schematic of the Aumund HBI cooling system.

Currently, several Aumund cooling conveyors using this new cooling method are used in production plants. With customised length and width according to the variability in capacities, the cooling conveyor can be designed to the specific situation at the plant. Capacities of more than 300t/h per conveyor are possible, this being sufficient for normal situations. Special attention must be paid to the exact material mix, for instance after first starting the briquetting presses some fines, or so-called 'remet', accumulate. This material can be cooled with the new cooling method too, but needs a special handling regime.

Recently, a very large installation in Russia's Lebedinsky GOK went into operation. LGOK's current capacity is 2.4Mt/yr of HBI. After a very short delivery time the startup was in December 2012. On these cooling conveyors a suction device for the water vapour produced for the spray cooling is connected to the material feed. The material feed is included into the housing of the conveyor through an enclosure connected directly to a briquetting presses.

The inlet devices for the water mist are installed at a specific distance from the material feed in conveying direction. This arrangement ensures very careful initial cooling by a directed flow of the water vapour (convective heat transfer). Subsequently, the injection of the sprayed mist leads to a cooling by vapourisation.

**PLANT EXAMPLES**

Three cases will now be described which illustrate that this technology is suitable for all direct reduction technologies, and on greenfield or brownfield sites. As the design of
Case 3 (see Figures 9 & 10) - brownfield installation
The example here is a 3 x 140t/h HBI plant with cooling from 800°C to 100°C. Each conveyor is approximately 40m long and had to fit onto the existing foundations from the former conventional cooling equipment.

CONCLUSIONS
The Aumund cooling conveyor system provides a number of advantages over conventional cooling. Product quality is improved as there is no cracking or spalling, hence fewer fines and also no re-oxidation. This offers the possibility for a higher HBI selling price. In terms of handling, the Aumund system provides much reduced water consumption and water treatment, no sludge, an integrated spillage water removal system and fully automated operation. MS

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