Function of blast furnace cooling system is to cool the furnace shell and prevent from the overheating and subsequent burn through. Cooling system removes the excess heat generated in the blast furnace which is otherwise loaded on the shell. Cooling system thus prevents the increase of the shell and lining temperature. Various methods exist for cooling of the shell for the blast furnace.

In earlier times, cooling boxes of different size, number and design were used for transferring heat of the furnace to a cooling medium in conjunction with external cooling (spray cooling, double shell). Blast furnaces with cast iron cooling staves are operating since mid-1900s. Cast iron stave cooling was originally a Soviet discovery from where it travelled initially to India and Japan. By 1970s, cast iron cooling staves have attained worldwide acceptance. Since the introduction of these cast iron stave coolers, the development work of blast furnace cooling got accelerated and today a wide variety of coolers are available for the internal cooling of the furnace shell to suit extreme condition of stress in a modern large high performance blast furnace.

Development of Blast Furnace Cooling Stave

“Irrespective of the use of so called refractory materials the best means of maintaining the walls of the blast furnace is with cooling water.” These words were spoken by Fritz W Lurman a well-known blast furnace man from the time shortly before the turn of century. The main function of the cooling system is to cool the furnace shell and prevent it from overheating and subsequent burn through. To accomplish this, the cooling system must be able to take up the excess heat generated by the furnace and loaded onto the shell. This heat will lift the shell and lining temperature too high, if the cooling system is not effective in dispelling it.

Cooling Stave:-

This invention relates to a cooling installation for metallurgical units, the walls of which are subjected to thermal fluxes of elevated temperature and, more particularly, to the cooling of blast furnaces by means of stave coolers. Modern blast furnaces are increasingly utilized at such velocities and pressure levels that it is important to control the heat fluxes and their transfer, particularly in the zones of the bosh, the body, and the lower, mid, and upper shaft. In particular, in the case of self-supporting units, it is indispensable that the shell not be affected by the temperature level and not be subjected to the variations in temperature which could lower the shell's resistance to the strains to which it is subjected. The heat flux emitted in the different zones of a blast furnace must be collected by a heterogeneous system consisting of a lining, a cooling element, that is, the stave cooler, a shell, such that the cooling element serves the double function of effective cooling of the lining and screening the passage of the flux towards the shell.
Types of cooling stave:-
Smooth Surface Cooling Stave: - The stave is of simple structure and good thermal conductivity, the hot face is smooth face with thickness of 70~140 mm. It is mainly used in the tuyere and below area as the inner lining of BF hearth cooling.

Common Brick Inlaid Type Cooling Stave:- The hot face of this kind of stave is spacing lined refractory brick, and mainly used in bosh, belly and middle and lower part of stack. Brick inlaid is high alumina brick, silicon carbide brick etc.

Common Ramming Mass Type Cooling Stave: - The hot face of this kind of stave is spacing lined dove tail with crushing refractory materials inside, and is mainly used in bosh, belly and middle and lower part of stack. Ramming material alumina carbon or silicon carbide brick

Complete Cover Type Brick Inlaid Type Cooling Stave: - The characteristic of cooling stave is hot face (working face) is completely covered by bricks with thin or non-lining structure to enlarge the furnace volume. It is mainly used in bosh, belly and middle and lower part of stack. Cooling stave arranged against the internal face of the shell between this latter and the refractory coating fulfill a double function. The staves are made of cast iron, steel, copper elements having a network of tubes in which circulates a cooling fluid, which in the prior art, is water, and which is subjected to a vaporization upon contact with the heat flux which the stave cooler has to be absorbed.

Copper flat plate coolers
Copper flat plate coolers have been used nearly in all the European blast furnaces. These coolers are either welded or cast in electrolytic copper. The usual plate sizes of copper flat plate coolers consist of 0.5 m to 1.0 m of length, 0.4 m to 0.8 m of 3 m width and a height of approximately 0.75 m. The vertical spacing of the coolers is 0.3 m to 0.6 m. In the zones with high heat loads, especially in the bosh and lower stack areas, the spacing is often reduced to 0.25 m. Copper flat coolers have a greater uniformity of material properties over the complete cooling element. In those regions of the blast furnace which are subject to mechanical damage, the front side of the cooling elements is usually reinforced with special materials. These coolers are mostly welded to the blast furnace shell to ensure gas tight sealing. The copper flat plate coolers have normally multiple channels with one or two independent chambers. One of the designs of capper flat plate cooler has six pass with single chamber. These coolers are designed to maintain high water velocities throughout the cooler, thus have an even and high heat transfer coefficient.

Copper stave
Since 1884, a cooling plate attached on blast furnace shell from tuyere to throat has been applied to protect the shell and to prolong the blast furnace campaign life. Around 1970, a new cooling system, a cast iron stave, was developed by the USSR suppliers. However, the cast iron stave has been shown to develop abrasions after a blast furnace operation of about 7 years, coupled with a high susceptibility to cracking under the severe heat load and temperature fluctuations. In 1979, the two copper staves were
installed for testing at No. 4 BF of Thyssen Hamborn and the wear on the copper stave during a 10-year campaign has been insignificant. Since 2000, many blast furnace operators have installed copper staves at the bosh, belly and lower shaft areas to extend the life of the cooling system to one campaign. The development of cooper staves was carried out both in Japan and Germany for use in the region of bosh, belly and lower stack to cope with high heat loads and large fluctuations of temperatures. While Japan has gone for cast copper staves, German copper staves are rolled copper plates having close outer tolerances and with drilling done for cooling passages. Drilled and plugged copper staves are typically designed for four water pipes in a straight line at the top and four water pipes in a straight line at the bottom. Materials for internal pipe coils include monel, copper or steel. Unlike cast iron staves, copper staves are intended to be bonded to the cooling pipe.