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Research Article

Study of Blast Furnace Stave Cooler Based on Heat Transfer Analysis

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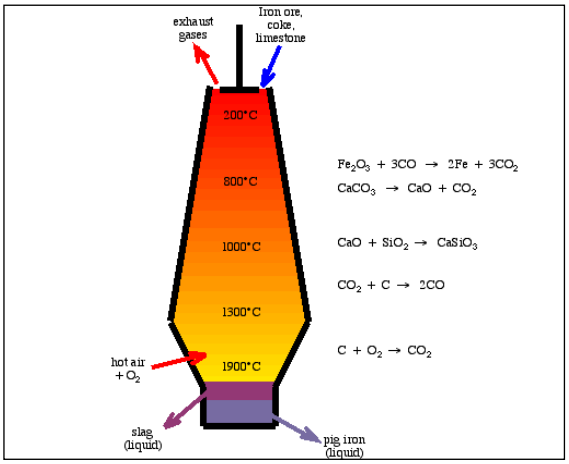
Abstract

The life of blast furnace is increase due to technology of furnace cooling very important method for metallurgical industry. Blast furnace mathematical model of stave cooler has been developed for heat transfer analysis and compare to experimental. Using ANSYS® software calculating the heat transfer and temperature of stave cooler. The result calculating using software ANSYS® and compare with blast furnace placed in RSP with experimental model. Heat transfer stave cooling of blast furnace has been done at different temperature from 575k to 1675k the result is compare with experimental for better result, in the stave cooling of blast furnace nitrogen and nano fluid (Al2O3) also as a cooling fluid in the place of water.

Keywords: Blast Furnace, Stave Cooling, Transfer Analysis, High Thermal

Introduction

In the blast furnace stave is cooling device for cooling the refractory lining stave having number of coil one or more than one coil. In the blast furnace refractory lining is installed in inner part of blast furnace to guard the steel shell and keep the inner profile and another type stave i.e copper stave is establish in the high thermal lode of blast furnace, in the Fig .1.1 shown stack to bally thermal load. Combustion is take place inside the blast furnace due to this large amount of heat is generated, inside the blast furnace lining cooling is effective technology for producing products. Hence due to copper stave cooler save from subsequent burning and overheating. Inside blast furnace very large amount of heat is generate so due to this heat cooling is important thing to save the furnace, water is a cooling medium for extracting the more heat inside the blast furnace. To protect the increase temperature of shell. There are so many methods for cooling of blast furnace shell. The staves are manufacture of cast iron, now in the place of cast iron copper stave are use. Which is very high conductivity and heat flux cast iron stave is 50% lower than copper stave. Campaign life of blast furnace by cast iron staves cooling which is not obey extra heat load. Copper stave show effective and good for overcome the extra hear and load.



Thermal Zone of Blast Furnace

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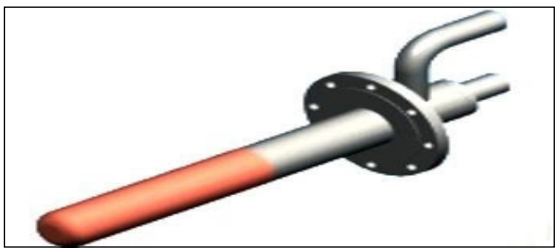
Types of Cooler

Plate cooler

In Europe plate cooler has been utilized as a part of all furnace heater. Plate coolers are for the most part made by either welded or cast in electrolytic copper. Plate cooler has kept in the zones with high warmth heaps of impact heaters particularly in the bosh and lower stack areas, arrangement of plate cooler demonstrated in underneath. These coolers are intended to keep up high water speeds all through the cooler, consequently have an even and high warmth exchange coefficient. The copper level plate coolers for the most part have different channels with maybe a couple autonomous chambers.

Cigar cooler

For unique blast furnace applications, Cigar Coolers can be either thrown or manufactured in a wide range of measurements or lengths, the configuration of Cigar cooler indicated in beneath. These are additionally utilized for enhancements to the current cooling framework amid a campaign. Cooler is by and large machined by strong copper bar to frame a barrel shaped center and a solitary channel is included by penetrating and stopping. Cigar coolers are ordinarily continued the middle lines between adjoining level plate coolers on a flat and vertical plane. For the premise of establishment of a cigar cooler typically a tube shaped opening is penetrated through the heater shell and existing headstrong coating with a center drill.



Cigar cooler

Stave cooler

Copper stave were produced by Japan and Germany in the mid 1990s yet the more noteworthy number of the establishments is in or after 2000. Dimension of copper fight are 1640mm, 900mm and 200mm length, breath and tallness respectively. Typical outline of fight cooler demonstrated in underneath.Copper fight are use in the area of bosh, paunch and lower stack to adapt to high warmth burdens and vast variances of temperatures. Stave cooler of Japan are thrown copper stave, however German copper fights are moved copper plates having close external resiliencies and with penetrating accomplished for cooling entries.

Types of stave cooler

Smooth Surface stave cooler

It having great warm conductivity and basic structure the hot face is smooth face. It is primarily utilized as a part of the front of tuyere and internal coating of BF hearth cooling.

Common Brick stave cooler

Use of common brick stave cooler is in bosh, lower part, stack and middle part. High alumina brick, silicon carbide brick is brick inlaid. Spacing lined refectory brick of stave is also known as hot face.

Objective of Present Work

- To examine the behavior of stave material at various load conditions.
- Design the stave cooler with 3-D model.
- From experiment to calculate the temperature difference.
- The experimental model used in RSP (Rourkela steel plant), the numerical result is compare with experimental result of RSP.
- In the place of water for cooling nitrogen and nano fluid is use.

Literature Eeview

Y. KO et al

He have analyzed the Thermal Behavior in upper –Hole Area. Thermal properties of mud-core is found, convection heat transfer coefficient of cast able and bricks of spool have a great effect on the top hole area temperature distribution they developed hearth model, which can estimate the trend of thermal behavior by manning thermal properties and they found temperature distribution of tap-hole area

Akash Shrivastava and R. L. Himte

Using heat transfer analysis he study stave cooler of blast furnace. The cooling of blast furnace by using two different type of skull in the lining material as well as two different type of bricks are considered, first they had chosen imperceptible thickness then other is certain thickness, the consideration of thickness in millimeter (mm), so

temperature load from 773k to 1573k the found that lining is better than other for heat extraction when use two different type of skulls.

Anil Kumar et al

He takes two other type of lining material for modeling of three dimensional blast furnace cooling stave and this analysis i.e high alumina bricks and silicon carbide brick. Stave with skull is used at different gas temperature from 773k to 1573k for the lining material. In the cooling process water temperature is taken 303k. Then result is concluding that thermal stress and maximum temperature of hot face are minimum in alumina brick and higher in silicon carbide. So he select silicon carbide is more effective then alumina.

W.Lijun et al

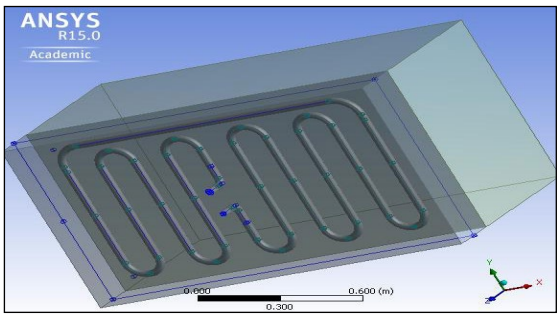
For modeling of three dimensional stave of blast furnace uses ANSYS. The increasing of velocity of water and reducing the temperature of water is not economical. The thermal stress and maximum temperature in the stave is control properly by adjusting operating conditions of blast furnace, coating layer gas flow is operating conditions, cooling channel, lining material and inter distance, gas clearance and Diameter.

W. Zhou et al

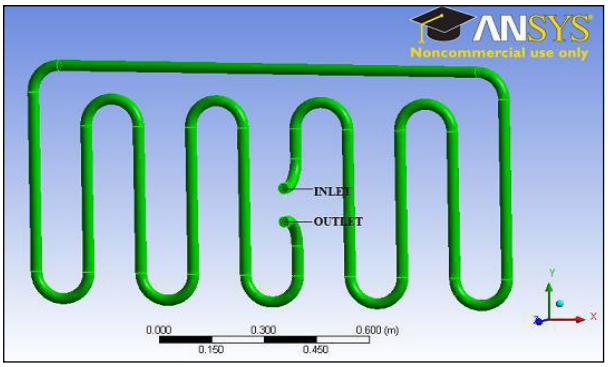
In the stave cooling of blast furnace study on hot face. Between gas flow and inlaid brick they use two equivalent coefficient, and stave and gas flow body. Heat transfer numerical calculation increases the accuracy about equivalent convection coefficient.

3-D Modeling of blast furnace stave

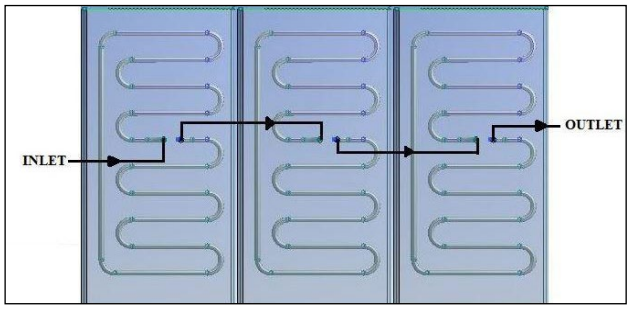
Inside the blast furnace highest thermal zone is lower most zones. To maintain, repair and save the blast furnace the processes stave cooling is very important. Life key parameter for the blast furnace is cooling of stave. Inside the blast furnace main body of furnace is manufacture by steel and stave cooler is manufacture by cast steel. The thermal conductivity, melting temperature tensile strength and specific elongation of cast steel is high so that is use in stave.



Three Dimensional Stave cooler of Blast Furnace



Cooling pipe of stave cooler



Stave cooler arrangement in Blast Furnace

Dimension of Stave Cooler

Part	Thickness	Width	Height
Stave body	0.2m	0.9m	1.64m

Dimension of casting coil in a stave

Part	Dimeter	Length
Casting coil	0.33m	8.42m

Different metal used in stave cooler

Metal	K(w/mk)	ρ(kg/m^3)	C_p(j/kgk)
Copper	387	8940	381
Cast iron	40	7500	460
Aluminum oxide	18	3690	880

Numerical Analysis

In this project a 3-D model is taken and solve by numerical and steady the behavior of temperature of wall, inlet and outlet of stave cooler. On the one side of bricks heated flux is given, the wall of bricks and stave are coupled and also wall of stave and cooling pipe body is coupled. At inlet mass flow rate is taken of fluid.

Assumption

- Steady state conductive heat transfer process
- Three Dimensional

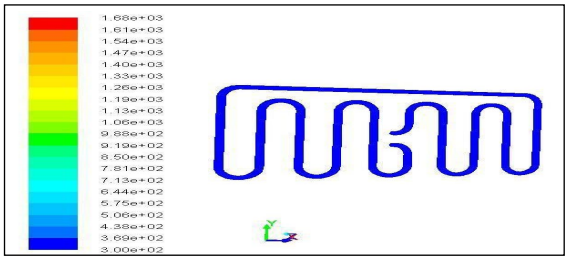
Boundary conditions of stave cooler for thermal calculation

Wall of stave cooler assumed to be insulated except hot wall.

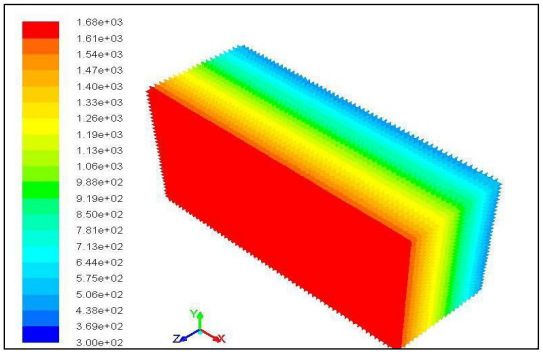
- Heat flux has given on the hot wall of stave cooler.
- Heat flux varied according to the position of Blast Furnaces.
- Cooling fluid entered at constant temperature i.e 300K.
- Mass flow rate has given to the inlet.

Results and Discussion

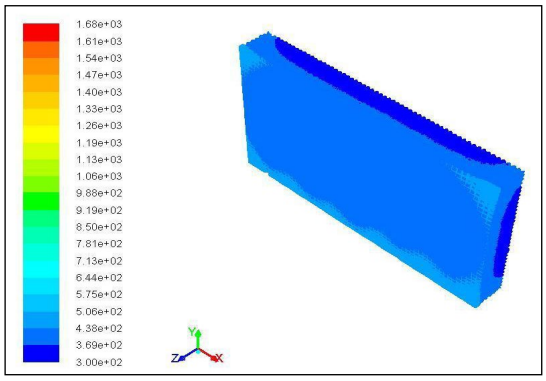
Calculation of actual temperature variation, heat flux with the use of experimental three dimensional model of stave, then after temperature variation of numerical model of stave cooler match to stave cooler running in RSP Blast Furnace, the study has been done with the use of cooling fluid neon fluid, water, nitrogen. In the calculation of heat flux, temperature variation cooling fluid mass flow rate is same for all coolant you can observed stave cooling by the water is better than nitrogen because of thermal conductivity of water is nearly four times than nitrogen, when mass flow rate of nitrogen is four times than water heat flux and temperature variation nearly same. When another cooling fluid neon fluid (Al2O3 with water volume by volume 20:80) is use the temperature variation and heat flux better result than water and nitrogen. The result calculating from numerical model stave cooler is same as result calculating with experimental. In the stave cooler different types of material are used like cooper and cast iron for analysis, than we found that copper is better than other material because the thermal conductivity of cooper is greater than other material.



Temperature contour of pipe inside the stave without thickness

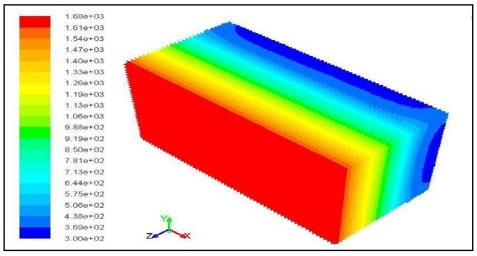


Temperature contour of only bricks

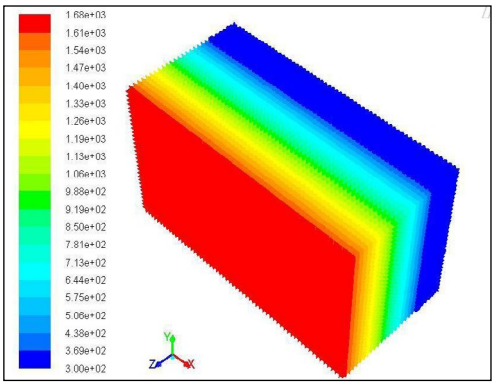


Temperature contour of only stave

Comparison



Temperature contour of stave cooler, stave is of cast iron



Temperature contour of stave cooler, stave is of cooper

Comparison between above two temperature contour the difference when stave is of copper the cooling is very festally in portion stave but when stave is of cast iron cooling is slower then stave is of copper. So when stave is of copper the life of stave is longer and cooling is of blast furnace is very festally.

Conclusions

The complete conclusion of this work is achieved on the basis of some boundary conditions, some parameter, assumptions all the result has been achieved. From RSP (Rourkela Steel Plant) all the data has been taken. Thus on the basis of this project 3-D model of blast furnace is taken and compression with experimental model in RSP, at different thermal loads from 500k to 1675k the behavior

of stave cooler with finite element analysis method. We study about three verity of material use like copper, cast iron and aluminum oxide for consideration of stave material of blast furnace.

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