Vandana Publications
IJEMR

Volume-7, Issue-3, May-June 2017
International Journal of Engineering and Management Research
Page Number: 252-258

Tuyere Design & Analysis with Different Material by using CAE Method

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ABSTRACT

The Blast furnace (BF) is a iron making process. It's a specialized counter-current reactor in which the reducing gas is produced by the carbon gasification of the coke with the oxygen of the hot blast injected via tuyere sat the lower part of the furnace. The hot air is flow from tuyere to blast furnace for proper combustion of coke, proper chemical reactions between the liquid metals. Tuyere is failure by the direct contact of molten metal's and the minimum heat loss of hot air into the tuyere is most important factor for blast furnace. In this project the analysis of different material for solving the tuyere failure problem by different analysis in ANSYS software.

Keyword-- Blast furnace, Tuyere, PRO-E,ANSYS, Static structure, CFD

I. INTRODUCTION

Blast furnace*:* Blast furnace is the processes in which hot metals and coke produce by different types of raw materials used. It is a very complicated and very tough in the modal mathematically form .various types of chemical reactions done at various stages at high temperature. Finally the molten metal produce and slag formation in below the tuyere. Hot metals are collect into ladle and transport that liquid metals into other unit such as casting unit. Mainly three raw materials used such as pig iron, iron ore and lime stone.

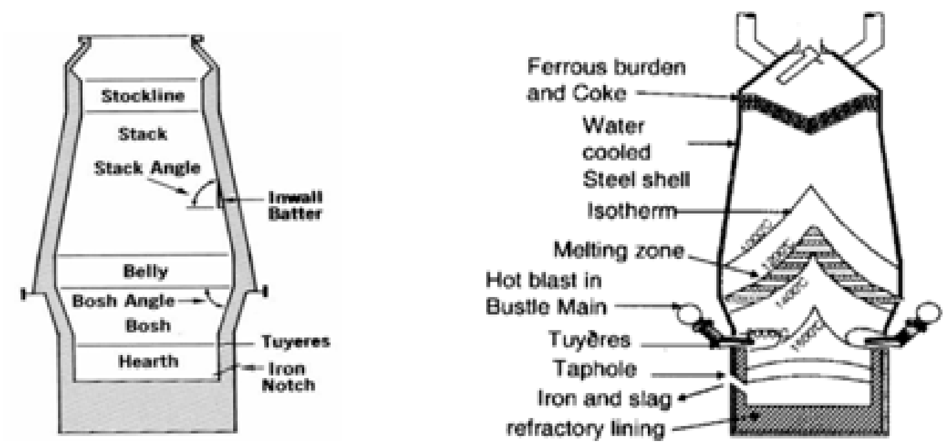

Figure 1: cross section of Blast furnace

Tuyere: Tuyere is the part of blast furnace which is used for hot air and PCI injected into the tuyere for proper combustion of coke and proper chemical reactions between the metals at very hot temperature zone. Tuyere cooler is also important part of blast furnace. It is used for tuyere cooling purpose tuyere cooling continuously for reducing the tuyere surface temperature's because the tuyere is fitted into very hot region temperature up to 1600-2500 °C.

Type of Tuyere:
There are four types of tuyeres used in blast furnaces. They are

I. Single Chamber Tuyeres,
II. Double Chamber Tuyeres,
III. Multiple Chamber Tuyeres, And
IV. Spiral Chamber Tuyeres.

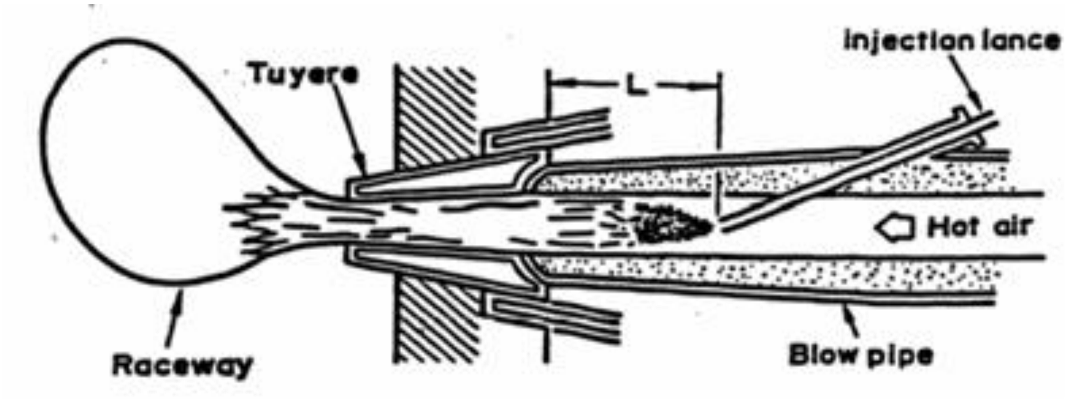

Figure 2: cross section of tuyere

Properties of Tuyere Design Materials:

S.N	Types Of Material	Thermal Conductivity (W/mK)	Density (Kg/m^3)	Melting point (^{0}C)	Young modulus (Pa)
1	COPPER	410	8940	1084	117 x 10^9
2	COPPER ALLOY (NI 10%)	401	8300	1200	110 x 10^9
3	SILVER ALLOY (CU 10%)	406	10490	1150	72.4x 10^9
4	BERYLLIUM	218	1890	1285	287 x 10^9

Table 1: Material properties

II. METHODOLOGY

This work is about the 3D designing and analytical analysis of the tuyere with refractory materials used in blast furnace of Bhilai Steel Plant. We have identified a best material selection for tuyere design at experimental base. Which is apply different boundary condition into the tuyere modal in ANSYS 14 software. A analytical model has been developed by designing software CREO (PRO E) and analysis with the help of ANSYS-14 software taking dimensions from BSP data base. To develop the model we have design the dimensionally identical tuyere with the help of work bench. The modal of tuyere developed is nozzle sapped in designing software and dimensionally identical to the actual tuyere used in BSP. The model developed and analysis of different module in ANSYS with different boundary condition with different materials. Analysis of tuyere in ANSYS 14:

- Computational fluid dynamic analysis (CFD)
- Static structural analysis

Design Data Parameter: Design parameters: The methodology combines 3-D CFD model, which is used to predict the hot face temperature for a given inner profile, 1-D heat transfer model, which is used to predict fine tune the inner profile. Tuyere part is very important in the blast furnace because a high velocity, high temperature air blast is coming from the tuyere which is an aid for the molten of the iron. It is a vital component portion in the blast furnace process, through this portion smelting process happens, and the desired product i.e. molten iron is making.

Tuyere length inside the blast furnace	3.59 cm
Inner dia. Of tuyere or outlet of the blowpipe	12.46 cm
Outer diameter of tuyere	10.5 cm
Lance inlet angle	7 deg.
Wall thickness of tuyere	0.1 cm

Table 2 : Data for Design

CFD Analysis: It is used to determined velocity, pressure, temperature and flow distribution effect of any part when fluid flow that part. In this project velocity finding when hot air is flow in tuyere. Several steps follow for analysis Several steps follow for analysis are shown below.
Step-1 Open Fluid Flow (CFX) from analysis systems
Step1.1 Right click on Geometry cell-import geometry-browse-select tuyere model (cfd.igs)-{go to continuity equation folder-select tuyerecfd.igs}-open. (close the geometry cell)
Step1.2 Right click on Mesh cell-edit-generate mesh.
Step1.3 Open mesh and edit the size and other property and not be change.
Step1.4 Update mesh and (close the mesh cell)
Step1.5 Right click on Setup cell-edit,
Step1.4 Right click on Analysis type-edit-in Basic setting, select analysis type (drop down)-steady state-apply-ok.
Step1.5 Right click on Default domain-rename as 'air domain' and then right click on air domain-edit,
Step1.6 Right click on air domain- insert- boundary-rename as 'Inlet'-ok.
Step-1.7 Right click on air domain- insert- boundary-rename as 'Outlet'-ok.
Step-1.8 Go to Solver-right click on solver control-edit

1	Upper Surface of Tuyere nose Temperature	1900—2500 ^{O}C
2	Inner Surface Of Tuyere nose Temperature	500 ^{O}C
3	Pulverized Coal Flow Rate	0.5 kg/s
4	Blast Air inlet Velocity	108 m/s
5	Blast Air outlet Velocity	750-1200 m/s
6	Inner Surface Of Tuyere Pressure	12-30 bar
7	Hot Oxygen Temperature	1000-1200 ^{O}C
8	Hot Oxygen Pressure	3.5 kg/c.m^2

Table 3: Boundary condition apply for CFD analysis and Thermal analysis

Static Structure Analysis: It is used to find out stress, strain, deformation etc by applied boundary condition .In this project equivalent stress and deformation find for different material and comparer of them and steps follow for analysis of tuyere are:
Step-1.1 open tool box and select analysis of static structure
Step-1.2 Material defined
a. Beryllium
b. Copper
c. Copper alloy
d. Silver alloy
Step-1.3 Defined input values: from above tables.
e. Boundary condition:
I. Apply fixed support at 6 hole (bolt hole)
II. Apply force load of 1N in x direction and y and z direction value 0
Step-1.4 Defined geometry
f. Right click on import geometry

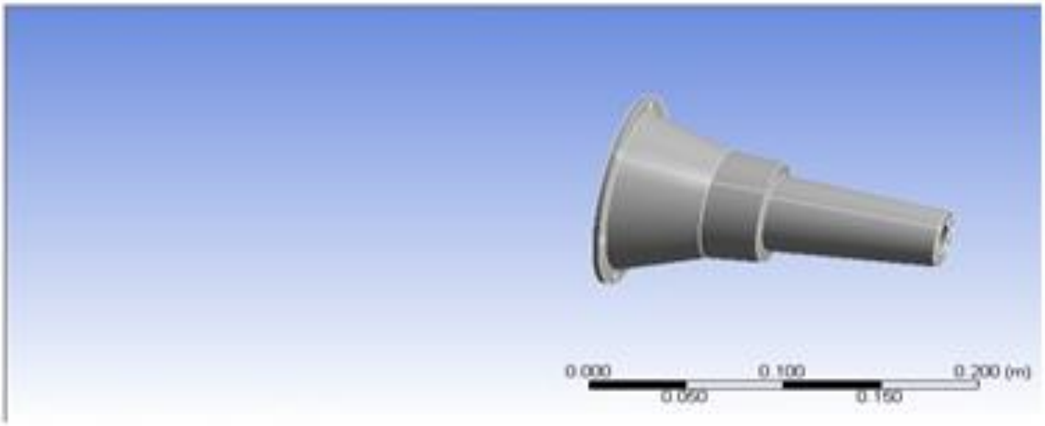

Figure 3: Tuyere geometry

Step-1.5 Defined model
a. Defined mesh
b. Click on mesh property

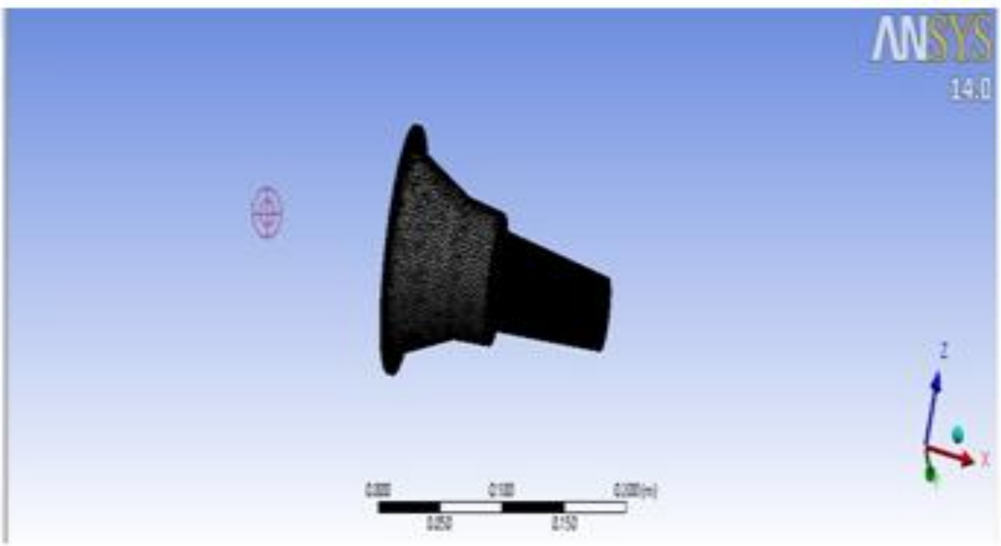

Figure 4 : Tuyere mesh

Step-1.6 Click part and select materialwhich at that time analysis.
Step-1.7 Select input parameter
(a) Fixed support
(b) Force
Step-1.8 Solution selects output parameter
(a) Deformation
(b) Equivalent stress
Step-1.9 Solve
Step-1.10 Result

Step-1.11 Change material from step 1.6 and solve this step follow for all material.

III. RESULT

Computational fluid dynamic analysis result

➢ velocity analysis

Input velocity (Vi) = 108 m/s
Output velocity(Vo)= 1080 m/s

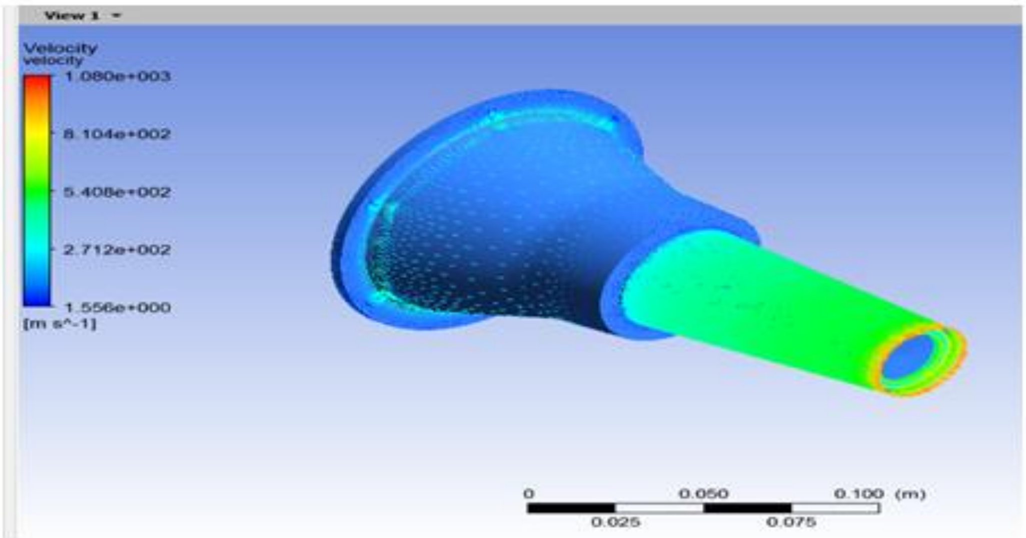

Figure 5: Velocity distribution

Static structure analysis results:

Material	Deformation (mm) Max	Equivalent stress	
		Emin	Emax
Copper	2.5223×10^{-9}	5.0013	26076
Beryllium	1.081×10^{-9}	4.5005	34190
Copper alloy	2.6978×10^{-9}	4.9461	26249
Silver alloy	0.0040521	5.1338	25909

Table 4: Result of static structure analysis

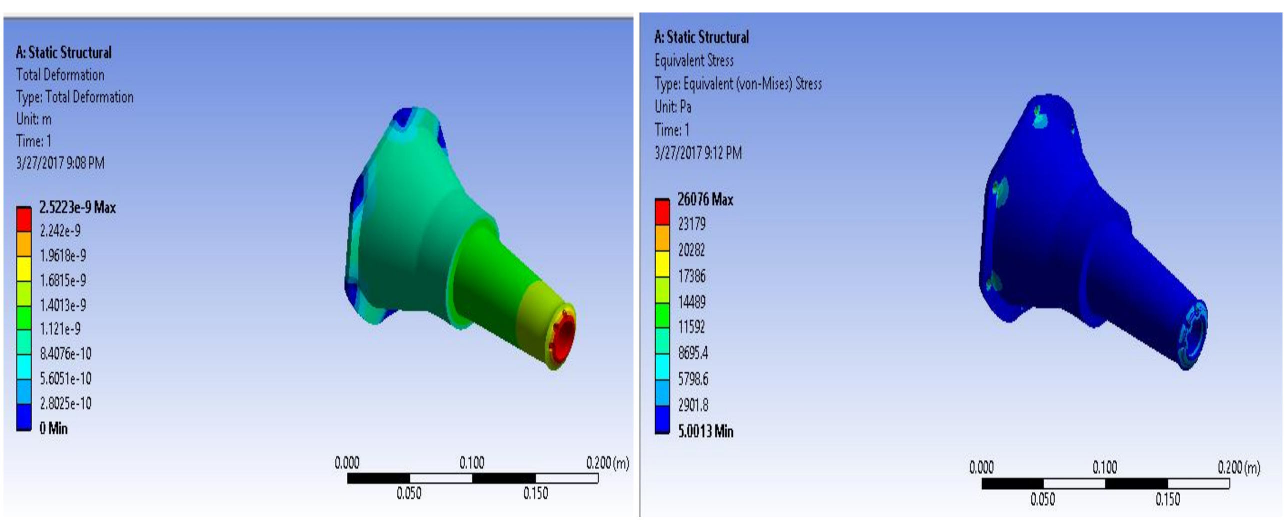

Figure 6 : Copper deformation and equivalent stress result

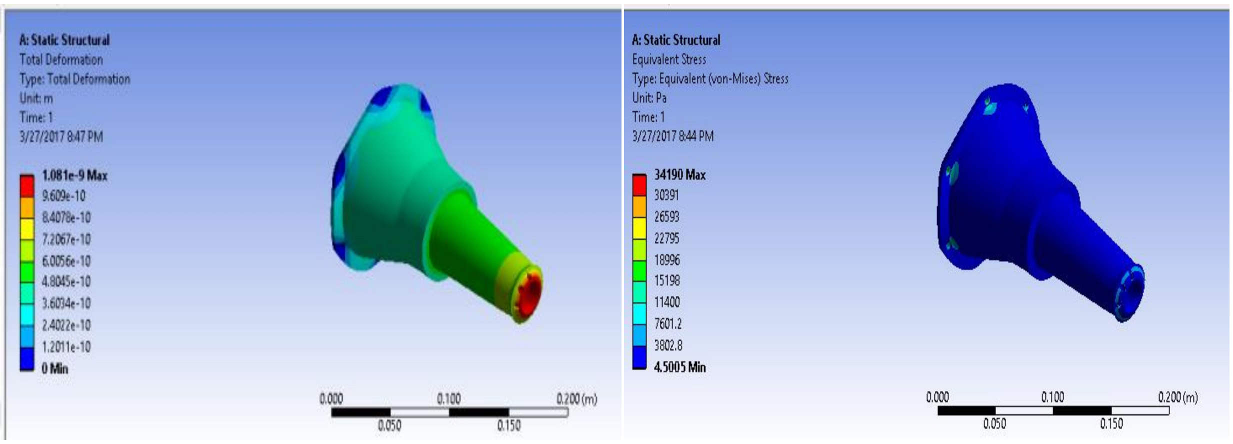

Figure 7: Beryllium deformation and equivalent stress result

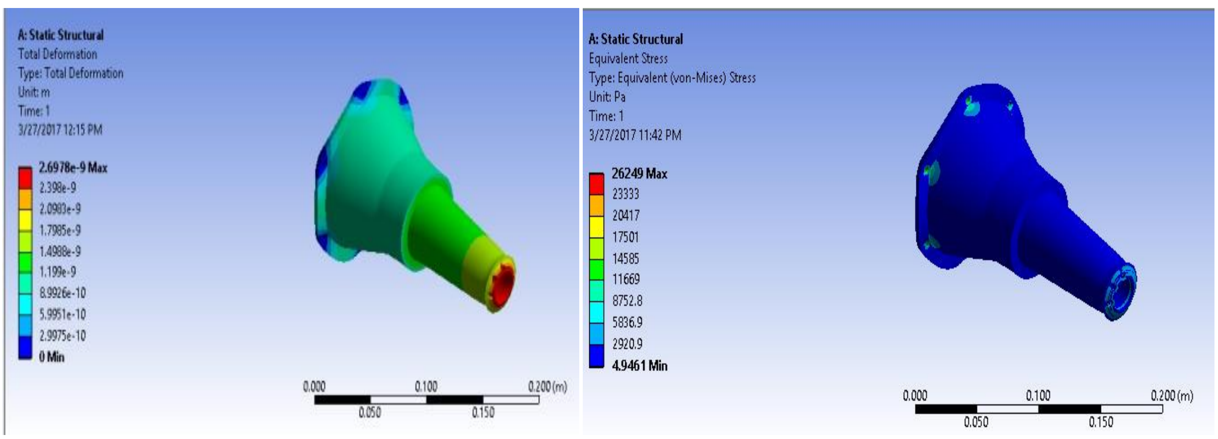

Figure 8: Copper alloy deformation & equivalent stress result

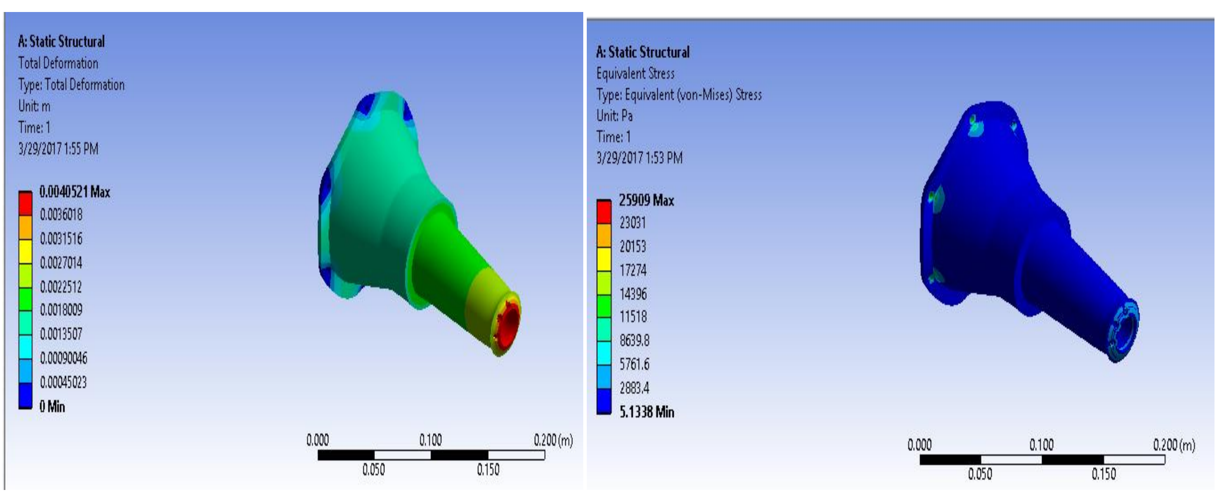

Figure 9: Silver alloy deformation & equivalent stress result

IV. CONCLUSION

The conclusion of tuyere design and analysis of different material are based on compared of their results. The numerical values of different analysis are shown in above chapter and compared the results.

Velocity effect: CFD analysis are done and finding the max speed at end point of tuyere the max value of velocity are needed for proper filling the pulverized coal in blast furnace ,proper combustion of coal ,chemical reaction of hot metals and so on.

Static structure analysis: Result of analysis are deformation and equivalent stress in body, and the best material for tuyere the minimum values of that analysis. compare only maximum values of the result

Deformation numerical value based ranking (max)

Beryllium< copper< copper alloy< silver alloy

Equivalent stress based ranking (max)

Silver alloy< copper< copper alloy< beryllium

Overall conclusion: The material for tuyere design on the bases of deformation beryllium is best but the values of deformation is very low of all materials so not selection of material for design purpose at the deformation bases. Compared the values of equivalent stress, silver alloy stress value is minimum the results values of the materials are safe range so stress bases selection of material consider. And can be design the tuyere by silver alloy,

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