4th ICEPIM & OMIC GAS 2018

Failure Investigation of Tie Rod used to control expansion of Bellow in Blast Furnace

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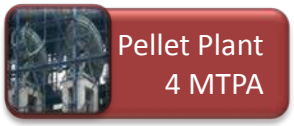
Process Flow at Dolvi in 2016

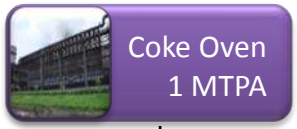
Jetty

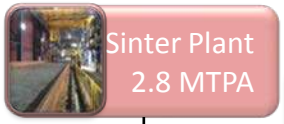
Iron Ore

Coal

Iron Ore & Fluxes

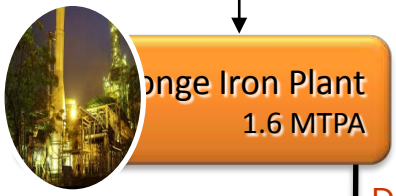

Pellet Plant
4 MTPA


Coke Oven
1 MTPA


Sinter Plant
2.8 MTPA


nter Plant
2.3 MTPA

NG COG

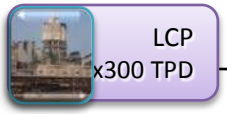

onge Iron Plant
1.6 MTPA


Blast Furnace
3.5 MTPA

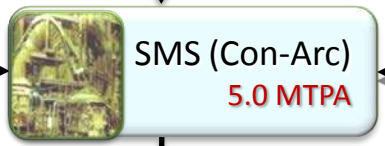
DRI

Hot Metal

BF Gas


LCP
x300 TPD

Cal. Lime


SMS (Con-Arc)
5.0 MTPA


53.5 MW
Power Plant


LCP
x600TPD

Liquid Steel


Thin Slab Caster


Billet
Caster

Slab


Hot Strip Mill


Bar Mill

HRC

3.5 MTPA

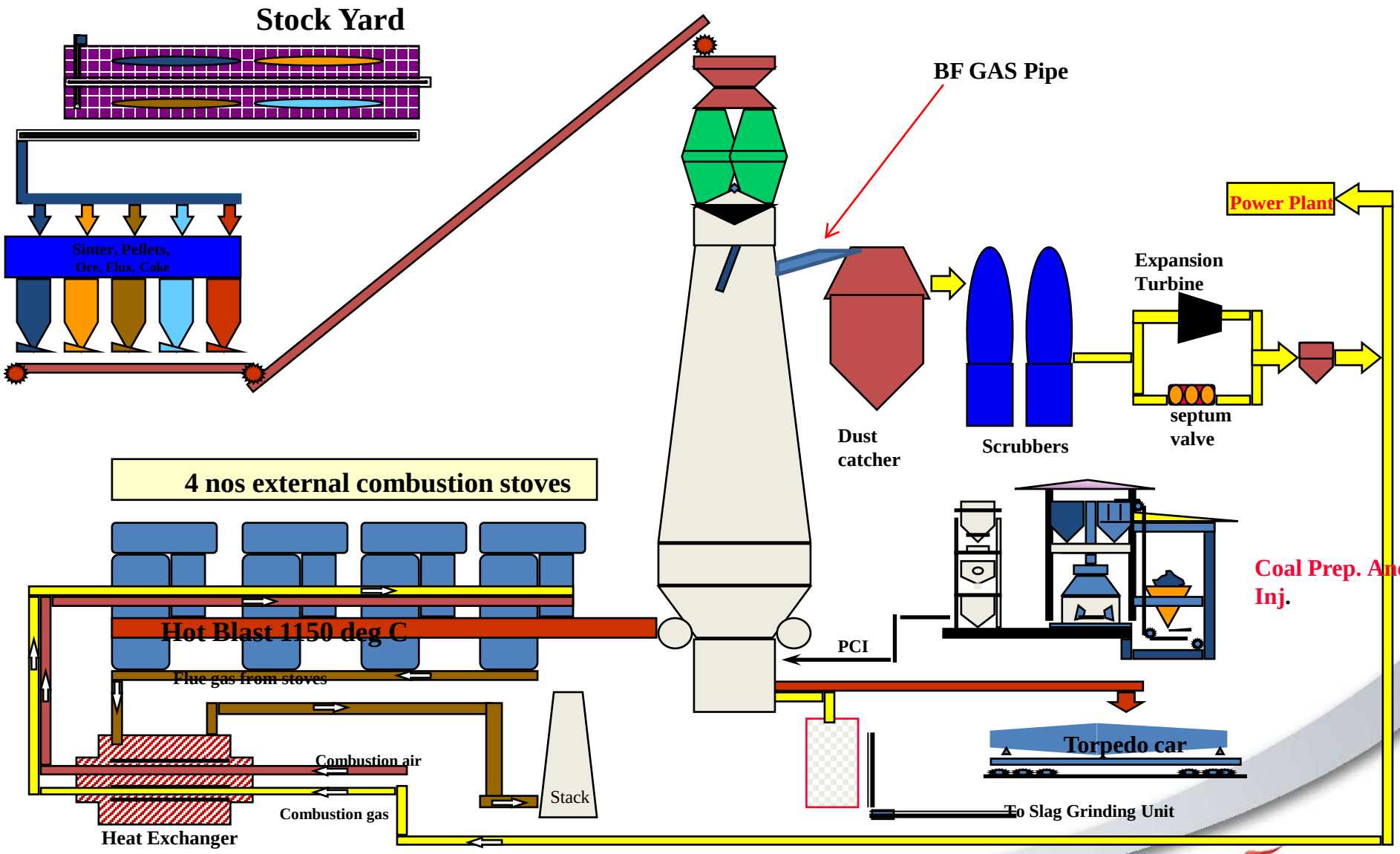
3.3 MTPA

1.5 MTPA

Engineering Solution - Rebuild BF

Addition of new facilities

Brief Introduction of Blast Furnace Process



JSW Dolvi

Specification & Usage of Material

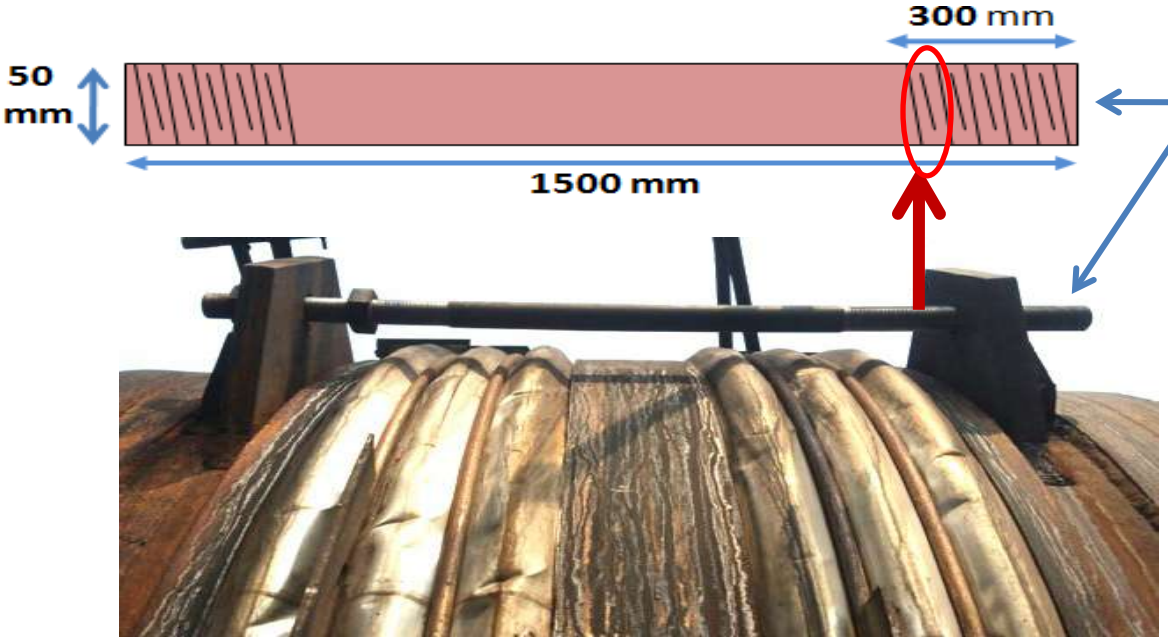
Material Standard : IS 1367, Class 4.6

Chemistry

C%	Mn%	Si%	Cr%	Ni%	P%	S%
0.50 max.	-----	-----	---	---	0.06 max.	0.15 max.

Mechanical Properties

Yield Strength Mpa	Tensile strength MPa	El%	Hardness HV10
----	400 min	-----	250 max



Tie Rod

Dimension : Length: 1500 mm , Dia. 50mm,
Weighing approx. 23 Kg

Usage: To restrict the expansion of bellow in a pipe carrying blast furnace gases. Four tie rods are used in single bellow.

Metallographic Investigation of Broken Tie rod

Background

There are four set of tie rods are used to restrict the expansion limit of bellow, placed in pipes carrying Blast Furnace gases.

The materials used in these sensitive areas should have high life time serving expectancy.

Premature (within 2 years) and frequent failures of Tie Rod led for root cause analysis.

Working temperature of the material is 60- 80 degree C.

Metallographic Investigation of Broken Tie rod Continued.....

Chemistry

%C	%Si	%S	%P	%Mn	%Ni	%Cr	%Mo
0.235	0.148	0.032	0.041	0.433	0.065	0.093	0.008

Mechanical property

YS(MPa)	UTS(MPa)	% El@ 5.65√A	Hardness	Impact @ RT
605.6	631.1	13	197 HV10	7.0 J

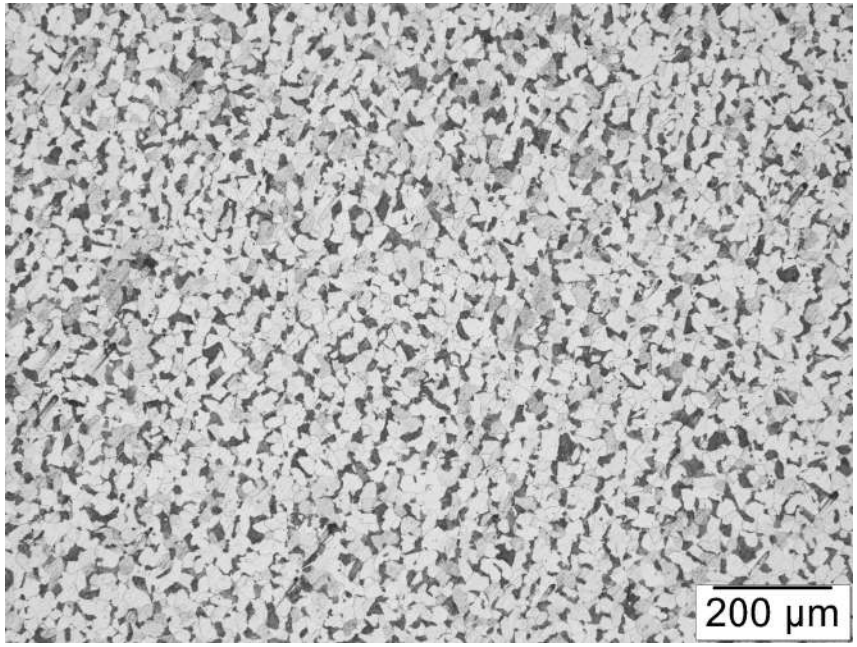
Observation:

Chemistry and the Mechanical Properties confirms that the material used is as per the specified Standard, IS1367 Cl 4.6

YS /UTS ratio is 0.96 which is very high

Metallographic Investigation of Broken Tie rod Continued.....

Metallographical Test



Note: Etchant used Nital 2%

Observations:

ASTM Grain Size Number 8.30 according to Intercept Method ASTM E 112-12

Microstructure shows uniform coarse structure of pearlite in ferrite matrix

No cracks were found on the cross section of the sample

Metallographic Investigation of Broken Tie rod Continued.....

Fractured Surface visual image

Observations:

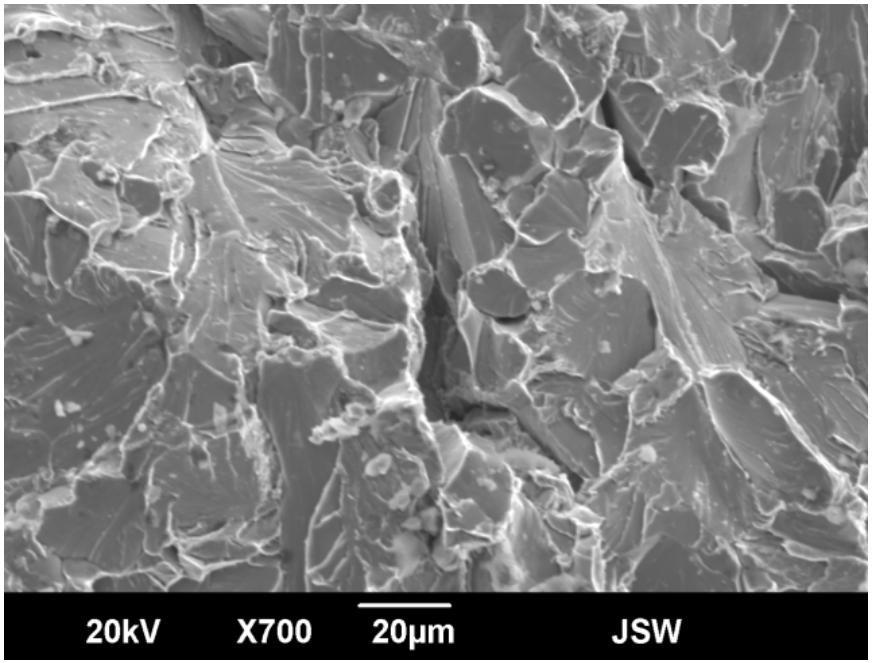
The location of failure is from the threads (most of the time)

"Chevron" pattern points to the origin of the brittle fracture (arrow)

Fatigue failure initiated at arrow and moved across the cross section, leads to catastrophic failure.

Metallographic Investigation of Broken Tie rod Continued.....

SEM Image of Fractured Surface



Observations:

Typical brittle fracture was found having river lines on the faces of the cleavage surfaces.

These type of fracture occur with very little plastic deformation near the of crack prior to rapture.

Grooves of the thread are the highest stress concentration point hence it become initiation point of crack generation.

Findings

- YS/UTS ratio is very high, it should be low to avoid catastrophic failure.
- Load generated during bellow expansion is too high for Tie rods to bear.
- Tie rod material specification IS 1367 Class 4.6 is not suitable for this application.

Action Taken

- Specification of the Tie rod material is replaced by EN 9.
- Material chosen having lower YS / UTS ratio to avoid catastrophic failure.
- Number of Tie rod increased from 4 to 16 to withstand load.

Action Taken

- EN9 Specification

Chemistry

%C 0.5-0.6, %Mn 0.5-0.8, %Si 0.05-0.35,

%S & P 0.06 max

Mechanical property in normalised condition :

YS 355 MPa min, UTS 700 MPa min, HB 210-255

It has higher strength and lower YS/TS ratio.

Thank You