Failure Analysis and Rectification of Sealing Valve Failures in Blast Furnace

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Abstract- Blast Furnace is one of the major departments of VSP where the conversion of raw materials like Iron ore, Sinter and Coke into molten metal (Pig iron) takes place. To charge raw material into Blast Furnaces which are operated at 2 Kg/cm^2 pressure Bell-less top (BLT) charging system supplied by M/s. PAULWURTH, LUXUMBURGE is provided.

In this project various mechanical equipment failures are studied and noted. Based on that failure analysis Sealing Valve failure is taken for further study, which is causing highest production loss to the company.

The function of all BLT equipment's studied and various probable causes for Sealing Valve failure are noted. Major causes contributing to the failure of Sealing Valve analysed and suitable alternatives are suggested.

Key words: Pressure value, Blast furnace, Bell less System.

I. Introduction

Blast Furnace

The line diagram of blast furnace is shown in figure 1.1 Blast furnace is cylindrical, tapered, counter vessel was several reactions take place at different zones. The process of reduction will tap hot metal as the main product and slag as by product from four tap holes, which are provided at the bottom side of the furnace.

A blast furnace is designed to operate at 2 kg/cm^2 working pressure at the furnace top to get the rated production. To charge the material in the furnace 2kg/cm2 pressure is to be maintained in the bin. A separate bell less top charging system is provided. The system is provided exactly on the top of the furnace and the main purpose of it is to distribute the required quantity of material uniformly into the furnace as and when the furnace required. As the volume of the blast furnace is very high - its raw material requirement is also very high, hence the charging equipment should operate continuously without any break.

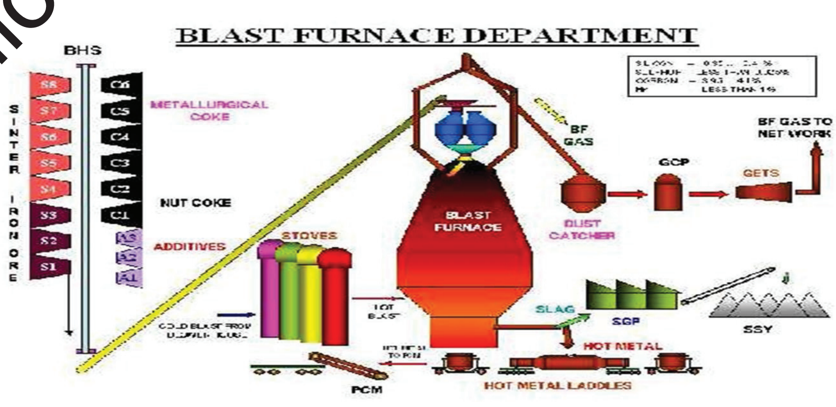

Fig 1.1 Blast Furnaces

2.2. Bell less Top Charging System

Bell less top valves like an upper sealing valve, lower sealing valve, material gate, equalizing valve and relief valves are required to be operated 300 times a day, especially receiving hopper material gate is required to be operated 600 times a day. Failure of any of these valves, valves leads to stoppage of B.F completely. Fig 1.2 shows different parts of Bell less top charging system.

The prime mover connected to these valves should very reliable and should work continuously without any problem. As the location of this valve is at height, weight of the prime mover should be less as possible to bear the structure weight. Considering all these points, hydraulic actuators was chosen as prime mover to all Bell less top charging equipment.

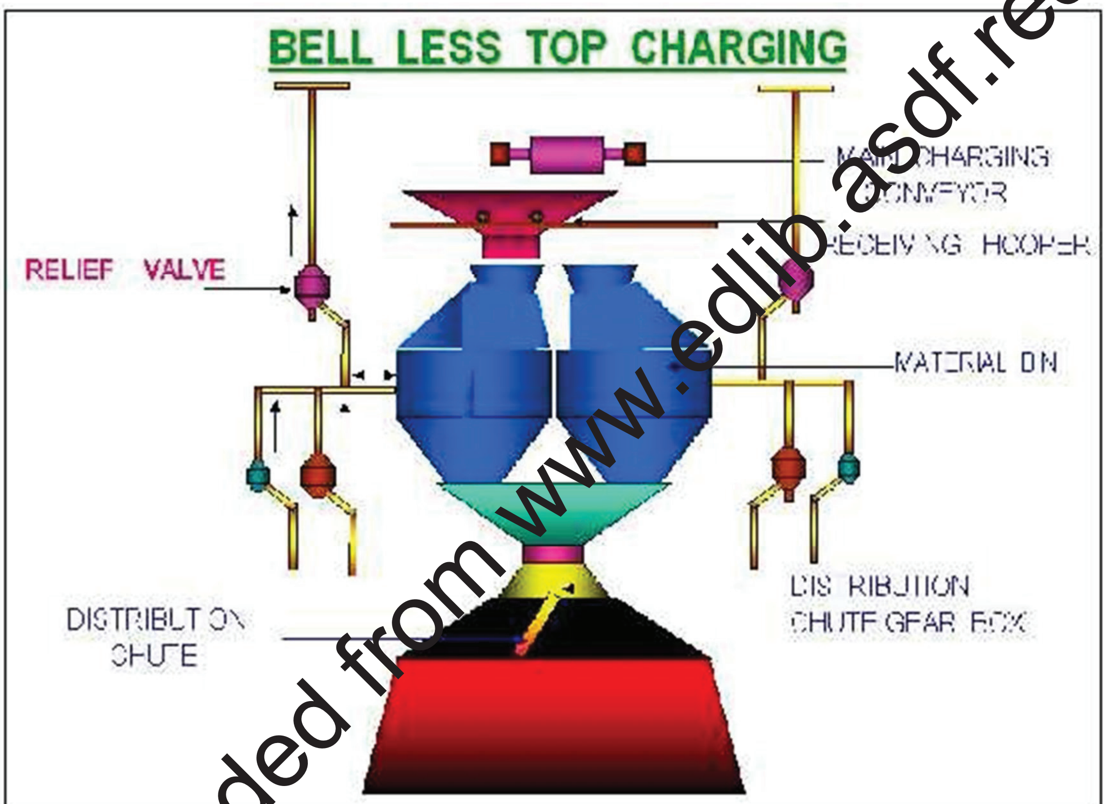

Fig 1.2 Bell less Top Charging System

Failure Analysis of the Bell less Top Charging System

3.1 Selection of problem

To select a problem for this project, data regarding various failures in Bell less top charging system are collected from past records. The following is the data in Table 1 of the major problems identified for the past three years:

Table 1:

				Wind restriction	Loss of hot metal(tons)
1.	Sealing valve failure	Nil	Nil	71.5	5577

2.	Hydraulic problems	8.15	5.30	6.10	3106
3.	Bleeder valve	10.20	Nil	Nil	2553
4.	Sealing valve seat leakage	6.25	Nil	Nil	1584
5.	Hatch cover leakage	3.25	1.25	0.25	1014
6.	Main charging conveyor	Nil	1.35	3.45	453
7.	Mobile hopper wheel failure	4.45	Nil	Nil	1128

2. Problem Definition and Analysis

Sealing valve description: Sealing valve plays an important role in Bell Less Top Charging System. These valves are meant for sealing the bin from Blast Furnace gas leakage which is driven by Hydraulic cylinder. They consist of flap and a seat with silicone rubber seal. The flap closes against the seat during closing, once the valve is closed, it will not allow any leakage through the valve. These valves are located one on top of the bin and another at the bottom. These are very critical valves. These valves are driven by hydraulic cylinders.

Sealing Valve Failure Means:

1. Bin is connected to furnace.
2. Bin is not ready to receive a fresh charge of raw material.
3. Entire bin operation that is charging process is stopped.
4. The complete Blast furnace production effected.

The two major reasons for failures are:

- Actuator Hydraulic cylinder end flange failure
- Actuator crank failure

From the above table it is clear that Actuator crank failure and Hydraulic actuator end flange failure together contributing to two third of the total failures. If these two failures are avoided, total sealing valve failures will be reduced to one third. Hence, these two main causes are considered for further analysis.

Analysis and Rectification of Acruator Crank Failure

4.2 Loads on the Crank/Lever

A total force acting on the lever at point A in Fig 1.3

= force exerted by the Hydraulic cylinder.

= Area of the piston X Maximum pressure in Hydraulic cylinder.

= $\pi/4 \times d^2 \times$ pressure.

= $\pi/4 \times (125)^2 \times 35$.

=429.514KN ~ 430KN.

[Since cylinder bore = 125mm
Hydraulic test pressure = 350 bar

1 bar = (10)5 N/m^2

1 bar = 0.1 N/mm^2 .Therefore 350 bar = 35 N/mm^2]

Total load acting on the lever at point A, F = 430KN.

Tangential Component of the Load = F Cos 408= 430 x Cos 408
= 329.39KN ~ 330KN.
Radial component of the load = FSin408= 430 x Sin408
=276.39KN ~ 276KN

Considering the reaction at point O

330 x350 = F_{Tk} x 110
F_{Tk} = Tangential force acting on the crank at key way
= (330 x 350)/110 =915KN

Crank failing at cross-section x-x

Cross-section of the crank at failure area = 10 x 218 + 10 X 95/2 x2
= 2180 + 950 = 3130mm^2

For given material C.S gr-4 IS2644

Maximum tensile strength = 1030 M pa

Maximum yield strength = 850 M pa

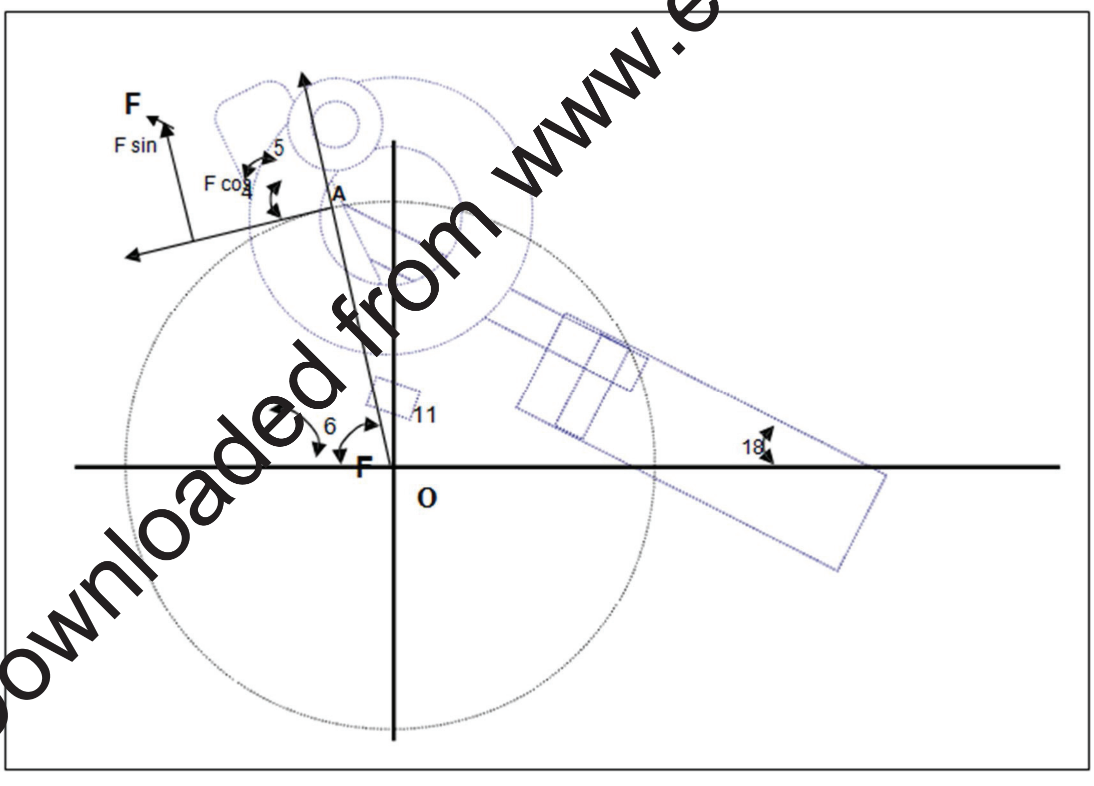

Fig 1.3
Therefore Induced stress in the Crank = Tangential force / Area of cross section
= 915 x $(10)^3$ / 3130 = 292 N/mm^2

Maximum tensile strength = 1030 N/mm^2
As the nature of the load is “impact load”. Consider factor of safety is 4

Then safe working stress = 1030/4 = 257 N/mm^2

As the Induce tensile stress in the Crank is 292 N/mm2 which is more than safe working stress. Therefore the design is unsafe.

Alternative

Increase the web thickness from 10mm to 25mm.

Then Area of resistance of keyway = 10 x 218 + 25 x 95/2 x 2

= 2180 + 2375 = 4555 KN/mm^2

Then stress in the Crank = 915 x 10^3/4555 = 200 N/mm^2
As the Induced tensile stress is less than safe tensile stress.

Therefore new design is safe.

Key dimensions:

L = 204mm B = 50mm t = 22mm No. of keys = 2 Nos. Generally, key will be the weakest joint in any design. Maximum torque that can be handled by this key is considering the shearing of key:

Maximum Torque transmitted $T = L \times w \times \tau \times d/2$
= 204 x 50 x 42 x 219/2
= 46909800 N-mm = 46910 KN-mm.

Considering Crushing of the key:

Maximum Torque transmitted $T = L \times t/2 \times \sigma_c \times d/2$
= 204 x 11 x 70 x 219/2
= 16414860N-mm
= 16414.860 KN-mm ~ 16415N-mm.

Taking smaller of the two values, we have maximum Torque transmitted by a single key = 16415KN-mm. Because two keys are provided to crank Maximum Torque transmitted by two keys = 2 x 16415 = 32830KN-mm.
Since the key is the weakest joint in the entire system. The torque transmitted by the lever/Crank should be more than 32830KN-mm. By using this analysis we can increase the production rate of the company.

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