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Failure Analysis for Blast Furnace Using What If Analysis

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ABSTRACT Blast furnace represents the dominate hot metal making production process worldwide and a largest unit in an integrated steel plants. The purpose of the blast furnace is to chemically reduce and physically convert iron oxides into liquid iron called hot metal. Handling of blast furnace units is not a simple issue. During the blast furnace operation various hazards like fire and explosion, blast furnace gas which is more hazardous and explosive in nature are arise. Safety analysis requires a thoroughly methodological investigation such analysis must include the ability to deal with problems involving human error. In this paper what if analysis a systematic brain storming approach is applied to the two nodes of blast furnace units to find out the hazards and its consequences arise during blast furnace operation. Based on the results of what if analysis two nodes are prioritized and safety precautions, recommendations were suggested for the safe operation of blast furnace nodes.

Key words: Blast furnace, what if analysis, hazard, blast furnace gas, fire and explosion

I. INTRODUCTION

A huge increase in steel production in recent years requires a sufficiently large production of iron. A prominent technology in the production of iron is even now blast furnace technology, which delivers iron in the form of hot metal. Blast furnace iron making faces a lot of difficulties to convert iron ore into pig iron. Various operational problems like refractory bricks lining damage, furnace pressurization, increase in temperature makes the blast furnace more vulnerable and lead to fire and explosion. It is very important to seek an effective and accurate method to improve the safety systems of blast furnace units. Succeed and maintaining a safe state during abnormal situations is essential for the safety design and safe operation of blast furnace. In recent years various reliability engineering techniques are used to improve the blast furnace safety. To analyze the hazards and to improve the blast furnace safety one of the most effective and critical brain storming techniques what if analysis is used in this paper.

A. Blast furnace

Blast furnace produces pig iron from iron ore by reducing action of a carbon at a high temperature in the presence of fluxing agent such as limestone. Iron making blast furnace consists of several zones a crucible shaped hearth at the bottom of the furnace, an intermediate zone bosh between hearth and stack. In a blast furnace iron ore, coke and limestone are continuously charged at the top of blast furnace. While enriched oxygen from air separation plant is blown into the bottom section of the furnace, so that chemical reactions take place throughout the furnace as the material moves downward. The end product are usually molten metal and slag phases tapped from the bottom at regular intervals and blast furnace gas exiting from the top of furnace is cleaned in gas cleaning plant and used as a fuel at captive power plants, for the burners at sinter plants, vacuum degassing boiler, pulverized coal injection plant and in furnace of bar and rod mill. Blast furnace gas contains carbon monoxide which is highly toxic and flammable and a small amount of hydrogen and methane.

B. What if analysis

What if analysis technique is based on the principle of team approach to analyze hazard. The What if analysis

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team made up of individuals with varying backgrounds and expertise the expertise is brought together during analysis sessions and through a collective brainstorming effort that stimulates creativity and new ideas a thorough review of the process under considerations is made. The team focuses on specific portions of the process called nodes. Generally they are identified from the P&ID of the process before the study begins. Then a series of what if type questions are asked between the team members. Once the causes are identified the team list the consequences, safeguards and any recommendations deemed appropriate. The process is repeated for the next deviation and so on until completion of the node. The team moves on the next node and repeats the process.

The analyze procedure formally examines all equipment step by step as well as deviation from the normal operation. What if analysis report includes all the deviation and their causes, consequences, implemented protection and the resulting suggestions. It can be successfully applied not only the existing plant but also to new designed techniques and equipment. A what if analysis is normally executed by a multidisciplinary team of experts in process plant design operation and maintenance who under adequate leadership systematically analyze the process P&ID to find out the causes and consequences of every abnormal deviation of the Process variables.

II. Node 1

Node 1 (figure 2.1) consists of raw material yard, blast furnace, pulverized coal injection, stove, air separation plant.

The raw material namely iron ore, coke, limestone dolomite and quartzite will come from different sources. They will be stacked in the raw material storage yard transported by conveyor system to the stock house. In blast furnace raw materials along with fluxes are reduced with metallurgical coke at a temperature of around 1400 degree Celsius to produce hot metal. Pulverized coal injection is a method for improving the performance of a blast furnace. Air separation plant installed to produce oxygen and nitrogen. Oxygen for enrich the blast inside the furnace and nitrogen for purging purpose.

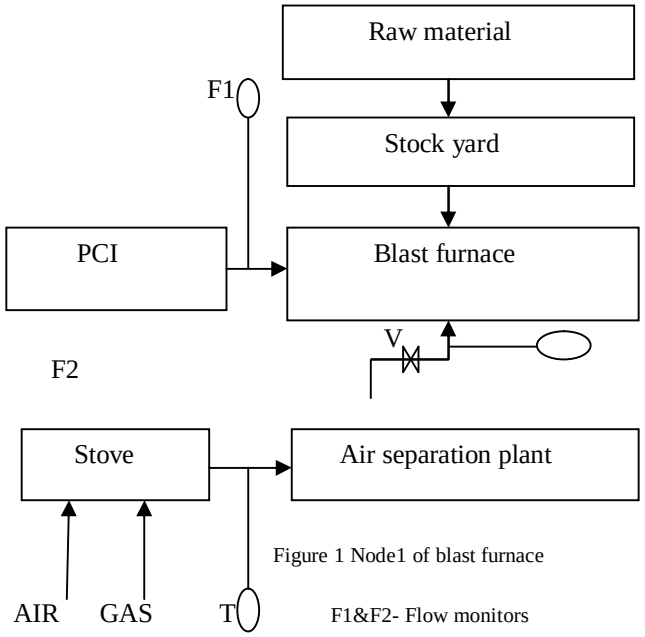

Figure 1 Node1 of blast furnace

F1&F2- Flow monitors

III. Node 2

Node 2. It consists of gas cleaning plant, dust catcher, stove, flare tower. Node 2 units help for the plant for various purposes and to control the emission levels to a predetermined level. Flue gas from the top of the blast furnace is collected in a dust catcher and then transport to the gas cleaning plant through pipe lines. In gas cleaning plant gas is cleaned by water spray. Protection. Dust catcher removes the heavy dust particles coming along with the blast furnace gas by reducing the velocity of the gas so that dust particles are left as the gas lost its ability to carry the dust particles. Flare system used to burn the dust and gases that cannot be cleaned by a gas cleaning plant. Flare consists of main components like structure pipe, flare burner and ancillary equipment for burning the flue gas LPG is used as fuel in flare system. It also provides safety during the emergency situation. Safety valves connected in the nodes help to reduce the pressure of gas flow and prevent the pipelines from damage

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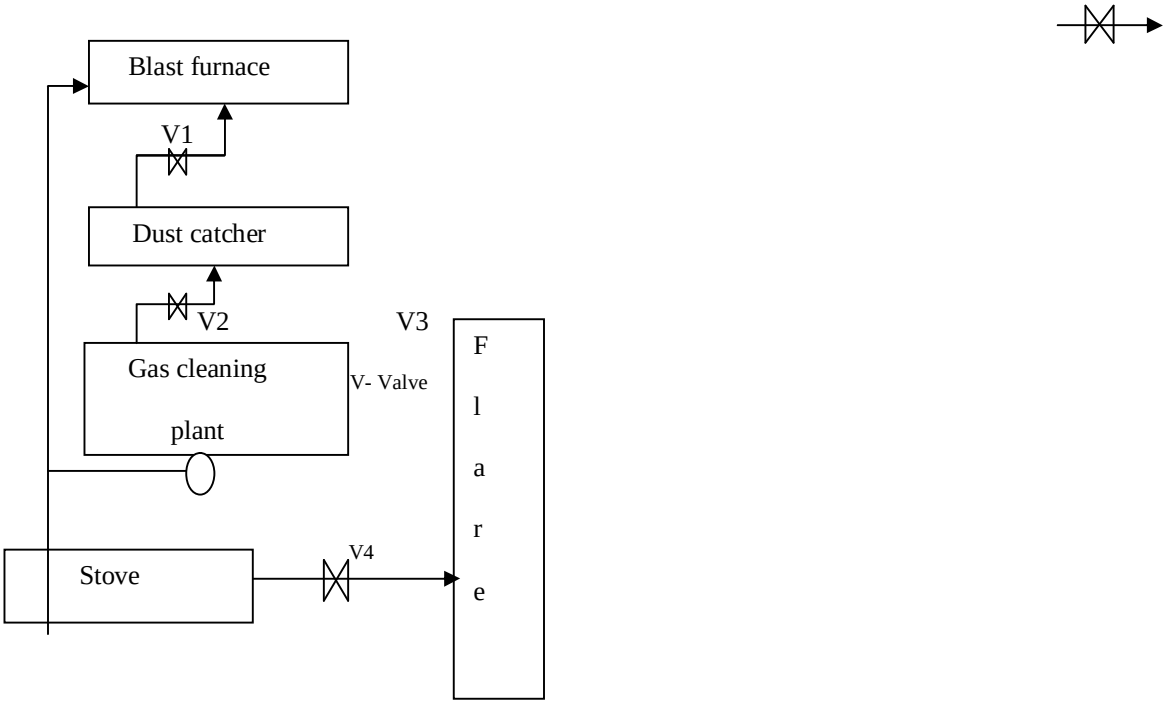

Figure 2 Node2 of blast furnace

V1, V2, V3, V4- valves

T- Thermocouple

Table 1 what if analysis for node1

What if	Consequence/hazard	Safe guard	Recommendations
What if oxygen flows from asp increase?	Fire &explosion	Safety valves, flow monitoring	Maintain the valve for easy to open or close; lubricate the valve frequently for better operation
What if cooling water Supply fails?	Fire &explosion	Redundant power supply available	Check the fuel level of generators daily.
What if flux is not added with raw materials?	Impurities cannot be removed.	Weighing system	Before charging the operator should ensure the ratio of raw materials.

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What if chutes inside furnace fail?	Blast furnace gas release while charging	Wear resistant material	Monitor the chute angle for every charging.
What if temperature in bf line is low?	Poor quality of hot blast is supplied for blast furnace	Thermocouples	Simulations trials need to plan. Thermocouple Clamping of edge should inspect time to time
What if blockage in Blow pipe of PCI occurs?	Reduce the influence of blast Furnace operation	Pressure transmitters for flow measurements	Implement safety interlock system for the PCI.
What if tap hole gun fails to work?	Hot metal cannot be tap out from furnace	Additional tap hole guns provided	Detailed instructions must be drawn up giving the precautions.
What if charging system fails?	No input for blast furnace	Regular maintenance	Good supplier for charging system ropes.
What if temperature in blast furnace reduced?	Lead to chilled blast furnace	Temperature monitoring system with infra ray imaging video system	Provide additional oxy-lance technology. Check temperature monitoring system for every 30 minutes
What if pressure increase in blast furnace?	Fire &explosion	Bleeder valves	Regularly check the sealing gasket. Flushing system to be introduced
What if flow in blower increase?	Overloading stove leads to rupture in stove	Standby system provided	Interlock system
What if nitrogen oxides leaks from blast furnace?	Cold blast syndrome		Gas chromatography
What if flow of oxygen decreases from asp?	Increase fuel rate	Flow monitoring	Safety inspection of pipe lines, periodic maintenance
What if pipe lines from asp damaged?	Pure oxygen leaks to the atmosphere	Leak detectors, pressure monitor	Provide sufficient level of gas monitors,
What if static electricity generated in conveyor?	Fire in conveyor	Earthling	Provide bonding and maintain the temperature as low to avoid static electricity.

Table 2 what if analysis for node2

What if	Consequence/hazard	Safeguard	Recommendations
What if blast furnace to dust catcher flow pipe ruptured?	Co poisoning& fire& explosion	leak detectors with warning alarm	Provide additional Co monitors and air line respirators

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What happens if valve closed in blast furnace line to dust collector?	As the result the safety valve opens bf gas vapor spreads to the atmosphere	Tripping switch	Check the tripping switch working condition regularly
What if vent valve damaged?	Gas from gas cleaning plant flows down stream	Non return valve	Optional purge connections
What if flare system does not work?	Dust spreads and forms a ignitable mixture	chimney	Maintain the flare system regularly
What if gas cleaning plant fails to work?	No fuel for captive power plant	Flare and chimney simultaneously used	Check the electrostatic precipitators regularly
What if flow in stove to chimney increase?	Damage in pipelines	Safety valves	Non destructive test can be carried
What if problem occurs in stove output line?	Problem in stove operation	Safety valves	Check the markings of the valves regularly
What if ignition occurs in operation?	Fire and explosion	thermocouple	Check the joining of thermocouples regularly
What if arrestors flame fails to work?	Flame from propagating back through lines lead to fire		Provide flame arrestors as per the standard
What if spectrum valve fails?	Top gas pressure increase and lead to explosion	Flow monitoring,	Maintain the valves, inspect any foreign particles accumulation
What if no flow in stove to chimney?	Dust leaks in atmosphere		Check all the valves using non destructing testing method
What if wet gas flows from to the power plant?	Damage the boilers	Temperature sensors	By using manometer check the resistance. Visually check for damage.
What if bleeder valve fails?	Temperature increase in furnace	Temperature monitoring	Monitoring temperature every 30 min. ensure all the valves operating in good condition
What if failure in wet gas cleaning plant?	Foreign particles enters in the valves and pipes		Maintain the gas cleaning system equipment. Clean equipment 2 weeks once.
What if reverse flow in compressor to stove?	Back fire	Isolation valves	To avoid back fire use the special design for back up isolation valves
What if ladle engine fails to work?	No pig iron for steel melting shop	Additional ladle engine are available	Inspect the engine regularly

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IV. RESULTS AND DISCUSSION

From what if analysis results table 4.1 and 4.2 all the hazards and its consequences are identified in two nodes of blast furnace. By comparing the number of hazards between node 1 and node2 nodes were priorities according to the result of what if analysis node 1(figure 1) has more catastrophic effect than node 2 (figures 2.)

Table no 5.1 Result of two nodes

Level	NODE 1	NODE 2
catastrophic	6	5
High	4	4
Medium	5	5
Low	0	3

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A. Discussions

The company should review the role and function of the Safety Department. At all drip water seals and valves, danger boards are displayed as per the Tamil Nadu factories rules 1950 schedule 32.Before starting any repair or maintenance work on gas lines permit is to be obtained which is mandatory. The process risks associated with safety-critical plant, especially ageing plant, should be thoroughly understood through rigorous assessment processes, with these being subject to regular review. Careful consideration should be given to providing emergency event-simulation training etc to build operator confidence and skills in emergency conditions. In emergency situations, there should be management arrangements such that there is a clear 'line of responsibility' for decision making. There should be no doubt whatsoever as to who is making which decisions. Bleeders are provided at various places. Color coding of gas line is done for easy identification. Painting of gas line is important to prevent corrosion. Oxygen resuscitators are kept ready for use. Steam and nitrogen purge valves are provided at some locations to facilitate purging of gas lines. Resting near gas lines and gas equipment is prohibited. Smoking is strictly restricted in plant. Digital co detectors are used for gas monitoring. Fire extinguishers are provided at gas consuming departments. It is essential that all personnel involved are aware of those risks and there are control measures, including arrangements for effective communication, in place such that adequate risk control is maintained.

V. CONCLUSION

What if analysis is a critical brain storming technique which is widely used in many areas and industries. What if analysis was conducted between the two nodes of blast furnace successfully. From the result table 1 and 2 of analysis nodes were compared and priorities. Node 1 figure no 2.1 has high risk values and more no of catastrophic and high hazards than the node 2 figure no 2.2 Based on these values safety precautions and recommendations were suggested for the blast furnace operational units.

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