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Risk Assessment of Blast Furnace II using Failure Mode Effect Analysis tool in COREX Steel Plant

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Abstract— Steel is produced from the raw materials iron oxide, coke, lime stone and metal scraps through various process. Blast furnacing, steel melting shop and hot strip mill are the main divisions of steel plant. Blast furnace is a tall reactor to process iron ore into pig iron, modern day blast furnace size range varies from 70 to 120 feet. Blast furnace iron making process is a complex task it has the potential hazards like fire and explosion, CO poisoning, hot metal sparks, heat stress, emission of air contaminants like particulate matter, sulphur dioxide and nitrogen oxides etc. Organization need to take necessary steps to manage the hazards and its consequences to perform work safely. . Failure mode effect analysis helps to identify all the possible system failure of these divisions and help in adopting control measures which are more efficient. Risk assessment through FMEA will help in increasing the safety of the system and there by the overall safety culture of whole plant is improved.

Index Terms— Blast furnace, Causes of failure, COREX Technology, Failure Mode Effect Analysis, Risk Assssment, Risk Priority Number, and Safety culture .

1 Introduction

Risk assessment using Failure Mode Effect Analysis is a very complex processes which include assessing the various system failures of the process and determining the risk associated with the failure. This method helps to determine the efficiency and suitability of the existing control measures incorporated into the system [1]. After assessing the failure mode, additional control measures are recommended, which is more efficient and reliable which can eliminate or control the risk to a minimum tolerable level [2]. The preliminary method for FMEA which has been adopted is general risk assessment of the process and analyzing the risk level [3] [4]. The use of FMEA tool helps to find the chances of failure of the system. It also helps to benchmark the standards of the current control measures which has been adopted. The blast furnace which has been taken for the risk assessment is a complex system, which comprises of many process and chances of failure of the system is higher [5].

Blast furnace plays a vital role in an integrated steel plant for producing pig iron which is then converted into various grades of steel in an arc furnace [6]. Raw materials like iron ore, coke, limestone are charged at the top of the blast furnace through skip car system. Coke is almost pure carbon act as a fuel as well as reduces the iron ore into pig iron. Hot air from stove is blasted in to the furnace making the coke burn much faster than the normal and temperature rises to 1200 degree celsius. Pulverized coal is injected through tuyeres at the velocity of 160 to 240 m/s to furnace to reduce the fuel consumption [7] [8]. Due to temperature rise various chemical reactions take place inside the blast furnace carbon monoxide reacts with unburned coke to form carbon dioxide that reduces the iron oxides in ore [9]. The molten iron is very dense so its runs to the bottom of the furnace. Impurities are removed by the lime stone used as the one of the raw material. Slag is an impurity which is lighter stays above the molten metal used for various purposes outside the plant. Blast furnace gas produced from the process is cleaned in gas cleaning plant and used as a fuel in captive power plants, Vacuum decomposing boiler. Excess blast furnace gas is burn using flaring system. Molten iron and slag is removed from different tap holes at regular intervals. Operation in blast furnace exposes workers to wide range of hazards that would cause fatal accidents. In past blast furnace explosion has shown many tragic and fatal accidents, so controlling the blast furnace operation is a complex task for the blast furnace workers and safety professionals. To prevent the accidents and unnecessary failures an effective risk assessment is important [10].

2 MATERIALS AND METHODS

2.1 Collecting the Accident History

- Accidents in the blast furnace are rare and there are very few direct accidents of the blast furnace.
- For the failure mode effect analysis, failure of the system is taken into consideration.
- Failure of the system will effect production and in worst case scenario it will result in accident
- Failure of the similar systems in the past is collected
- The data collected is compared with the process of the blast furnace [11].

2.2 General Risk Assessment

In the first stage, general risk assessment of the blast furnace is

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carried out. This help to identify the risk associated with the blast furnace.

Following are the steps involved in the Risk Assessment:

- Identifying the jobs which take place in the blast furnace.
- The hazards associated with the job are taken into account.
- Determining the consequence of the hazard
- The effect of the hazard are categorized in 4 main areas namely the people, environment, assets and reputation.
- PEAR is known as the severity and each are given as number according to the risk matrix.
- Probability as well as the risk is also given a number based on the risk matrix.
- Control measures are suggested which are reliable and which are more safe.

The general risk assessment gives an idea about the hazards associated with the blast furnace and with this information failure mode effect analysis can be carried out effectively [11].

2.3 Failure Mode Effect Analysis

The most effective tool in the Risk Assessment is the Failure Mode Effect Analysis (FEMA) process. It is more reliable and effective in determining the risk as well as the vulnerability in the sytem [12]. FMEA tool is used to determine the risk assessment of the blast furnace 3.

Following are the steps involved in the FMEA:

- FMEA is a method which helps to identify the chances of failure of the system component and the effect of the failure.
- During the assessment, past history is also considered and the lessons learned from the past accidents are taken.
- FMEA is determined by calculating the risk priority number.
- Risk priority number is calculated as the product of occurrence, detection and severity.

2.4 Risk Priority Number

When performing a Process or Design FMEA, the Risk Priority Number (RPN) is a calculation to sort the risks from highest to lowest. It is a technique which is used to determine the risk associated with failure of the system.The RPN is calculated by multiplying the three scoring columns: Severity, Occurrence and Detection [12].

$$RPN = Severity \times Occurrence \times Detection \quad (1)$$

2.4.1 Severity

Severity defines how serious the failure of the system wil be. It is defined from the number ranging from 1 to 10. In which the 1 be the least sever and the 10 be the most.

2.4.2 Occurrence

It is defined as, how often the chances of the failure will occur, if the failure occurs frequently which is determined by 10 the control measures have to be more reliable and effective. The least occurrence failure will be having a value 1.

2.4.3. Detection:

Detection is the assessment to determine whether the current control measure can detect the failure in the system and how effectively. The control measures in the system should always be reliable and efficient.

Through FMEA more reliable and efficient control measures are suggested which will activate during the time of a accident

2.4 Steps involved in FMEA

Following are the steps involved in FMEA:

- Understand all the process involved in the system
- Collecting the data of accident history of the similar system from the past
- Brain storming with the dept. in charge about the chances of the failures in the system.
- Identifying the cause as well as the effect of the failure.
- Severity, occurrence and detection of the failure is determined.
- Risk priority number is determined by taking the product of severity, occurrence and detection.
- If the current control measures installed in the system are not reliable control measures are suggested.
- Based on the suggested control measures severity occurrence and detection are determined.

3 RESULT AND DISCUSSIONS

Tabl 1 shows the results obtained from Failure Mode Effect Analysis of the Blast Furnace II and Figure 1 is the graphical reprsntation.

From the FMEA analysis of the blast furnace and after calculating the RPN value, it has been found that the tapping house of the blast furnace is having the highest risk priority number (144).

The current control measures may not be sufficient if a major accident occur in the blast furnace. If the recommended control measures are in cooperated in the existing systems, accidents could be prevented to a large extent [12].

Apart from the tapping house, the other factor having higher risk is the cooling water supply pump (120), if this fails the explosion will be very severe. Recommended control measures will decrease the probability of accident and associated damages and loss of life and work hours, which ultimately improve the Safety culture productivity and worker morale in the organization.

SL. NO	COMPONENTS /PROCESS	FAILURE MODE	FAILUREE FFECT	FAILURE CAUSE	EXISTIONG CONTROL	S	O	D	RPN	ADITIONAL CONTROL
1.	Blender valves	Failed to operate	Explosion	Corrosion	Reliable supplier	09	2	3	54	Periodic maintenance
2.	Conveyor feeder belt	Friction	Fire	Improper maintenance	Belt sway switch	07	4	1	28	Lubricate the rotating parts regularly
3.	Skip car rope for raw material charging	Rope breakage	Fatality/Disability/Injury	Overloading and corrosion	Weighing the load	03	2	2	12	Calibrate the load cells digitally
4.	Cold blast blower	High pressure flow	Rapture in stoves and burners	Failure of valves	Flow regulator	08	2	2	32	Interlock the system
5.	Hot blast blower	Stove shell rupture and crack	Fire & explosion	Excess Heating	Thermo-couple	10	4	3	120	Periodic maintenance and monitoring
6.	Blast furnace gas injection	Pipe line crack and rupture	Co poisoning	Over pressure	Gas Detectors	10	3	2	60	Provide detectors with automatic alarm system
7.	Oxygen injection	Pipe line rapture	Fire & explosion	Over pressure	Detectors	10	1	4	40	Provide detectors with automatic alarm system
8.	Cooling water supply pump	Pump failure due to clogging	Fire & Explosion	No power supply	Redundant power supply	10	6	2	120	Real time monitoring of fuel level of diesel generator
9.	Tapping hose	Oxygen hose cuts and bruises	Fire	Ageing and corrosion	Reliable supplier	09	4	4	144	Periodically replace the Hose
10.	Hot molten metal lifting by crane	Rope breakage	Hot metal ladle fall from height down	Overloading	Safe working load are marked	10	3	2	60	Interlocking with alarm
11.	Gas leaning filter bags	Filter bag failure	Improper gas cleaning	Heating	Monitoring system	05	3	3	45	Periodic inspection

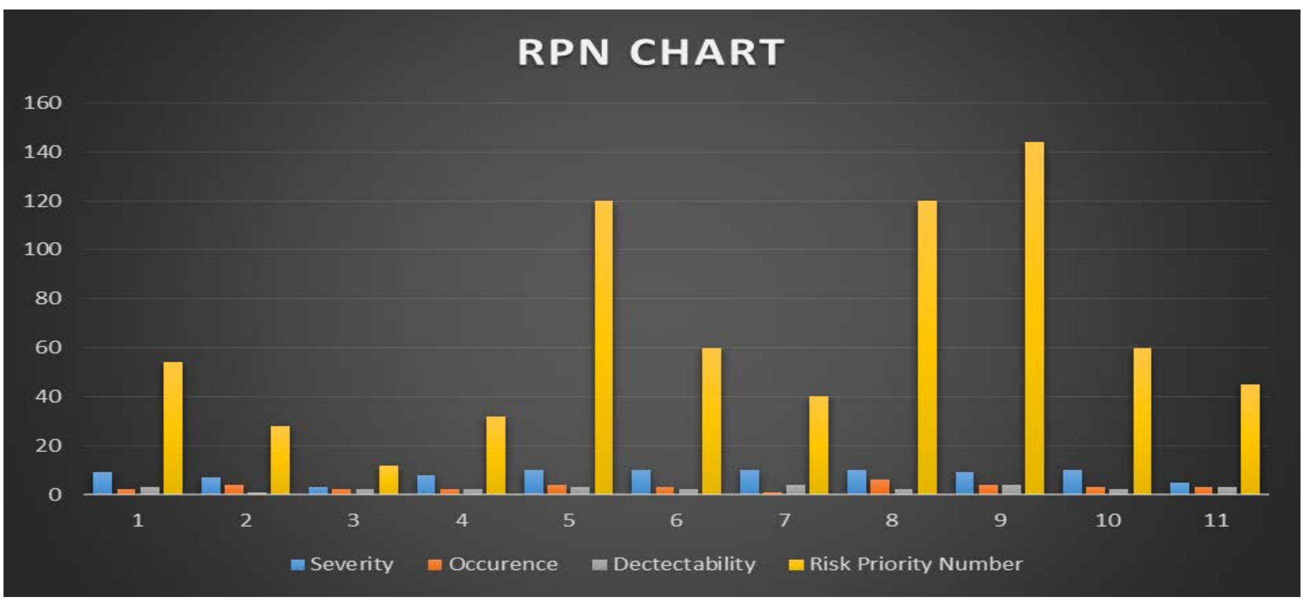

FIGURE 1. RPN Chart

Higher value of risk priority number was obtained for tapping hose process RPN=144. Detailed safety audit should be conducted on the casting area to reduce accident rates. Proper housekeeping, awareness and training and training should be given to the workers involving in cast house activities. Barriers, shields should be arranged to prevent cast house workers from exposure to molten metal sparks. Proper training should be given to all operators and workers on fire fighting and Emergency management, this will further reduce risk priority number value.

4 Conclusion

Risk and hazards are common in industry, identifying the hazard and analyzing the risk associated with it is any important step.

Identifying the risk and assessment can be done effectively with the help of risk assessment tool. FMEA is one of the tool for the risk assessment and which is more reliable and effective is identifying the risk associated to the system. Using the FMEA tool it is convenient to measure the failure of the system.

Using this tool, failures of the system components in the blast furnace were identified and control measures were suggested which are more reliable and effective in detecting as well as controlling the failure of the system.

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