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Identification Hazards and Risk Assessment in Power Plant

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Abstract
In this advance technology descend and population blast, continuously increasing the power requirement to full fill this requirement increasing power generation. Power generation process lead to consider on the health and safety of people. In this paper show the details of hazard identification and its assessment and with controls parameter such as Hazard Control -controlling of hazards and associated risks with the hazard. Control Measures- providing information on training, supervision on the hazard, education, analysing the risks, controls measure for the employees affected by the hazards with evaluation of hazard.
In thermal power plant used coal as a fuel, this type of power plant which is driven by steam and generates electricity by expanding the steam in the boilers and connect turbines to the generators which converts mechanical energy into electrical energy. This type of affect the accidents, injury to human lives, damage to property and environment becomes quite high. For protecting plant from such condition, risk assessment required is must.
from the result, we finding operating modes of design and determined the hazard rankings method and applications to find the optimal method safety management, along with the elimination of the source of the hazard effects.
Furthermore, an example is shown how to do or calculate the quantitative risk assessment for the various hazards that comes across various operations in hydrocarbon industry.
Keywords *Hazard identification and risk assessment, Fire protection system,Rankine cycle, Risk index Boiler Turbine.*

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I. Introduction

India is the largest coal producing country in the world that has made the country to have numerous coal-fired thermal power plants requiring nearly 440 million tons of coal annually [1, 2]. The energy available in the coal is converted into electricity in a coal-fired thermal power plant, and this conversion of coal to electricity takes place in multiple stages. The process begins from coal transportation from the nearby mines, and the transportation could be done either by railway wagons or by trucks to the coal handling plant for crushing through conveyor belt and to bowl mills for pulverization, and then, the finely crushed coal is taken to the furnace. During this process, there are several hazards associated with it such as exposure to coal dust, noise, vibration, heat stress entanglement between conveyors; so as to avoid these hazards, there are lots of safety devices installed in conveyors that includes belt sway switch (BSS) and pull chord. The purpose of installing BSS would be evident while any emergency occurs in the conveyor system. Belt and other systems except crusher will trip in case of operation of BSS. After that the heat generated from the combustion of coal boils water in the boiler to produce steam at a high pressure and temperature. The steam generated is superheated and fed to the turbine, rotating the blades at a certain rpm, and converts heat into mechanical energy. The hot water is recycled and circulated through the cooling towers. The electricity is produced in the generator. All the operations are monitored through the control room operations [3, 4]. But the major disadvantage involved in this coal-fired thermal power plant is that it emits quite a good amount of pollutants which directly impacts worker health and the environment, and the entire process of operation of the plant is associated with major physical hazards related to noise, vibration and heat [5]; in addition, there are fire and explosion hazards, ergonomics incompatibility at workplace, non-ionizing radiation, control room operations, electrical hazards, etc. [6, 7]. The CFTPPs require maintaining storage of a large quantity of chemicals and other materials for subsequent use, such as chemicals like liquid chlorine, hydrochloric acid and flammable/combustible materials (furnace oil, light diesel oil, coal, Hydrogen). Therefore, to combat with these hazards and for early identification of risk and assessment of the hazards, a comprehensive HIRA is prepared for major hazard prone area of the plant. Now to generate electricity in a coal based thermal power the coal has to pass through several stages simultaneously with water which then converts into steam starting from coal storage area to the switchyard and to make the understanding of the process.

Many authors, explaining the essence of risk and the way to determine the definition of risk,represent different approaches and concepts of the notion of risk, present to the framework of the logistics to the process [8-9]-Risk as a deviation from the goal is an approach that involves making the wrong decision that led to the deviation from the goal, which involves the interaction of these two factors, because the decision cannot be judged to be wrong without analysing the goal. Deviation from the goal contains the intensity and probability of realization of a negative event. Risk as a possibility of a wrong decision is an approach that is part of the goal deviation approach.It is very difficult to measure the risk of a particular decision because the risk assessment is made after the event, analysing the scenario of the event and how certain decisions affected the realization of the risk. This approach also includes correlation between the set goals, for the reason that a particular decision cannot be judged wrong without analysing the goal.

II. Literature Review

Hazard in important and common point in different types of power plant. In thermal power plant coal is stored there is always risk of burn because of different way to accident happened in plant such as in summer high temperature, explosive and other accident. The burning of coal leads to the emission of poisonous gases with underlying health affect and environmental problems [10-11]. Combustion of coal harmful affect to environmental because of production harmful gas such as carbon monoxide (CO), sulfur dioxide (SO2) and sulfur trioxide (SO3), and nitrogen dioxide (NO2) and nitric oxide (NO) etc [12].

PM degree, individually and in combination with NO_2 in air, increases the amount of radical based reactive oxygen species and contributes to DNA mutation, and damage of protein and lipids which may constitutively activate membrane proteins which increase of some serious diseases, including lung cancer, cardiovascular diseases and reproductive disorders [13].

These radionuclidesnmay pose radiation risks externally due to their gamma-raynemissions and internally due to radon and its progeny that emit alpha particles [14].[15] evaluated the reliability of steam and power generation systems in a thermal power plant by dividing each system into subsystems and modeling the relationships between the overall system status (good/reduced efficiency/reduced capacity/failed) and subsystem status (full capacity/reduced capacity/failed) using a Markov model. [16] modeled a combined cycle power plant as a digraph assuming nodes as subsystems and edges as flows of materials (e.g., air, gas, or water) between subsystems. The digraph was translated into a matrix defining the value of diagonal elements as the reliability of subsystems and that of the off-diagonal elements as the reliability of connectedness.

The 2011 Great East Japan Earthquake hit a large area of the pacific side of east Japan, where several nuclear and thermal power plants are located, which led to power shortages in both the affected area and the rest of Japan.

Power shortage analyses are often used for developing policies to be applied during a power crisis. Bo et al. [17] reviewed previous blackouts around the world and summarized their impacts and recovery measures.A limited study of power plant failure during a power crisis was presented [18], which investigated the effect of heavy use of thermal power plants during the California electricity market crisis of 2000–2001. They demonstrated that the outage rate decreased significantly compared to historical outage rates at counterfactual conditions and concluded that high electricity prices motivated the power supply companies to emphasize generator maintenance.

Induction furnace slags (IFS) gathered from a local metallurgical industry, which were experimentally investigated in a previous work [19]; and other three solid wastes gathered from the local coal power plant industry (i.e. Coal fly ashes (CFA), Coal bottom ashes (CBA), and Coal bottom clinker (CBC)). Finally, a laboratory experimental investigation was conducted on these three later collected wastes in order to assess their TES potential up to 800 ◦C. Thus, their thermo-physical and chemical properties were evaluated, as well as their thermal stability up to 800 ◦C. Furthermore, the obtained results are compared with those of IFS and those of investigated TES materials in literature.

Some Industrial waste increase the chances of environmental and social hazard, which affect the human health, specially chemical industries waste is more dangers because of toxic gas produced. Some of researcher interested in this work field. [20] investigated the high temperature materials. This This material is the result of the vitrification process of the toxic asbestos containing wastes inside a torch plasma furnace at a temperature of 1400 ◦C [21].

[22] the development process of a computer-aided system for hazard zone identification in ship power plants size of tasks for hazard zone identification can be decreased by using opinions of experts in the field of design, operation, and maintenance, the solution of tasks for hazard zone identification requires use of a computer because the procedure for generating solutions many times repeated.Nuclear thermal power has more dangerous compared to all type thermal power plant because of harmful particle emitted like alpha , beta and

gamma radiation. These are more harmful radiation affect the human body as well as environmental. The transient behaviour and related dynamic safety issues arising from the linkage of nuclear and thermochemical hydrogen production plants have attracted more attention in recent years. Studies on small-scale dynamic fluctuations of the heat requirements of S–I thermochemical hydrogen production plants have been reported [23]

Traditional nuclear safety research has been focusing on the safety of nuclear reactor core and its thermal hydraulic system, and the chemical plant safety has examined the probability of fires, blasts, leaks, and spills [24] In comparison, the corrosion attack on the pipes by steam, supercritical water, and supercritical CO_2 depend on temperature and pipe materials. As to the molten salts, the research has been performed in the past decades on the chemical corrosion and abrasion phenomena [25].

A petrochemical industries incurred several fire and explosion accidents, which had considerable negative impact for the industry on both environmental and safety issues , the unpredictable factors during the process having risk to runaway reaction, thermal explosion, fire, and exposure to harmful toxic chemicals release due to the huge heat and gas products by thermal decomposition could not be removed from the process.

Organic peroxides and azo compounds are highly thermally sensitive and can readily cause extended thermal hazards, as their thermal decomposition generates large quantities of heat and gaseous pollutants [26].

III. PROBLEM IDENTIFICATION

Risk evaluation and assessment is the efficient way of evaluation of risk associated with the hazard which is identified. In the identification of hazards, the main objective is to ensure, all possible hazards are identified. Processes that can be utilized are:

1. Previous experience of accidents or occurrences.
2. Experienced offsite specialists (Consultants).
3. Fault tree analysis to determine underlying hazards that might not be evident at first glance.
4. Safety Statistics.
5. Work Process evaluation.
6. Significant incident, near miss or accident reports.
7. Consultation with experienced employees.

Dividing the work place e.g.-by activities, equipment, geographical area, specific job activity. Processes can be broken up into nodes and then each node can be examined independently as to what can go wrong. All hazards are to be identified whether minor/major or likely/less likely and findings to be recorded.

OBJECTIVES

1. To identify the potential hazards, probability of occurrence and the possible severity at workplace and quantify the risk associated with those hazards.
2. To make recommendations to mitigate the risk and hazards involved in the power plant.

ASSESSMENT OF RISK AND ITS RANKING

The goal of each risk assessment is to identify hazards, determine risk ranking with controls, and to revise the implementation of risk controls from the previous risk assessment sessions. Risk assessment is the process of assessing the probability of existence of specific consequences or undesirable events of known severity.Identification of risks which are the most need of attention and option for achieving risk reduction Identification of risks which needs to be careful ongoing management, the nature of ongoing management and its indicators which shows that the risk shall be managed. Identification of triggers which might be useful in order to monitor the hazard and initiate actions if elimination is not feasible.

IV. MYTHOLOGY

Coal-based power plants are complex in nature. There are number of processes and steps which are being executed at every moment, Hazard analysis involves the identification and quantification of various hazards (unsafe conditions) by interviewing, performing JSA and consulting with the workers and employees, or by safety walks, safety inspection, etc. Then risk evaluation has been done given below figure. 1 the power plant by categorizing the task into various job steps and identifying their associated hazards, consequences, their existing control measures and then finally calculating the risk based on frequency and severity.

Steps include:

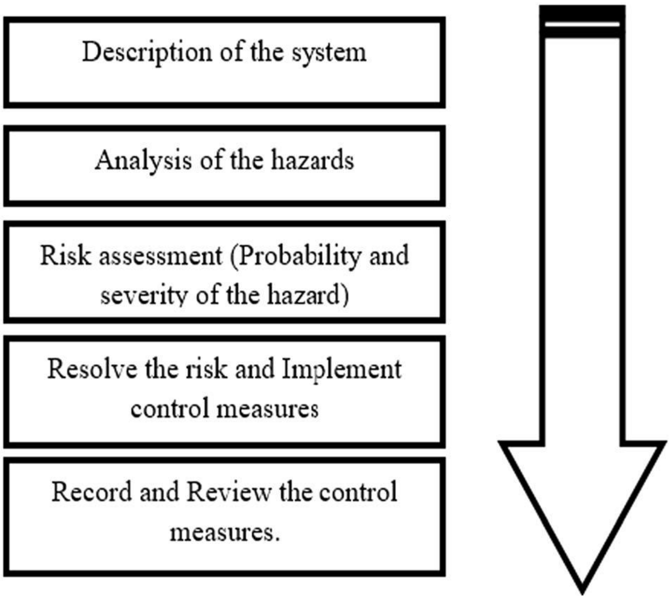

Figure 1. Steps follow in this project

Hazard Identification and Risk Assessment (HIRA)[27] Hazard analysis involves the identification and quantification of various hazards (unsafe conditions) by interviewing, performing JSA and consulting with the workers and employees, or by safety walks, safety inspection, etc. Then risk evaluation has been done by giving numeric value to the probability and severity of each hazard [13]. A HIRA is prepared for turbine–generator (TG) area, boiler, switchyard and for CHP area of the power plant by categorizing the task into various job steps and identifying their associated hazards, consequences, their existing control measures and then finally calculating the risk based on frequency and severity.

V. RESULTANDDISCUSSION

Hazard identification and risk analysis was carried out for a thermal power plant and the hazards were identified and risk analysis was carried out-

1. Hazard Identification

1). **Coal Handling Plant Hazard**

I. Fall from the height during work on conveyer belt, conveyer control roometc
I. Fire in coal storage
I. Coal dust explosion in coal conveyer bunker
V. Respiratory problem due to coal dust
V. Catches on conveyer belt
I. Injury during maintenance on ball mill
I. Injury during coal handling like slip and trip
I. Rail line and other transport line accidents
X. Struck by falling object

2). **D.M. Plant Hazard**

I. Fire hazard
I. Chemical burn by Spillage of sulphuric acid and caustic soda lye during unloading, overflow, Damage on storage tank or pipe line
I. High noise level

3) **Boiler Hazard**

I. Explosion in boiler due to over pressure and temperature
I. Explosion in boiler due to improper combustion of fuel.
I. Water tube burst due to Failure in boiler water level control
V. Burn injury due to hot water and hot steam pipeline leakage
V. Fire in diesel supply line
I. Sleep , trip and from the height during routine work, maintenance or inspection
I. Burn injury by hot fly ash
I. Catches on the moving part of the machinery like F.D. fans or motors

⟨. Burst of the equipment body due to over pressure and over temperature
⟨. Exposure to the hot surface of pipeline or machineries.

4. **Turbine hazard**

I. Fire and explosion on hydrogen tank
I. Explosion in turbine due to cooling system failure
I. Explosion in turbine due to cooling system failure
/. Fire on cooling oil
/. High noise level

5. **Switch Yard Hazard**

I. Fire on transformer
I. Electric shock and electric burn routine work, maintenance or inspection of electrical panels in switch yard
I. Slip , trip and from the height during routine work, maintenance on switchyard

6. **Other Hazard**

I. Fire on ammonia storage tank
I. Fire hazard on fuel storage tank
I. Control room fire hazard
/. Eye irritation and respiratory problem from the exposure of ammonia leakage from storage tank or pipeline

2.

3. Risk Assessment -

Then risk evaluation has been done by giving numeric value to the probability and severity of each hazard

S.N.	Job steps in sequence	Potential hazard	consequences	Legal compliance	Existing control measures	Additional control measures
1	Switchyard area					
a.	Switchyard operation	Charge accumulation due to mutual induction	Pinching effect	N	Avoid passing under high tension power lines and any contact with other in the area	
		Occurrence of faulty current due to earth fault	Electrocution/ Fibrillation	N	Proper grounding	
		Sagging of transmission line	Electrocution/ Fibrillation/Burn	N	Inspection of wire and proper maintenance	
		Blasting of circuit breaker	Electrocution/ Fatality	N	Inspection	
		Arc flash from electrical panels	Burn		LOTO System PPEs	
		Presence of reptiles and regular frequency	Snake bite / Fatality	N	Use of PPEs	
b.	Switch Yard Maintenance	Fall Form Height	Injury/Fatality	N	Proper fall protection system permits , On jab training , supervision	Compliance of fall protection system as per IS 3521/ on job Training of workers / Mock Drills
		Electrocution during testing activities	Injury/Fatality	N	PPEs permit Supervision	
		Heat stress	Burn/ Unconsciosness with immediate attention	N	Avoid exposure, Job rotation	
2	Boiler operation &Maintenance					
a.	Boiler operation	Formation of clinker	Explosion in boiler	Y	Peoper combustion of coal, maintaining access air , periodic inspection of	

					furnace	
		Fuel oil leakage	Fire/ water pollution and other environment effect	Y	Maintaining flow and pressure , maintenance of control valves	
		Coal dust leakage	Respiratory problem irritation on eyes	Y	Proper PPEs and use of boiler suits	
b.	Maintenance	Fire Hazards	Injury/ fatal	Y	Combustion Material should not be present in the vicinity /Substitution	
		Electrocution	Fibrillation / Burn/fatal	Y	Proper isolation from electrical panels use of PPEs	
		Exposure to the hot surface of pipeline or machineries	Skin Burn	Y	Use of PPEs such as gloves atc.	
		Slip, trip and fall from height	Injury / Fatal	Y	Proper barricading proper guardrails	
	Turbine–generator area					
c	Turbine Operation	Steam Leakage	Burn/Fatality	N	Maintenance and inspection / proper insulation	
		Over speeding of turbine		N	Tripping of turbine using governing system/ mechanical tripping using fly ball	
		Hydrogen leakage		N	Use of seal oil system/ proper functioning of DPRV valve /Regular trial of DC seal oil Pump	Leak detection system should be installed at point which are prone to l eakage /Awareness and training
		Noise and vibration		Y	Use Of PPEs	
		Overheating of insulation	Fire which can cause burns/body injury	N	Periodic replacement of insulation and inspection	
		High Vibration causing damage to oil lines	Heavy fire/Fatality	N	Proper maintenance of shaft and bearing lubrication	
3	Turbine maintenance	Electrocution due,improper isolation of equipment from HT/LT panel	Burns/fatality	N	LOTO system/use of PPEs	
		Unsafe lifting and hoisting	Fall of load /braking of chain / injury due pending effect	N	On job training proper inspection of chains and ripes	
		Entanglement	Fail due to entanglement in cables, cut/bruises	N	Proper staking of cables	
		Slip and trip Hazard	Injury	N	proper housing keeping	
	Turbine floor	Slip and trip from stairs	Injury	N	proper housing keeping to avoid any obstacle	
		Unsafe lifting	Injury/Pendulum effect	Y	Proper inspection and maintenance of hoisting equipment chains, rope,	

					slings / on Job Traning / use safe work load chart	
		Noise and Vibration	Hearing impairment	Y	Use of proper PPEs	
		Fall of Object	Injury	N	Use of proper PPEs Housekeeping	
		Hydrogen storage causing blast	Burn /fire	Y	Proper sealing of cylinder/ prohibition of use of mobile phones and electronic equipment / No hot work in vicinity	
4	**Coal handling plant (CHP) area**					
a.	Maintenance activities	Slip due to oil or grease	Body Injury	N	Periodic Cleaning / housing keeping	
		Exposure to dust	Respiratory Discomfort Hearing Impaired injury	N	Arresting leakage and use of noise mark	
		Exposure to noise	Hearing impaired	N	Use of earplugs	
		Poor illumination	Eye strain Injury	N	Adequate lighting /hand lampuse	
		Fall between gaps	Physical injury requiring medical aid	N	Ensuring all opening	
b.	Wielding activities	Electric Shock	burns	Y	Proper permit SOP	
		Exposure to metallic dust	Cancer	Y	PPE, Job rotation	Quality of PPE should improve/ Awareness and training program
c.	Coal Unload at TUC	Exposure of coal dust	Respiratory Discomfort	N	PPE, Water Sprinkler	
		Fall on gating	Injury	N	Proper traning as well as working under supervision proper lighting	
		Struck by truck	injury	N	Trained Manpower deployed under strict supervision	
d.	Crusher and vibro- feeder	Exposer to high noise	Hearing IMPAIRED	N	PPE/ not full time operation	
e.	operation	Exposure of coal dust	Respiratory Discomfort	N	Dust suppression	
		fire	burn	N	No fine Dust accumulation, water washing	
		Exposure to rotating part	Amputation/Injury/ Fatality	N	Rotating Part covered with gurd ,PPE, work carried	
f.	Conveyor operation / coal transportation	Belt Snapping/ falling of VGTU	Physical Injury	N	Regular belt survey/ joint replacement / choking of belt before taking in to service	
		Struck by falling stone/coal/objct from cvy	Injury	N	PPE/ Instruction Display board barricading	
		Falling in walk-way	Injury	N	Free from any obstruction, oil, grease/house keeping	
		Stuck up in idler frame	Injury	N	Safe distance for cvy, wearing tight	

					cloth	
		Struck by counter weight	Injury	N	Proper fencing of counter weight , PPE	

VI. CONCLUSION

In this paper, we observe that with the help of hazard identification and risk assessment method, it is very easy to find the hazard condition in power plant. As discussed in the paper, hazard analysis and risk assessment can be used to establish priorities so that the situation which are most dangerous and possess a high-risk factor are addressed first and those least likely to occur and least likely to cause major problems can be considered later. To prepare this HIRA an, onsite survey is conducted in the running unit of the power plant and the area includes the switchyard (T-G Turbine–generator) area and the boiler area, and results showed that the major risk possessed hazards in switchyard is the presence of snake and reptiles at regular frequencies; in boiler area the major hazard is coal dust leakage; and in T-G area, it is hydrogen leakage, unsafe lifting and hoisting in turbine maintenance activity. Other risks associated with the turbine operation were loss of lubrication causing internal rubbing and the destruction or ceasing of the bearings, turbine over speed causing severe damage due to imbalance, higher vibration, etc. After identifying these hazards in the proposed power plant, the risk associated has been assessed and the existing controls reviewed. The risk rating of the possible hazard is evaluated which divides them into significant, non-significant, acceptable and unacceptable risk levels. The risks which are at unacceptable level, possible corrective action is also recommended there to improve safety measure and analysis.

To reduce the environmental impact of the identified risks, measures can be taken from managerial to technical measures and even closing these plants through larger scale usage of renewable energies.

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