Learning from Major Incidents in Power Plants

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Abstract

In India, the installed capacity of Power Plants (coal / gas / diesel / naphtha based) is of the order of 1,04,917.5 MW capacity. However, inorder to reach the per capita consumption levels of developed countries, considerable number of power stations need to be built. Apart from availability of power, quality and continuity are also the main issues in India.

Statistics provided by DGFASLI indicate an Incidence Rate of 14.42 (for the year 1998, Industry Sector - Electricity, Gas and Steam), which is next only to Textile Industry. Accidents in power plants not only result in the loss of life and property but also have a substantial impact on the interruption of business – both to the power plant as well as the consumers. It would be interesting to note that, 43 % of the businesses which face interruption do not resume at all while for 20 % of them it takes as much as two years to resume full operations.

Majority of the Incidents in power plants have occurred in any one of these areas – transformer yard, coal crusher house, cable gallery, coal storage yard, Switchyard, Conveyor, Turbogenerator hall or Hydrogen storage.

This paper aims at

1. Highlighting the major accidents that had occurred in the past in power stations
2. Analysis of the causal factors in these incidents and
3. Recommendations suggested, based on national and international standards, to prevent the recurrence of such incidents

With the advancement in the capacity of the power plants, the critical components like the steam and the gas turbines have many technical problems to be solved – critical cooling systems, stringent material specifications etc., to ensure safe operation of the plant. Incorporation of safety in the design stage and assuring that it is maintained well during operations would ensure the success of power stations in delivering *Safe* and *Clean* power.

Contents

1.0 Introduction

1.1 Power Scenario in India

The commercial power generation in India has gained substantial momentum in the past three decades. The total installed capacity of power utilities has increased from 16,664 MW in 1974 to 104918 MW in March 2002. Electricity generation, which was only about 4.1 billion units in 1947, has risen to 515 billion units in 2001-02.

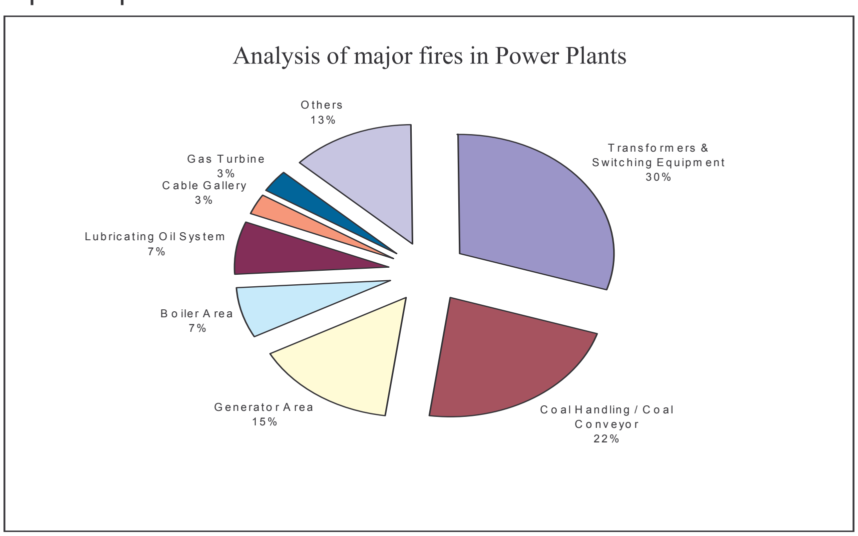
The per capita consumption of power in India is about 350 kWh, which is one of the lowest in the world. With industrialization gaining rapid pace and the economy looking up with good contribution from the manufacturing sector, the Government of India is taking proactive steps to set up new power plants. Based on the demand projections made in the 16th Electric Power Survey, over 1,00,000 MW additional generation capacity needs to be added by 2012 to bridge the gap between demand and supply of power. New electricity bill passed in 2003 is expected to provide the required fillip to power generation activity in country.

1.2 Safety in Power Plants

The safety record of power plants in India is not so impeccable. Analysis of the data published by Director General of Factory Advisory Services and Labour Institute (DGFASLI) indicate higher Incidence rates compared to other Industry sectors. For the year 1998, the Electricity, Steam and Gas sector has had an incidence rate of 14.42, which is next only to the Textile Industry.

Power plants use bulk quantities of combustible material like coal, diesel, naphtha and lubricating oil and hence are more prone to fire accidents. Fire is considered to be a major hazard in the operation of power plant and hence the cause for its initiation needs to be eliminated.

An analysis of major fires (where loss is more than 50 lakhs) in thermal power plants indicate that the fire in transformer / switching equipment contributed to 30 % of the accidents. While the fire in generator accounts for 15 %, fire incidents in coal handling plant and associated equipment are to the tune of 22 % of the fire accidents. The pie chart below depicts the areas where fire incidents have occurred in thermal power plants.



1.3 Lessons Learnt

Safety has become an inherent part of business operations as majority of the incidents have not only led to injuries and damage to property, but have also resulted in interruption of business and damage to reputation.

Section 2 and 3 detail two case studies of fire in Indian power plants. An attempt has been made to analyse the causes and suggest suitable corrective actions.

Section 4 highlights the various loss control initiatives to be adopted by power plants to prevent fire losses.

2.0 Incident Analysis – 1

2.1 Incident Summary

Type of Loss	Fire in Captive Power Plant
Location	Captive Power Plant of one of the largest Indian Refineries
Year	1990s
Estimated Loss	Rs. 3 Crores

2.2 Details of the Premises

- Capacity of the Refinery was 6 MTPA
- Fuel Oil based Power Plant of capacity 3 x 12 MW commissioned in 1982
- Double storey configuration.
  First floor : Turbines and Generators ; LxWxH – 60 x 20 x 15 m
  Ground Floor : Auxiliary systems like lubricating oil system
- Turbine hall partially made of concrete and steel grating
- Boilers generate steam at 64 kg/sq.cm at a steam temperature of 400 deg.C
- No automatic fire protection system for turbine / generator
- Basic approved fire hydrant system provided for the power plant
- Refinery has its own fire brigade equipped with DCP and foam tenders

2.3 Chronology of the Incident

On the day of Incident
03.00 a.m.: Units 1 & 3 were operating in full swing. Operator passing through the area of TG set 3, observes flame and smoke coming out through the steel grating plate from the ground floor.
Operator immediately raises the alarm and informs the refinery fire brigade.
Assessing the gravity, power supply (except emergency supply) of the plant was shut down before the arrival of the fire brigade.
03.02 a.m.: First fire tender reaches the location of fire and starts fire fighting operations.
Emergency DC supply could not be used as probably the cable was burnt
Fire fighting personnel attack fire from the ground floor entry point. They use flood lights and Self Contained Breathing Apparatus (SCBA) to locate the seat of fire as the place was filled up with dense sooty smoke.
2 Foam and 1 DCP tenders pressed into service to control fire.
04.00 a.m. : Fire declared 'controlled'
2000 kg of DCP and 2000 litres of foam compound were used to extinguish fire

2.4 Brief Description of the Lubrication System:

The turbine and generator of all the three units are provided with independent lubricating cum hydraulic system for each unit. The main lubrication oil reservoir is located at ground floor from where oil at different pressures are fed to bearings and governing system from common header.

The operating pressure range of governing system is 4.5 – 5.0 kg/ sq.cm. and that of bearing lubricating system is 1.5 – 2 kg / sq.cm.

The system is so designed that TG set will trip off if the pressure of the governing lubricating system comes down to pre-set points. The set point of governing system was 1.5 kg / sq.cm. and that of lubricating system is 0.7-kg/ sq.cm.

The lubricating oil of commercial name Servo Prime – 57 is used and has a flash point of 210 deg. C (closed cup).

2.5 Probable Cause and Analysis

Probable Seat of Fire : The circumstantial facts point to the ground floor where Main equipment of the lubricating oil system are located.

2.5.1 Probable Causes:

Leakage of lubricating oil from the lubricating oil system located in the ground floor:

Spot investigations revealed that the centrifuge used for the filtration of lube oil was badly damaged due to fire. It can be concluded that the source of leakage was the centrifuge and the source of ignition could be because of anyone of the following:

- Temperature of the operating steam is around 400 deg. C which is more than the auto ignition temperature of the lubricating oil.

- Soaking of the pipe lagging with lubricating oil due to small leakage and subsequently, self-igniting.

2.5.2 Incident Aggravators:

1. Spread of fire through cable gallery – cable entry points not protected

2. Early collapse of concrete slab roof resting on steel trusses – Loss of steel strength due to increase in temperature

3.0 Incident Analysis – 2

3.1 Incident Summary

Type of Loss	Fire in the Rotary Discharge Machine / Conveyor belt area of coal handling plant II
Location	Thermal Power Station in North India
Year	1990s
Estimated Loss	Rs. 60 lakhs

3.2 Details of the Premises

- Plant Commissioned in 1989
- Two Stages:
  - Stage 1: Units 1, 2, 3 and 4 each of 110 MW capacity
  - Stage 2: Unit 5 of 210 MW capacity
- Plant runs round the clock in three shifts
- One fire station with three fire tenders. The plant has approved TAC fire hydrant system

3.3 Chronology of the Incident

On the day of Incident
01.30 a.m.: Operator of the Coal Handling plant notices fire coming out from the conveyor area of the coal handling plant
Operator informs the plant fire brigade
Fire tender reaches the incident spot and starts the fire fighting operations
03.00 a.m.: Fire brought under control
05.00 a.m.: Fire totally extinguished
Three fire tenders used for controlling the fire.

3.4 Probable Cause and Analysis

Probable Seat of Fire : Basement of the coal handling plant

Probable Cause : Spontaneous ignition of the coal

3.5 Brief Description of the Rotary Discharge Machine

The Rotary Discharge Machine has two parts:

- *Rotary Wheel* moves horizontally and feeds the raw coal on to the conveyor from the coal yard. The Rotary Discharge machine moves forward and in the process coal is supplied to conveyor belt. Longitudinal movement of the Rotary Discharge Machine is achieved through the hydraulic system.

- *Dust Extraction System* consists of bag filters through which the air above is sucked in. The coal particles are extracted through the vacuum system.

4.0 Loss Control Initiatives for Power Plants

4.1 Use of Linear Heat Sensing Cables:

Section 6.5.2 of Tariff Advisory Committee (TAC) – Fire Alarm Guidelines recommends installation of Linear Heat Sensing (LHS) Cables for Cable galleries.

Few other areas where LHS cables can be used in a power plant are:

- Critical Transformers
- Conveyor belts
- Critical Electrical Panels

4.2 Passive Fire Protection Systems:

- Passive fire protection system for cable galleries
  (Use of products like fire resistant pillows, sealing compounds, Fyrefyba ceramic fibre)

- Application of fire resistant coating on critical power cables
- Encasement of steel structures in the turbine shed areas

4.3 Fire Prevention and Protection in Coal Storage

❖ The site should be free of vegetation such as shrubs, weeds etc.,
❖ No steam line or any other flammable material pipeline should pass through the coal storage area / yard.
❖ Majority of the hot spots will be within 1 – 1.25 m of the surface and all stacks should be therefore inspected weekly for overheating. This can be detected by:

  - Smell - low volatile chemicals coming off
  - Discoloration - white / yellowish powder deposits

❖ Monitoring of stack temperature by either inserting tubes or by infrared camera to detect hot spots.

4.4 Active Fire Protection Systems

- The entire plant area shall be provided with approved Fire hydrant system and portable fire extinguishers and maintained as per the national / international standards.

- The fire hydrant points shall be provided in critical areas like the coal handling plant.

- Total Fooding system (Carbon dioxide / FM 200 / NAF S III) may be installed in the TG area.

4.5 Risk Based Maintenance System

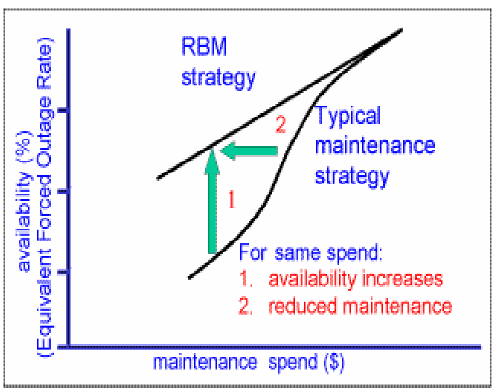
Industry is recognising that benefits may be gained from adopting formal risk-based maintenance approaches to plant integrity management through improved targeting and scheduling of inspection and maintenance effort.

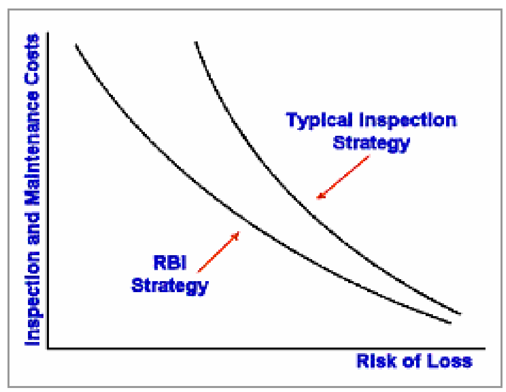
Optimization softwares have the following features and they can be utilized for improving the availability and the reliability of the plant:

- Interfaces with computerised maintenance management system
- Time based risk-auditing module - equipment ranked by risk and remaining life
- Maintenance frequency based on formal reliability rules - remaining life indicator module
- Facilitates selection of optimal mitigation measures

Benefits:

- Improved Safety and Increased Availability
- Optimum maintenance spend
- Facilitates increased run times, reduced outage time / costs and fewer forced outages





4.6 Thermal Imaging and Audit of Electrical Safety Systems

Thermal Images of critical panels / equipment would unearth the inherent defects and the potential failures. The benefits of thermal imaging are:

- Location of potential problems
- Reduce downtime and emergency repairs
- Reduce man hours on preventive maintenance by pinpointing priority areas that need immediate repair
- Extended equipment life
- Increased reliability of plant power distribution system
- Prevent risk of fire due to electrical failure
- Prevent accidents, personal injury and property damage
- Reduce casualty loss of equipment

Periodic Electrical Safety Audits of the plant would help in ensuring:

- ❖ Systematic, critical appraisal of all potential electrical hazards involving personnel, plant, services and operation method and
- ❖ Review compliance of plant electrical installation (installation & maintenance) with reference to the statutory regulations.

A typical Electrical Safety Audit would focus on the following elements:

- Statutory compliance with respect to Indian Electricity rules
- Physical inspection to identify electrical hazards (shock, fire, explosion, overloading) and to suggest electrical safety solutions
- Review of plant lightning protection system (need, adequacy, installation and maintenance)
- Review of static electricity hazards in the plant operations (if applicable)
- Review of hazardous area classification and selection of flameproof electrical equipment in the plant, including maintenance aspects (if applicable)
- Review of electrical preventive maintenance system (including tests, documentation, history cards, etc.)
- Review of electrical accidents and near-misses in the plant to identify the root causes
- Review of electrical systems & procedures (work permits, interlocks, lockout tags, etc.)
- Review of the importance given to electrical safety in the company safety policy, safety committee, continuous electrical risk identification, etc.
- Assessing the integrity of insulation of cables by carrying out insulation resistance tests on a sample basis
- Review of the earthing system (installation & maintenance aspects), including sample earth resistance tests
- To identify areas of overloading by carrying out load current measurements and compared against cable current carrying capacity calculation

4.7 Hazardous Areas Classification:

In power plants that utilize fuels that are highly hazardous such naphtha, natural gas etc., the probability of fire or explosion do exists because of various reasons. As per the standards, the installation of electrical equipments in hazardous areas should be as per the area classification.

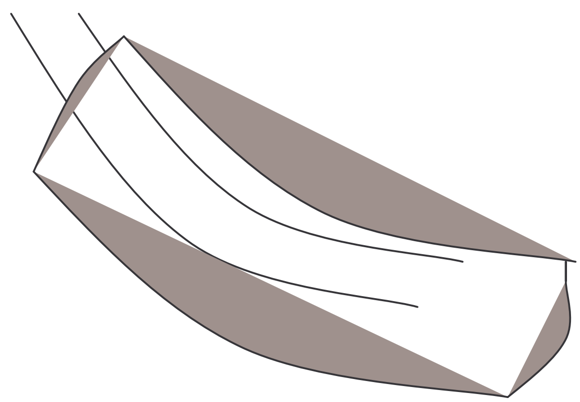
The areas in power plants, which are prone to fire accidents of this sort, are:

- Boilers
- Tanks and cylinders that store hazardous fuels including the pipelines
- Hydrogen cooled generator housing and
- Battery rooms

It is to be ensured that the hazardous area classification be strictly adhered to during the plant expansion / modifications. A comprehensive Management of Change procedure would take care of this.

4.8 Special Protection

High-pressure oil lines of the turbine generator system should be run within another pipe so that the outer pipe will contain the oil from a high-pressure leak. Where it is impracticable to secure adequate separation between hot steam lines or parts and oil pipes, the oil lines might be encased within a metal duct or baffles might be installed to deflect oil away from hot surface that might cause ignition.



4.9 Use of Fire Retardant Low Smoke (FRLS) Cables

Use of FRLS cables are to be made a procedural requirement. All the maintenance activities including the contracted functions should be monitored and ensured that any replacement / new wiring is done with FRLS cables.

4.10 Fire Water Disposal

Adequate care / provisions should be taken during design of fire protection system for disposal of firewater. When large quantity of water is applied along with foam / other fire fighting compounds and if these pipelines are connected to the public drainage system, the problems of enviromental pollution and liability may arise.

5.0 Conclusion

> The first duty of business is to survive and the guiding principle of business economics is not the maximization of profit, it is the avoidance of loss.
>
> **- PETER DRUCKER**

The review of the fire incidents in power plants suggests that adequate built-in safety systems and adherence to safe operating and maintenance procedures would help in ensuring a safe operation of a power plant and continuity of power supply to the consumer. The loss control initiative suggested in the paper would act as a guideline in implementing the loss control system for a power plant.

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