Experimental Investigations to Optimize the Utilization of Energy Resources

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Abstract: - In world more than 65% of non-renewable fuels are consumed by thermal, gas, nuclear, diesel power plants and process industries. They emit huge amount of pollutants and skew up large quantities of ash in to environment causing pollution and lead to adverse effects on the environment. Hence, it is absolutely necessary to tackle this menace. The renewable energy resources shall provide more than half of our energy requirements by the middle of this century. Our country will need many more professional people with thorough knowledge of the renewable energy resources, physical and technological principles, their economics, their environmental impacts and integration with the world energy systems, potentials for world energy requirements. Present study has been carried out to identify the potential of energy resources in the global and Indian energy scene. Driven by the rising population, expanding economy, search of improved quality of life, energy usage is expected to be doubled by 2008. The power sector needs to solve the series problem of energy shortfall. The power sector of developed countries needs to utilize the energy resources by using optimality conditions for sustainable energy development. The important elements which have been discussed during the power plant management are power production and quality management system and standards (PPMS), power plant resource planning (PPRP), power plant environmental impact assessment (PPEIA) and management plans (PPEMPs), safety by management objectives (SBMO), disaster management and mitigation in power plants, maintenance management, power training and software tools. The study covers uneven distribution of energy resources, technological considerations on losses encountered during generation, distribution and appropriate mixing strategies of resources, their optimality conditions, environmental pollution and mitigation. This will lead us to take national policy decisions, integrative actions for generation and distribution of power and enable us to plan out equal power production towards sustainable energy development in our country.

Key-Words: - Environment, Energy, Management, safety, Resources

1 Introduction

World's human population is ranging 10-12 billion. Out of which, the population in India alone is nearly one billion. They need to be provided with adequate energy supplies cleanly, safely, and sustain ably. The energy consumption in India is 3% of the global level which ranks sixth in terms of energy demand accounting for 3.5% of world commercial energy demand. Power is the basic necessity for the economic development of a country. The production of electrical energy and per capita consumption is an index of standard of living in any nation. Development of heavy and large-scale industries/medium, small scale, agriculture, transportation totally depend on electric power generation. The basic energy sources for generating electric power are thermal, hydro and nuclear. That is most of the energy we use are from sources like coal, oil, natural gas and nuclear fuels[2]. These are commercially viable sources for large scale production of electrical energy. These primary energy non-renewable resources will be no more available after 200 years on earth. The sources which are being used to overcome the energy crisis are non-conventional renewable inexhaustible solar, wind, hydro, tidal, wave, biomass, biogas, geothermal, ocean thermal energy resources. However these resources are commercially not viable in developing countries, because of the productivity and quality of electric power does not cope up with the present requirements that is per capita energy consumption and demand is considerably to be a costly affairs. For example for the developed countries like USA, power production in million kW is 600-700 and per capita energy consumption is 9000 to 10000 kWh. On the other hand for the developing countries like India the power production in million kW is 80-90 and per capita energy consumption in kWh is 900 to 1000 which is ten times lesser than the developed countries [1]. Developed countries like USA, Germany etc. have 1/5 (20%) of the world' s population are responsible for consuming 4/5 (80%) of the world's goods and services and uses more than half of the world's energy. Developing countries like India, China have 1/5 of the world population consumes only 10 % of the world's goods and services and accounts for 5% of the energy consumption. The per capita annual energy consumption in the USA is 8.80 Tonnes Oil Equivalent (TOE) .

The per capita annual energy consumption in India is 0.32 TOE.

The global average is 1.68 TOE.

India's Per capita consumption of energy is 310 KGOE (kg of oil equivalent)

China's Per capita consumption of energy is 779 KGOE.

Thailand Per capita consumption of energy is 319 KGOE.

Brazil Per capita consumption of energy is 1051 KGOE.

Japan 's Per capita consumption of energy is 4011 KGOE.

USA's Per capita consumption of energy is 7861 KGOE.

The power sector of developing countries needs to solve the problem of energy shortfall. The power sector of developed countries have to utilize the energy resources in optimality conditions for sustainable energy development. Hence professional people involved in the power plant sector need to study the energy resources by systematic identification, studying the existing resource conditions, comparison with the standards, prediction, assessment, and evaluation of quality power production and incorporation of mitigation measures for proper mixing of various power plants to optimize the usage of energy resources using the state-of-the art technologies. They need to utilize optimum energy resources for production and delivery of power by using innovative technologies. The optimum selection of power plants for mixing strategies depend upon improved technologies available, plant size, power production and energy utilization, rate of pollution, power availability, energy generation cost, transmission cost, operation and maintenance cost. This research paper highlights the relevant information on improved technologies available for optimum utilization of energy resources. These strategies will certainly help professional people to utilize the present resources of energy with utmost care in the global and Indian levels with maximum efficiency and thus required electrical power can be supplied at the cheapest rate to cope up the per capita energy consumption and sustained energy development [2].

2 Problem Formulation

2.1. Global and Indian Energy Scenes

The energy resources of a country change with respect to time, technology, economic conditions and new discoveries. Under present conditions, India's major commercial energy resources are coal, gas, hydropower and nuclear fuels and non-commercial energy resources include firewood, vegetable waste, cow dung and charcoal. Recent technological advances have aroused considerable interests in alternate type of energy resources such as solar energy, geothermal energy, tidal power, ocean thermal power, wind power and wave power .

The sources of energy is given below;

Table 1 . Sources of Energy

Derived from	Sources	Classification
1. Name	Coal, Oil, Gas Solar, Wind, Wave & Biogas, biomass, ocean	Conventional Non – conventional
2. Heat stored in the earth	Geothermal	Non-conventional
3. Nucleus of Atom	Fission and Fusion	Conventional
4. Pull of the moon	Tidal	Non-conventional
5. Water potential energy	Hydropower	Non-conventional

One of the mega missions to transform our country into developed country is reliable and quality electric power. India consumed 3% of world energy consumption despite having 17% of global population. The energy consumption will be doubled by 2010 that is 17 X 10^{11} units/ annum.

This study reveals that systematic identification of the potential of all resources in the global and Indian Energy scene for optimum usage in power plants.

2.1.1 Coal

The most important commercial energy available in India is coal and is the largest source available in the country. The coal deposits are found mostly in Bihar with nearly one third of the total reserve of the country. Orissa and Madhya Pradesh also have deposits of coal. As per the survey conducted in 2004, India's coal reserve has been estimated as 300 billion tones. Lignite reserves are estimated to be around 10 000 million tones as on 2004. Of these nearly 6 500 million tones are located in Neyveli in Tamilnadu, Pondicherry, Rajasthan, Gujarat and Jammu & Kashmir.

Some of the coal fed thermal and coal gasified combined cycle power plants in India is given below:

Table 2 . Combined Gas Power Plants

Name, Location	Capacity (MW)	Combined gas cycle
1. Neyveli thermal power station – Tamilnadu	1000	100 MW
2. North Chennai power station – Tamilnadu	630	100 MW
3. Ennore thermal power station – Tamilnadu	450	100 MW
4. Korba Thermal power station – Madhya Pradesh	2100	100 MW
5. Nagpur Thermal Power Station - Maharastra	700	100 MW

2.1.2 Oil

Oil is an important source of energy [1]. In India, oil is produced in two sedimentary basins, those of the Assam Arakan basin occupying parts of Assam extending to Nagaland, Meghalaya, Tirupura, Manipur and Mizoram and Gujarat basin. Important fields in these areas are Naharkotiya and Ankleshwar as well as Bombay High Offshore region. The potential of Bombay High wells has been estimated at 20 million tones per year. India's annual requirements of oil is about 75 million tones. Recently reserves of petroleum have been discovered in the foothills of Himalayas, Sunderban region of West Bengal, Coastal Orissa, Andhra Pradesh, Tamilnadu and Kerala.

2.1.3 Natural Gas

The natural gas is another important source of energy used in domestic, industrial and commercial sectors. In India, production of natural gas has increased from 12.78

billion cubic meters in 1988 to 17.98 billion cubic meters in 1996 and 25.05 billion cubic meters in 2003. The proved recoverable reserves of natural gas in India was estimated to be 686 billion cubic meters in 1990 and 1200 billion cubic meters in 2003. The present indications are that the production will increase and that the reserves of gas will last longer than oil.

Table 3. Energy available from non-renewable energy resources

Resources	Energy	Percentage	Balance resource Availability
Coal and lignite	200 X 10^{21} J	85%	250 years
Natural gas	9.5 X 10^{21} J	5%	150 years
Petroleum	11.7 X 10^{21} J	5%	30 years
Uranium	13.7 X 10^{21} J	5%	50 years

Table 4 . Global and Indian patterns of energy and their usage.

Types of fuels	Energy usage in Global pattern , %	Energy usage in Indian Pattern , %
1. Oil	37.5 %	30.2%
2. Gas	24.3 %	7.8%
3. Coal	25.5%	55.6 %
4. Nuclear	6.5%	1.4%
5. Hydro	6.3%	5.2%

The above table shows that 90% consists of fossil fuels included are oil, gas and coal.
India has only 0.8% of the world's oil and natural gas and rest of the oil & gas requirements are imported .
So far, our national effort in the development and application of renewable energy has not yielded any result of significance. With imported technology, some wind power firms are coming up but the total capacity in the national context is negligible. India has got hydro and nuclear potential. Technology for the design of thorium based reactors and fusion reactors are yet to be investigated.

Table 5. Wind energy generation countries in the world with their generation capacities

Country	Generation capacity, mega – watt
Germany	10650
United states	4329
Spain	4039
Denmark	2515
India	1507
Italy	755

The table depicts the top six wind energy generator-countries in the world;

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Table 6. Indian and global energy resource scenario

Types of Resources	World Potential	Indian Potential	Harness Capacity & installed capacity
Coal	5 X 10^{12} T	85 000 Million tones	115 000 MW @ 630 MW
Petroleum	0.4 X 10^{12} KL	40 000 KL	1000 MW/ @630 MW
Water potential	3 X 10^{6} MW	84 000 MW	53040 MW/ @360 MW
Nuclear reserve (Thorium and uranium)	3 X 10^{5} T 50 000- 80 000 T	33 000 MW	7072 MW/@ 470 MW
Solar energy	1.8 X 10^{11} MW	200 000 MW	1000MW/@ 20 MW
Wave energy	140 000 MW	40 000 MW	1000MW/ @20 MW
Wind energy	16 X 10^{6} MW	30 000 MW	992 MW/ @ 720 MW
Tidal energy	64 000 MW	1500 MW	@ 600 MW
Geo thermal energy	62 000 MW	1000 MW	@20 MW
Ocean thermal energy	70 000 MW	Under investigation	Under investigation
Bio-gas energy	80 000 MW	1 500 MW	1500 MW/ @ 100 KW
Gas energy Integrated gasification combined cycle	50 000 MW	5 000 MW	@120 MW/ @1500 MW @100 MW

Given below conversion factors have been used for identifying the potential of resources :

1 kWh of electricity = 0.096 m^3 of gas , 0.0001 ton of coal
1 Ton of petroleum = 1.64 T of coal = 12 300 kWh of electricity = 1.170 m^3 of natural gas
1 ton of coal = 7.285 kWh electricity
1 ton of kerosene = 1.68 ton of coal
1 m^3 of fuel oil = 1.539 ton of coal
1 kg of propane = 0.002 ton of coal

2.2. Energy Economics

The ratio of energy consumption to GDP is defined as the energy intensity of the economy. Our economic development is depending on population growth, economic development, and technological progress; GDP growth occurs through an increase in population; with a demand for housing, transportation, consumer goods, and services thus increase in energy consumption[1]. With a GDP growth of 8% set for the 2020 , the energy demand is expected to grow at 5.2%. GDP growth is parallel to energy consumption;

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Table 7. Estimated energy demand

Primary Fuel	**Unit**	**Demand (in Original Units)**		**Demand (MTOE)**	
		2006-07	**2011 – 12**	**2006 – 07**	**2011-12**
Coal	Mt	460.50	620.00	190.00	254.93
Lignite	Mt	57.79	81.54	15.51	22.05
Oil	Mt	134.50	172.47	144.58	185.40
Nature Gas	BCM	47.45	64.00	42.70	57.60
Hydro Power	BkWH	148.08	215.66	12.73	18.54
Nuclear Power	BkWH	23.15	54.74	6.04	14.16
Wind Power	BkWH	4.00	11.62	0.35	1.00
Total Commercial Energy				411.91	553.68
Total Non-Commercial **Energy**				151.30	170.25
Total Energy Demand				563.21	723.93
Mt: Million Tonnes: BCM : Billion Cubic Meters ; Billion Kilo Watt Hours .					

Table 8. Geographical spread of primary commercial energy resources in India

Region	**Coal (Bt)**	**Lignite (Bt)**	**Crude Oil (Mt)**	**Natural Gas (BCM)**	**Hydro ower (TWH)**
Northem	1.06	2.51	0.03	0.00	225.00
Western	56.90	1.87	519.47	516.42	31.40
Southern	15.46	30.38	45.84	80.94	61.80
Eastern	146.67	0.00	2.19	0.29	42.50
North-Eastern	0.86	0.00	166.17	152.00	239.30
Total	220.98	34.76	733.70	749.65	600.00
Bt: Billion Tonnes; BCM : Billion Cubic Metres; TWH ; Trillion Watt Hours ; Mt; Million Tonnes					

Table 9. Renewable energy sources potential

Source / Technology	**Units**	**Available Potential**	**Actual Potential**
Bio – Gas	Million	12	3.22
Bio – mass – based Power	MW	19 500	384
Efficient Wood Stoves	Million	120	33.86
Social Energy	MW/Km^2	20	1.74
Small Hydro	MW	15 000	1 398
Wind Energy	MW	45 000	1 367
Energy Recovery from Wastes	MW	1 700	16.2

Table 10. Trends in commercial energy production during the last four decades

	Unit	Production in Various Periods					
		1960-61	1970-71	1980-81	1990-91	2001-02	2006-07
Coal	Mt	55.67	72.95	114.01	211.73	325.65	405.00
Lignite	Mt	0.05	3.39	4.80	14.07	24.30	55.96
Crude Oil	Mt	0.45	6.82	10.51	33.02	32.03	33.97
Natural Gas	BCM	-	1.44	2.35	1.79	29.69	37.62
Hydro Power	BkWh	7.84	25.25	46.54	71.66	82.80	103.49
Nuclear Power	BkWh	-	2.42	3.00	6.14	16.92	19.30
Wind Power	BkWh	-	-	-	0.03	1.70	4.00
BkWh : Billion kilo watt hour , BCM; Billion cubic meter							

Table 11. Trends in supply of primary commercial energy during the last four decades

Source of Energy	**Production in Various Periods**					
	1953-54	1960-61	1970-71	1980-81	1990-91	2001-02
Coal	23.62	35.64	36.48	56.96	94.68	133.89
Lignite	-	0.01	0.81	1.23	3.34	6.52
Crude Oil	0.19	0.46	7.01	10.79	33.92	32.03
Natural Power	-	-	0.60	1.41	11.73	26.72
Hydro Power	0.24	0.67	2.17	4.00	6.16	6.37
Nuclear Power	-	-	0.63	0.78	1.60	5.15
Wind Power	-	-	-	-	-	0.14
Total	24.05	36.78	47.67	75.19	151.43	210.82
Net Imports	2.20	6.04	12.66	24.63	31.69	87.85
Commercial Energy Supply	26.25	42.82	60.33	99.82	183.12	298.67
Primary Non-Commercial Energy Supply	64.13	74.38	86.72	108.48	122.07	139.02
Total Primary Energy Supply	90.38	117.20	147.05	208.30	305.19	437.69
Provisional						

Table 12. Share of net energy imports in primary commercial energy sector

Year	**Coal**	**Petroleum oil and lubricants (POL)**	**Electricity**	**Total**
1980-81	0.25	25.45	-	25.70
1990-91	2.22	15.56	0.07	17.85

2001-02	4.12	26.25	0.04	30.41

Table 13. Energy savings potential during the tenth five- year plan

End-use Type	Potential Energy Savings, MkWh
Motors and drive systems (Industry and agriculture sector)	80 000
Lighting (domestic, commercial and industrial sector)	10 000
Energy intensive industries	5 000
Total	95 000

Table 14. Present energy availability scenario as on January 2005

Sector	1998	2004	Increase, %
Generation, kWh	422	531	25.85
Capacity, MW	89 167	1 079 73	21.0
Power Load Factor, %	64.7	72	7.4
Transmission Line, circuit km	1 23 267	1 58 484	28.5
Trade, MW	2 600	8 000	207.0
Outlay, Rs. (in crores)	8 180	14 667	79.0
Consumers. Nos. (in crores)	9.3	11.4	22.5
Pump Sets	1 18 49 406	1 37 92 420	16.5
Investment, Rs. (in crores)	1 24 526	2 36 625	90.0
Energy Shortage, %	-	8.0	-
Peak Shortage, %	-	14.0	-
Electrification			
	Overall	Urban	Rural
	42.7%	75.8%	30.4 %
Rural Electrification			
Bihar: Jharkhand: Uttar Pradesh:	5% villages 10% villages 20% villages		

3 Problem Solution

3.1 Combined Cycles

A Combined Cycle is a combination of cycles operating at different temperatures and pressures, each being operated independently.
The higher temperature cycle is known as topping cycle and the lower temperature cycle is known as bottoming cycle.

Various energy conversion processes and their thermal efficiencies are given below.

Table-15. Thermal efficiencies of the various power plants

Sl.No.	Power Plant	Efficiency
1.	Steam power plant	20 to 30%
2.	Simple Gas turbine power plant	20 to 25%
3.	Nuclear power plant	30 to 32%
4.	Diesel plant	35 to 42%
5.	Combined cycle power plant	50 to 55%

It is the combination of simple Gas turbine power plant and steam power plant. Here, the Gas turbine unit is similar to that in a simple gas turbine plant. However, the exhaust is not wasted into the atmosphere. The heat is recovered in a heat recovery boiler and the steam so generated is supplied to the steam turbine unit for further production of power. Thus, substantial energy recovery is achieved through this system.
The thermal efficiency of combined cycle power plant is about 55%. The combined cycle power plant using natural gas are being installed in Gujarat. Maharashtra, Rajasthan, U.P. Karnataka has planned for capacity of 14,000 MW by the year 2006.

The following salient features in the combined cycle power plant have been incorporated .
Coal gasification,
Modeling and simulation studies
Design of various modern heat exchangers
Reactor columns
DAS software
Process plant operations
Pneumatic and electronic filed sensors
Design of digital distribution systems
Transmitters
C++ softwares systems

3.2. Power Plant Resource Planning (PPRP) – A Software Tool

What is PPRP?

PPRP is a software that helps to integrate nearly all the functions of power plant organization, enabling to plan, track and see its Resources ‘6 M’s; in the best possible way to receive its customers [3].
The Resources ‘6 M’s are [1] Men
[2] Machine
[3] Method
(4) Material
(5) Money
(6) Market
PPRP effectively integrates the islands of information within the organization.
Why is PPRP Required?
Speed of the business
Study of treadmill of business environment
New realities in business
Approach to PPRP Implementation - A Road Map
Road Map for successful implementation of ERP in companies are
Clear Management commitments
Top class PPRP leadership
PPRP only after process improvement
Training to implementation task force and user group
Right choice of PPRP packages
Four options for developing PPRP Packages
Developing an own PPRP package (in-house development)
Modifying and enhancing the capabilities of the existing system
Buying readymade package
Engaging a software company

Correct approach to PPRP

The options are strategic decisions and need a substantial capital investment. Right option is to be selected only after evaluating the cost-benefit analysis.

3.3 Power Plant Environmental Impact Assessment (EIA)

EIA is a systematic identification and evaluation of potential (effects) impacts of proposed projects, plans, programs, legislative actions relative to physical-chemical, biological, cultural, socio-economic conditions of the total environment [3].

It is a planning and decision making process which involves 3 'E's namely engineering, economics and environment.

Prediction and assessment of impacts is carried out through the following steps.

Identification of impacts

Preparation of description of existing resource conditions

Procurement of relevance quality and quantity standards

Impact prediction

Assessment of impact significance

Identification & incorporation of mitigation measures

3.4 . Power Production And Quality Management Systems

Power production and quality management systems (PMS) is a continual cycle of planning, implementing, reviewing and improving the activities which a power plant organization does to meet its obligations.

PMS is a systematic approach for managing the power production and quality. The essential characteristic of a PMS is that its various components interact to provide measurable information enabling continual improvements. The systematic approach means that the processes are stable and repeatable, yield more predictable outcomes and adopt new learning to continual improvement.

The standards, which describe the elements of a management system that can be expected to deliver continually improving the performance.

1.Managing their interactions with the power production in a more effective, systematic manner.

2.Saving money and staff time required to manage production and quality of power in the power plant

3.Relating effectively to the communities and stalk holders

4.Improving the image among customers and stalk holders

5.Engaging in a process of continuous learning

Necessary standards are required on power plant management systems to assist all the levels of management and to assist in achieving the performance, enhancing internal management system efficiency, optimum utility of resources and anticipating regulatory / legal requirements.

Power plant management standards (PPMS)

The power plant management system should cover the following areas ,

PPMS –1: PPMS management systems

The formal elements of a power plant management system include policies, planning, implementation, verification and management review

An organization structures, responsibilities and accountability

Implementation systems and operational controls

Measurement and auditing systems

Systems for periodic management reviews of the PPMS

PPMS code-2: General guidelines for developing and implementing PPMS

PPMS code-3: power plant auditing principles and guidance

PPMS code-4: power plant performance evaluation guidance

PPMS code-5: power plant -labeling guidance

PPMS code-6: Life cycle assessment principles and guidance

PPMS code-7: Terms and definitions

PPMS code-8: Inclusion of power plant technical aspects in standards (Guide)

Key systems components in PMS

1.A power policy statements actively promoted by senior management
2.Planning process oriented toward integration of all events of the management
3.Well defined organizational structure, role and responsibilities and accountability
4.Implementation systems and operational controls
5.Measurement and auditing systems
6.Systems for periodic top management review of the PMS
Cost and benefits of PMS

The actual benefits will depend on the degree to which management is willing to invest time and specific resources toward a full implementation of PMS.

Operational costs savings
Public participation and relations benefits
Potential employee and community relations benefits
Framework of PMS

The key elements of a PMS consistent with the requirements of the PMS specifications. The PMS framework has five major sections, which are organized with the plan, do, check, act, model, which are the planning process, power policy, checking and corrective action, PMS implementation and operation, and management review.

3.5 Maintenance Management in Power Plants

Importance of proper repairs, operation & maintenance of power plants
Reduces the Manufacturing cost
Reduces the downtime
Reduction in Idle time of machines
Reduction in idle time of man
Minimum Breakdown
Provide good working condition
Provide almost Safety condition
Optimum production capacity
Upkeep and repair of machines
Testing and inspection for wear and tear
Lubrication, cleaning and timely inspection
Provide for the Salvage
To predict the obsolete of the old equipments
For replacement analysis
Periodic maintenances further reduction in maintenance cost.

Mechanical failures and improper handling, improper operating conditions in power plants may be disastrous. Proper operations, repairs, overhauling and inspections are to be carried in such a way that no mechanical failures, proper handling and proper conditions facilitate the safety in power plants industries (4).

3.5.1 Trouble shooting

A power plant engineer/ technician need to investigate thoroughly the maintenance, operation, repair and overhauling of the power plants equipments by identifying the problems, preparing the necessary trouble shooting statements, predicting, analyzing and evaluating the problems thereof using procedures and systems and need to solve the problems by incorporating the mitigation measures.

3.5.2 Inspection

1. All parts open and closed are inspected for wear and tear. 2. Worn out / unworkable components are removed. 3. Necessary settings, adjustments to be done. Proper lubrication is to be provided. 4. Various fasteners to be tightened, 6. All parts are to be inspected for wear and tear. 7. All safe guards are to be checked.

3.5.3 Repairs

1. All repairable parts of the system after inspection are corrected for small repairs and minor defects are rectified. 2. Systems like open systems may be repaired. 3. All aircraft engine components are to be adjusted and repaired as per the conditions.

3.5.4 Overhauling

1. Dismantling the assembly and replacing the systems such as damaged components may be replaced and various sub mechanisms are to be aligned / adjusted, 2. All the systems are completely dismantled. 3. Components, worn-out and beyond repairs are replaced. Structures and safety guards may be repaired as the conditions, 4. Cleaning, inspection, tightening up and readjustment minor replacements , 5. Adjustments and checking

for proper functioning and efficiency, 6. Planned and scheduled reconditioning and reassembly including replacements are preformed.

Process-I: Inspection and checking of parts

Process-II: There adjustments repairs, and replacement

3.5.5 Repair cycle

Typical Repair cycles for a power plant system need to be followed as per the repair cycle mode.

Repair cycles involves 15 inspections (I), 4 repairs(R), 1 overhauling (O) which are given below:

The repairs cycle follows:

I-1, I-2, I-3, (1 to 6 months), I-4, I-5, I-6, I-6, R-2, I-7, I-8, I-9, R-3, I-10, I-11, I-12, R-4, I-13, I-14, I-15, O-1

"I" denoted Inspection, "R" denotes Repairs, "O" denotes overhauling

3.5.6 Types of maintenance

A power plant is maintained on the basis of the following maintenance practices.

3.5.7 Breakdown maintenance

Maintenance that can be done after break occurs[2]. This type of maintenance is performed due to unpredictable failures of system components, which cannot be prevented. This is done due to gradual wear and tear of the parts and breakdown takes place. The defects are rectified when components cannot perform its function and longer performance. This maintenance practices are very expensive due to idleness of power plant .

Preventive maintenance

The power plants systems are maintained on the basis of prediction or periodic checking. This ensures the following checks. 1. Reduction in maintenance cost, 2.To locate the sources of troubles and solve the problems before breakdown, 3. Inspection, lubrication, checking up finding the breakdown costs, idle time of machine is less and avoiding breakdowns, 4. Maintaining the quality and ensures proper conditions, 5. Ensures minimum wear and tear, 6. Ensures safety and minimized the accidents and disasters, 7. Ensures maximum efficiency

Scheduled maintenance

Inspection and lubrication activities are preformed at predetermined schedules. This type of maintenance is also called as planned and scheduled maintenances:

Predictive maintenance

It makes the use of human senses. The instruments used are namely audio gauges, vibration analyzer, noise monitoring meters, strain gauges, checking for hand touches and for unusual sounds.

3.6 Safety By Management Objective In Power Plants (SBMO)

Achievement of a safe and healthy work place is the responsibility of the institution, the industry manager, the supervisory personnel and finally of the industry personnel themselves. All power plant employees must make every effort to protect themselves and their fellow workers. The manager should realize that accidents have causes, and therefore can be prevented buy a good safety program.

The enactment of worker's compensation and occupation-disease laws has increased materially the cost of insurance to power plant industry. The increased cost and the certainty with which it is applied have put a premium on accident-prevention work. This cost can be materially reduced by the installation of safety devices. Experience has shown that approximately 80 percent of all power plant accidents are preventable [3].

Planning involves decision-making in advance taking due account of the constraints and priorities resource available.

3.7 Formulation of Safety Policies

Policies are the basic guidelines which dictates the thinking style as well as the actions to achieve the desired goals /objectives.

Principles, rules/norms to be adopted by the management

Target , authorities, norms and standards
Formation and functioning of safety committees.
Safety personnel, scope and responsibilities
To provide suitable base for coordination of safety activities in the various levels
To provide cogent, coherent and distinct objectives of goals
To provide fruitful cooperation to translate safety activities into action at all levels
To provide effective platform for initiation and motivation in the field of safety
Provide a course of action which can ensure the accepted norms of safety are not violated.
Proactive measures to prevent accidents
Safety by management objective (SBMO)
Use of personal protection equipments
Incorporation of safety devices, machine guards and appropriate material handling systems
Proper training to operators and innovative training facilities to adopt to the machine requirements and to safeguard from disasters.
Maintenance of a proper working environment
Proper operation, repair and maintenance of the power plants , premises and appurtenant structures, plants and equipments .
Proper planning and designing at the grass – root level.
Proper supervision, checking and inspection of the various processes relating to industrial complexes .
Proper checking of the materials, so that sub- standard materials are weeded out.
By insisting the concept of safety in the workers and the management through safety consciousness programmes, e.g. safety weeks, Safety slogans, safety campaigns, safety quizzes etc.,
Documentation of the accident measurement and control
Induction of safety management
Emergency preparedness programme and control centers
Disaster management and mitigation

3.8 Disaster Management and Mitigation in Power Plant

Disasters causing damage to human life, property, infrastructure and economy. Requisite safety measures have to be provided for such hazards [3]. Prevention is better than cure. Once disaster occurred, it is very difficult to handle and control it. Hence proper planning shall always handle and mitigate the various kinds of disasters effectively, for which open, transparent and efficient systems have to be followed. There is a need for systematic identification, preparation, prediction, assessment, evaluation of disaster events and incorporation of mitigate measures. Disaster management is a sequential and continuous process planning. The disaster management must also involve co-ordination activities about disaster events with all participatory sectors. The officials of the participatory sectors must be imparted specialized on-campus and off-campus training in the emerging areas of disaster management modules.

4 Conclusion

The present research has been carried out to identify the potential of all energy resources in the global and Indian energy scene. This has facilitated to find out solutions on appropriate mixing requirements and strategies for optimum utilization of energy resources using the innovative technologies by the power industries and thus power produced can be cheaper which will help to grow the industries. The power sector of developing countries needs to solve the series problem of energy shortfall. The power sector of developed countries need to utilize the energy resources in optimality conditions for sustainable development in the world. The study also emphasizes by the power industries for systematic identification, studying the existing resource conditions, preparation of documents, comparison with the standards, prediction, and assessment, evaluation and production of quality and reliable power and incorporation of mitigation measures for proper mixing of various power plants to optimize the usage of energy resources using the state-of-the art technologies. The optimum selection of power plants for mixing strategies depend upon improved technologies available, plant size, power production and energy utilization, rate of pollution, energy generation cost, transmission cost, operation and maintenance cost. The important elements which have been discussed during the power plant management are power production and quality management system and standards (PPMS), power plant resource planning (PPRP), power plant environmental impact assessment (EIA) , management plans (PPMPs), safety by management objectives (SBMO), disaster management and mitigation, maintenance management and software tools. The study covers with special reference to the uneven distribution of energy resources, the various technological considerations on losses encountered in power generation as well as distribution and also appropriate mixing strategies of these resources considering optimality conditions including the mathematical modeling of energy functions for mixing of power plants. This will facilitate to take national policy decisions and integrative actions for generation and distribution of power and planning of equal power development in all States lead to sustainable energy development in our country.

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