

Effect of Planned Preventive Maintenance Application on the Performance of Egbin Thermal Power Station

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Abstract

This paper surveys the performance of gas-turbine plants in Egbin Thermal Power Station and evaluate the effect of planned preventive maintenance on the performance of egbin thermal power station.Today's economic climate requires that industries aims at achieving maximum production capability, while minimizing capital investment through quality and routine maintenance structure. Performance assessment was embarked upon to analyze the current situation of the power station. Overall equipment effectiveness model (OEE) approach which comprises of availability rate, performance rate, and quality rate, was used to carry out this work. The investigation revealed that among the five years duration used for this study 2005 has the maximum average availability rate, performance rate and quality rate of 95%, 87% and 81% respectively, which indicate that impact of maintenance policies was encouraging at that year. Further studies show that the low rate of the subsequent years was caused by the shutdown of unit-6 due to shaft bending.

Keyword:OEE (Overall Equipment Effectiveness) Model, PPM (Planned Preventive Maintenance), Steam Power Plant, Availability & Performance rate, Reliability & Failure rate.

Introduction

Energy is one of the major building blocks of modern society. Energy is needed to produce/manufacture goods and services from natural resources and to provide many of the services we have come to take for granted. Economic development and improved standard of living are complex processes that share a common denominator, the availability of an adequate and reliable supply of energy. Electrical energy pervades all sectors of the society such as banking, agriculture, industries; education e.t.c. Energy supplies are key limiting factor to economic growth. We have become a very interdependent world and access to adequate and reliable energy resources is central for economic growth (Ausubel et-al, 1989).

The inefficiency performance of NEPA was as a result of many factors within and outside its control. On the part of NEPA, Poor workers attitude to work, Poor policies and corruption were identified. The consumers' illegal and unpatriotic activities were another. Power supply is a social responsibility of government to its citizens and should remain so. (Lawal, 2005)

Due to the basic that availability of electricity is one of the main key to national growth, since these premises must be supplied constantly to attain global level, a maintenance policy must be concretely strategized to regulate it.

Maintenance costs have risen steadily over recent years in proportion to total investment. Simultaneously, the growth of mechanization and automation means that reliability and availability have become key issues in the Nigerian power-industry.

In the Nigeria electric-power industry. Maintenance costs over 70% of the total production expenditures. Unplanned downtime has resulted in lost electricity-generation and requires resources to be diverted to get the system running again, i.e., lower profitability occurred. Therefore, electric power stations are facing major challenges to shorten downtimes and reduce maintenance costs per MWh of output. In order to improve the maintenance schemes that are implemented, self-assessment of the existing maintenance process and schedules have to be conducted (Eti et al, 2005). The study made emphasis that the main purpose of an in-house self-assessment is to identify activities in need of improvement by analyzing the current situation, partly by internal and external benchmarking, which is a key tool for improvement and raising productivity.

It will be difficult to make any improvement on performance of any machine or equipment without performance assessment which led this research to the understudy of operation and maintenances of a power plant. That is the main reason this study focuses on the power plant major component parts and their respective auxiliaries, because if any equipment developed any fault it will definitely affect the particular unit involved which result in downtime (Maruben, 2006).

Methodology

The following methods were used to evaluate the performance analysis of Egbin Thermal Power Station.

PLANNED PREVENTIVE MAINTENANCE STRATEGY

Planned preventive maintenance can be carried out either if the equipment or system concerned is in service or out of service; these types of maintenance embedded four specific types of preventive maintenance which includes routine maintenance, preventive replacement, identification of dormant failure, and identification of degradation condition.

POWER STATION RELIABILITY MEASUREMENT

Reliability and Failure rate

One indicator of reliability ($R(t) = e^{-\lambda t}$) of an item is the rate at which the item fails and it is called failure rate. The number of failure occurring per unit time is known as failure rate. Failure rate λ (t) can be defined as the reciprocal of MTBF and can be express as follow,

One of the major parameter used to measure reliability is mean time between failures (MTBF). The mean time between failures is an extremely important characteristic in reliability predictions. It is applicable to repairable equipments.

According to R.H.Caplen (1972), MTBF can be defined as the mean value of the length of time which elapses between failures.

It can be computed base on two main types of test known as the non-replacement and replacement methods.

By replacement method, the MTBF, m of a system may be measured by testing it for a total period of time t_n (where t_0 = time that the test starts and t_n = time of the n^{th}failure or fault), during which n faults or failures occur. Each fault if repaired and the equipment put back on the test, the repair time being excluded from the total time T results in the observed MTBF given by m = T/n

$$m = \frac{[(t_1-t_0) + (t_2-t_1) + \ldots\ldots + (t_n-t_{n-1})]}{n}$$

$$= \frac{t_n-t_0}{n} = \frac{T}{n} \quad \text{--} \quad 1.$$

(If t_0 = 0 is the reference starting time)

Where n = number of failures,

t_0 = time of start of trial

t_1 = time to 1st failure

t_2 = time to 2nd failure

t_n = time to n^{th} failure.

T = total time of operation

It can also be express that MTBF is the reciprocal of failure rate.

i.e. MTBF, $m = 1/\lambda$ --- 2.

According to (Aigbe and Igboanugo, 2003) MTBF is the ratio of total time of operation to total number of failures.

$$MTBF = \frac{\sum_1^6 T}{K} \quad \text{--} \quad 3$$

MTBF of a power station can be express as summation of reliability from 1 to n. Since will using Egbin thermal station as a case study which consist of 6 units, then MTBF can be express as,

$$M_{ps} = \Sigma_1^6 R_{ps}(t)\, dt \quad \text{--} \quad 4$$

$$= R(t) = e^{-\lambda t} \quad \text{--} \quad 5$$

Where, M_{ps} = mean time between failure of the power station

R_{ps} = reliability of the power station

Conclusively, reliability of a power station can be evaluated with the help of MTBF tool, which definitely cause improvement in the performance of a power station, upgrade the maintainability and reliability of a power plant.

POWER STATION EQUIPMENT EFFECTIVENESS MEASUREMENT

Maintenance objectives can be achieved by re-engineering the process of delivering maintenance services. Commonly used maintenance indicator is the equipment performance, i.e. availability rate, performance rate and quality rate.

Overall Equipment-Effectiveness (OEE) model

Calculation of the OEEmodel

The product of loss rate with respect to availability, performance and quality is termed the resulting OEE and provides an indication of the performance achieved.

- Availability (operating rate) = $\frac{(\text{Total time} - \text{Downtime})}{\text{Total time}}$ --------------- 6 3.6

$$\sum_1^6 A = \frac{A1 + A2 + A3 + A4 + A5 + A6}{6}$$

A = availability rate
A_1, A_2, A_3, A_4, A_5, A_6 is the respective availability rate of unit-1, 2, 3, 4, 5 and 6.

- Performance rate = $\frac{\text{Total energy output}}{\text{Time}}$ ---------------------------------- 7

$$\sum_1^6 P = \frac{P1 + P2 + P3 + P4 + P5 + P6}{6}$$

P = performance rate
P_1, P_2, P_3, P_4, P_5, P_6 is the respective performance rate of unit-1, 2, 3, 4, 5 and 6.

- Quality rate (yield), Q = $\frac{(\text{Total energy production} - \text{Rejects})}{\text{Total energy production}}$ ---------- 8

Total energy production = Total Running Hour * 220Mw
.Rejects = Total actual energy production – Energy generated
Thus:
OEE = availability x performance rate x quality rate

$$OEE = \sum_1^6 A + \sum_1^6 P + Q \quad \text{--} \quad 9$$

Conclusively, reliability and effectiveness of the power plant can be determined with help of MTBF parameter and OEE model.
1-Year = 12 months,
12 months = 56 weeks,
56 weeks = 365 days,
1-day = 24hours,

1-year = 365 days * 24 hours = 8760 hours.

RESULTS AND DISCUSIONS

Performance Rate

Year	2005	2006	2007	2008	2009
Unit – 1	88	92	59	83	81
Unit – 2	91	80	80	64	95
Unit – 3	92	83	7.3	29	73
Unit – 4	93	84	82	80	81
Unit – 5	88	88	73	83	83
Unit – 6	98	15	0	0	0
Ave. rate	91.7	73.7	60.3	67.8	82.6
Max. rate	98	92	82	83	95
Mini. rate	88	15	7.3	29	73

The table above depicts the performance rate of Egbin Thermal Power Station from the year 2005 to 2009. Unit-6 has the highest performance rate of 98% in the year 2005, followed by unit-4, 3 and 2 with these respective rates 93%, 92% and 91% while unit-1 and 5 has the minimum rate of 88%. In the year 2006 unit-1 has the maximum performance rate of 92% followed by unit-5, 4, 3, and 2 with the rates of 88%, 84%, 83% and 80% while unit-6 has the minimum performance rate of 15%. It can be infer that there is a inhibiting factor responsible for insignificant result of the unit-6. Record shows that unit-4 has the maximum performance rate in the year 2007 then followed by unit-2, 5 and 1 with rates of 80%, 73% and 59% but unit-3 has the minimum rate of 7.3% which indicate poor output, while unit-6 is offline depicting zero performance rate. Unit-1 and 5 has the maximum performance rate of 83% in the year 2008, the rate descend to 80% for unit-4, 64% for unit-2 and 29% for unit-3 indicating the minimum performance rate while unit-6 remained offline. Record shows that unit-2 has the maximum rate of 95% in the year 2009, it descend to 83% for unit-5, 81% for both unit-1 and 4 while unit-3 has the minimum performance rate of 73% but unit-6 still in offline condition.

The average performance rate ranges from 91% to 60.3% between year 2005 and 2009. Record shows that year 2005 has the highest performance rate of 91.7%, 2006 has 73.7% , 2007 has the lowest average rate of 60.3%, 67.8% from 2007 to 2008 and 82.6% from 2008 to 2009. The insignificant and lower performance rate of the power station can be caused by internal militating factors such as the following;

- Turbine inlet steam temperature
- Turbine inlet steam pressure
- LP exhaust steam pressure and temperature
- Final feed water temperature
- Spray water flow etc.

The factors outlined above are explained in details in subchapter 2.10.

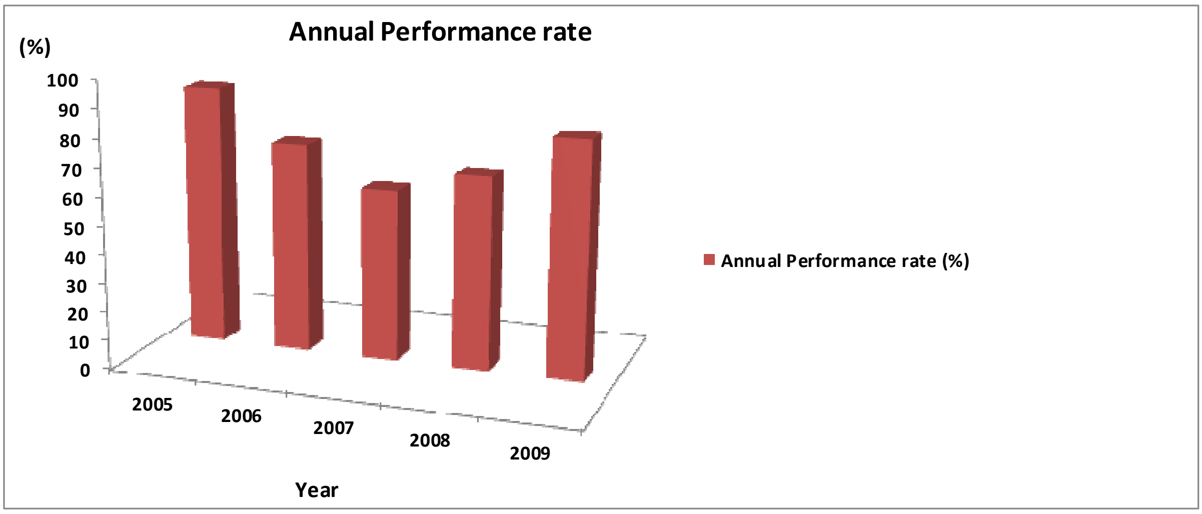

Figure 1. The above chart represents the power station performance rate for a period of five years

Overall Equipment Effectiveness

Year	2005	2006	2007	2008	2009
OEE (%)	71.1	41	18	37	29

The above table depicts the Overall Equipment Effectiveness of Egbin thermal Power Station which ranges from year 2005 to 2009. Record shows that in the year 2005, OEE has the maximum rate of 71.1% indicating the enormous impact of maintenance policy applied with a reduction in downtime. Though 2005 has the maximum rate but it can still be improve if internal assessment is embark on integrated with profound bench marking and refine the preventive maintenance policy used before final application. It unfortunate that OEE drastically reduced below average rate to 41% depicting the low effort and impact of maintenance policy applied from year 2005 to 2006. From year 2006 to 2007 the impact maintenance policy made is not encouraging as a nation planning to generate above 6000MWH, I believe maintenance personnel effort can be boost to arrest any factor responsible for this low output. Record shows that year 2007 has the lowest OEE rate. The rate increases to 37% from 2007 to 2008 and the subsequent year 2009 it decreases to 29% depicting the low impact of maintenance policy applied.

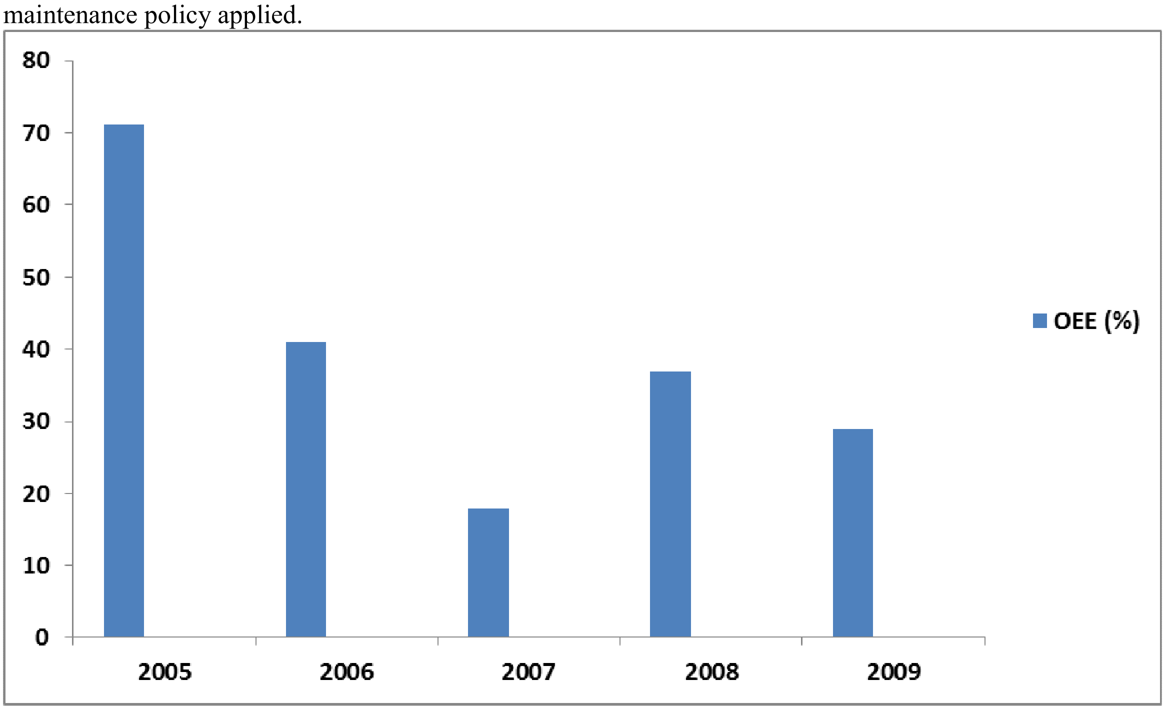

Figure.2. This chart represents the Overall Equipment Effectiveness of the power station from year 2005 to 2009.

The above chart depicts the impact of maintenance action applied on each year used in these studies.

Conclusion

A power plant performance analysis has been conducted at Egbin Thermal Power Station, Ijede – Ikorodu Lagos State. Results of the power plant performance analysis showed that among six units in the station only unit-4 has the highest total running hours of 36,726.7H for a period of five years (2005-2009), year 2005 has the highest total running hour and performance of the power station is at maximum in the year 2005. Performance evaluation shows that enormous impact of maintenance policy was applied on the power plant in the year 2005. Based on the performance analysis carried out in Egbin Thermal Power Station the following conclusions were arrived at:

- For over a five year period (2005-2009), an average annual availability rate is 95.7%, 94.3%, 80.2%, 80.5%, and 80.3%.
- The average annual performance rate from 2005 to 2009 is 91.1%, 73.7%, 60%, 67.8%, and 82.6%.
- The annual equipment effectiveness of the power station from 2005 to 2009 is 71.1%, 41%, 18%, 37%, and 29%.
- Analysis shows that among the three types of outages, forced outages is the most occurring one which greatly reduced the effectiveness of the power plant.
- The lowest total running hour was recorded for unit-6 from the year 2007 to 2009 due to shutdown of the unit which is traceable to shaft bending connecting the steam turbine and the generator.

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