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IMPROVEMENT OF THE RELIABILITY OF THE GENERATOR COOLING SYSTEM BY MODELING THE FAILURE PATTERN USING STATISTICAL ANALYSIS AND MINITAB: CASE STUDY NORTH BENGHAZI POWER PLANT

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Abstract

Generator cooling system in North Benghazi power plant considered one of the most important auxiliary systems like all the power plant in the word, using force convection method to cooling the generator means we need parts like motors, fans and pumps. This component and else in the system have to monitor and maintenance continually. Improvement the reliability of this system inverts positively on the power plant by decreases unexpected showdown and maintenance cost. The failure distribution pattern and the mechanical sign of failure such as noise vibration and temperature by expect failure time by study statistically the five years history have been studied in this investigation. It was observed that the normal distribution is fit failures pattern and the mechanical problems especially in the belt behind the most failure reasons of this system gave high noise as clear sign of failure start.

Keywords: *power plant, generator cooling system, failure pattern, statistical analysis*.

Nomenclatures

A: a , m^2
h_c: he tr cc , W/m^2k
Q: Cc he r , w
ΔT: d te ℃
x: ti , d
μ*: is the location parameter*
σ*: is the scale parameter*
∅(x): is *the Cumulative distribution function*
φ(-x): is Probability density function

1. Introduction

Whatever power plant types are dividing to main and auxiliary systems or components all of these systems or components are something important thing do to produce the electricity, problem on it means problem in availability of the electricity. Generator is classified as the main component of the power plant which we need to cooling from the heat generation from the excitation current passing through the winding. Generator cooling system is doing this job and it is classifying as the auxiliary system. Without expected failure and low maintenance operating cost during their duty we looking for determine reliability modeling for different types of thermal power plant can make a good decide to efficient maintenance strategies [1]. Difference maintenance strategies for difference systems gas turbine power plant depended on many factors like safety, machine importance for the process and failure frequency [2]. Least-Squares Curve-Fitting (LSCF) and Maximum Likelihood Estimator (MLE) techniques in identifying the failure distribution and the parameters of machine's component [3]. With unknown mathematical model we can using (MINITAB) program which offer different type of distribution to find fit function or model [4]. Air and hydrogen are the commonly liquid used to cooling a stator and a rotor of generator and Convection heat transfer is main mechanism considered [5] .noise , high vibration, and high temperature are a advanced warning that is in the process of failing, base to it can eliminate total machinery breakdown [6]. Two gas turbine unit from Siemens company type 4000F have the same operating condition installed in same location called (GT31 ; GT32), started work almost at the same time and have the same kind of generator cooling system, we note two thing first both system have fragrantly an expected problem during the year, and the second thing is the generator cooling system in GT32 has more problem than GT31.

The purpose of this study to expect failure time for the both units, clarify operation measurement which gave failure sign, furthermore the most failure cause.

2. System description

The air is the gas which used to cooled the generator where transfer the heat from the winding of generator to cold water by using the heat exchanger, using the close cycle to cooled the water from the heat absorbed from the air. outdoor system used for this duty consisted of:-

1) (Air / Water) heat exchanger: Electric-Resistance-Welded Carbon heat exchanger (SA214) used to cooling the dime water which absorbed the heat from the air inside the generator fig (1).
2) Low Voltage Three Phase motor: used as the driven motor to motivate the fan as per in figure 1.
3) Fans: (5052 aluminum, a marine alloy) is the material of four blade used to motivate the air through the heat exchanger as per in figure 2.
4) Ballet (V Type) : (Power Grip GT2) ballet used to transfer the motion from the driven motor to the fan as per in figure 2.
5) Electronic vibration switch: (440/450) electronic switches utilize a solid state crystal accelerometer which provides an electrical output when it is deformed by the vibration forces as per in figure 1.
6) Centrifugal pump: use to circlet the water through the close cycle.
7) Distributed control system: is operator and control this system manually or automatically to keeping the water temperature around 23 °C , divided this system to four group each group consisted from two fans as per figure3 inter interchange while the temperature increase.

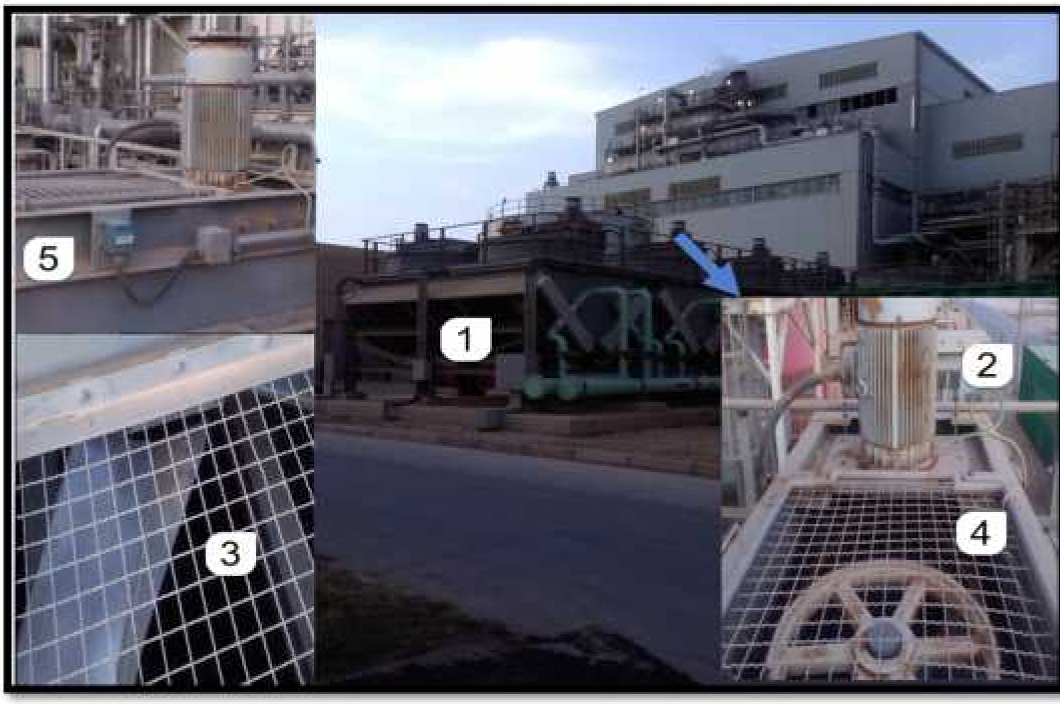

Figure 1. Generator cooling system component

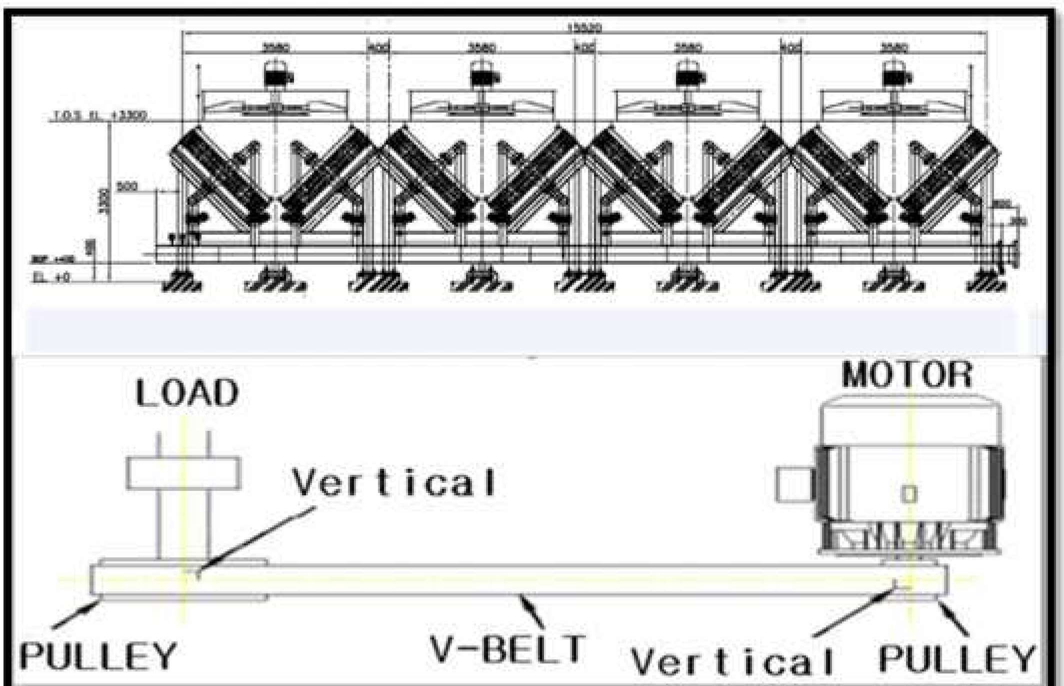

Figure 2. Generat component arrengment and pulley connection type

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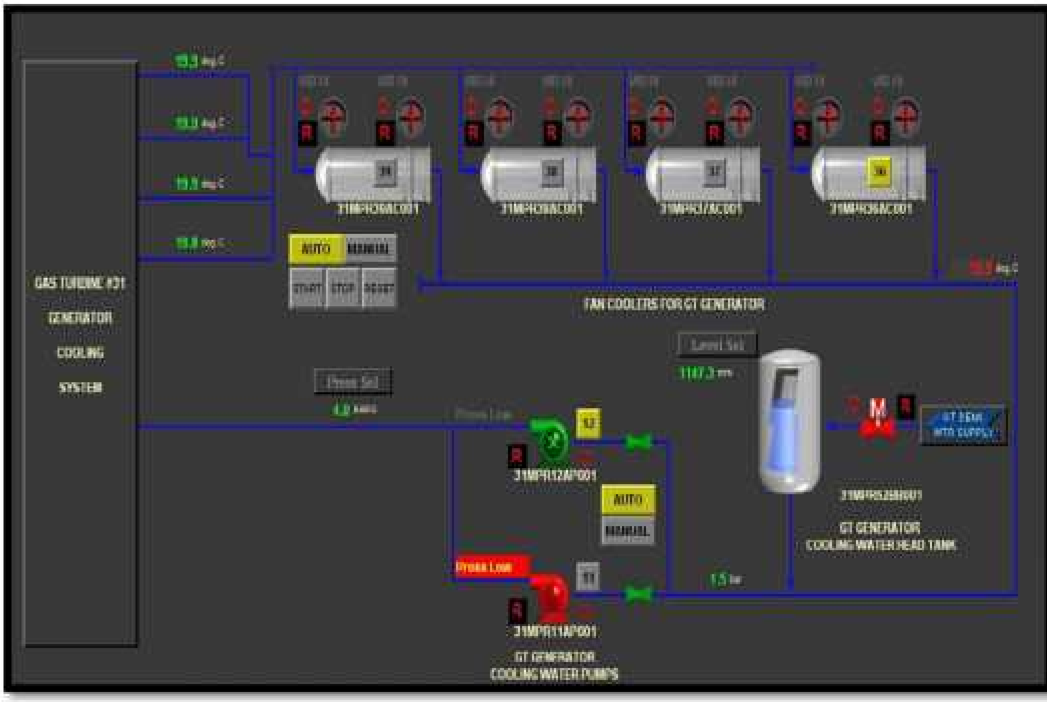

Figure 3. Graphic diagram of distributed control system

3. Statistical analysis

Using statistical analysis of faultier time data is one of the most commonly technique in industrial field . by determination which type of distribution the data follow , and represent their behavior by four function (the probability density function , the cumulative distribution function, the hazard function , and the reliability function) where [7]:

1. The probability density function: description the shape of the distribution.
2. The cumulative distribution function: is the area under the probability density function.
3. The hazard function: is the probability of failure in a very small time interval given survival to the beginning of the time interval.
4. The reliability function: is the complement of the cumulative distribution.

Many types of distribution are classified in statistical science depending on the area of application and the data which we are analyze, continuous distribution and there types treated our data.
By using MINITAB program we can Identify the distribution of our Data , and three measures you need to know:
1. Anderson-Darling statistic (AD): Lower AD values indicate a better fit. However, to compare how well different distributions fit the data.
2. P-value: You want a high p-value. It's generally valid to compare p-values between distributions and go with the highest. A low p-value (e.g., < 0.05) indicates that the data don't follow that distribution.
3. LRT P: For 3-parameter distributions only, a low value indicates that adding the third parameter is a significant improvement over the 2-Parameter version. A higher value suggests that you may want to stick with the 2-Parameter version; for normal distribution:-

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A) Probability density function:
The general formula for the of the normal distribution is

$$f(x) = \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}} \quad (1)$$

Where :
μ is the location parameter
σ is the scale parameter
when μ=0 and σ=1
Is called the standard normal distribution and the equation become

$$f(x) = \frac{e^{-(x)^2/2}}{\sqrt{2\pi}} \quad (2)$$

B) Cumulative distribution function:
The formula for the cumulative distribution function is

$$f(x) = \int_{-\infty}^{x} \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}} \quad (3)$$

Not that this integral does not exist in a simple closed formula it is completed numerically.
C)-Hazard function:
The formula for the hazard function of the normal distribution is

$$h = \frac{\emptyset(x)}{\varphi(-x)} \quad (4)$$

where:
$\emptyset(x)$ is the Cumulative distribution function
$\varphi(-x)$ is Probability density function
D) Reliability function:
The formula for the reliability function of the normal distribution is

$$f(x) = \int_{x}^{\infty} \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}} \quad (5)$$

4. Mechanical analysis

According to data sheet for the system component which consist of the design data, material type, and operation condition we make mechanical analysis by compared with instantaneous operation data using measurement tool install in the system itself or using portable tools like X-Viber device fig (4) to discover the problem.

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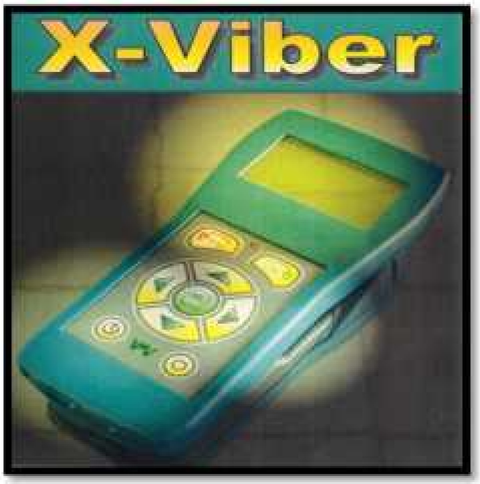

Fig 4. vibration portal device

4.1. Cooling mechanism

Convection heat transfer is the main mechanism using in our system to transfer the heat from air surrounding of the generator to the atmosphere and using the water as a cooling fluid.
According to Newton's Law of Cooling

$$Q = Ah\Delta T \quad (6)$$

The Convection heat transfer depended in the three parameters:
1) Heat transfer area of the surface.
2) Convective heat transfer coefficient of the process.
3) Temperature difference between the surface and the cooling fluid [8].

Low temperature difference means low heat transfer, to make more heat transfer we need more work in the mechanism of force convection heat transfer.

4.2. Mechanical operating measurement

Temperature and vibration measurement are methods to provide a complete analysis of mechanical condition specially for rotating equipment, gives good indicator about condition of system by comparing between allowable or design data and the online data if any changes happen will be note and analyzed

4.2.1. Vibration monitoring

is the most common tools used today in power plant field [9]; by using online monitoring for main rotating part or using portable device will identified problems early and avoid the suddenly failures, exceed the vibration reading more than designed or allowable vibration means there is a problem start and analyzed to know the source of problem.

4.2.2. Temperature monitoring

when temperature increase means Excessive heat is generated by friction caused by faulty bearings, inadequate lubrication, misalignment, imbalance, misuse, or normal wear.

5. Results and discussion;

From statistical analysis:

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By using one of the most fames statistical program (MINITAB) we found the best distribution can represent the failure of both unit (GT31 ,GT 32)

Unit GT31

From the collecting data shown in the table (1) we found it fit to the normal distribution, and the Probability density function is

$$f(x) = \frac{e^{-(x-1\ \ .5\ )^2 / (2*6\ .8\ ^2)}}{6\ .8\ \sqrt{2\pi}} \qquad (7)$$

Table 1 Time period between failures of generator cooling system GT31

31			
N.o	**DAY**		
1	110		
2	100		
3	126		
4	141		
5	224		
6	221		
7	254		
8	230		
9	246		
		SUM	**AVR**
		1652	183.55

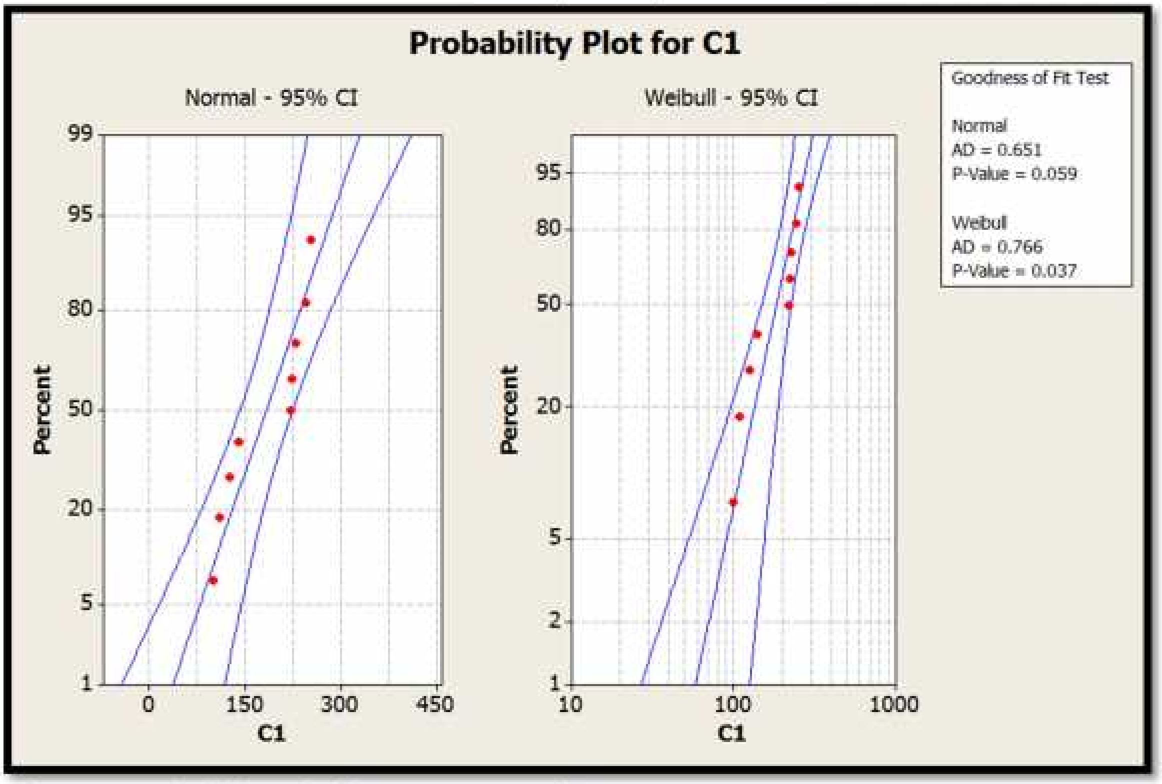

Figure 5 Probability plot for generator cooling system GT31

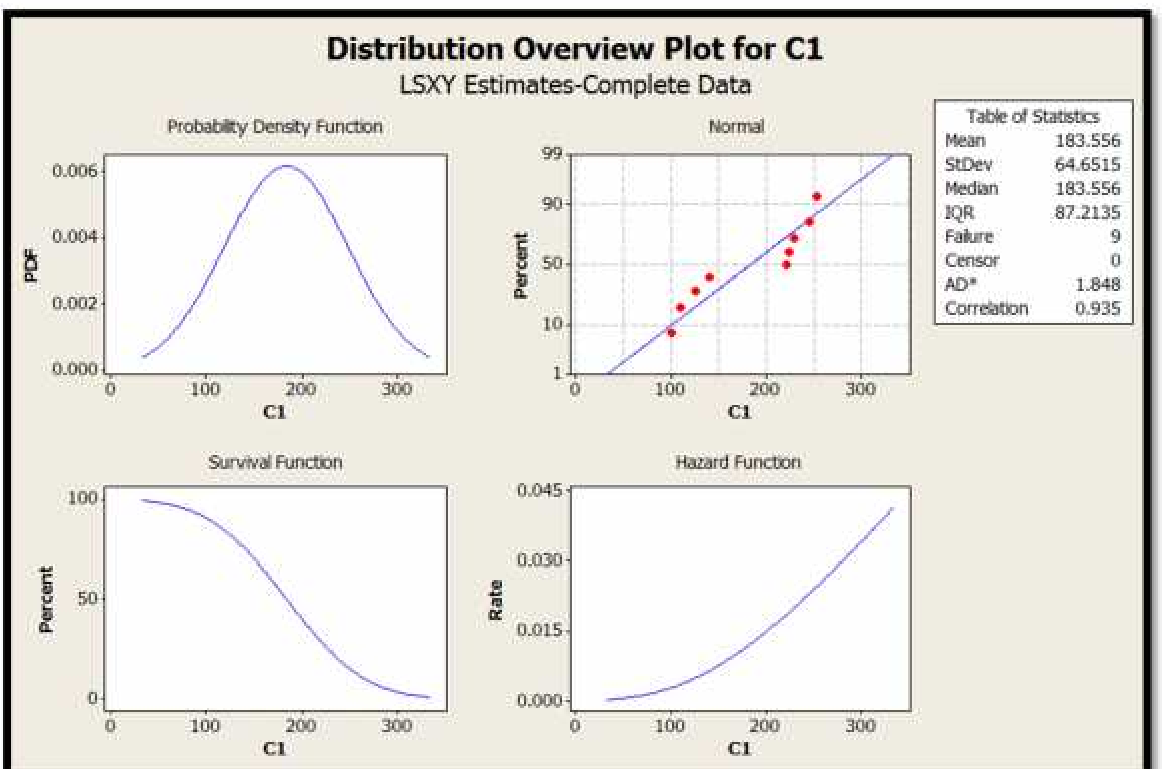

Figure 6 Distribution overview plot for generator cooling system of GT31

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Unite GT32

From the collecting data shown in the table (2) we found it fit to the normal distribution, and the Probability density function is

$$f(x) = \frac{e^{-(x-1\ \ .6\ )^2 / (2*2\ .0\ ^2)}}{2\ .0\ \sqrt{2\pi}} \qquad (8)$$

Table 2 Time period between failures of generator cooling system GT32

32			
N.o	**DAY**		
1	140		
2	130		
3	193		
4	150		
5	98		
6	134		
7	158		
8	104		
9	140		
10	175		
11	130		
12	100		
		SUM	AVR
		1652	137.66

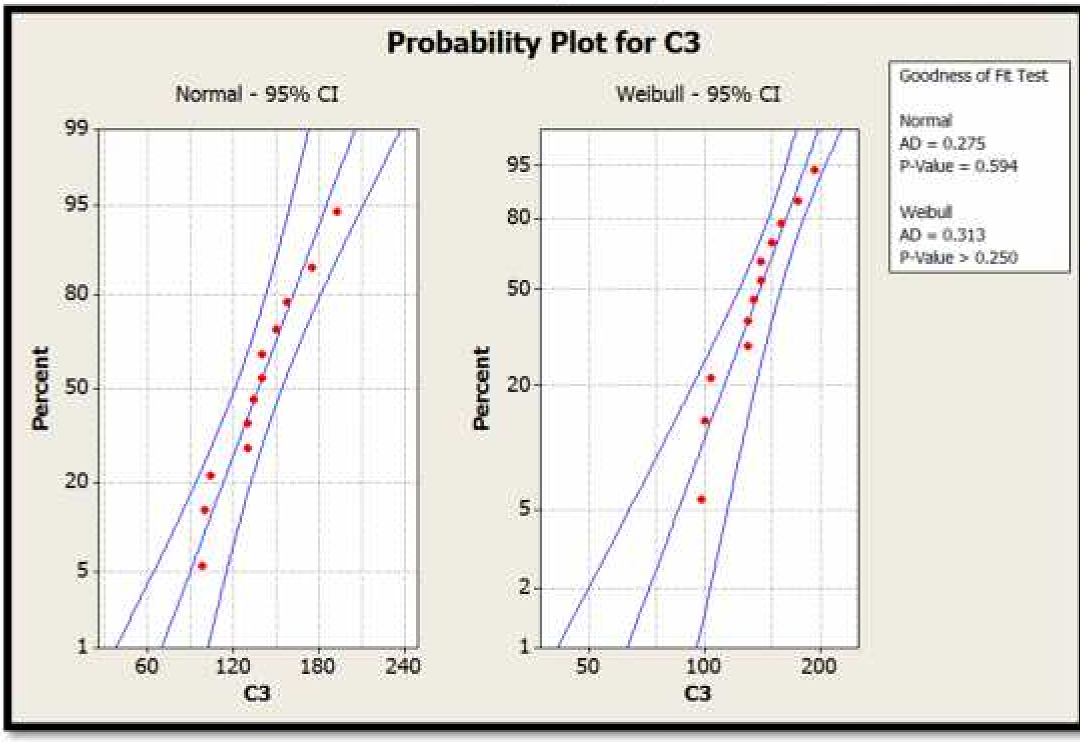

Figure 7.Probability plot for generator cooling system GT32

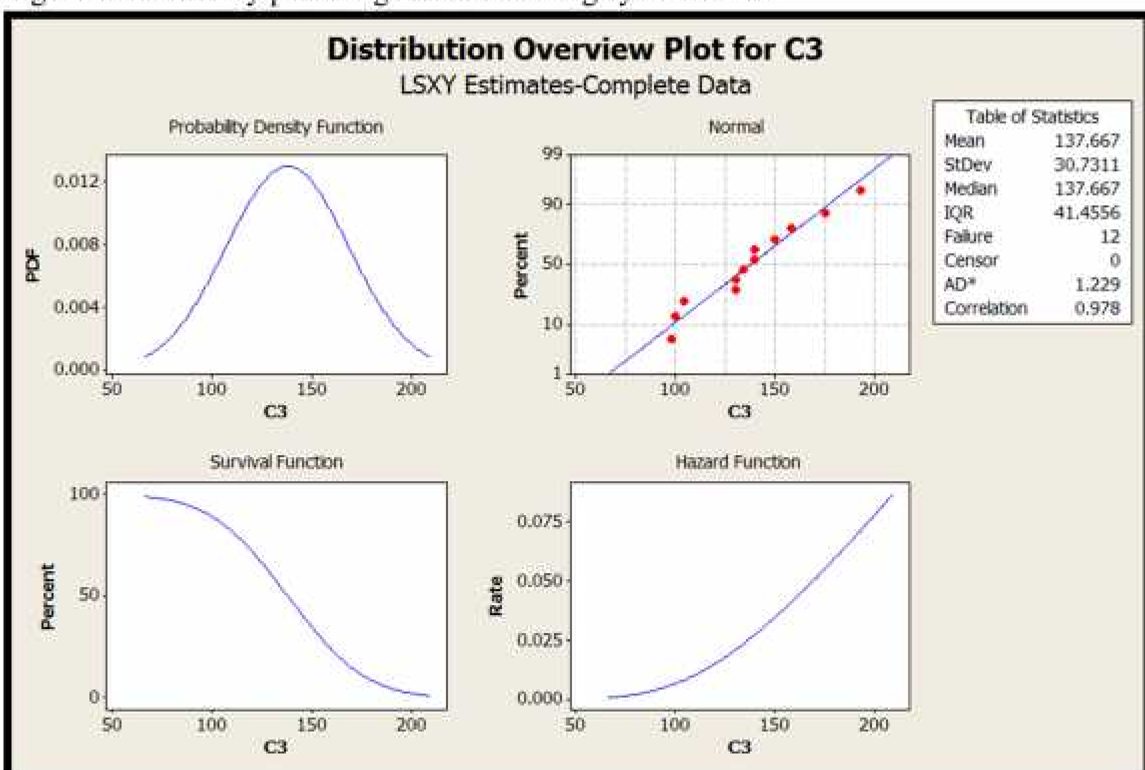

Figure 8. Distribution overview plot for generator cooling system of GT32

From mechanical analysis;

1) as shown in figure 9 the cooling system for GT32 in the close area than GT31, causes the surrounding for cooling system GT32 higher than the surrounding for cooling system GT31 this is mean more work for cooling system GT32 to absorbed the necessary heat.

Figure9 place of generator cooling system for GT31 and GT32

2) the most failure happen in belts, during the system is operating vibration and noise at fan and motor end increased gradually and Overheating occur in bearing , that gave good indicator the problem is start and have to considered to maintenance before sudden fault happens.

6. Conclusions

In this study the Normal distribution is fit to represent faultier behavior of sub system for power plant, and it is good tool help mechanical analysis to predict the failure, both of statistical and mechanical analysis become important in industrial field to increase the reliability and decrease the cast.

7. References

Hamed Sabouhi , Ali Abbaspour , Mahmud Fotuhi-Firuzabad , Payman Dehghanian 2015 Reliability modeling and availability analysis of combined cycle power plants/

ASIS SARKAR , DHIREN KUMAR BEHERA , AND BIJAN SARKAR "2011 The maintenance strategy selection of a gas turbine power plant system"

Rosmaini Ahmad, Shahrul Kamaruddin, Mohzani Mokthar and Indra Putra Almanar. " 2006 Identifying the Best Fit Failure Distribution and the Parameters of Machine's Component: A New Approach"

Magued l.Osman 1997 Exploring amixture of distribution using minitab"

A.K.Raja ;Amit Prakash Srivastava ;Manish Dwived "2006 Power Plant Engineering"

R.S.Rajesh "1999 Pump troubleshooting through vibration analysis"

Johnd.Kalbfleisch , Rossl . Prentice " 2002 The statistical analysis of failure time data second edition".

William S. Janna"2000 Engineering Heat Transfer Second Edition"

Anders Brandt "2010 Noise and Vibration Analysis: Signal Analysis and Experimental Procedures"