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Distribution Transformer Future Failure Prediction using Extreme value model

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Abstract: Utilities deliver power to their customer through a network of generation, transmission lines, substation & distribution system. A distribution system carries power from substation transformer through feeder circuit to distribution transformer located near customer. Distribution spending is one of the largest costs for most utilities also cause of concerns as network increases day by day along with the increasing power demand. Utilities are constantly looking forward to increase productivity in the distribution system. So to improve the Productivity of distribution system and managing financial asserts properly we have decided to work on the Distribution Transformer Future Failure Prediction using statistical data obtain from the various DISCOM with Extreme value Distribution Model.

Keywords:- Extreme value Distribution Model, Distribution Transformer, Probability density function, cumulative distribution function.

I. INTRODUCTION

An electric power network is designed to transmit and distribute electricity with a high level of reliability and deliver the supply availability and quality expected by consumers. The equipment investment is conventionally driven by the technology and is orientated to ensure the safety and reliability of the network. The new economic circumstance, created by the liberalization of electricity markets and the introduction of competition, requires the investment to focus on network economic efficiency as well as reliability. The design and maintenance of electric power network have developed to the stage of balancing its functionality and investment/ replacement efficiency by analysing the main risks under which the network is operating and may operate in the future.[1]

In distribution network most of investment is in installation and operation of distribution transformer, also the quantity of distribution transformer required is also large, particularly at the distribution level, the failure of a distribution transformer could cause power supply interruption and reduce the reliability of the remaining system. The intensive expenditure on purchasing new transformers and the long-term replacement might not be avoided when failure occurred. Moreover the influences to surrounding environment should also be a cause of concern.

According to survey performed in 2014 we found that, there are at present total installed distribution transformer in Gujarat is 694374 & failure of transformer every year is 41432 so from data we get that percentage failure of transformer is around 6 % & repair or replacement cost per transformer is around 2 to 3 lakhs.

As a fundamental step towards transformer life management, population failure trend has been evaluated by statistics since 1980’s and 1990’s in North America. Utilities are now benefitting from the sharing and integrating of transformer lifetime data Reliability models developed from other disciplines were applied inpower transformer failure prediction. By estimating the population mean life and the failure risks, the age when the population reliability begins to reduce and thus a preventive replacement action needs to be implemented is determined.

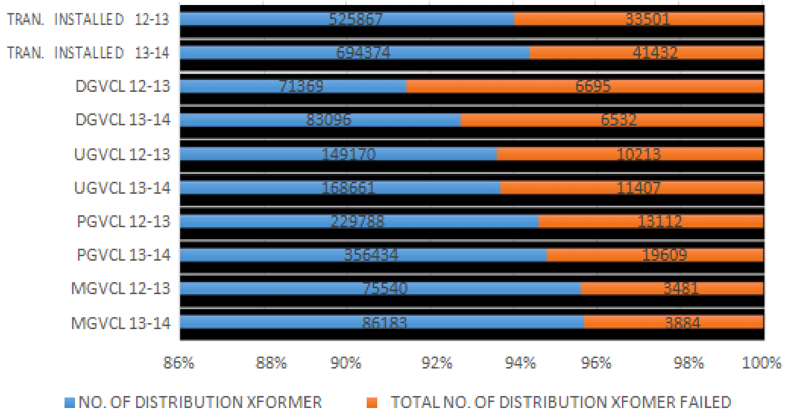


Figure 1 Distribution transformer Installed and failed of various DISCOM

II. EXTREME VALUE DISTRIBUTION MODEL

Statistical analysis on product reliability has been developed since 1940's due to the demands of modern technologies. Particularly in power systems, the lifetime prediction of generator windings, engine fans, turbine wheels, cables and transformers have been analysed via statistics since the 1980's. Generally in engineering practice, transformer population failure hazard is exposited as the instantaneous failure probability at a specific age t, by knowing a certain amount of transformers have survived till age t-1. It is mathematically expressed as the ratio of the failure number within age t (n(t)) and the number of exposed transformers at age t (N(t)).

h(t)= n(t)/N(t)

The smallest extreme value distribution is an extension of the Weibull distribution; it is used to describe certain extreme phenomena such as the temperature minima, material strength, as well as the first-failed-component determined product failure. In the context of this thesis the name is in briefly quoted as
"extreme value distribution".[1][2]

The PDF of the extreme value distribution is expressed as

$$f(t) = \frac{1}{\ } * \{ \frac{(\ )}{\ } \} * ' - \{ \frac{(\ )}{\ } \} -$$

and CDF is calculated as

$$F(t) = 1- ' - \{ \frac{\ }{\ } \}.$$

Where δ is the scale parameter and λ is the location parameter and both of them have the same unit as age t. λ is the age corresponding to 63.2% of CDF and it is called the population characteristic life. When applied in product lifetime data analysis, λ is always suggested at least 4 times as great as δ.

The relationship between age t and F(t) can be derived as
t= ∗ ln*− ln,1 − ( )-+ +

Which are used in the graphic plotting approaches of fitting lifetime data into the extreme value distribution model.

III. STATISTICAL ANALYSIS

The science of statistics has been dramatically developed since 1940's due to the growing requirement of modern technologies. Statistics application in areas of human life, medical research and military machine maintenance were much concerned in the early periods. Since 1950's and 1960's biomedical studies suggested advanced analysis methods; these methods were further developed by engineers in Products design and manufacturing. Particularly in power systems, the lifetimes of generator windings, engine fans, turbine wheels, cables, transformers and insulation material strength are more and more concerned by statistics.[3][4]

The common procedure according to which the product lifetimes are analyzed statistically can be concluded in four steps as follows:[5][8]

Step 1: collecting data;

Step 2: selecting the proper distribution model(s);

Step 3: fitting the data into the distribution model(s) and determining the best-fitted parameter(s) by optimal approach;
Step 4: carrying out the goodness-of-fit test to check the presumed distribution model(s)
Collection of data for one circle of DISCOM during the survey which is presented in table form. Then the data fitting for the instantaneous failure is done.[6][11]

Here,
$F(t) = (i - 0.5) / (N + 0.25)$…………….IEC standard

Is taken for the calculation of curve fitting. The linear relationship derived for curve fitting is:
t= ∗ ln*− ln,1 − ( )-+ +

Comparing it with $Y = m X + C$
$m = \delta$
$Y = t$
$X = \ln \{ - \ln [1 - F(t)] \}$
$C = \lambda$

So for probability plot we required to find parameter δ and λ

AGE (YEARS)	FAIL	CUMULATIVE FAILURE(i)
1 < t < 2	81	81
2 < t < 3	43	124
3 < t < 4	37	161
4 < t < 5	33	194
5 < t < 6	35	229
6 < t < 7	51	280
7 < t < 8	71	351
8 < t < 9	133	484
9 < t < 10	217	701
10 < t < 11	301	1002
11< t < 12	54	1056
12< t < 13	9	1065
13 < t < 14	11	1076
14 < t < 15	9	1085(N)

Table 1 Distribution transformer failure data

The result obtains from the calculation for fit is presented in table 2. This result is plotted to obtain the linear curve equation for finding the parameters.[15][16][12][13].

Age (t)	Fail at t	Cumulative failure (i)	F(t) instantaneous	X= ln{-ln[1-F(t)]}	Y=t
1 < t < 2	81	81	0.0741	-2.5640	2
2 < t < 3	43	124	0.1137	-2.1136	3
3 < t < 4	37	161	0.1479	-1.8322	4
4 < t < 5	33	194	0.1782	-1.6283	5
5 < t < 6	35	229	0.2105	-1.4424	6
6 < t < 7	51	280	0.2575	-1.2115	7
7 < t < 8	71	351	0.3229	-0.9417	8
8 < t < 9	133	484	0.4455	-0.5281	9
9 < t < 10	217	701	0.6454	0.0361	10
10 < t < 11	301	1002	0.9228	0.9405	11
11< t < 12	54	1056	0.9725	1.2791	12
12< t < 13	9	1065	0.9808	1.3744	13
13 < t < 14	11	1076	0.9910	1.5498	14
14 < t < 15	9	1085(N)	0.9999	2.4434	15

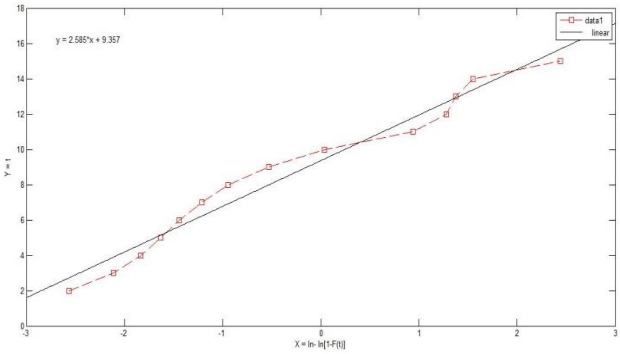
Table 2 Extreme value distribution model calculated data

The graphical plotting shows the equation of linear as:

Y= 2.585 X + 9.357

So the following parameter is obtained,

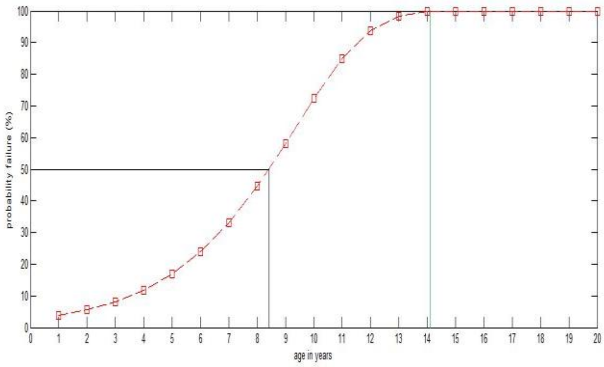
δ= 2.585 λ= 9.357



Putting all this parameter in the cumulative failure probability :

F(t) = 1- ,— { }-

Varying t from 1 to 20 we get the required probability cure of future failure of transformer fleet. So the graph show the future failure of the next fleet which is going to install. It shows that 50 % of my fleet will fail at the age of 8.3 years from graph and at the age of 14 years our entire fleet will be failed and replaced with the new one.



IV. CONCLUSIONS

With the help of statistically linked mathematical model we can predict the future failure of Distribution Transformer of previous fleet installed and existing fleet to be installed. By the use of data obtain of predicted failure financial resource can be properly utilized and future planning of procurement can be done for distribution transformer failure. By this way we can improve the system productivity and can manage the financial.

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