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RESEARCH ARTICLE

RELIABILITY EVALUATION OF COMPOSITE SYSTEM WITH AGING FAILURE

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Abstract

Reliability is concerned with the system capability of survival. In the past forty years, customer expectations have been increasing in response to evolving new technologies. As part of these evolutions, they are demanding from their suppliers: products with higher quality, low initial cost, improved customer support and products that are easy and inexpensive to maintain. For a supplier to survive, succeed and be profitable in today's market, It must do the following:
a) Constant improvement in the quality of the products.
b) Minimization of the cost.
c) Be flexible and responsive to the customer's requirement.
This deals with reliability evaluation of combined generation and transmission system known as composite system. It describes a technique calculate composite system reliability with aging failure.
The reliability evaluation deals with the
a) Calculation of aging failure rate & aging repair rate of all Components of the system.
b) Calculation of EENS value of all Components of the system by performing Reliability Analysis using SKM'S PTW 6.5.

Introduction:-

Reliability is concerned with the system capability of survival. In the past twenty years, customer expectations have been increasing in response to evolving new technologies. As part of these evolution, they are demanding from their suppliers:
products with higher quality, low initial cost, improved customer support and products those are easy and inexpensive to maintain. For a supplier to survive, succeed and be profitable in today's market, it must do the following:
a) Constant improvement in the quality of the products.
b) Minimization of the cost.
c) Be flexible and responsive to the customers' requirement.

Previously the criteria and techniques used for reliability assessment were all deterministically based. The essential weakness was that they did not account for the probabilistic or stochastic nature of system behaviour and component failures. However, the probability theory alone cannot predict either the reliability or safety of the equipment. It is only a tool available to the engineer in order to transform his knowledge of the system for the prediction of future behaviour of the system.

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This deals with reliability evaluation of combined generation and transmission system known as composite system. It describes a technique calculate composite system reliability with aging failure.
The reliability evaluation deals with the

c) Calculation of aging failure rate & aging repair rate of all Components of the system.
d) Calculation of EENS value of all Components for aging failure of Transformer's & Circuit Breaker's of the system by performing Reliability Analysis using SKM'S PTW 6.5.

Justification,Importance Of The Project:
So basic Objective is to calculate EENS value of loads connected to the system with Skm's PTW 6.5 .

Detailed Description Of The Project:
The RBTS is a 6 bus system composed of two generator buses, 5 load buses, 9 transmission lines and 11 generating units. The total installed capacity is 240 MW and the system peak load is 185 MW.

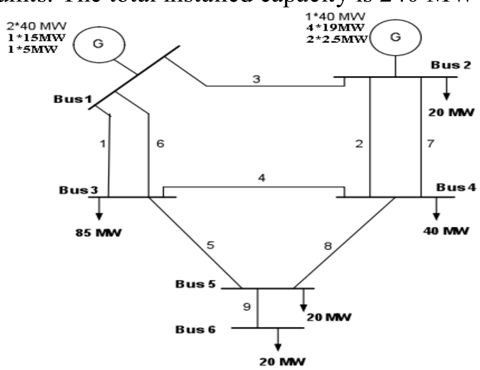


Figure1: Single Line Diagram of RBTS system

Rbts Data
Table 1:- Bus Data for RBTS system.

Bus	Peak Load,MW		PG	Q VAR Limit,MVAR		Voltage Limits,pu	
	Active	Reactive		Max	Min	Max	Min
1	0	0	1.00	50	-40	1.05	0.97
2	20	0	1.20	40	-75	1.05	0.97
3	85	0	0.00	0	0	1.05	0.97
4	40	0	0.00	0	0	1.05	0.97
5	20	0	0.00	0	0	1.05	0.97
6	20	0	0.00	0	0	1.05	0.97

Generation Data
Table 2:- Generator data for RBTS system.

Bus No.	Rating(MW)	Failure Per Year	Repair Time(hours)
1	40	6	45
1	40	6	45
1	10	4	45
1	20	5	45
2	5	2	45
2	5	2	45
2	40	3	60
2	20	2.4	55
2	20	2.4	55
2	20	2.4	55
2	20	2.4	55

Rbts-Transmission Data

The relevant reliability data for the nine 110 kV lines in Fig. 1 in terms of the permanent and transient failure rates and the permanent outage repair times are given in [11]. The outage duration of a transient outage is considered to be less than one minute. Outages of substation components which are not switched as a part of a line are not included in the line data.

Table 3:- Line Data For RBTS system.

From Bus	To bus	R	X	B	Current rating	Failure Per Year	Repair Time
1	3	0.0342	0.18	0.0212	0.49	1.5	10
2	4	0.1140	0.60	0.0352	0.409	5	10
1	2	0.0912	0.48	0.0564	0.409	4	10
3	4	0.0228	0.12	0.0142	0.409	1	10
3	5	0.0228	0.12	0.0142	0.409	1	10
1	3	0.0342	0.18	0.0212	0.49	1.5	10
2	4	0.1140	0.60	0.0352	0.409	5	10
4	5	0.0228	0.12	0.0142	0.409	1	10
5	6	0.0228	0.12	0.0142	0.409	1	10

Table4: Elements reliability data

Element	Failure rate		Duration		
	Permanent	Active	Permanent	Maintenance	Switching
Busbar	0.001	0.001	2.0	1.0	0.0
Cir.Breaker	0.02	0.02	24	1.0	0.0
Transformer	0.015	0.015	15	1.0	0.0
Disc.Switch	0.002	0.002	4.0	1.0	0.0

Table5:- Load Reliability Data.

Load at	Failure Frequency[1/yr]	Duration[h]
Bus 2	0.47	**1**
Bus 3	0.216	**1**
Bus 4	0.855	**1**
Bus 5	0.002	**5**
Bus 6	1.002	**9.989**

Aging Failure Rate:

The Value of η is calculated from the following formula:

η = 1000000/(FailureRate*EXP(GAMMALN(1+1/Shape Parameter(β))))

Failure Rate Calculation Formula= $\left(\frac{\beta}{\eta}\right)\left(\frac{t}{\eta}\right)^{\beta-1}$

Where β = Shape parameter

η = Scale parameter

Table 6:- Aging Failure rate for Aging of Tx's.

Time(hr)	β =0.5	β =1.0	β =1.5
$t=8760\times1$	0.087	0.015	0.00236
$t=8760\times5$	0.039	0.015	0.00527
$t=8760\times10$	0.027	0.015	0.00746
$t=8760\times15$	0.022	0.015	0.00913
$t=8760\times20$	0.019	0.015	0.0105

t=8760×25	0.017	0.015	0.0118
t=8760×30	0.016	0.015	0.0124
t=8760×35	0.015	0.015	0.0139
t=8760×40	0.014	0.015	0.0149

Aging Repair Rate:

The Value of θ is calculated from the following formula:

θ = 1000000/(Failure Rate*EXP(GAMMALN(1+1/Shape Parameter(α))))

Repair Rate Calculation Formula= $\left(\frac{\alpha}{\theta}\right)\left(\frac{t}{\theta}\right)^{\beta-1}$

Where α = Shape parameter

θ = Scale parameter

Table 7:- Aging Repair rate for Aging of Tx's.

Time(hr)	θ =0.5	θ =1.0	θ =1.5
t=8760×1	2.73	15	0.000115
t=8760×5	1.22	15	0.000257
t=8760×10	0.866	15	0.000363
t=8760×15	0.707	15	0.000445
t=8760×20	0.612	15	0.000513
t=8760×25	0.547	15	0.000574
t=8760×30	0.500	15	0.000629
t=8760×35	0.463	15	0.000679
t=8760×40	0.433	15	0.000726

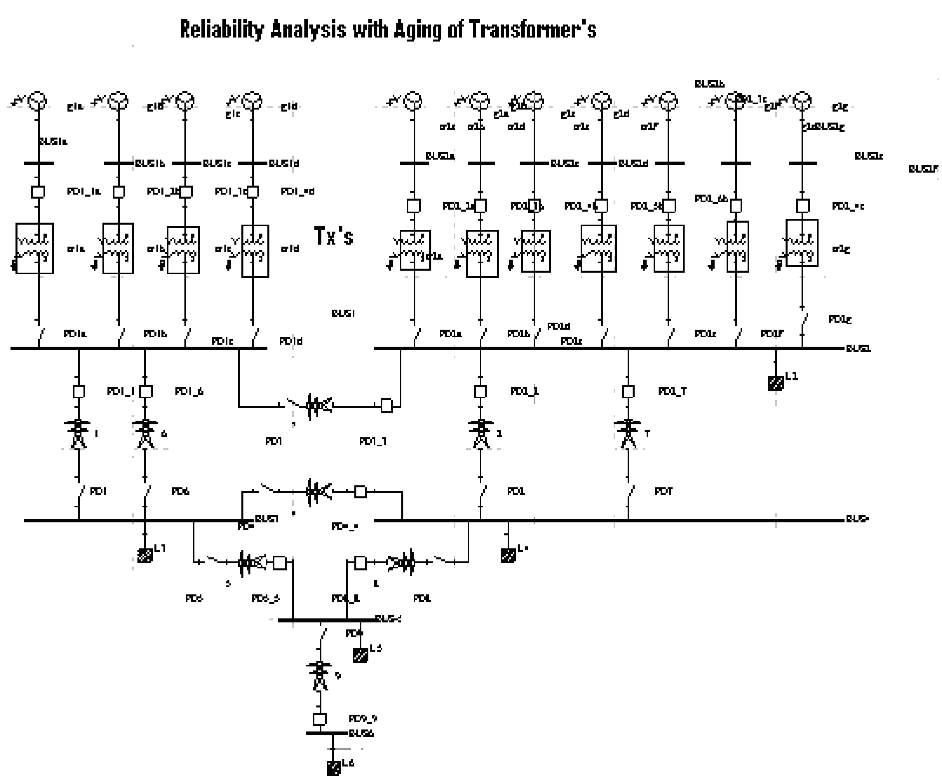


Fig 2:- One line diagram of RBTS system in SKM's PTW 6.5 for aging of Tx's.

Case 3a: Non repairable aging failure for β=0.5

A nonrepairable aging failure for **β=0.5** refers to a random fatal failure in the normal operating stage of the life basin curve. Obviously, it corresponds to a decreasing failure rate and therefore can be modeled using an exponential distribution.

Table 8:- EENS Value for Aging of Tx's for β=0.5.

Time (hr)	Reliability Analysis EENS (Kwh/year) Value for Aging of Tx's for β=0.5				
	L2	L3	L4	L5	L6
0	8855688.94	820.60	7000745.07	81967029.91	85576849.91
1	8855688.93	820.56	7000464.56	81966403.38	95575902.39
5	8855688.89	820.39	6999336.69	81963884.14	95572092.43
10	8855688.83	820.16	6997913.76	81960705.56	95567285.30
15	8855688.78	819.92	6996476.30	81957494.17	95562428.51
20	8855688.71	819.66	6995024.31	81954249.97	95557522.07
25	8855688.65	819.38	6993557.79	81950972.97	95552565.98
30	8855688.59	819.12	6992358.74	81948293.37	95548513.37
35	8855688.59	819.12	6992358.74	81948293.37	95548513.37
40	8855688.59	819.12	6992358.74	81948293.37	95548513.37

Case3b: Chance Failure for β=1

A nonrepairable chance failure refers to a random basin curve. Obviously, it corresponds to a constant failure rate and therefore can be modeled using an exponential distribution.

Table 9:- EENS Value for Aging of Tx's for β=1.

Time(hr)	Reliability Analysis EENS(Kwh/year) Value for Aging of Tx's for β=1				
	L2	L3	L4	L5	L6
0	8855688.94	820.60	2065266.86	81867494.39	95477314.39
1	8855688.94	820.60	2065266.86	81867494.39	95477314.39
5	8855688.94	820.60	2065266.86	81867494.39	95477314.39
10	8855688.94	820.60	2065266.86	81867494.39	95477314.39
15	8855688.94	820.60	2065266.86	81867494.39	95477314.39
20	8855688.94	820.60	2065266.86	81867494.39	95477314.39
25	8855688.94	820.60	2065266.86	81867494.39	95477314.39
30	8855688.94	820.60	2065266.86	81867494.39	95477314.39

35	8855688.94	820.60	2065266.86	81867494.39	95477314.39
40	8855688.94	820.60	2065266.86	81867494.39	95477314.39

Case3c: Wear Out Period for β =1.5

A nonrepairable wear out failure refers to a random fatal failure in the normal operating stage of the life basin curve. Obviously, it corresponds to a increasing failure rate and therefore can be modeled using an exponential distribution.

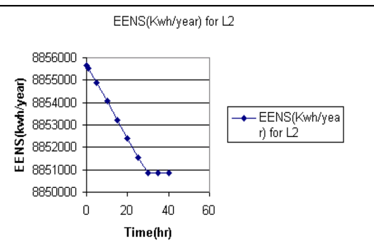
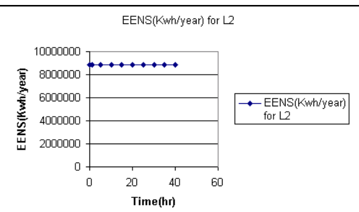
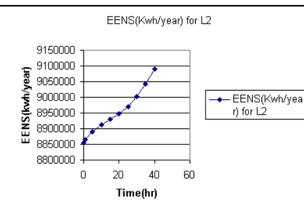
Table 10:- EENS Value for Aging of Tx's for β =1.5.

Time(hr)	Reliability Analysis EENS(Kwh/year) Value for Aging of Tx's for β =1.5				
	L2	L3	L4	L5	L6
0	8855688.94	820.60	2065266.86	81867494.39	95477314.39
1	8855689.41	822.60	2065267.87	81867494.89	95477314.89
5	8855690.81	828.56	2065270.89	81867496.40	95477316.40
10	8855691.82	832.84	2065273.07	81867497.49	95477317.49
15	8855692.49	835.69	2065274.51	81867498.21	95477318.21
20	8855693.24	838.87	2065276.12	81867499.02	95477319.02
25	8855694.36	843.63	2065278.54	81867500.23	95477320.23
30	8855696.03	850.74	2065282.14	81867502.03	95477322.03
35	8855698.31	860.43	2065287.06	81867504.49	95477324.49
40	8855701.13	872.40	2065293.13	81867507.52	95477327.52

Result:-

From the Reliabilty analysis we get the life basin curve by plotting EENS value with time for α=0.5, α=1.0, α=1.5.

Table11:- Time Vs EENS (kwh/year) plot For aging of Tx's,Cb's and Switch's for base case.

EENS(Kwh /year) value	β =0.5	β =1.0	β =1.5
L2			

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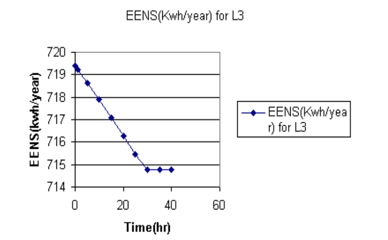
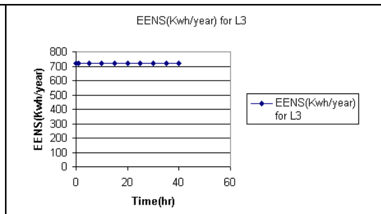
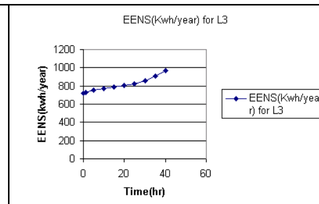
<tr><td>L3</td><td>
</td><td>
</td><td>
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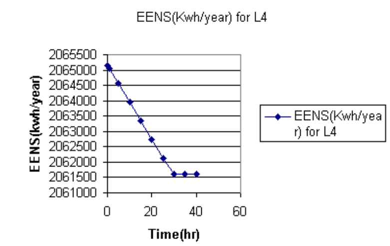
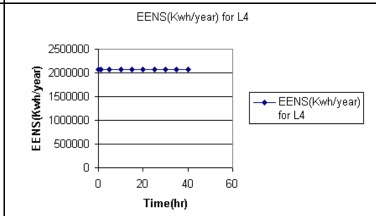
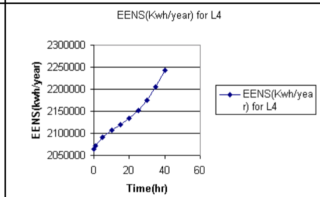
<tr><td>L4</td><td>
</td><td>
</td><td>
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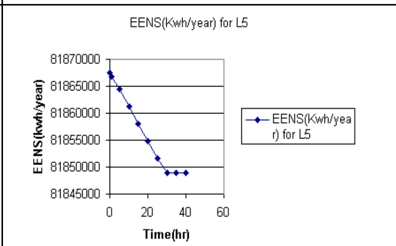
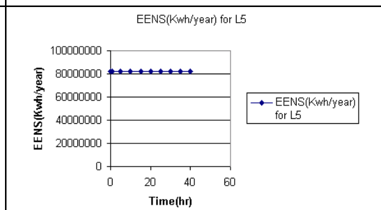
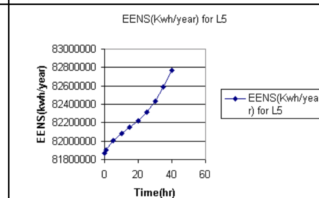
<tr><td>L5</td><td>
</td><td>
</td><td>
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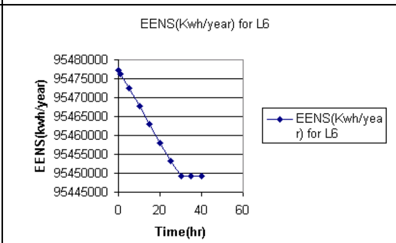
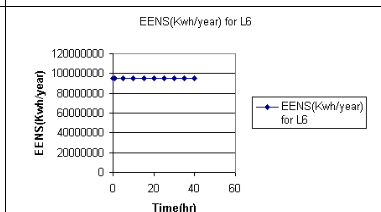
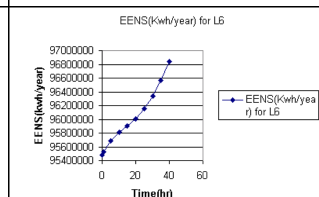
<tr><td>L6</td><td>
</td><td>
</td><td>
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