Optimal Power flow for IEEE-9 Bus System Using etap

S.Anil Kumar, Dr.M.Siva Sathya Narayana, B.Amarnath Naidu, G.Venkata Subba Reddy

***Abstract---** generally the loads connected to the power system are inductive in nature which consumes reactive power. Power flow analysis is used to find bus voltage, real and reactive power flow across each bus. Optimal power flow analysis is used to reduce a system real and reactive power loss which in turn minimizes the fuel cost of the system. This paper compares load flow analysis and optimal powe flow analysis for IEEE-13 bus system using etap software.*

***Index Terms**—real power, reactive power, optimal power flow, etap.*

I. INTRODUCTION

The conventional power flow or load flow issue is expressed by determining the loads in megawatts and megavars to be provided at specific nodes of a transmission network and the magnitudes of the voltage together with an entire topological depiction of the network including its impedances

In optimal method of power flow, Planning and operating requirements very often ask for an adjustment of the generated powers according to certain criteria. One of the main requirements is the reduction of losses.

Etap standards for electrical transient and analyser program which easy and less time to calculate load flow analysis

In paper [1],newton rapson method is explained for load flow calculation, in paper [2], different load flow methods like newton rapson method, gauss siedel method and fast decoupled method is explained.in paper[3] improved power flow technique is explained,in paper [4] contingency analysis of power system operation is explained and in paper [5]-[10] the optimal power flow method is explained.

II. METHODOLOGY

Normal Load flow method:

Load flow Analysis is used to determine voltage across each bus, real and reactive power flow across each bus .In this paper Newton-Rapson method is employed to calculate voltage and power across each bus.

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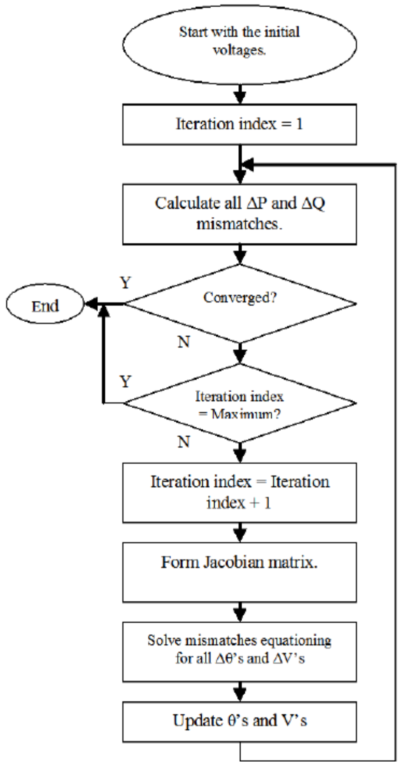

Fig.1.Flowchart of Newton-Rapson Method

$$S_i = P_i + jQ_i = V_i \sum_{k=1}^{n} V_{ik} V_k \;\ldots\ldots(1)$$

$$S_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \Big/ (\delta_i - \delta_k - \theta_{ik}) \ldots\ldots(2)$$

$$P_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \cos(\delta_i - \delta_k - \theta_{ik}) \ldots\ldots(3)$$

$$Q_i = \sum_{k=1}^{n} (V_i\, V_k\, Y_{ik}) \sin(\delta_i - \delta_k - \theta_{ik}) \ldots\ldots(4)$$

Optimal Power flow method:

In Optimal Power Flow method, the main objective is to reduce overall system losses by reducing branch losses.

Pi (V,θ)=PGi- PDi

Qi (V, θ)= QGi- QDi

PGmin ≤ PG ≤PGmax

QGmin ≤ QG ≤QGmax

Vimin ≤ Vi ≤Vimax

Plmin ≤ Pl ≤Plmax

The following steps are involved for calculation of optimal power flow across each bus.

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Step 1: Read data namely cost-coefficients, B-coefficients, P limits and power demand.
Step 2: Make an initial guess λ and Δλ for the Lagrange multiplier.
Step 3: Calculate the generations based on equal incremental production cost.
Step 4: Calculate the generations at all buses using the equation

$$P_n = \frac{1 - (f_n/\lambda) - \sum_{m \neq n} B_{mn} P_m}{(F_{nn}/\lambda) + 2B_{nn}}$$

Step 5: For each unit, check the generation limits and impose the limits in case of violation.

If $P_n > P_{nmax}$, set $P_n = P_{nmax}$
If $P_n < P_{nmin}$, set $P_n = P_{nmin}$

Step 6: Check if the difference in power at all generator buses between two Consecutive iterations is less than a prespecified value. If not, go back to step 3.
Step 7: Calculate the loss using the relation

$$P_L = \sum_m \sum_n P_m B_{mn} P_n$$

And calculate mismatch between generator power and demand plu losses.

$$\Delta P = |\Sigma P_G - P_L - P_D|$$

Step 8: Check if ΔP is less than ϵ (a specified value)
If yes, stop calculation and calculate cost of generation with these values of powers. Otherwise, go to step 9.
Step 9: Increase λ by Δλ (a suitable step size); if $\Delta P < 0$ or Decrease λ by Δλ (a suitable step size); if $\Delta P > 0$ and repeat from step 4.

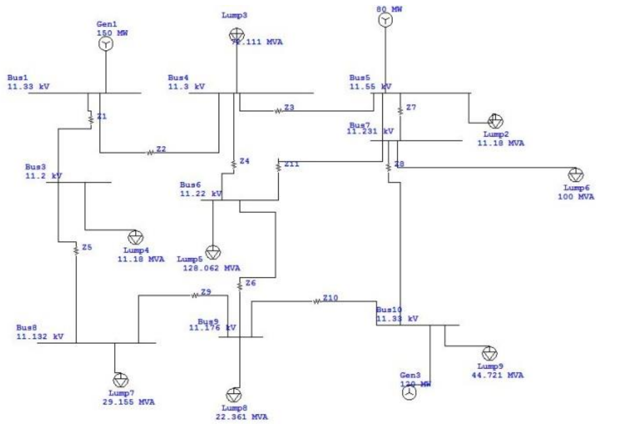

Fig.2.IEEE 9-Bus System

III. RESULTS AND DISCUSSIONS

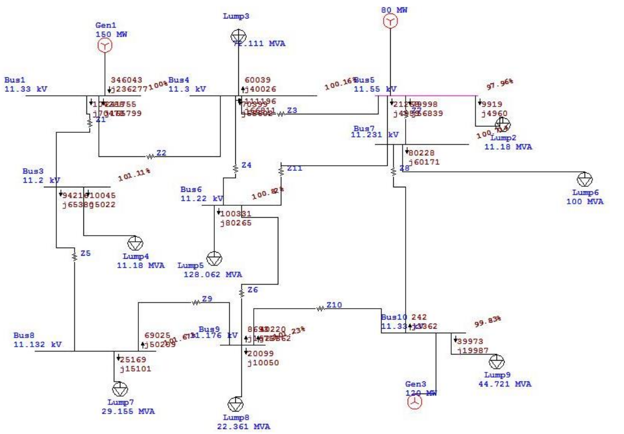

Fig.3.Load flow calculation by Newton-Rapson Method

S.No	From	To	N-R method Real power (MW)	Opf method Real power(MW)
1	Bus 1	Bus 3	104.29	127.78
		Bus 4	241.75	300.36
2	Bus 3	Bus 1	-104.26	-127.76
		Bus 8	94.21	115.31
3	Bus 4	Bus 1	-241.63	-300.28
		Bus 5	111.20	140.42
		Bus 6	70.40	85.66
4	Bus 5	Bus 4	-111.17	-145.40
		Bus 7	79.99	99.94
		Bus 6	21.26	28.28
5	Bus 6	Bus 4	-70.38	-85.65
		Bus 9	-8.69	-10.34
		Bus 5	-21.25	-28.28
6	Bus 7	Bus 5	-79.99	-99.93
		Bus 10	-0.24	0.59
7	Bus 8	Bus 3	-94.19	-115.30
		Bus 9	69.02	84.05
8	Bus 9	Bus 6	8.69	10.34
		Bus 8	-69.02	-84.04
		Bus 10	40.22	10.34
9	Bus 10	Bus 7	0.242	-0.59
		Bus 9	-40.21	-48.77

Tab.1 comparison of Real power flow across each bus using LF and OPF method

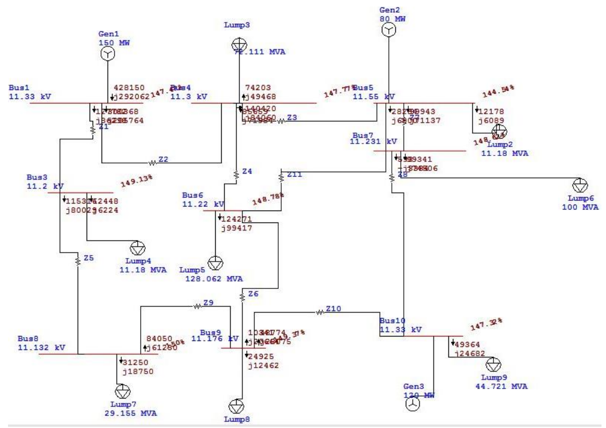

Fig.4 Optimal power flow calculation

S.No.	From	To	N-R method Reactive power (Mvar)	Opf method Reactive power(Mvar)
1	Bus 1	Bus 3	70.47	86.29
		Bus 4	165.79	205.76
2	Bus 3	Bus 1	-70.40	-86.25
		Bus 8	65.38	80.03
3	Bus 4	Bus 1	-165.44	-205.51
		Bus 5	66.81	84.06
		Bus 6	58.60	71.98
4	Bus 5	Bus 4	-66.76	-84.02
		Bus 7	56.84	71.13
		Bus 6	4.96	6.80
5	Bus 6	Bus 4	-58.55	-71.94
		Bus 9	-16.76	-20.06
		Bus 5	-4.96	-6.80
6	Bus 7	Bus 5	-56.81	-71.12
		Bus 10	-3.36	-3.38
7	Bus 8	Bus 3	-65.31	-79.98
		Bus 9	50.21	61.23
8	Bus 9	Bus 6	16.76	20.66
		Bus 8	-50.17	-61.20
		Bus 10	23.36	28.70
9	Bus 10	Bus 7	3.36	3.38
		Bus 9	-23.35	-28.06

Tab.2 comparison of Reactive power flow across each bus using LF and OPF method

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From the above table, the load flow across each branch is determined by using newton-rapson method and optimal power flow method. The real power and reactive power flow is calculated across each bus .the power flow from one bus to anoher bus is tabulated and the results are compared with optimal power flow method. As compared to newton-rapson method, the optimal power flow method reduces the line losses in the network which in turn minimizes the fuel cost of the system.

CONCLUSION:

In this paper, for ieee-9 bus system normal load flow method is compared with optimal power flow method. As compared to normal load flow method, optimal power flow method reduces the losses in the system and gives better results for cost minimization.

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