The Performance Analysis of A Medium Transmission Line using Mathematical Method

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***Abstract*— Transmission line is the heart of power system network. Proper design of transmission line is essential for optimum power flow to load. In this era to design of simulation and automation we need proper design criteria for transmission line in power system network. In this paper we have analyzed of transmission line design criterion and discussed the effect of varying length , load distribution on sending end power factor, voltage regulation and transmission efficiency. In this paper we will suggest a solution process for choosing line design criterion before selecting distribution voltage and length.**

Keywords*— *Transmission line length, performance of transmission line, power transmission efficiency and regulation, line losses, optimum transmission line design criteria.

INTRODUCTION

The efficient and optimum design and planning of electrical power distribution have occupied an important role in the electric power company. Today's architecture of power system network is very complex due to maintained uninterruptedly, highly reliable supply. For that reason modern power system is connected in grid network which makes the system complex and unstable. So, maintaining proper balance power flow we have to focus on line design criteria. Only proper balanced design makes power system more reliable healthy and economic.

For that reason we have analyzed mathematically and point out some preliminary considerations in design of medium transmission line. Most of the transmission lines in power system are of medium length (50-250 km).When any transmission company distributed its load to distribution lines then it must analyze the effect of length on demand supply because every length is not suitable to supplying any load in any area. If we design our voltage and transmission line without proper mathematical analysis, it will be created wrong choice of distribution line length and choice of transmission voltage which will be effect the choice design rating of different instruments which are used in transmission for protection, and power distribution. The wrong design will have dangerous effect on power system network. It will create not only huge loss of power but also huge loss of revenue. And in long run the system can be explored. Here is the importance of our research. Here we have changing transmission line length and loads to finding out sending end design parameters. After analysis we have seen that we cannot set firstly our sending end parameters without analysis receiving end load and voltage study. Previous researchers are focused only effect of load flow study in power system design. In my point of view the research gap is that we are focusing the higher things, higher analysis but we are not considering basic initial design criterion. A plant cannot be survived if we are not care from the roots. Without roots no plant will be grown up. Similarly in any design of transmission line we have analyzed from initial design criterion. Which we will discuss in this paper .We have studied here to find optimum design of choice of voltage, power factor, and line length. By analyzing the effect of transmission line parameters on sending end power factor, voltage regulation and load gives us a better economic perspective.

II

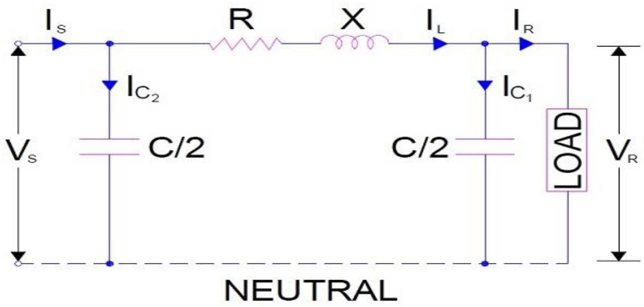
Theoretical Details: The performance of power system is very important in power system engineering which mainly depends on the performance of transmission line. In transmission lines most of the transmission lines are medium transmission lines (50-250 km & voltage > 20 KV) where the effect of line capacitance cannot be ignored. These capacitance are shunt capacitance distributed uniformly all over the line. But we assume it concentrated at one or more points. We must know the effects of line parameters on sending end power factor, voltage regulation, and transmission efficiency.

Our main aim is to reduce the loss while transmitting power through transmission line. For that we need proper design criteria which will help us to make our power system more economical. The effect of varying length and varying load and the result of combining both of them is a completely new approach for designing of medium transmission line.

Generally the range of efficiency is 90-95% and the range of voltage regulation is 10-20%. But we will see in this paper that how this criteria can be easily missed if we do not make proper design of the transmission line.

III

Mathematical Details-: *Here we have used nominal pi method for calculation of the problem. So, firstly we will discuss a little bit on this method with circuit diagram.*



[1]

Let I_R = load current per phase
R = resistance per phase
X_L = inductive reactance per phase
C = capacitance per phase
Cos φ_R = receiving end power factor (lagging)
V_S = sending end voltage per phase

We have chosen here the medium transmission line because our maximum transmission lines are medium transmission line for that reason we have considered here medium transmission line for this analysis.
Aim: - Power System profit mainly depend on Industrial load. For earning money from this system proper voltage choice and sending end design required. A distribution company before supplying connection and load proper choice of sending end power transmission required which is totally depends on loads and transmission line.

IV

Procedure:-

i) 1st step: Load taken 20MW.That means suppose 20MW load is demanded by industry. We analysis that which length is suitable to distribute this loads. If we find the optimum line length of distribution then we can easily design from which substation load will be diverse.
ii) 2nd step:- For 50Km,100 Km,150 Km length(3 phase,50 HZ) analysis with below line constants resistance/phase/km = 0·1 Ω, reactance/phase/km = 0·5 Ω, susceptance/phase/km = 10 × 10− 6 S.
iii) the line supplies load of 20 MW at 0·9 p.f. lagging at 66 kV at the receiving end
iv) 3rd step: analysis by nominal π method : (a) sending end power factor (b) regulation (c) Transmission efficiency
v) 4th step: After calculating voltage regulation and Transmission line efficiency Analysis its different conditions.

Medium Transmission line					
SL Number	*Load Power(MW)*	*Length(KM)*	*Sending End PF*	*Voltage Regulation (%)*	*Transmission Efficiency (%)*
1	*20*	*50*	*0.9*	*7.78*	*96.57*
2	*20*	*100*	*0.91*	*15.27*	*94*
3	*20*	*150*	*0.88*	*1.14*	*116.14*

Statement:-

i) Our 20 MW load is fixed, aimed to find which length we will design for distribution
ii) We seen that fixed receiving end criterion (We cannot allowed receiving end variation of design parameters like voltage, power, power factor) so we find out sending end design criterion.
ii) Each case we measure voltage regulation and efficiency and seen that when line length is variable 50,100,150 (KMS) then VR (%) 7.78, 15.27, 1.14 and T.E (%) 96.57, 94,116.14.So it is clearly seen that for 20 MW load suitable line length is 50 KM that VR (%) 7.78 and T.E (%) 96.57 and P.F .9 which is indicates a practical design .Because VR must be lies (0-10) and T.E (>95%) which is matching criterion. If VR is increasing then TL will suffers huge losses and system becomes unstable by changing other TLD criterion.

Decision:-

i)Choosing of T.L totally depends on Load.
ii) Lower load distribution wills choice lower T.L. So it is more advantageous to distribute it from near Substation or Generating Station.
iii) We can design moderate length for same load but voltage regulator or reactive power compensator devices should be installed otherwise regulation will be increasing and efficiency will be dropped down.

In case II(Table-1,SL-2) we seen that when we consider line length 100 KM(+50 KM with S.L.1,othercondition of RE.L constants) then efficiency dropped to 96.57 to 94 (%) i.e, dropping to 2.57 and regulation increases 7.78 to 15.27 i.e 7.47.(means voltage differences are increasing) that indicates if we want to distributed same load from far end substation we have to installing Voltage regulator in nearer to sending end lines

i) But when we tested 20 MW load for 150 KM length we are not getting any suitable practical design criterion because we see that VR (%) decreases to 1.14 (best) but T.L.E comes to 116.14 which is totally unrealistic design. Because T.L.E never be exceeds 100 and it should be always operated less than 100(Our T.L always operated with inductive load).

So we can concluded here that if we want to supplying same load (20 MW, low load) from higher T.L substation or G.S then system will be overexcited and reverse power flow can be occurred. So we can tell that if we want to increase our T.L from optimum design we must be careful about this matter and proper FACTS devices and reactor design required.

Medium Transmission line(Pie network) consider constant line length and variable Loads					
SL No	Length(KM)	Load Power (MW)	Sending End PF	Voltage Regulation (%)	Transmission Efficiency (%)
1	100	20	0.91	15.27	94
2	100	40	0.79	35.55	88.6
3	100	60	0.7	57.6	86.08

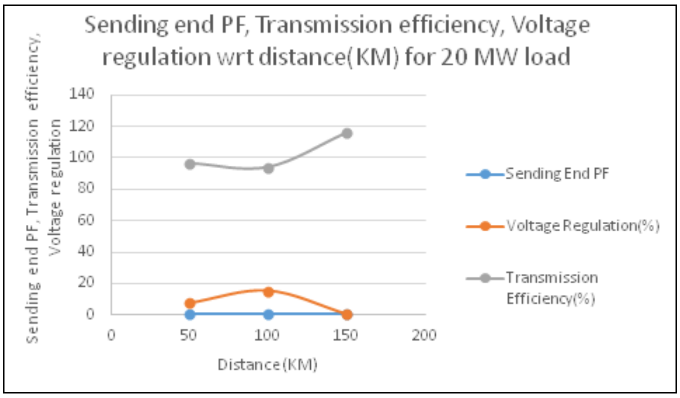
Statements:-

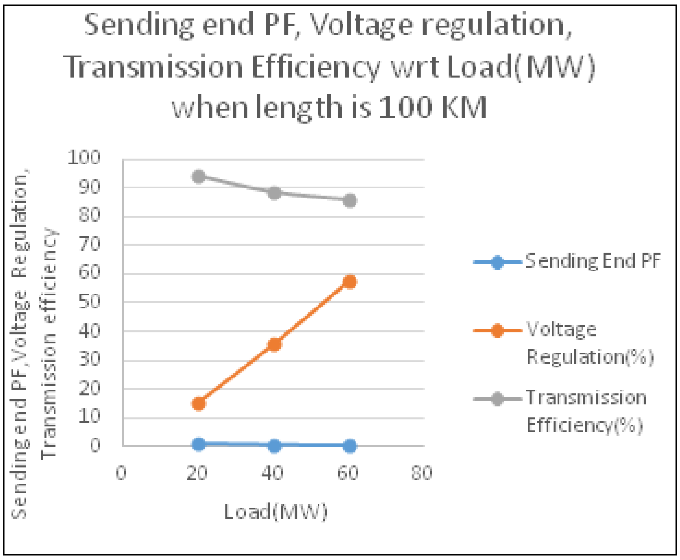
i) ***It is seen that when T.L is 100 (K.M) and change the loads 20, 40, 60 (M.W), best design is load 20 MW, P.F .91, V.R (%) 15.27 and efficiency 94 %.***

ii) ***If we want to design to higher loads in same length then V.R will be 35.55 and 57.6 and T. E will 88.6 and 86.08 at load (MW) 40 and 60 respectively. These are not suitable design.***
Conclusion: - Choice of load design is also important for any transmission line.

In table 1 we see that by increasing length from 50 km to 100 km the efficiency is falling. But when we change the length to 150 km over excitation is happening which is bad for the system. . So, we can conclude that very less or very high length for medium transmission is not suitable because there is a chance of over excitation. On other side we can see in table 2 that the efficiency is falling when we are increasing the load. So we can combine this two effects i.e. we can increase the load amount when there is a chance of over excitation.

Results:-





Conclusion: *So in this paper we found that when sending end P.F decreases, transmission efficiency decreases, and voltage regulation increases when the change of load increases but the length is fixed . We also see the mathematical results for changing length but with fixed load on sending end pf, transmission efficiency, and voltage regulation. We can find more such criteria to consider by analyzing mathematically in future which can set criteria to consider for highly economic power transmission.*

REFERENCES:-

[1] *https://electricalbaba.com/nominal-t-and-nominal-pi-model-of-transmission-line/*
[2] *Principles of Power System" –V.K.Meheta & Rohit Meheta*
[3] *A Course in Power Systems"-J.B.Gupta ,S.K.Kataria & Sons,4th Edition*
[4] *Estimation of Technical losses in Transmission and Sub – Transmission Network of Andhra Pradesh",J.Sreedevi,C. Prabhakar,P.V Bala Subramanyam ,M.M Babu Narayan,B.N.Sarkar,National Power system Comference.*