Optimization of Loss Reduction using FACTS Device (SVC & STATCOM) in Unregulated Power in Extra High Voltage Transmission System

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***Abstract*—** The losses are an important constituent of consideration for reduction and thereby enhancing the available power transfer capability of power system. Loss minimization is two stage processes – (1) planning phase and (2) the operational phase. The paper discusses briefly planning phase activities. The various method of minimization the power losses in the operational phase have been presented in the paper with emphasis on one technique- the Flexible Alternating Current Transmission System (FACTS)devices such as SVC,UPFC,STATCOM etc. The Flexible Alternating Current Transmission System device sere the latest power electronic devices(SCR,IGBT,MOSFET) by which the losses can be minimization and power transfer capability enhanced. SCR Controlled Series Compensator (TCSR) is used to reduced the power losses in transmission system. The method is tested on IEEE 9 bus, 14 bus, 30 bus systems in power system and validated. Results have been presented and analyzed in our paper.

Keywords:- Power Transfer Capability, B-Losses Coefficients, UPFC,STATIC VAR COMPANSATOR(SVC), TCSC,TCS,TSR.

1. Introduction:-

The quantification and the minimization of the power losses is important because it can lead to more economical operation of electrical power system. if we know how the power losses occur, we can take steps to limit the losses. Hence if more losses can be reduction the power can be consumed efficiently.

Power Losses results from current flow with resistive material and magnetizing energy in the transformers and motors generator. Other sources such as the dielectric and rotational power loss. Three facts considering for reduction the unnecessary losses associated with resistive material are

- Reducing the resistance/impedance.
- Decrease the current.
- Increase the voltages.

Magnetizing loss can be minimized by minimizing the line voltage (in per unit terms).several paper has been written in the 1960s and 1970s, which gives the comparison of actual measured of the transmission loss in an power system with consideration of the loss coefficient.

Modern power system being highly interconnected over the long distance high voltage transmission to carry power from sources to various loads. The Electric power transmission efficiency-enhancing actions and technology includes:-

- FACTS (flexible alternative current transmission system).
- Distributed generation/micro grid.
- Underground distribution lines.
- Power electronic transformer.
- High efficient energy storage devices.
- Higher transmission voltages.

India's electricity grid suffer from highest transmission and distribution losses in the world-nearly 29%.this is attributed to technical losses and theft. The paper presents the interest of the others discussing few planning and determining the losses in transmission system under various conditions presenting an effective method of reduction the losses.

1.2 Losses in Power System

Power Losses is define

$$P_{Loss} = P_G - P_R$$

Where P_{Loss} = total losses P_G = power generation

P_R= **power** received

Classification of losses:-

Mainly there is two types of losses:-

A) Technical losses:-

It is internal losses, and occurs due to the power system component. They occur naturally .it is function of the system design parameter and the dynamic state of the power system. It can control by two ways:

1. By proper design of system parameters, under planning stage.
2. Controlling the parameters during power system operation by use of devices such as FACTS(flexible AC Transmission system), under controlling stage.

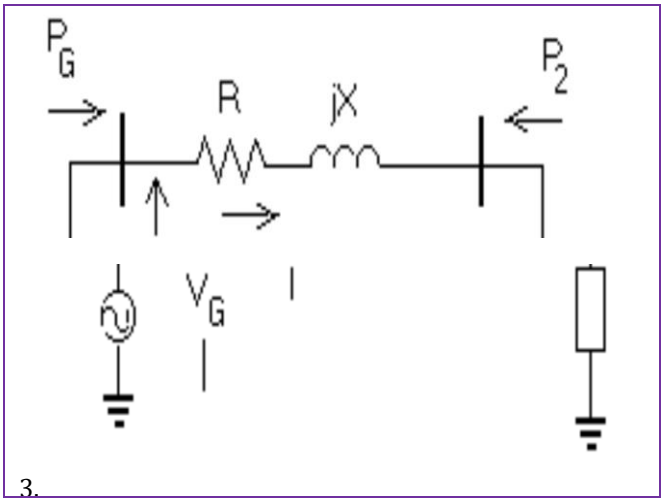

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Fig1. 2.1 Stages of Management of Technical Losses

B) Non technical losses:-

It is power losses caused by some external action to the power system and consist primarily of electrical theft, error in accounting and record-keeping.

3. Effect of electrical power Losses:-

Losses cause various harmful effects. Common effects are as follows:-

- Losses increase the operating & maintenance cost of running a power system.
- Thermal losses reduced the overall lifetime of the electrical equipments.
- Losses responsible for the poor power factor.
- Losses minimized the reliability of the power system.
- Losses reduced the efficiency of performance of the system.

Management of technical losses:-

Management of technical losses is a two stage operation:-

1. Planning Stage

2. Monitoring Controlling & Maintenance Stage

Modeling methods of technical losses:-

(1) Fundamental method

Power loss is proportional to the resistance of the wire & the square of the current

$$P_{loss} = RI^2$$

For system which delivers a certain amount of active power (p), over a particular supply voltage (V), the current (I) flowing through the cables is given by

$$I=P/V$$

Thus the electrical power lost in the line is

$$P_{loss} = RI^2 = R(\frac{P}{V})^2 = \frac{RP^2}{V^2}$$

Power loss is proportion to resistance(R) & inversly proportional to the voltage(V).HVDC is used to reduces the current and increase the voltage and minimised the power lost in the during transmission line.HVDC is used to transmit large amount of power over long distances or for interconnections between asynchronous power grids.When electrical energy is require to be transmitted over a long distance, it can be more echonomical to transmite using direct current DC instead of AC for long transmission line, reduce the losses and the construction cost.

(2) Conventional method

B-Loss Coefficients are the commonly adopted conventional method to calculate the incremental loss. The B-Loss Coefficients equation transmission losses as a function of the output of all the generation power plants. The B matrix Loss is practical method for loss calculation since 1960. We an calculate the line power loss as:-

$$P_{LOSS} = 3\ I^2\ R$$

$$P_G/\{(3^{1/2})V_G COS_G\}$$

Where VG is the magnitude of the generated

voltage (line-to-line)

$\cos\phi_G$ = generated power factor

$$PLOSS = (PG2)\frac{R}{[VG\ COS\phi G]}$$

for fixed voltage(V) & power factor

$$P_{LOSS} = BP_G^2$$

Power losses can be expressed is given by

$$P_L=P_1B_{11}+2P_1P_2B_{12}+P_2B_{22}$$

$$\sum_{m=1}^{k}\ \sum_{n=1}^{k} Pm\ Bmn\ Pn$$

P_m & P_n is the electrical power generation from all sources

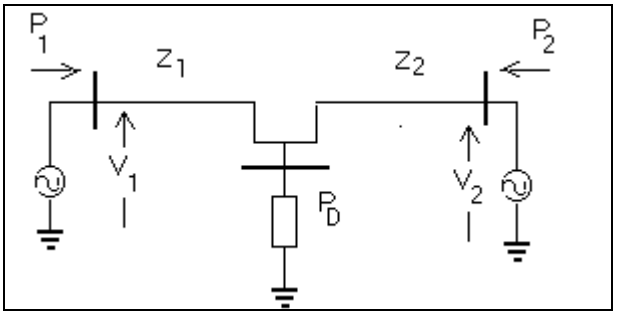

Fig. 1 FACTS Devices and Its practical Implementation

FACTS provide very effective and economical performance to control the power transfer capability into the large interconnected AC transmission system. FACTS consists improvement of dynamic behavior & enhancement of system reliability. It minimized the power losses & improved the voltage profile. Operating margins can be reduced due to fast controllability. So the power transfer capability enhance up to the thermal limits. The transient stability limit is increased therefore the dynamic security is improved and reduced the system blackouts caused by cascading outages. The low frequency oscillations are damped with the helps of auxiliary stabilizing controllers to enhance the steady state stability. FACTS Controllers overcome the problem voltage fluctuations & dynamic over voltages. FACTS device increase the system load ability too. It plays very important role in control and operation regulated power systems.

4. Modeling of FACTS Devices

There is many types of model are proposed FACTS Device. This types are termed A,B and here for convenience .Fig.[3] the block diagram of the FACTS Devices:- (a) TCSC (b) TCPST (c) UPFC (d) SVC(e) STATCOM. Shown in fig.4 the reactance(X) of the line can be changed by the TCSC. Therefore FACTS can be used to control power flow by changing parameters of power system and generation cost can also be reduced.

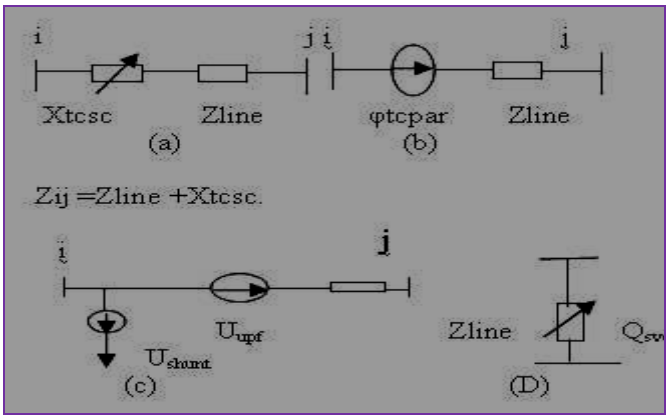

Fig. 4 Block diagram of FACTS devices

(a) **TCSC** (b) **TCPST** (c) **UPFC** (d) **SVC**

Practical implementation of TCSC:-

The rated value of TCSC is vary with the reactance of the transmission line where it was located. Degree of compensation is exist in the range of 0.2 X_{line} to 0.7X_{line}.

In India, two TCSCs have been installed on the Rourkela-Raipur twin circuit 400kV power transmission inter connecter between the Eastern and Western regions of the power grid. The length of the inter connecter is 413 km. The main purpose of this major AC inter connecter is to enable export surplus energy from the eastern to the western regions of India during normal or abnormal conditions. The TCSC are located at the Raipur end of the lines. The TCSC enable damping of inter area power oscillations.

5. Optimal Analysis

Optimal Location of the TCSC Base on the Real Power (P) Loss .The objectives for device placement may be one of the following a) Reduction of power loss in particular line. b) Reduction in total system real power loss. c) Reduction in total reactive power loss. d) Maximum relief congestion in the system. For the first objective the TCSC is placed were maximum loss is occur. For next 3 objectives the method base on the sensitivity approach is used.

Approach Proposed:-

Power Flow Analysis carried out by MATLAB and Power World Simulation. TCSC was modification by increasing the reactance (X) of the line by 20% to 70%. After placement of the TCSC power flow analysis done and compared with the base case data.

6. Results Analysis:-

FACTS devices improve the power transfer capability by reducing the power losses. Just like that

(1) Objective function value is minimized by the 1.32$/hr.

(2) The power flow analysis converged in 0.15sec with FACTS as compared to without FACTS.

(3) For the 9-Bus system total 10.7MW losses occur without FACTS.TCSC is located where the loss is maximum. The electrical power transmission line suffer with maximum losses between busses 5&6 ,so the TCSC is placed between buses 5&6.Total MW losses is reduced up to 9.9MW.thus the total electrical power losses is reduced by 6.7% with re placement of FACTS Devices(SVC,STATCOM,UPFC). In 14-bus the maximum MW Power losses is occur in the HV transmission between the buses 1&2.Hence the FACTS Device, TCSC is located between the buses 1&2 .the reduction in losses was observed to be 18%.1n 30-Bus system also the lines

having maximum losses were detected and TCSC located. The power loss was reduced 9.5%.

(4) The Table 2 below shows the % reduction in power loss with FACTS Devices.

(5) The graph of the Losses Vs Line No 9-Bus is shows in Figure 5.

(6) The graph of losses Vs Line No of 30-Bus in Figure

Power System	Real Power Loss Reduction
9-Bus	6.6%
14-Bus	17%
30-Bus	9.4%

Table 2 % Loss Reduction with FACTS

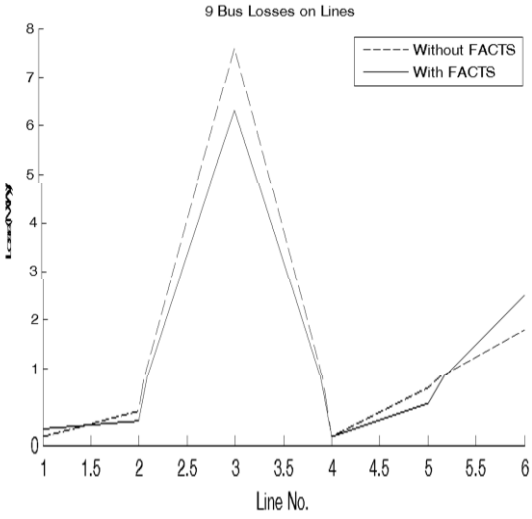

Fig. 6.11-Bus System Losses Before and after Placing FACTS

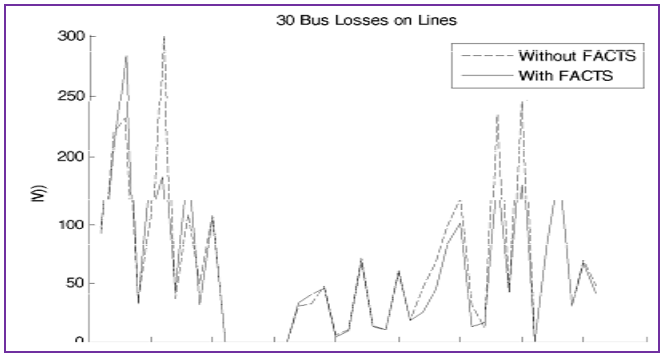

Fig.6.2 -30-Bus System Losses Before and after Placing FACTS

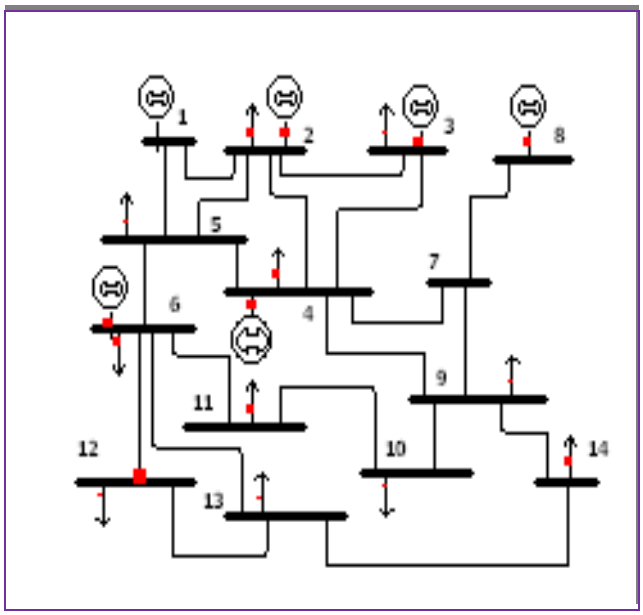

FIG. 5 IEEE 14-BUS TEST SYSTEM

7. **Conclusion:-**

Most research focuses on the large transmission system. This research project addresses this shortcoming. Losses increase the cost of operation of a power system. Hence, loss minimization would be very advantageous goal to use to optimize the generation &delivery of electrical energy. FACTS devices have provide most effective method for loss reduction. The effectiveness of TCSC is demonstrated on IEEE 9- bus, 14- Bus System & 30-bus IEEE Power System. Main conclusion of the paper are:**1)** The simple and direct method of placing TCSC in the line having maximum power loss has shown effective results in loss mitigation &enhancement ATC. **2)** The placement of the FACTS devices increase system ATC & mitigation real power loss. **3)** Time of convergence is less.

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