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Should we transform our lines to HVDC?

HVDC versusHVAC

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Abstract- Generally lines transmitting power from one point to another are high voltage alternating current (HVAC) lines. Though alternating currents has its own disadvantages they are used keeping in mind the economical aspects. There are many Researchers and Industrialists who are involved in advancing High Voltage Direct Current (HVDC) transmission lines, facing the limitation offered by HVAC transmission lines. The HVDC transmission lines had limited voltage rise for transmission but advancement in power electronics help in overcoming that limitation of HVDC.

Keywords- Alternating Current, Direct Current, Transmission lines, Power Transmission.

I. INTRODUCTION

After the generation of electricity Edison researched in transmission of power from one place to another through Direct Current (DC) but had its own disadvantages discussed later in this article the solution was then given through High Voltage AC transmission lines. From here, HVDC will be referred for HVDC transmission lines and HVAC will be referred as HVAC transmission lines.

AC transmission lines are accepted universally and this led to fall of DC transmission lines. But High Voltage AC Transmission lines have its own limitations. Engineers and researchers are engaged in development of HVDC. Currently HVDC have been implemented at many grids and are operational with high efficiency than HVAC.

We have tried to furnish on and distinguish between HVDC and HVAC with a detailed explanation for the same.

II. HISTORY OF ELECTRICITY POWER TRANSMISSION

In Late 19th Century a name Edison was renown around the world. His researches covered many fields. Edison converted his inventions in commercial successes. In the case of his invention of light bulb he created a complete power system generating electricity and delivering it to customer energizing their light bulbs. Edison's system typically used a steam engine to drive a system creating DC electricity. Fig.1 represents an Armington & Sims engine which Edison used for generating DC electricity. Edison built many plants around the world realizing that there was a huge market for electrical light. There was one technical problem with these transmission: power loss.

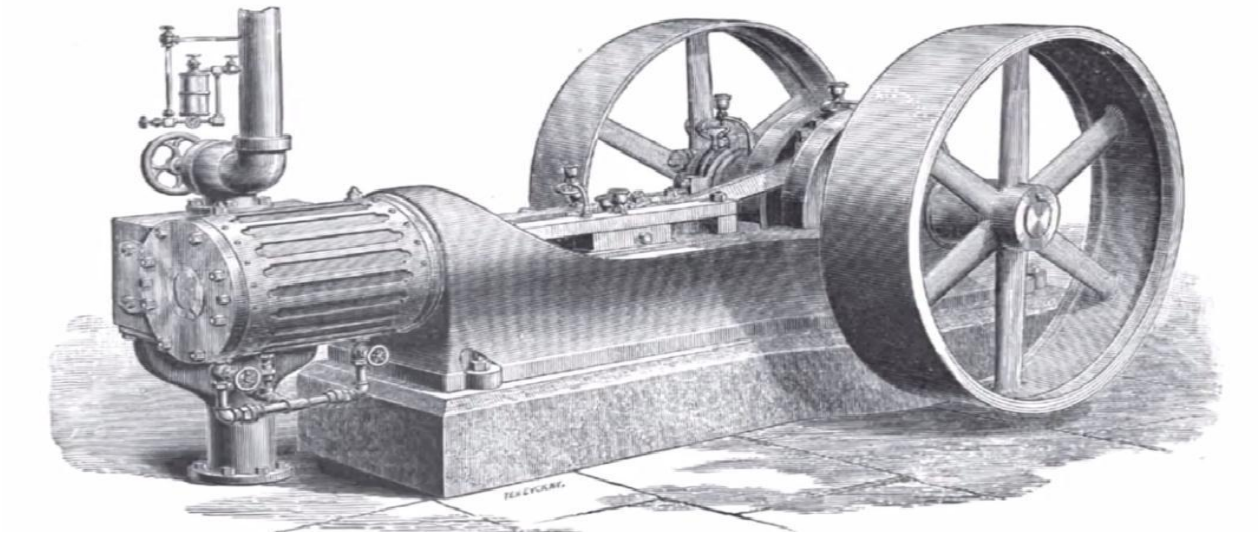

Fig.1 Sims & armington steam engine

The DC power transmitted over some lengths from the power plant were consumed as power loss thus every customer or user had to be in given certain range of power plant, which was not at all feasible . Nikola Tesla, a Serbian engineer, arrived with the solution introducing alternating currents. He understood that power does not rely only on voltage but equally also relies on current, for a given power a low voltage require a higher current and a higher voltage requires a low current. The metal wires have some resistance the power was dissipated as heat. He understood the above theory and introduced HVAC for transmission. The transformation of voltage and current in AC was easy with the help of transformers but not in DC as the power required was quite small. This invention was universally accepted hence transforming the DC links to HVAC. The demand of 21st century world has increased tremendously which increased the voltage level of HVAC to EHV and UHV. At this level the disadvantage of HVAC is increasing. Advancement in power electronics draws attention towards HVDC which would be discussed further.

III. High Voltage Alternating Currents (HVAC)

After the acceptance of the theory of transformation of voltage and current through transformer given by Nikola Tesla the links from the power stations to the consumer were slowly transformed to HVAC. Thus HVAC were utilized. Developing the power stations at suitable place was now possible considering safety as essential. Power was generated in AC, transferred to EAV or UHV using transformers. This power reaching at usage point was transformed to useable AC supply with the help of step down transformers (pole mounted sub-station) which was available for household uses as well as industrial use.

Advantages:

(1) Electricity was transferred to longer distances efficiently through HVAC links.
(2) Due to easy transformation of voltage it was now easy to make availability of power for industrial as well as residency.
(3) The protections of power components were easy. (4)

Maintenance of AC substation is easy and cheaper

When voltage was transmitted at UHV & EHV voltage the electrical losses increased gradually for AC links. The problems which arouse for HVAC are:

(1) An AC line requires high core size as compare to DC line due to phenomenon like Skin effect, causing higher impedance of line.
(2) The transmission towers constructed requires more materials and space.
(3) Synchronization between two systems is vital process. Using HVDC can simplify that process.
(4) In undersea cables, additional AC losses occurred due to additional impedance offered by surrounding water.

IV. HIGH VOLTAGE DIRECT CURRENT (HVDC)

DC itself states that a constant level voltage (zero frequency) is used. Different equipment's needed different voltage levels for their usage hence number of transmission links also increased as shown in fig.2. In olden times we didn't have any option to increase or decrease the voltage level as in case of ac links, so that decrease level of current, reduces transmission losses and also decrease the no. of overhead transmission links.

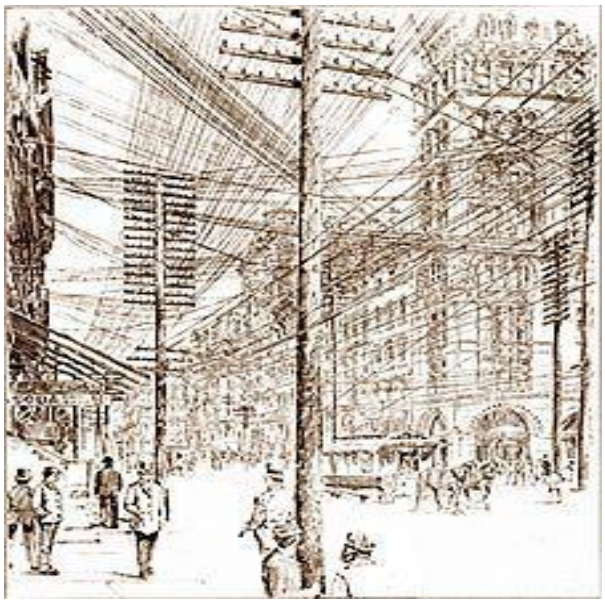

Fig.2 Multiple transmission lines were required for different voltages.

But today with the advancement of power electronics it is easy to convert AC to DC which is discussed in detail below. Thus generated voltage can now be converted to HVDC and used for transmitting. Let us know the advantages of HVDC transmission lines.

(1) Entire cross section of conductor can be used as there is no skin effect in dc transmission lines.
(2) There is no inductance, capacitance, phase displacement and surge problems in DC transmission lines.
(3) DC lines has less corona less and reduced interference with communication circuits. (4)

There is no stability problem and synchronizing difficulties.

It also involved some disadvantages as under:

(1) Production of electric power at high voltage was not possible due to commutation problems.

(2) DC voltage cannot be transferred to High voltage i.e. they cannot be stepped up. (3) There was a limitation in using DC Switches and Breakers.

V. HVDC over HVAC in transmission

The selection of HVDC over HVAC can be understood easily by knowing the advantages of using HVDC over HVAC transmission lines:

- Low transmission losses over long distances.
- The Voltage drop in HVDC is less than HVAC line for same voltage ratings, due to absence of inductance.
- Enabling use of Submarine cable or underground cable over long distance with fewer losses.
- No skin effect in HVDC system so whole cross section of cable can be used for transmission.
- Asynchronous grids also can be easily connected.
- The potential stress on insulation is less in DC system than in AC system for same voltage rating.
- DC lines have less corona loss.
- HVDC lines have less interference with communication circuits.
- HVDC lines are free from dielectric losses
- There is no phase displacement and surge problems in HVDC transmission lines.
- Magnetic field from HVDC is less in compared to HVAC lines.
- Full control of power flow, enabling efficient power trading between regions.
- Number of lines required for transmission is also less for same transmission of power.
- The right-of-way width for overhead transmission lines is also less.

Below graph(fig.3) shows the cost and line losses for 2000 km lines at 12000MW power for 800Kv AC 8 lines, 1000Kv AC 5 lines, 500Kv DC 4 lines and 800Kv DC 2 Lines.

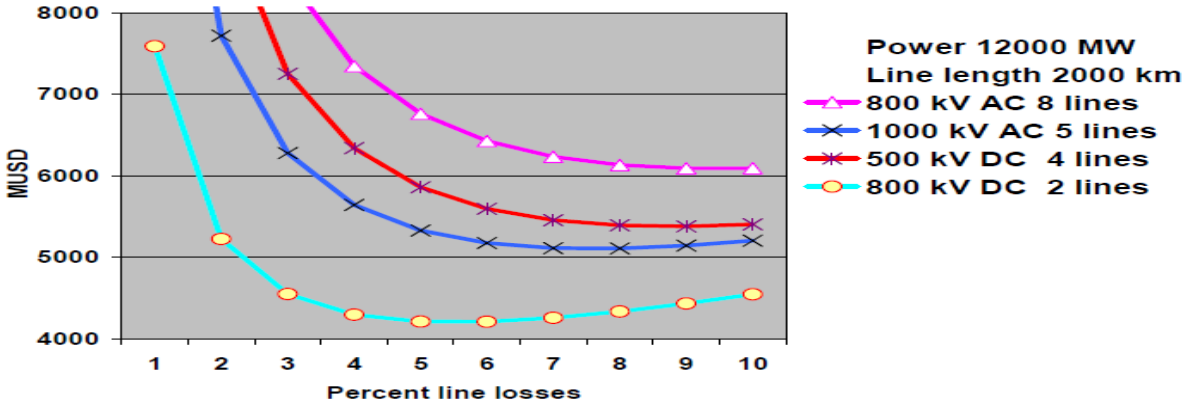

Fig.3 Cost Comparison with Losses

Moreover below graph shows relation between the cost and distance of transmission lines.As shown here we can say that after some distance referred to as "Break-Even Distance" the cost of AC lines increases than DC lines and losses in DC is also less than that in AC.

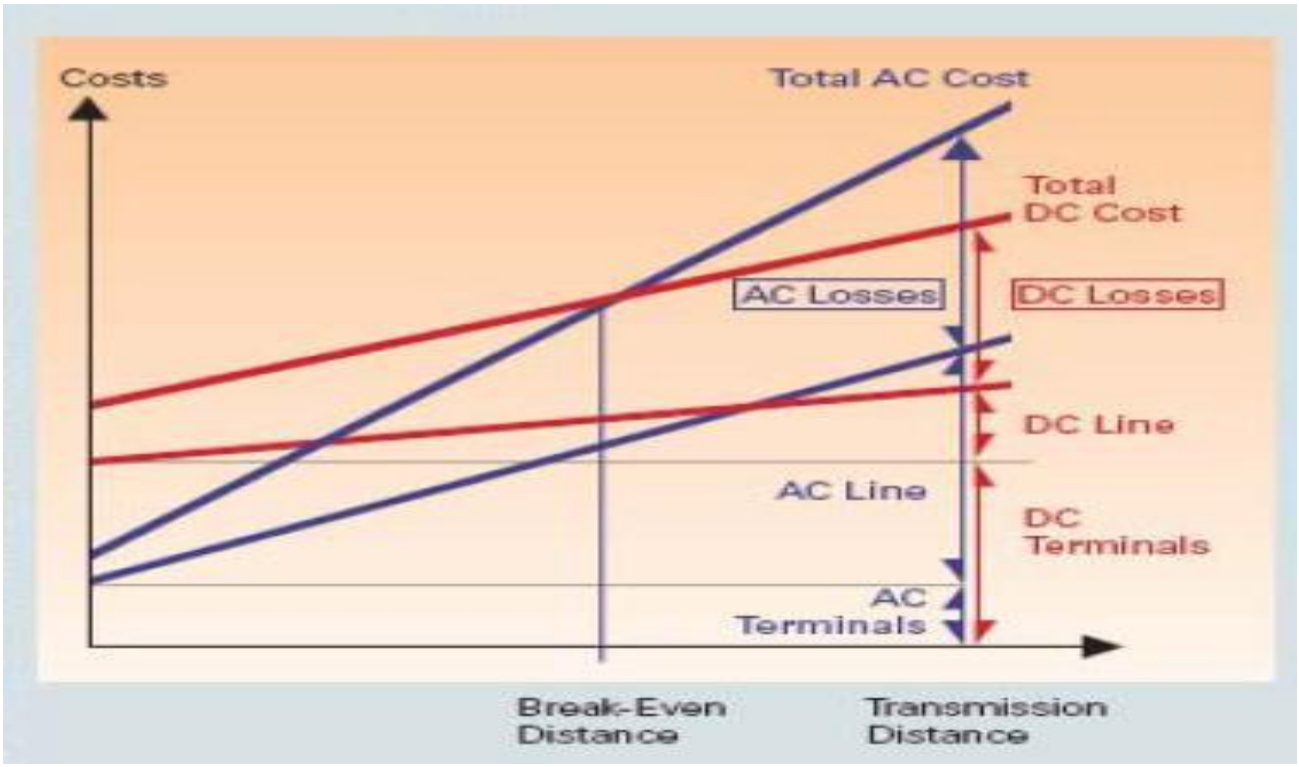

Fig.4 Relation between cost and distance

Owing to the following points we can say that we should transfer our lines to HVDC but there are some problems in doing so which got resolved with the advanced technology the detailed discussion of how to use HVDC lines is discussed below.

5.1 Transmission through HVDC

Though transmission with the help of HVDC had many advantages over HVAC the disadvantages are as follows:

- Voltage Levels can't be changed in DC lines easily.
- Generation of High Voltage power was not possible due to commutation problems.

The above two problems were the only points in the late 19th century for Edison which he was not able to solve at that time. But with the advancement of Power electronics it was able to convert power from AC to DC which led to solution to one of the above problems.
Power was generated in ac was transferred to HVAC with the help of Transformer this HVAC was Transferred to HVDC with the help of IGBT and then used for transmission. At the receiving end HVDC was again transferred to HVAC with the help of IGBT. Thus transmission became easy and losses which occurred in transmission also got reduced.

5.2 Components for HVDC Transmission:

- An IGBT or thyristor is a semiconductor device that is used for conversion of ac to dc and thus can be considered as a heart without which nothing is possible in transmission with HVAC supply.
- After the generation of power in ac a transformer is required for converting the voltage level at high range.
- Smoothing reactors are used to limit dc fault current, prevent resonance in dc circuit.
- Harmonic filter on ac side of supply to supply reactive power and to prevent harmonics to enter in converter system.
- DC filter circuits are used for better performance.
- Surge arrester to protect the system from lightning and switching overvoltage protection. A

Schematic diagram for HVDC transmission links is shown in fig.5.

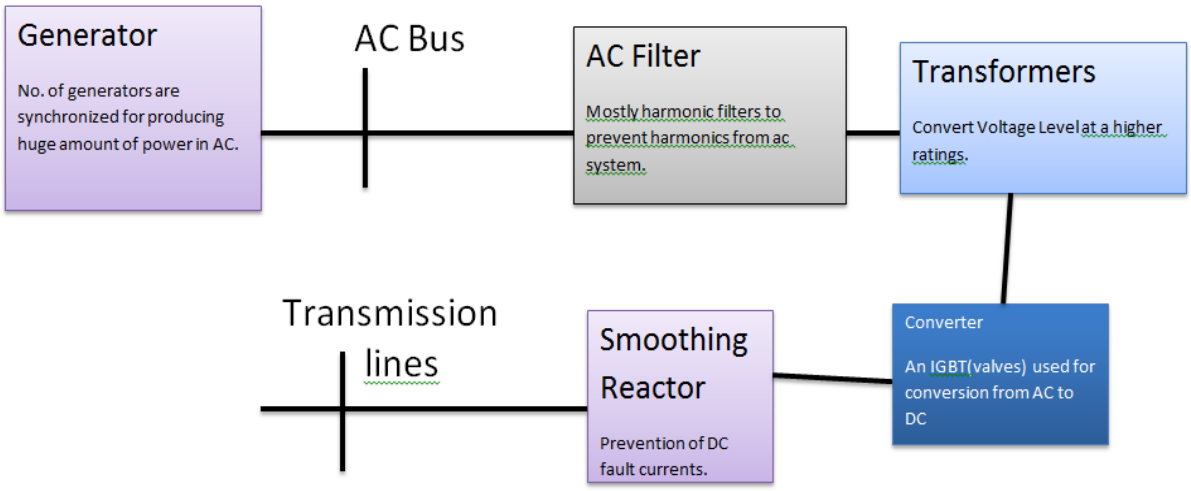

Fig.5 Schematic diagram for HVDC transmission links

CONCLUSION

Electrical energy has become a vital part of human life. With advance in technology, one can overcome the difficulties faced earlier. HVDC and HVAC both have their own limitation and advances over each other. The role of electrical engineering concepts plays greater role to implement HVDC and HVAC. Thus we have discussed both of the transmission lines, their advantages and disadvantages. The world needs efficient way to transfer electrical power. HVDC transmission can be considered among that way, as it can also fulfill the increasing demand of electrical power. Concluding at last we would say that HVDC Transmission is efficient when the distance is larger than the break even distance so for long lines and high power transmission HVDC lines should be used moreover for underwater & underground lines too HVDC should be preferred.

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