Porcelain versus Polymer Insulator- A Changing Era in Transmission Lines

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Abstract

For the past few years with an increase in the globalization, the environmental challenges and an increase in pollution levels have become a global phenomenon as well as matter of discussion. The power transmission lines passing through transverse areas within the country as well as worldwide are facing various problems related to environment and pollution. Such an exponential increase in the pollution levels lead to frequent faults in transmission lines which finally lands to permanent breakdown of transmission lines. These breakdowns sometimes may leads to collapse of grid and are also inconvenient to everyone besides interrupting the growth of nation as well as society breakdown. Over the years engineers and scientists have made efforts to meet such threats and to overcome situations rising form the failure of transmission lines the environmental challenges and an increase in pollution levels. The scientific community proposes a solution to resolve transmission failure by adopting polymer insulators instead of conventional porcelain insulators because the demand is on increase by virtue of its proven inactive use.

In this article, an effort has been made to understand difference between the two and agency would decide the type of insulators to be deployed for ensuring long life of transmission line with respect to rate of rise of pollution in country.

1. Introduction

India is one among the top 10 most polluted countries in the world. The urbanization and industrialization are the major sources to an increased pollution level in the country. The thick approach to capitalism has failed to put a check on the pollution. Environmental monitoring regulations and protections acts are also not matching with pace of development.

A substantial increase in the industrial sector has also evolved to be as a host to modern technologies giving birth to newer chemicals, emissions etc. The graphical representation of the pollution level in India is given below in Fig.1 [1].

Many authors have carried out the work on the different aspects of the insulators on the transmission lines to evaluate the better performance options. A study was conducted on the on the combination of critical flashover (CFO) voltages of the fibreglass distribution and with polymer and porcelain insulators and the results obtained indicated that added CFO voltage by fibreglass pole is highest at dry condition with negative polarity lightning impulse, and has the lowest value at wet condition with positive polarity lightning impulse [2]. Again a study of the electric field distribution along creepage path of a cap and pin porcelain insulator string of transmission line have been carried out using Finite element method (FEM). The electric field behaviors of insulator using in polluted areas were analyzed considering the pollution layer conductivity and dry band width parameters [3].

A study examining the flow of leakage current on sand-polluted composite insulators has been carried out which subsequently shortens the insulator life or lead to flashover thus interrupting the power supply. The study also derives the probabilistic features of the insulator's leakage current, which in turn enables a risk assessment of insulator failure [4].

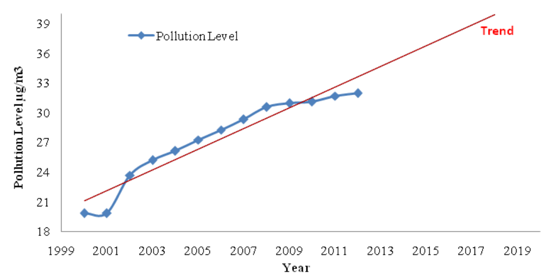

Fig: 1. Trend of pollution level in India [1]

A study on the electrical reliability of DC line ceramic or composite insulators which can lead to their failure have been carried out and the results obtained showed that the environment of dc lines is more damaging to insulation than that of comparable ac lines. The result obtained also revealed that thermal breakdown and ionic migration is the reason for breakdown of ceramic insulators [5].

The effects of pollution and high altitude on the flashover performance of short samples of five kinds of UHV/EHV dc composite long rod insulators were analyzed and the results obtained indicate that influence of salt deposit density on the flashover voltage is related with the profile and the material of the insulator. The values of exponent so obtained are smaller than those of porcelain or

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glass cap-and-pin insulators, clearly indicating that the composite insulators have certain advantages in severe pollution regions [6].

A finite element technique was employed to investigate the insulator surface electric field under dry sand-pollution conditions with different sand grain sizes for an ABB designed composite insulator. The technique was used to simulate the insulator and seek electric field distribution on the polluted insulator model as well as around it and clearly justify the use of such insulators in these critical areas [7].

Pollution problem in transmission system starts when pollutants existing in air settle on the surface of insulator subsequently degrading the electrical properties of insulators.

Different agencies like CPRI/CEA & world level affected utilities have conducted studies on pollution levels from time to time [8]. Pollution on insulators appears in following ways;

a) Bird dropping
b) Brick kilns
c) Thermal plants
d) Industry discharge chemicals/fly ash
e) Agricultural ash/ burning, wild fire etc.
f) Mineral handling process
g) Salt due to coastal areas
h) Cement industry, oil refineries etc
i) Commercial and domestic vehicles (railway yards, highway crossings etc.)

The pictorial representation of the pollution deposit can be seen in Fig.2 (a) & (b) as given under-

Fig: 2(a). Source of Pollution on Insulators from Power Plants

Fig: 2(b). Source of Pollution on Insulators from brick kilns

The level of deposit on insulators mostly depends upon wind speed and direction. It also depends upon the area /locality from source of pollution. Clouds & fog during winters acts as a catalyst to create flashovers.

2. Measurement of deposition on insulators

The deposits on insulators are measured in a technical terms called as ESDD (equllient salt deposit density) and can be seen in Fig.3.

Fig: 3. Deposition of Pollution on Insulators

Due to the deposition on the insulators, the pollution levels has been categorised as given blow in Table1-

S. No	Level	ESDD (mg/sq.cm)
1.	Light	0.03-0.06
2.	Medium	0.06-0.20
3.	Heavy	0.20-0.60
4.	Very Heavy	>0.60

There occurs a change in the insulation distance with an increase in the pollution level and is a gradual phenomenon.

Table: 2. Insulation Distance have also been Categorized

System volts	Minimum creep distance (mm)	
	Moderate Pollution	***Heavy Pollution***
72.5	1100	1700
125	1850	2800
145	2250	3400
245	3800	5600
420	6480	9660

Table: 3.There is a strict need to design insulators depending upon the requirement which can overlook the pollution from the different agencies. The insulators can also categorized on the basis of pollution level as well as creep distance

S. No.	Pollution level	Minimum creep distance (mm/kV...phase to phase)
1.	Light	16
2.	Medium	20
3.	Heavy	25
4.	Very Heavy	31

Again, the time has arrived to ensure long trouble free life of insulators/ transmission lines, and the same can be done with the design of insulators for 36 kV/ mm. The Government of India is putting up all efforts to control pollution levels but due to deforestation and urbanisation. The pollution mapping is continuous type of job and need to review after every 2/3 years for awareness towards the technocrats as well a civil society. Also stringent enforcement of laws is a must thing.

3. Replacement of conventional Porcelain insulators with polymer based insulators

With passage of time conventional type porcelain insulators are being replaced by polymers and are giving better performance in polluted areas. In our country the process of replacement of conventional insulators is still developing and was considered for the use for the last 8 to10 years and in large scale for the last 5 to 6 years. The polymer based insulators were in use worldwide for the last 25 years. In our country their performance in long run is yet to be established and particularly in areas where temperature falls below -10oC [9].

4. Comparative study of the conventional Porcelain insulators with polymer based insulators

A comparative study of the conventional Porcelain insulators with polymer based insulators has been presented considering various parameters which include general, technical as well as miscellaneous (other) factors. The comparative study has been tabulated below in Table 4 given below [10]-

Comparison of Polymer versus Porcelain Insulators		
General Comparison		
Factors	**Ceramics**	**Polymer**
Weight	Heavy and the approx. weight of 400 kV string is 135 kg	Lighter and offer an equal as well as better strength. Approx. wt of 400 kV string is about 20 kg
Fragile Ability	Highly fragile to shock & vibrations	Not fragile to shocks
Packing and Transport	Risky and expensive	Easy and economical
Installation	Risky, expensive & more labour is required	Very easy and economical
Handling	Difficult and needs to be handle with care	Easy to handle
Maintenance Cost	Being fragile in nature the maintenance cost is moderately high	Low when compared to porcelain
Vandalism (stone pelting/ gun shots)	More susceptible	Highly resistant
Breakages & Secondary Damage	Highly fragile, about 10-15% breakage are reported during transportation, storage and installation	Flexible, highly resistant to breakage. But susceptible to cuts and scratches
Technical Comparison		
Mechanical failure	Life span reduces with time because separation due to pins getting eroded	Single piece. Hence no such problems occured
Resistance to flashovers and punctures	Resistance is lower but can sustain maximum of 2 to 3 flashovers and then require replacement	High resistive and if once the flashover takes place, the insulator needs to be replaced immediately
Anti tracking and erosion resistance	Low tracking resistance	Excellent tracking resistance and also avoids erosions or tracking of the housing materials
Dielectric strength	Reduces with age	Excellent insulation performance
Contamination and pollution	Affected	Less affected
Hydrophobicity	Non-hydrophobicity, as porcelain forms water films on the surface making easy path leading to flashovers	Hydrophobicity properties of silicon rubber provide better behaviour and resists wetting by forming beads of water without the need of washing or greasing even in humid or polluted climates. Hence, low failure rate combined with low overall operating and maintenance costs
Self cleaning quality	Dirt, sand, salt & snow are easily attracted but gets cleaned during rains	Due to hydrophobicity, the self cleaning is required
Tensile strength	Good	Excellent due to crimping technology
Maintenance	Needs maintenance like cleaning ,washing and greasing	No maintenance. Difficult to work on insulator due to dimension limitations
Performance in snow	Better	Comparatively poor, develops cracks with passage of time
Manufacturing process	Long manufacturing process leading to	Pollution free, safe and less process

	long delivery schedule, manufacturing process causes pollution and health risk	time. Hence short delivery periods
Safety	Susceptible to explosion & breakages, due to high fragile properties	Provide high level of safety, superior flexibility and strength. Not susceptible to explosion.
Design	Design flexibility is limited. Requires larger and heavier towers for installation and more space	Insulator design allows for adaptations to suit specific needs such as creep distance subsequently resulting in space saving and lower cost
	Other factors	
Part replacement	Possible	Not Possible
shelf life	Excellent	Develops fungus/algae
susceptible to reptiles/rats (Storage)	Nil	Very easy and eats way
Life Expectancy	> 25 Years in Non-Polluted areas	Yet to established in Long Run.

5. Advantages of Polymer based insulators

i. One of another major advantage of polymers is that voltage distribution is uniform all along length of string, hence no chance of flash over /overshoot exists.

ii. Another advantage of polymers is of its flexibility in design/shape. It can be given any type of shape to obtain required creep distance suitable to customers.

The different figures indicating the polymer based insulators are given below in Figures 4(a)-(d).

Fig: 4(a).

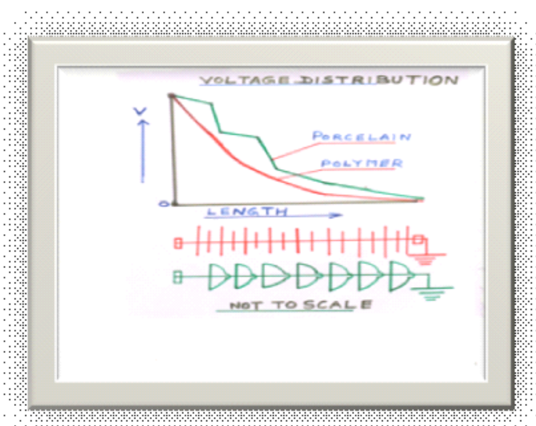

Fig: 4(b).

Fig: 4(c).

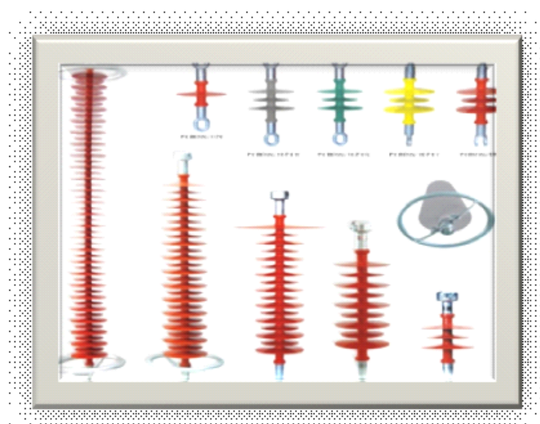

Fig: 4(d).

6. Limitations of Polymer based insulators

i. Eating by rats etc during storage

ii. Notching by birds

7. iii. In the event of damage, whole string requires replacement. Whereas in porcelain replacement of damaged /broken insulators is possible.

iii. Bad storage- Due to bad storage petticoat has a tendency to shear. Polymers have also tendency to develop algae, fungus and lichens. This is bluish-green and yellowish type deposit on petticoats. This reduces ph value, lowers hydrophobicity and decolourisation, finally drying the bands leading to breakage of the insulators.

The pictures of different limitations of the polymer based insulators are presented below in figures 5(a)-(d)

Fig: 5(a).

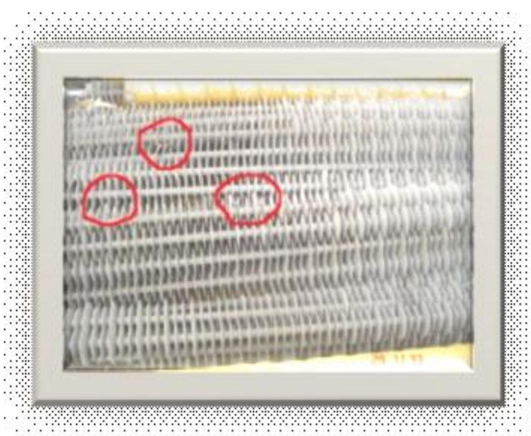

Fig: 5(b).

Fig: 5(c).

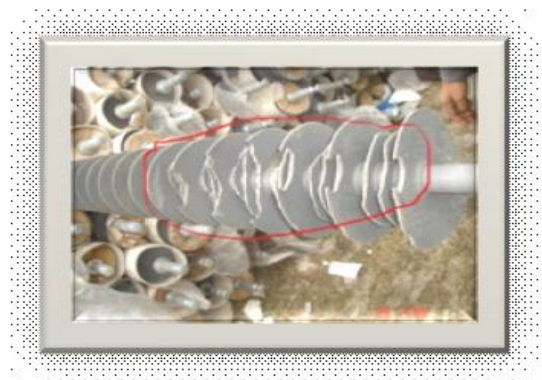

Fig: 5(d).

7. Conclusions

The present study can be concluded in a way that polymer requires testing / inspection from time to time, particularly when stored in open. Periodical cleaning will retain its properties directly relating to prolong shelf life.

However, the Power grid and other transmission utilities have changed porcelains to polymers in recent times (since 2011-12) which eventually showed a drastic fall in transient faults. Such technology in the power transmission has also increased system security and reliability.

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