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(Accredited by NAAC, NBA, Approved by AICTE New Delhi & Permanently Affiliated to JNTUH)
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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

Department: Electrical & Electronics Engineering

Innovative Teaching Method-2020-21

Title of Innovative method/activity : Flipped Class Room

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Designation : Assistant Professor

Course Name : EHVAC Transmission

Objective of method: This activity orients such that the students are assisted to remember the concepts of the course during their examinations. Also inculcate the interest and involvement of students completely during the lecture session and understand the topics easily.

Topic Covered through activity: Concept of Corona loss and measurement of audible noise

Description of method: A flipped classroom is an instructional strategy and a type of blended learning, which aims to increase student engagement and learning by having pupils complete readings at home and work on live problem-solving during class time. This style of teaching also involves giving students the at-home tasks of reading from textbooks or practicing concepts by working, for example, on problem sets. Students watch online lectures, collaborate in online discussions, or carry out research at home, while actively engaging concepts in the classroom, with a mentor's guidance. In planned flipped teaching lessons, the teacher hands out lesson teaching material one week before the lesson is scheduled for the students to prepare talks.

Fig: Flipped Classroom

Corona Effects-I: Power Loss and Audible Noise

The average power-handling capacity of a 3-phase e.h.v. line and percentage loss due to I 2R heating were discussed. Representative values are given below for comparison purposes.

System kV	400		750		1000		1150	
Line Length, km	400	800	400	800	400	800	400	800
3-*Phase MW/circuit* ($P = 0.5\ V^2/xL$)	640	320	2860	1430	6000	3000	8640	4320
% Power Loss = 50 *r*/*x*	4.98%		2.4%		0.8%		0.6%	
kW/km Loss, 3-phase	80	20	170	42.5	120	30	130	32.5

When compared to the I^2R heating loss, the average corona losses on several lines from 345 kV to 750 kV gave 1 to 20 kW/km in fair weather, the higher values referring to higher voltages. In foul-weather, the losses can go up to 300 kW/km. Since, however, rain does not fall all through the year (an average is 3 months of precipitation in any given locality) and precipitation does not cover the entire line length, the corona loss in kW/km cannot be compared to I2R loss directly.

A reasonable estimate is the yearly average loss which amounts to roughly2 kW/km to 10 kW/km for 400 km lines, and 20-40 kW/km for 800 km range since usually higher voltages are necessary for the longer lines. Therefore, cumulative annual average corona loss amounts only to 10% of I2R loss, on the assumption of continuous full load carried. With load factors of 60 to 70%, the corona loss will be a slightly higher percentage. Nonetheless, during rainy months, the generating station has to supply the heavy corona loss and, in some cases, it has been the experience that generating stations have been unable to supply full rated load to the transmission line. Thus, corona loss is a very serious aspect to be considered in line design.

When a line is energized and no corona is present, the current is a pure sine wave and capacitive. It leads the voltage by 90°, as shown in Figure 3.1(a). However, when corona is present, it calls for a loss component and a typical waveform of the total current is as shown in Figure 3.1 (b). When the two components are separated, the resulting in phase component has a waveform which is not purely sinusoidal, Figure 3.1 (c). It is still a current at power frequency, but only the fundamental component of this distorted current can result in power loss.

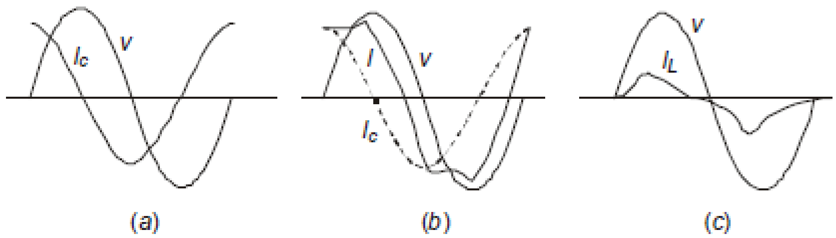

Fig:1 Corona current waveform.

CORONA-LOSS FORMULAE

List of Formulae

Corona-loss formulae were initiated by F.W. Peek Jr. in 1911 derived empirically from most difficult and painstaking experimental work. Since then a horde of formulae have been derived by others, both from experiments and theoretical analysis. They all yield the power loss as a function of (*a*) the corona-inception voltage, *Vo*; (*b*) the actual voltage of conductor, *V*; (*c*) the excess voltage (*V* — *Vo*) above *Vo*; (*d*) conductor surface voltage gradient, *E*; (*e*) corona-inception gradient, *E*o; (*f*) frequency, *f*; (*g*) conductor size, *d*, and number of conductors in bundle, *N*, as well as line configuration; (*h*) atmospheric condition, chiefly rate of rainfall, r, and (*i*) conductor surface condition.

A. Those Based on Voltages

(i) Linear relationship: Skilling's formula (1931):

Pc α V – Vo

(ii) Quadratic relationship

(a) Peek's formula (1911):

Pc α (V – Vo)2

(b) Ryan and Henline formula (1924):

Pc α V (V – Vo)

(c) Peterson's formula (1933):

Pc α V2. F (V/Vo)

where F is an experimental factor.

(iii) Cubic Relationship

(a) Foust and Manger formula (1928):

Pc α V3

(b) Prinz's formula (1940):

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Pc α V2 (V – Vo)

B. Those Based on Voltage Gradients

(a) Nigol and Cassan formula (1961):

Pc α E2 In (E/Eo)

(b) Project EHV formula (1966):

Pc α V. Em, m = 5

In order to obtain corona-loss figures from e.h.v. conductor configurations, outdoor experimental projects are established in countries where such lines will be strung. The resulting measured values pertain to individual cases which depend on local climatic conditions existing at the projects. It is therefore difficult to make a general statement concerning which formula or loss figures fit coronal losses universally

AUDIBLE NOISE: GENERATION AND CHARACTERISTICS

When corona is present on the conductors, e.h.v. lines generate audible noise which is especially high during foul weather. The noise is broadband, which extends from very low frequency to about 20 kHz. Corona discharges generate positive and negative ions which are alternately attracted and repelled by the periodic reversal of polarity of the ac excitation. Their movement gives rise to sound-pressure waves at frequencies of twice the power frequency and its multiples, in addition to the broadband spectrum which is the result of random motions of the ions, as shown in Figure 3.3. The noise has a pure tone superimposed on the broadband noise. Due to differences in ionic motion between ac and dc excitations, dc lines exhibit only a broad bandnoise, and furthermore, unlike for ac lines, the noise generated from a dc line is nearly equal in both fair and foul weather conditions. Since audible noise (AN) is man-made, it is measured in the same manner as other types of man-made noise such as aircraft noise, automobile ignition noise, transformer hum, etc.

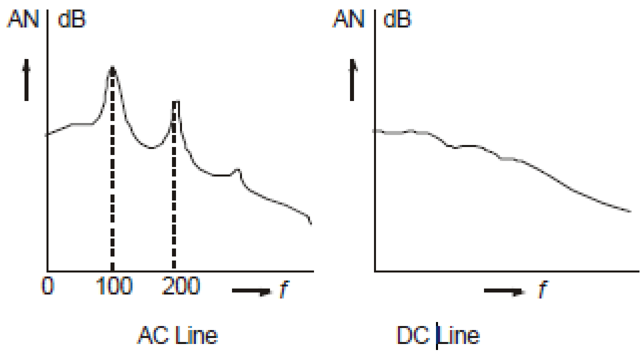

Fig: 2. Audible Noise frequency spectra from ac and dc transmission lines

Audible noise can become a serious problem from 'psycho-acoustics' point of view, leading to insanity due to loss of sleep at night to inhabitants residing close to an e.h.v. line. This problem came into focus in the 1960's with the energization of 500 kV lines in the USA. Regulatory bodies have not as yet fixed limits to AN from power transmission lines since such regulations do not exist for other man-made sources of noise. The problem is left as a social one which has to be settled by public opinion.

LIMITS FOR AUDIBLE NOISE

Since no legislation exists setting limits for AN for man-made sources, power companies and environmentalists have fixed limits from public-relations point of view which power companies have accepted from a moral point of view. In doing so, like other kinds of interference, human beings must be subjected to listening tests. Such objective tests are performed by every civic minded power utility organization. The first such series of tests performed from a 500-kV line of the Bonneville Power Administration in the U.S.A. is known as Perry Criterion. The AN limits are as follows:

No complaints: Less than 52.5 dB (A),

Few complaints: 52.5 dB (A) to 59 dB (A),

Many complaints: Greater than 59 dB (A), The reference level for audible noise and the dB relation will be explained later. The notation (A) denotes that the noise is measured on a meter on a filter designated as A-weighting network. There are several such networks in a meter.

Design of line dimensions at e.h.v. levels is now governed more by the need to limit AN levels to the above values. The selection of width of line corridor or right-of-way (R-O-W), where the nearest house can be permitted to be located, if fixed from AN limit of 52.5 dB(A), will be found adequate from other points of view at 1000 to 1200 kV levels. The audible noise generated by a line is a function of the following factors:

(a) the surface voltage gradient on conductors,

(b) the number of sub-conductors in the bundle,

(c) conductor diameter,

(d) atmospheric conditions, and

(e) the lateral distance (or aerial distance) from the line conductors to the point where noise is to be evaluated.

The entire phenomenon is statistical in nature, as in all problems related to e.h.v. line designs, because of atmospheric conditions. with atmospheric conditions but also with the hours of the day and night during a 24-hour period. The reason is that a certain noise level which can be tolerated during the waking hours of the day,26 when ambient noise is high, cannot be tolerated during sleeping hours of the night when little or no ambient noises are present.

AN MEASUREMENT AND METERS

Decibel Values in AN and Addition of Sources:

Audible noise is caused by changes in air pressure or other transmission medium so that it is described by Sound Pressure Level (SPL). Alexander Graham Bell established the basic unit for SPL as 20×10^{-6} Newton/m2 or 20 micro-Pascals [2×10^{-5} micro bar]. All decibel values are referred to this basic unit. In telephone work there is a flow of current in a set of head-phones or receiver. Here the basic units are 1 milliwatt across 600 ohms yielding a voltage of 775 mV and a current of 1.29 mA. For any other SPL, the decibel value is

$$\text{SPL (dB)} = 10 \text{ Log}_{10} (\text{SPL}/20 \times 10^{-6}) \text{ Pascals}$$

This is also termed the 'Acoustic Power Level', denoted by PWL, or simply the audible noise level, AN.

Fig: Flipped Class Room

Outcome: students are able to understand the concepts clearly.

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