Research on Danger Electromagnetic Influence during Unipolar Earthing Short-circuit Fault Operation of HVDC Systems

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Abstract

When the unipolar earthing short-circuit fault of the HVDC transmission line has happened, should consider the danger electromagnetic influence on adjacent metal pipes which the aperiodic component of fault current waved. In this paper, excitation source in the pipeline, pipeline resistance between the coupling coefficient, pipe and DC line transient inductive coupling coefficient and with complex connection relationship of voltage and current distribution pipe network have been discussed.

Keywords

HVDC, Unipolar Earthing Short-circuit, Electromagnetic Influence.

1. Introduction

In 2000, China had approved to start the West East Pipeline Project, hundreds of millions of cubic meters of pipelines had been laid in each year. The coverage is very broad[1]. With development of the western development, UHV power transmission project have been included in the development of plans[2]. For this, UHV transmission lines and oil and gas pipelines are often parallel close to or crossing cross. When the transmission lines in the short-term abnormal working state, or the unipolar earthing short-circuit fault of the HVDC transmission line has happened, there will have dangerous electromagnetic influence on the oil and gas metal pipeline.

2. Research on Danger Electromagnetic Influence during Unipolar Operation of HVDC Systems with Ground Return

When the HVDC transmission line under the condition of unipolar ground return, short circuit current of DC lines will be running current jump to the fault current, fault current value is higher at the initial stage, but in the later stages of the transient, fault current approximation for sine wave. Therefore, should mainly consider the short circuit current metal pipe adjacent to the initial phase of electromagnetic effect.

The research on danger influence of HVDC transmission lines on the adjacent pipelines can be conducted from the following four aspects: excitation source in the pipeline, pipeline resistance between the coupling coefficient, pipe and DC line transient inductive coupling coefficient and with complex connection relationship of voltage and current distribution pipe network.

 When the unipolar earthing short-circuit fault of the HVDC transmission line has happened as shown in figure 1. The metal pipe AB which parallel to transmission line length is L, horizontal spacing is x. The metal pipe has a resistance of cathodic protection R. Considering transmission line distribution parameters, calculates transient lengthways induced electromotive force which established by a DC circuit transient currents on the pipeline. Pollaczek integral can be used in the frequency domain calculation first, then using FFT and IFFT or numerical Laplace transform (NLT) technique to obtain the time domain solution [3]. Also can use recursive convolution method to calculate the transient inductive electromotive force [4]. For induction electromotive force, the most important we focus on is its peak. By comparing the peak value is in accordance with the prescribed standards or not, to analysis whether there is a danger.
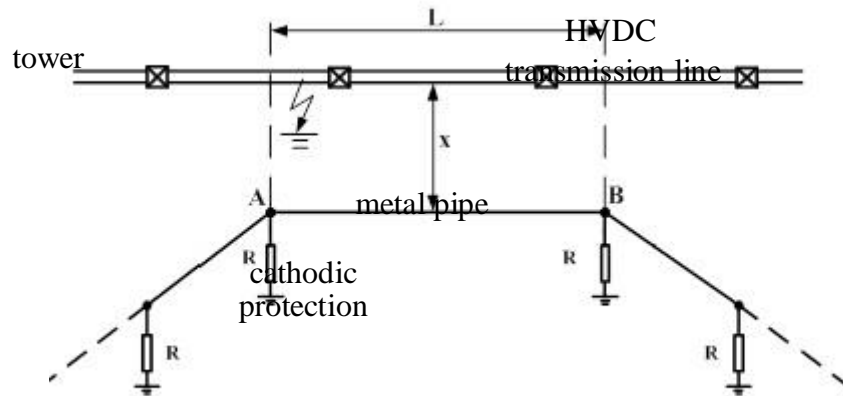
Fig.1 Danger influence of unipolar earthing short circuit fault of UHVDC transmission lines on the adjacent metal pipelines

Generally, buried oil and gas pipelines, taking the form of piecewise grounding at the time of construction, so we can not consider capacitive coupling effects, consider only by inductive coupling and resistance coupled together to form the pipeline to ground voltage[5]. Among that, the resistive coupling coefficient between the pipelines is the mutual resistance between two finite length conductor sections in the earth. Now analytic calculation formula for the mutual impedance can already by the integral of a generalized Sommerfeld integral nuclear with duplicate mirror equivalent method. A method can be used to solve the formula which is based on a discrete complex image of the generalized Sommerfeld integral (GSI) for fast calculation [6,7]. Compare with the numerical integral method, computational efficiency can be increased by more than 20 times under the same precision.

When transmission lines are in the situation of unipolar earthing short circuit, the inductive coupling between pipeline and DC transmission line is affected by induced eddy current in the earth. Considering eddy current mainly concentrated in the surface soil, therefore, assume that the earth pressure for the single layer soil model. The inductive coupling, in time domain, there is no analytic calculation formula. But in the frequency domain, that can be expressed by Pollaczek formula. So numerical value of inductive coupling coefficient can be obtained by approximating Pollaczek integral.

Now, study of electromagnetic coupling between pipeline and DC transmission line do not consider the relationship between the pipelines, at the same time, generally do not consider the effect of cathodic protection system of pipe system. Only considering the actual situation of pipeline system, power lines and underground metal pipelines between the inductive coupling and impedance coupling effect. Based on the transmission line theory, the pipelines can be equivalent to an active two-part network. Using the unknown port voltage to establish equations, so that the distribution of pipe network voltage and current can be obtained. Using this model to analyse has the advantages of being highly efficient, low computational complexity.

After get the line voltage and current distribution, according to the pipeline leakage current to ground, effect of pipeline corrosion can be evaluated. According to the steady state voltage distribution along pipeline, to assess the effect of DC line on the cathodic protection system. Transient and steady-state line each point to ground voltage is also the basis of assessment of pipeline effect on personal safety.

3. Safety Protection in Danger Influence of HVDC Transmission Lines on the Adjacent Pipelines

When the UHVDC transmission line under normal working condition of bipolar metallic return. In that condition, there is almost no danger electromagnetic influence on the adjacent gas-oil pipelines. While the HVDC transmission line under the condition of unipolar ground return, there may have

danger electromagnetic influence on the adjacent gas-oil pipelines. Thus, when DC transmission line and oil-gas pipelines parallel close to or crossing cross, should pay attention to the danger influence of HVDC transmission lines on the adjacent pipelines. Transmission lines and metal pipes local terrain, horizontal distance between transmission lines and metal pipes and other factors should be fully considered. According to different conditions timely replacement pipeline anticorrosive coating.

Acknowledgement

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