

EVALUATION OF THE MAGNETIC INDUCTION ON METAL PIPELINES BY AC POWER CABLE CIRCUITS

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ABSTRACT

Magnetic induction voltages on the metal pipes lying in close parallel with AC power cable circuits were calculated numerically, using the 2-D harmonic magnetic finite element analysis. The influence factors of the induction voltage were studied and their impacts were compared. It was found that cable tunnel could screen the magnetic induction of cables on metal pipes outside effectively. Distance and material permeability were key factors to determine the pipe induction voltages, while pipe wall thickness and material resistivity had nearly no effect. In the final, some measures were provided to reduce the magnetic induction effect.

KEYWORDS

AC power cables; Metal pipes; Magnetic induction voltage; Influence factors; Reduction measures

INTRODUCTION

In recent years, electromagnetic fields generated by power transmission lines and their impact on environments and human beings have caused widespread concerns, especially with the increasingly higher voltage levels and transmission capacities of power grids. The electromagnetic field problem of overhead lines was recognized early and a lot of related research work has been carried out. Comparatively, much less has been done about underground power cable lines^[1-6].

As China's economy continues to grow and demand for energy increases, the power cable circuits and oil or gas pipelines are in rapid expansion. For the heavy population density and limited land resources, cable circuits and oil or gas pipelines are often laid in close proximity in the path planning, or even to share the same corridors^[7]. In these cases, the electromagnetic effects of the cable circuits on oil or gas pipelines must be taken into consideration.

To guarantee safety of the operating personnel, ensure life of the insulation layers and the cathodic protection equipments of pipelines, and reduce pipe corrosions, the induction voltages must be controlled within the allowable range in the engineering design and construction stage. Therefore, it is important to research the magnetic induction of AC cable circuits on metal pipes nearby^[8-9]. The magnetic induction voltages of metal pipes near AC power cable circuits are influenced by many factors. It is necessary to discuss the various factors in detail, and to find some effective measures to reduce the magnetic induction effect.

1 2-D MODELING OF LINES

1.1 Basic assumptions and calculation

conditions

It is assumed that the AC power cable circuits are very long, straight and in parallel, and that the magnetic field to be calculated is far away from their extremities. The metal pipes are in close parallel with the power lines. Therefore, the research task becomes a two-dimensional problem restricted to the plane perpendicular to the cable axis. The currents in three-phase cables are assumed to be balanced and the frequency is 50Hz.

1.2 Description of the method

The proposed calculation method is based on the electromagnetic induction law which can be written as:

$$u = -\frac{d}{dt} \int_S \vec{B} \cdot d\vec{S} \quad [1]$$

Where u is the electromotive force (EMF), \vec{B} is the magnetic flux density and S is the area defined by a closed circuit.

The above equation shows that the electromotive force u of a closed circuit is proportional to the magnetic flux rate of change over time. Then, bring the vector magnetic potential into the equation [1] and utilize the classical Kelvin-Stokes theorem to transform it as follows:

$$u = -\frac{d}{dt} \int_S \nabla \times \vec{A} \cdot d\vec{S} = -\oint_l \frac{d\vec{A}}{dt} \cdot d\vec{l} \quad [2]$$

Where \vec{A} is the vector magnetic potential and l is the boundary of the circuit.

As we know, the induced potential is a time variable in the magnetic field at the power frequency. In this paper, our research only concerns about the maximum value of EMF, and the evaluation of the magnetic induction influence on the metal pipe by the cable circuits is based on it.

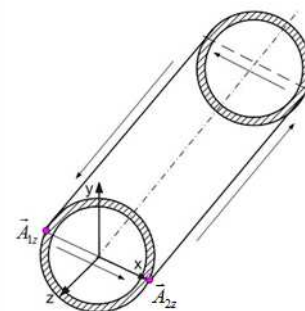


Fig.1. Schematic diagram of the magnetic vector potential integral path

In a simplified two-dimensional magnetic field analysis, the integral path of the magnetic vector potential is shown in