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Life estimation of distribution transformers considering axial fatigue in loose winding conductors

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ABSTRACT

This paper presents an experimental study on axial fatigue behaviour of loose winding conductors of aluminum and copper wound distribution transformers. Algorithms are presented for estimating the life and switchings withstand capability of distribution transformers by considering axial fatigue in loose winding conductors. The life and switchings withstand capability of distribution transformers have been calculated by using experimentally determined results of fatigue life cycles of winding conductors corresponding to stress. The experiments were conducted considering wire sizes and other parameters of 25 kVA distribution transformers. The outcomes of this study can be used as a guide for designing and producing reliable distribution transformers by selecting suitable conductor diameter which may has better fatigue life cycles endurance capability. This study is useful especially for frequently energized distribution transformers having insignificant protection against cold load pick up and inrush current.

1. Introduction

In power deficient, poorly designed and haphazardly expanded power distribution networks, many distribution transformers (having insignificant protection against cold load pick up and inrush current conditions) are failing much before reaching their design life. In some of the areas of India, the failure rate of distribution transformers (DTs) is over 25% per year. In these areas, the power outage occurs frequently due to various reasons such as planned and unplanned load shedding, maintenance, extension works and faults. Thus, repeated energization of the DTs is required for power restoration in distribution networks which in turn causes frequent cold load pick up (CLPU) and inrush current conditions in the DTs. The CLPU condition is caused by loss of diversity among thermostatically controlled electrical devices during restoration of power in distribution networks. This condition produces a load current which may be several times higher than the normal value and persists for few minutes to several hours [1]. The inrush current generates during energization of the transformer due to magnetic saturation of the core containing residual flux. The inrush current is found to be non-sinusoidal in nature and its magnitude ranges from 10 to 20 times of the rated current [2]. Owing to the slow attenuation of the transients, the effects of inrush current may persist for several seconds before attaining the steady state condition [3].

The CLPU and inrush current cause electro-magnetic and thermal stresses on the high voltage (HV) winding conductors for long duration [4,5]. Earlier, the authors [6] have identified and reported the elongation in the HV winding conductors owing to creep as one of the reasons for failure of repeatedly energized DTs having insignificant protection against inrush current and CLPU. Also, the authors [7] have reported the assessment of life and switchings withstand capability of

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