variables of spring and remnant flux in the circuit breaker, the phase of the source that provides power for the circuit breaker coil, and others. If semiconductor components are used as substitutes for circuit breakers, their on-state voltage or resistance result in very large power consumption. Therefore, this method is difficult for practical applications. During the switching-on period, a core with a DC source is used to introduce an air gap into the magnetic circuit. The method tends to worsen some of the characteristics in the magnetic circuit, and its reduction of the inrush current is finite. This study attempts to decrease the inrush current by asymmetrical winding. Differing from the traditional symmetric winding structure in transformer design, the objective is procured by changing the secondary winding coil distribution. This method can provide a high inrush equivalent inductance for reducing inrush current, and a suitable leakage inductance for voltage regulation and short-circuit current. In the modern Asymmetrical winding configuration technique, the same attention has been paid on the appropriate voltage regulation and short circuit current in the design of transformer. From the structural parameters of transformer, the leakage inductance and inrush equivalent inductance are to be analyzed which takes care of magnetizing inrush current in transformer before the transformer manufacturer under the corresponding leakage inductance value[6]. The magnetizing inrush is a transient and occurs primarily when a transformer is energized. The major source to reduce this inrush current is the inrush equivalent impedance during this period. If we are in a position to increase this inrush equivalent inductance, inrush current gets reduced to a considerable extent. So, the characteristics and the magnitude of inrush equivalent impedance must be understood. The impedance of the transformer is a combination of resistance and inductance. The magnitude of winding resistance is so small that it can be ignored in the discussion of restraining inrush current [6]. A larger value of impedance reduces the short circuit current, but increases the voltage regulation. Therefore, impedance of transformer ought to be controlled within an appropriate range. Different distribution transformers of the S-P-S and S-P-S-P structures can be used for demonstration purposes. Calculated values of leakage inductance will vary with the value of x in S-P-S structure and the values of x and y in the S-P-S-P structures. So, the asymmetric winding configuration affects the magnitude of leakage inductance A transformer requires an appropriate leakage inductance to match the rating interrupting capacity of the breaker and low voltage regulation. The per unit value of the equivalent impedance Z% and the voltage regulation e% are set in standards for impedance. Before performing the experimental switching-on, transformers should be demagnetized using a variable AC source to eliminate the residual flux in the core. The relationship between the maximum inrush current and inrush equivalent inductance, the increase in inrush equivalent inductance and the decrease in inrush current are all proportional to each other. Moreover, these relationships demonstrate that the main cause of the reduction in the inrush current is the increase in the inrush equivalent inductance, as implemented by the method of coil winding distribution. Using this method, restrained inrush current will be able to increase the rating of the capacity and voltage, because the size of the iron coil, size of the oil duct, thickness of the wire, thickness of paper insulation etc are all increased. So, this study presents a new viewpoint in the design for a transformer that involves a multilayer structure and an altered winding coil distribution to restrain the inrush current. The limited inrush current, satisfying the low voltage regulation and providing a suitable short-circuit impedance are equally emphasized. The inrush equivalent inductance and the leakage inductance are determined from the structural parameters of the transformer in asymmetrical winding configuration such that the various magnitudes of inrush currents can be estimated before the transformer manufacturing with the corresponding leakage inductance magnitude.

5. Conclusion

The phenomenon of core flux reduction can greatly simplify closing strategies, allowing the delayed strategy to be very effective. The delayed strategy can also provide a reduction of inrush transients when switching transformers with more than three core legs and no delta connected winding. However, complete elimination of inrush currents is not possible with theses configurations.

In Sequential phase energization technique, there is an optimal neutral resistor value for the proposed scheme. This value is a compromised value between the need to suppress the inrush currents when the first two phases are energized and need to suppress the current when the third phase is energized. It is not essential to use an exact optimal value. Resistances around the optimal value are almost equally effective. With the proposed resistance value(s), the neutral resistor based scheme can lead to 80% to 90% reduction on inrush current[3]. A small neutral resistor size of less than 10 times the transformer series saturation reactance can achieve 80 to 90% reduction in inrush current among three phases.

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