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Designing a Reactor for Use in High Voltage Power Systems and Performing Experimental and Simulation Analysis

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ABSTRACT

In recent time, magnetically controlled shunt reactors are widely used in solving power quality problems. These reactors are designed to reduce system reactive power, control high super/special high voltage grid voltage, suppress power frequency, regulate overvoltage, eliminate generator excitation, dynamically compensate transmission line power charge, suppress secondary arc current, suppress system resonance. By using suitably designed silica plate core reactors at the input of the frequency converters in the electrical distribution system, the level of harmonic currents drawn from the electrical power distribution system can be reduced to certain rates. The core material, the air-gapped nature of the reactor core, and the sizing of the reactor have a great influence on the harmonic level of the current and its ability to reduce losses in the reactor. In this study, three reactors with different core materials and different air gap gaps are designed for a certain voltage value. Parametric analysis of the reactors designed to see the changes in inductance values depending on the load level has been made both theoretically and experimentally and using the Finite Element Method. As a result of the analysis, the inductance stability, losses and compliance of the reactors with the standards are presented. The reactor's magnetic circuit is modeled with ANSYS@Maxwell, realizing a solution based on this method. The magnetic circuit is simulated to see the behavior of the reactor. In addition, real-time verification of the designed alternating current reactor has been made. Optimum design was obtained by using different core materials and different core air-gaped tested experimentally. The effect of the air gap distance in the core on the magnetic field and inductance value was also obtained.

Keywords: Reactor; finite element method; air-gapped; electromagnetic flux.

1. INTRODUCTION

In recent years, power quality problems have increased due to non-linear loads, the use of which has become increasingly common with the development of technology. Current or voltage disturbances that may occur in power systems such as harmonics, voltage fluctuations, voltage collapses, voltage spikes, instantaneous voltage interruptions cause low quality electrical energy. These power quality degradations; Failure of the devices used by the consumer, damage to some devices such as microprocessors sensitive to current or voltage imbalance used in the industry may result. Reactors are used to minimize reactive power losses in energy transmission/distribution systems. Saturated reactors; It can be divided into two classes as magnetically controlled shunt reactor (MCSR) and orthogonal-flux controlled reactor (Ma C, at all., 2014). However, as an important type of tuned shunt reactors, MCSRs are widely used for reactive power control in extra high voltage (EHV)/extreme high voltage (UHV) networks with continuously adjustable capacity, low harmonic and high control characteristics. Compared to fixed reactor and thyristor-controlled reactors (TCR), MCSR also has advantages such as reducing active power losses, increasing operational safety by reducing the number of switching in step-up transformers under load, correcting system ripple, and being flexible (Xu X 2014; Chen B at all., 2016). In addition to the electronic devices listed above, devices that control voltage and power indirectly by breaking AC voltage are also considered as devices that produce harmonics similar to rectifiers. For this reason, AC line reactors should be used to limit the harmonic levels of the current they draw from the electrical power grid. If AC reactors are not selected appropriately or not used at all, harmonic current components drawn reach very high values. Thus, power quality problems such as harmonics, voltage fluctuations, and sudden voltage dips occur in the grid system. The least costly method of removing power grid pollution is the removal of the pollution at its source. For this purpose, mostly in order to reduce the harmonic level in the rectifier inputs of the devices and to ensure their compliance with international standards AC input reactors are used (Heatcote M 2007.)

Reactors are used to provide inductive reactance to the circuit for many reasons. Reactors; fault current limitation, harmonic filtering, VAR compensation, and load balancing, etc. Performing many operations is among the purposes of reactors (Balci S at all., 2013). High voltage transmission lines, especially long ones, generate a substantial amount of reactive power at light loads. Conversely, they absorb reactive forces in the reverse direction at heavy loads. As a result; To balance the reactive power in the system, compensation must be applied in the transmission or distribution line for given operating conditions.

Under heavy loads, the reactive load balance is negative and capacitive compensation is required. This is usually accomplished by using shunt capacities. Conversely, the balance of power is positive at light loads and inductive compensation is required. This is achieved with the help of shunt reactors (Altin N at all., 2013).

The inherent capacity of lightly loaded transmission lines causes two types of overvoltages. These voltages can be controlled by shunt reactors.

The first of the overvoltages that occur; As a result of the forward capacitive charge current generated by lightly loaded transmission lines passing through the inductance of the line and through the system the operating voltage increases depending on the length of the line along the line. The backward reactive current consumed by the reactor reduces the voltage increase by damping the leading capacitive charge current.

The second of the overvoltages that occur; It is the interaction of the line's capacity and any inductance that can saturate or ferroresonance. For example, when a transmission line connected to the end of the line is put into operation, the voltage at the end of the line interacts with the transformer inductance and creates harmonics that cause overvoltage. In order to prevent such overvoltages, shunt reactors are connected to the system tertiary. Thus, it is ensured that the voltage value that will saturate the transformer is not reached, besides, an inductance that does not saturate is connected parallel to the transformer impedance (Zheng T at all., 2015).

Various reactor designs have been made over time. Iron core reactors are produced in a similar structure to transformers. It can also be called a transformer without secondary winding. In order for the shunt reactor to absorb reactive power, the magnetic circuit reluctance must be increased. The distributed air gap method is used to obtain the desired reluctance value. Due to the high magnetic permeability of the core material, it is the air gap that is predominant in determining reluctance. Inductance value is not very dependent on core magnetic permeability and core saturation does not occur in the normal steady-state current.

In this paper, the effects of the parameters used in the design of the shunt reactor as a result of the simulation studies using the Finite Element Method (FEM) were investigated. The reactor design process was discussed and the effects of the selection of core material on the operating performance, the size of the required air gap distance, and the determination of the variation of the inductance value according to the load current were discussed in detail. Different designs of a reactor were made with realistic materials with silicon additives such as M125-027S and M530-50A, which can be used in reactor design produced following European Union norms. Depending on the load type, the design should be made in such a way that there is no saturation in the magnetic circuit. Modeling and analysis processes of the shunt reactor, which was designed considering these criteria, were performed with FEM based electromagnetic software. Parametric analysis of how inductance values change depending on load current changes in case of using different core materials. In addition, properties such as core loss, flux distribution, and saturation effect in rated currents were examined in detail. The positive and negative aspects between the two core types are stated and their comparative analysis is presented.

In this study, the literature review of the control methods applied for magnetically controlled reactors was made in detail. In this study, it is aimed to provide a broad perspective on application engineers and researchers about the state of magnetic control reactors technology and power quality problems. A list of research publications on the subject is also included for a quick reference. This paper differs from previous studies in the real-time verification of the designed AC reactor. The optimum design has been achieved by using different core materials tested experimentally. The effect of the air gap distance in the core on the magnetic field and inductance value was also obtained.

2. MATHEMATICAL MODEL OF THE AC REACTOR

Due to the asymmetrical behavior in 3-phase core structures, a mathematical model can be developed by considering the equivalent inductance value. The environmental equations in the specified directions for the flux circulating in the magnetic equivalent circuit shown in Figure 1 are given by equation (1-5) respectively. It is clearly seen that the mid leg flux will be greater than the outer legs with the effect of asymmetry (Wojda R.P and Kazimierczuk M.K 2013).

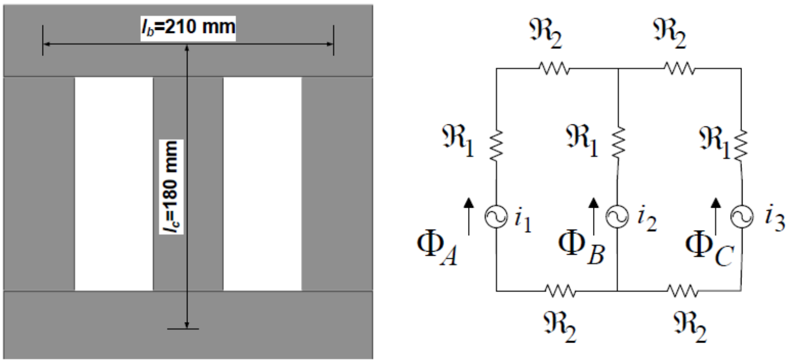

Figure 1. Three-phase core equivalent circuit

$$i_1 = \Phi_A(\Re_1 + 2\Re_2) \quad (1)$$
$$i_2 = \Phi_B\Re_1 \quad (2)$$
$$i_3 = \Phi_C(\Re_1 + 2\Re_2) \quad (3)$$
$$\Phi_B = -(\Phi_A + \Phi_C) \quad (4)$$
$$\frac{Ni_2}{\Re_1} = -\left(\frac{Ni_1}{2\Re_1+2\Re_2} + \frac{Ni_3}{2\Re_1+2\Re_2}\right) \quad (5)$$
$$i_2 = -\left(\frac{i_1+i_3}{\Re_1+2\Re_2}\right) \quad (6)$$

In this circuit, $\Re_1$ and $\Re_2$ represent the reluctance of the leg and yoke parts of the core, respectively. In three legged core structures, the rate of asymmetry changes depending on the yoke and leg dimensions. Thus, the asymmetry ratio (θ) can be determined per-unit by equation (7) (Wojda R.P and Kazimierczuk M.K 2013).

$$\theta = \frac{l_b-l_c}{l_c} \quad (7)$$

The Ampere Law for an N-winding reactor is defined by equation (8) (Arabul AY at alla., 2015). Therefore, the equations for the magnetic field strength in the yoke and leg parts of the three-phase trident core can be obtained as equations (9) and (10), respectively.

$$\oint_c Hdl = N.i \quad (8)$$
$$H_b l_b = N(i_1 + i_3) \quad (9)$$
$$H_c l_c = Ni_2 \quad (10)$$

Equation (11) can be written according to the magnetic field intensity for the asymmetry ratio expressed in equation 7 according to the size of the yoke and leg dimensions of the core.

$$\theta = \frac{N(i_1+i_3)/H_b - Ni_2/H_c}{Ni_2/H_c} \quad (11)$$

Here, the asymmetry ratio according to the yoke and leg dimensions in the core given in Figure 1 is 1/6. Since there are no air gaps in transformer cores, the asymmetry effect occurs more. However, in reactors, unlike transformers, the reluctance in the legs of the core is very high due to the effect of air gaps, so the asymmetry ratio is very low. The ratio of asymmetry in gapped cores is obtained by equation (12) by proportioning the reluctance values of the yoke and leg parts. Since the structural asymmetry of the core changes the equivalent inductance value of the reactors, it affects the filtering performance.

$$\theta = \frac{2\Re_2}{\Re_1 + \Re_g} \quad (12)$$

The core and mutual inductance values of the windings in the three-legged core are formed by the coupling effect. Accordingly, the equivalent inductance value of the reactor should be taken into consideration during the design phase. Three-phase winding equivalent circuit model of the reactor is shown in Figure 2.

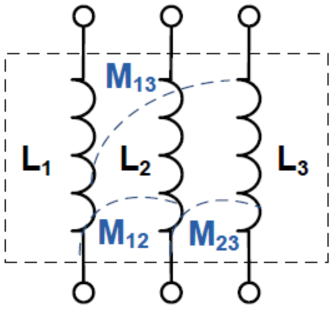

Figure 2: Winding model of three phase reactor [8].

According to the defined winding model, the inductance matrix can be formed as given in equation (13). Where, L1, L2 and L3 are the self-inductances of the windings, and Mij is the mutual inductance.

$$\begin{vmatrix} L_1 & M_{12} & M_{13} \\ M_{21} & L_2 & M_{23} \\ M_{31} & M_{32} & L_3 \end{vmatrix} \quad (13)$$

The variation of self and mutual inductance values for each winding according to asymmetry ratio is given by equations (14-17) respectively (Arabul AY at alla., 2015). Thus, for the three-legged core, the inductance values of the outer legs and the mutual inductance values of neighboring windings are equal.

$$L_1 = L_3 = \frac{L_{eq}(2+\theta)}{3(1+\theta)} \quad (14)$$

$$L_3 = \frac{2L_{eq}}{3} \quad (15)$$

$$M_{12} = M_{23} = \frac{L_{eq}}{3} \quad (16)$$

$$M_{13} = \frac{L_{eq}}{3(1+\theta)} \quad (17)$$

3. DESIGN AND ANALYSIS OF AC REACTOR

Reactors are defined as magnetic circuit elements that store energy and transformers transfer energy. Reactors need air space between core parts to store energy. Thus, thanks to the air gap, the B-H magnetization curve becomes linear and the flux value in the core can be easily adjusted with Ampere Winding (NI). In the reactor cores, the air gap reluctance and the reluctance of the magnetic circuit are represented in series. Figure 3 shows the core and air gap reluctance elements in the magnetic circuit of a reactor and the equivalent electrical circuit.

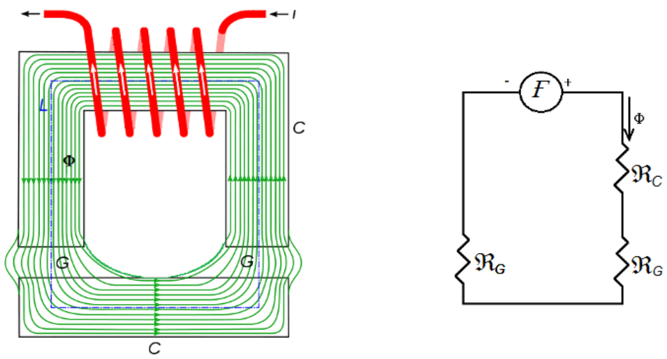

Figure 3. Electromagnet with air gap and magnetic circuit equivalent

When the number of turns of the reactor windings is defined as N and the current through the winding is I, the magnetic flux that will circulate in the core as Ampere-Winding NI determines the value of Φ. Generally, the air gap surface Ag is the same size as the cross section of the core Ac. The permeability of the core varies according to the permeability of the cavity and the relative permeability value of the core material as in equation (18):

$$\mu_c = \mu_r . \mu_0 \quad (18)$$

The total reluctance value of an air gap reactor core is the sum of the series connected circuit elements as given in equation (19) (Heatcote M 2007.):

$$R_t = \frac{l_t}{\mu_e A_c} = R_c + R_g = \frac{l_c}{\mu_0 \mu_r A_c} + \frac{l_g}{\mu_0 A_c} \quad (19)$$

Here, 1c represents the average length of the core, 1g air gap distance, Rc and Rg represent the core and air gap reluctances, respectively. Since the permeability of the gap is μ0 = 4π10-7 H/m, a very high magnetic resistance occurs in the air gaps in the core and the equivalent reluctance value for any magnetic circuit varies depending on the air gap distance. In Equation 18, when the core section is divided as a factor, it can be simplified as in Equation (20).

$$\frac{l_t}{\mu_e} = \frac{l_c}{\mu_0 \mu_r} + \frac{l_g}{\mu_0} \quad (20)$$

Thus, the effective permeability (μe) value can be calculated according to the dimensions of the reactor core and the air gap distance as expressed in equation (21). The μc in this equation represents the permeability of the core material.

$$\mu_e = \frac{\mu_c}{1+\mu_c\left(\frac{l_g}{l_c}\right)} \times \frac{l_c \mu_c}{l_c \mu_c} = \frac{l_c}{\frac{l_c}{\mu_c} + l_g} \quad (21)$$

3.1 AC Reactor Core Design

In this section, the design steps of the core, which has an important role in shunt reactor design, and the formulas used in these steps are explained. By examining the shunt reactor label values and official specifications used in transmission lines in our country, nominal voltage and power values were selected as 345 kV and 195 MVAr, respectively. In the formulas used, Ve refers to the nominal voltage, Ie the nominal current, f the frequency, ϕm the maximum magnetic flux, and the constants depending on the structure, Qm the maximum reactive power of the reactor, L the inductance value of the reactor, N the number of turns of the core.

$$L = \frac{V_e^2}{\omega Q} \quad (22)$$

$$K = 4.44 f 10^3 K_t \quad (23)$$

$$K_t = \left(\frac{Q_m}{l_e N}\right) \quad (24)$$

$$N = \sqrt{\frac{L}{\mu_0\left(\frac{Ag}{lg}\right)}} \tag{25}$$

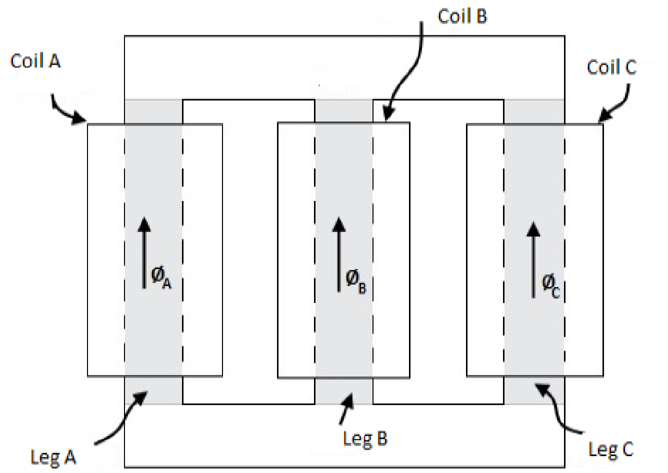

Figure 4. Basic structure of 3-legged shunt reactor core.

The number of turns can be calculated using the reactor's inductance and the ratio Ag/lg. In this formula, Ag represents the air gap area and lg the total air gap length.

$$A_g l_g = \frac{Q}{\left(\frac{\pi}{\mu_0} B_m f\right)} \tag{26}$$

When Equation (22) is examined, it is seen that Ag and lg are in a one-to-one relationship with the reactive power (Q) and maximum magnetic flux (Bm) value of the shunt reactor (Reece A and Preston TW 2018). The value of should be chosen depending on the core material used and calculations should be made accordingly. The relevant value should be chosen less than the saturation value that appears on the B/H curve of the core material. Otherwise, the core will be saturated during operation and the shunt reactor will not function. Using the Ag/lg value determined with Equation (22), the total air gap area (Ag) and the total air gap length (lg) values can be obtained. Determination of these values has an important effect on the dimensions of the designed core (Reece A and Preston TW 2018). After the calculation of Equation (22), the cross-sectional area of the core leg will also be found together with the Ag value found. The value of Ag can be calculated in this way or by using the formula specified in Equation (27).

$$A_g = \frac{\phi_m}{B_m} \tag{27}$$

After calculating the Ag value, the radius of the core leg (d/2) can be calculated using Equation 28.

$$A_g = \pi\left(\frac{d}{2}\right)^2 \tag{28}$$

$$A_w = H_w B_w \tag{29}$$

As can be seen from Figure 1, the window part of the core to be designed can be calculated using the formula given in Equation 25. In Equation 25, the H_w and B_w values represent the height of the core window and the width of the core window, respectively.

The ratio of height (H_w) and width (B_w) values that make up the core window (H_w/B_w) is a parameter that affects efficiency and economic criteria in reactor design, and this value was chosen as 2.1 to be used in the first design when the previous studies were examined. Additionally, the winding fill factor (Ku) 0.6 and the current density (j), which are the constants that will affect the winding and thus the inductance value, were chosen as 3.2 A/mm^2. In addition, the winding fill factor (Ku) has an important role in determining the position of the winding to be fitted to the core window. After all calculations were made, the 3-legged core was created as in Figure 5.

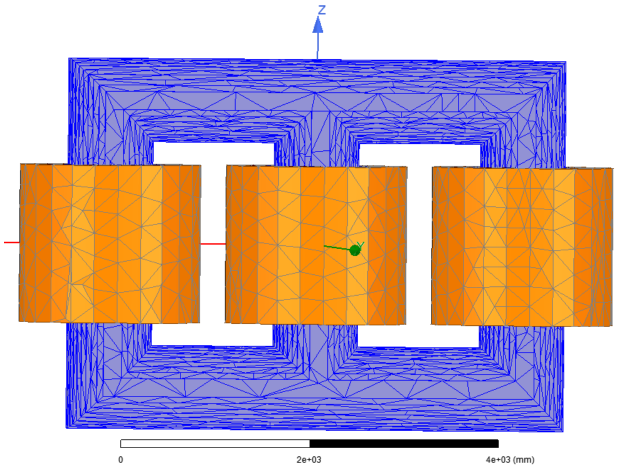

Figure 5. Structure of designed shunt reactor and mesh.

Table 1. Parameter of reactor

Parameter	Value
Rated power	300 MVAr
Frequency	50 Hz
Winding resistance	1.7 Ω
Current density	1.8 A/m^2

3.2 Determination of Reactor Windings

One of the most important parameters in determining the winding to be used in shunt reactor design is the inductance value of the winding. Since the inductance value of the winding is also used in the core design, it is calculated using the formula given in Equation (18). When the formula of the inductance value is examined, the effect of reactive power, nominal voltage and frequency values on the winding inductance is seen.

In the dimensioning of the winding to be used, the fill rate (Ku) value of the core window and the conductor cross section values play a decisive role. When the window area calculated is multiplied by the fill factor value, the area to be covered by the winding in the core window is determined.

$$A_w = H_w B_w \tag{30}$$

After determining the area to be covered by the winding, the dimensioning of the winding should be made by taking into account the winding area value and the number of windings by using the copper conductor cross-section value to be calculated in Equation (31). In the selection of the winding cross section, attention should be paid to ensure that the space between the conductors and the thickness of the conductors are at the value specified in the standard.

$$A_{cu} = \frac{I_e N}{K_u J} \tag{31}$$

With the change of the number of air gaps used in the reactor core, the core permeability value will decrease and consequently the magnetic flux density and inductance values will decrease. At the same time, with the decrease of the inductance value, the current value to be drawn will also increase and the current winding will be inadequate.

4. ANALYZING THE AC REACTOR USING THE FINITE ELEMENT METHOD

In simulation studies, 3D FEM analysis was performed using Ansys Maxwell program in order to observe the effects on the designed reactor. In the analysis method used, the reactor was completely designed using FEM and Eddy losses were neglected. Magnetostatic equations are used in inductance calculation. The reliability of FEM used has been proven by previous studies. Three-dimensional model was created based on this validity and reliability. According to the Poisson Vector equation given in Equation (32), the mesh method was applied to the designed reactor (mesh) and linearity was achieved (Özüpak Y and MAMIS M. S 2019).

$$\nabla\times\left(\frac{1}{\mu_0\mu_r}\nabla\times\vec{A}\right)=\vec{J} \qquad (32)$$

In equation (32), A represents the magnetic potential vector and represents the relative permeability. Parameters such as flux density and magnetic flux density can be easily calculated after the magnetic potential vector is calculated. Using the equations given below, the energy density and additionally the inductance value created by the energy accumulated in the air gap can be found.

$$w_m=\frac{1}{2}\vec{H}\vec{B} \qquad (33)$$

$$W_m=\iiint W_m dv \qquad (34)$$

$$L=\frac{2W_m}{I_m} \qquad (35)$$

Where, Wm wm, B and H used in the formulas given in Equations 33, 34 and 35 represent magnetic energy, energy density per unit volume, magnetic flux vector and magnetic field strength, respectively (Özüpak Y at all., 2019). During the FEM analysis, the maximum current was applied and each piece was separately divided into small meshes to obtain more accurate results.

4.1 Analysis results of AC Reactor with 3 air gaps in its core

After simulation and analysis of the model designed with 3 air gap cores using the equations given in this study, the winding inductance value of the AC reactor, the current drawn by the reactor and the losses are presented in Figures 8-10.

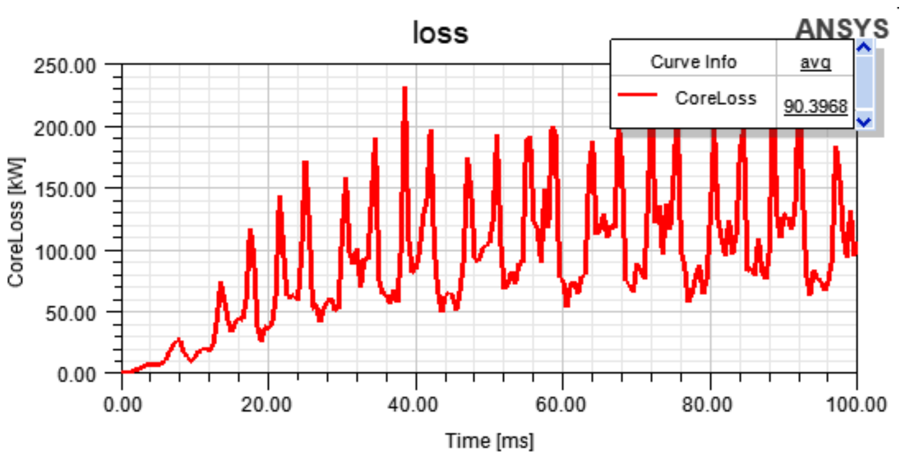

Figure 8. Core loss curve

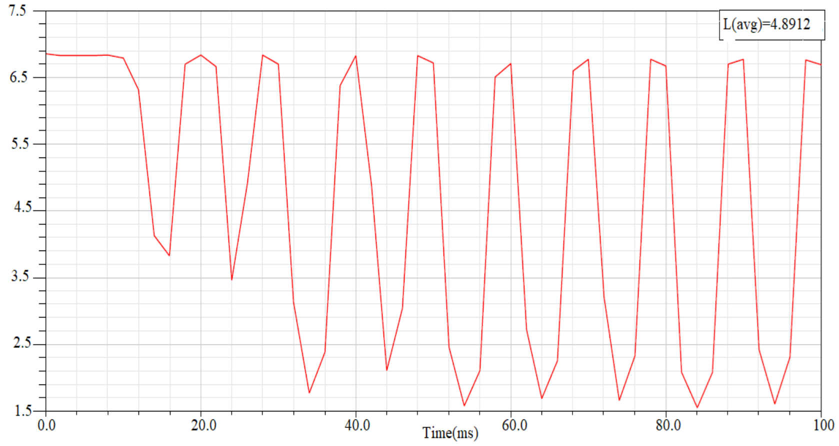

Figure 9. Winding inductance value

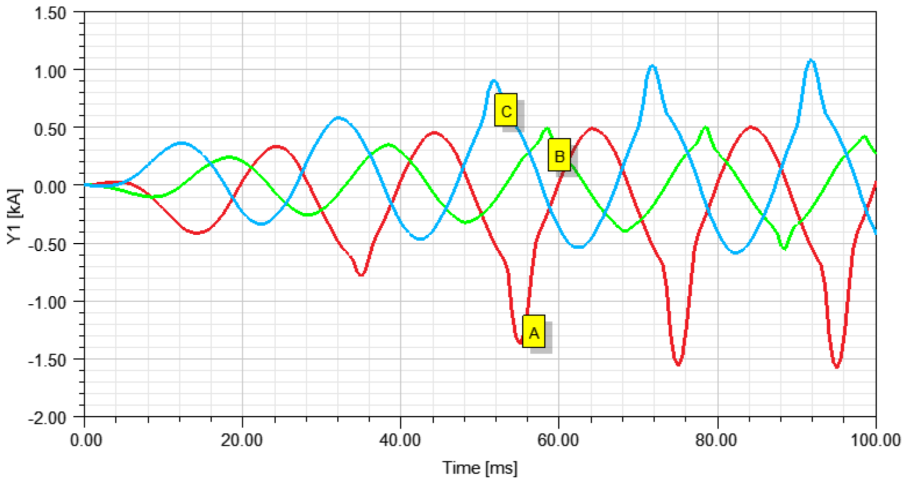

Figure10. The current curve of the reactor

The studies were obtained by experimental, theoretical calculation and simulation. The results obtained are presented in Table 3 below.

Table 3. Comparison of the results

Parameter	Theorical result	Experimental result	Simulation result
Enductance (H)	4.89	5.3	4.96
Corelosses (kW)	91.02	92.01	90.39
Magnetic Flux (T)	1.57	1.63	1.59

The winding inductance value has been found close to its calculated value. When the energy accumulated in the air gap is integrated and added to the winding inductance, the reactor inductance is calculated as 4.89 H. It has been observed that the current drawn by the reactor is close to the calculated value. Looking at these values, it is seen that values close to analytical calculations are reached. When the core loss value is examined, it is seen that there is an average core loss in the stable operating range of the reactor. Looking at the magnetic flux lines at steady time, it is seen that the leakage fluxes are quite high and the B magnetic flux values are quite high in the parts of the air gap as can be seen. As a result, extra losses occur and there is a possibility that the core will reach saturation more easily.

4.2 Analysis Results of AC Reactor Core Designed with 15 Air-Gaps

In this section it is concluded that the most effective method to reduce the leakage fluxes occurring in the air gap specified in the examinations of the designed and simulated AC reactor model, the number of air gaps should be increased. Increasing the number of air gaps means that the total air gap length value calculated in the reactor design is kept constant and this length is evenly distributed along the core leg. In this section, the results of the study for 15 evenly distributed air gaps are given. With the increase of the number of air gaps, the magnetic permeability of the core increased and as a result the inductance value decreased. This situation has caused the core dimensions to increase. The number of turns of the winding and accordingly the length of the winding have been changed in order to bring the falling inductance value to the normal level and to ensure that the increasing current decreases to the nominal level with the decrease of the inductance value. The number of windings (N) made for 3 air gaps has been increased to normalize the effects of inductance drop and current increase in 15 air gaps. When the modeled AC reactor is simulated, the obtained current, winding inductance, core losses and magnetic flux lines are given in Figures 11-13 respectively.

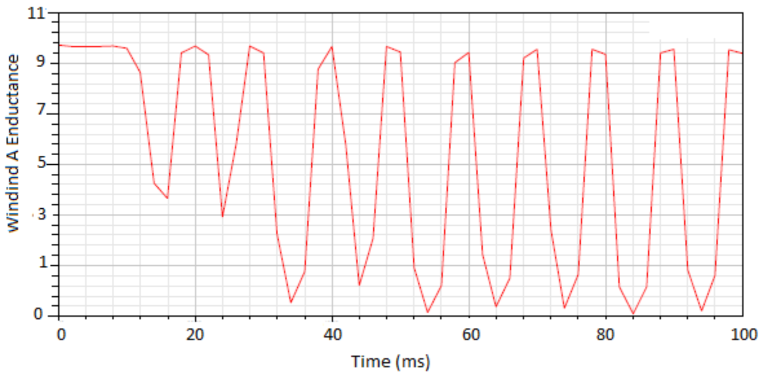

Figure 11. Winding inductance value

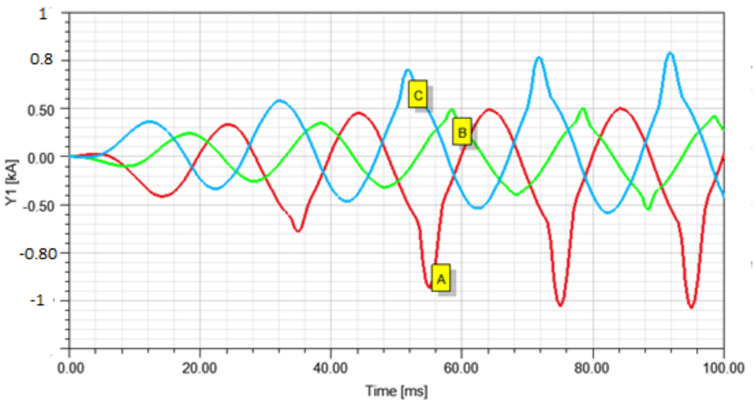

Figure 12. The current curve of the reactor

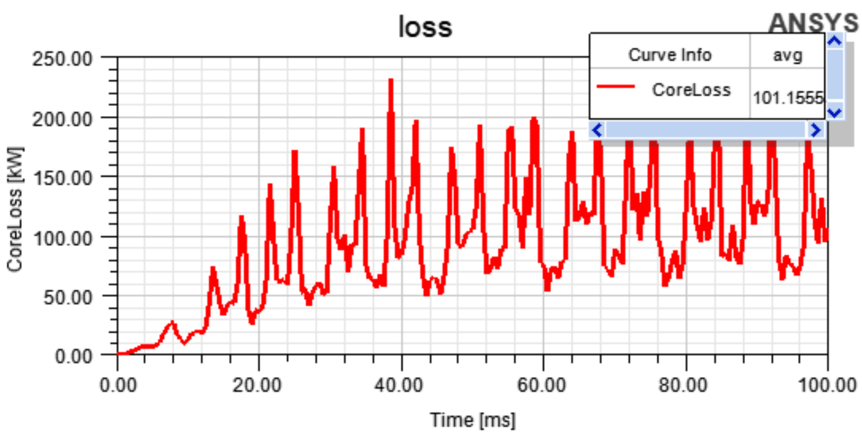

Figure 13. Core loss curve

The studies were obtained by experimental, theoretical calculation and simulation. The results obtained are presented in Table 4 below.

Table 4. Comparison of the results

Parameter	Theorical result	Experimental result	Simulation result
Enductance (H)	5.93	6.57	6.1
Corelosses (kW)	99.3	103.6	101.2
Magnetic Flux (T)	1.63	1.73	1.66

In the evaluation made according to the results of the simulation study, it was seen that the result of the work done to increase the falling winding inductance value was obtained and the winding inductance came to 6.1 H levels. On the other hand, when the values of the current are examined, it is seen that the value decreases with the enlargement of the winding. Current and inductance values varied as expected in analytical calculations, but remained slightly far from the values in the calculations. When core losses are examined, it is seen that the average value taken from the moment the reactor starts to work stably is 101 kW for M125-027S material.

4.3 Results of 27 Air Gap Core Analysis AC Reactor

Due to the fact that the desired improvements could not be seen in the 15 air-gap core structure, the results of the simulation study evaluated, 27 air gap designs were designed using the specified formulas. The number of windings used in the newly designed core has been increased as a result of the calculations in order to reduce the current to its nominal value and to achieve the desired inductance value. With this designed model, it is aimed to reduce the leakages occurring in the air gaps as much as possible, to reach the desired level of current and inductance values and to reduce core losses. After simulation and analysis of the model designed with 27 air gap cores using the equations given in this study, the winding inductance value of the AC reactor, the current drawn by the reactor and the losses are presented in Figures 14.

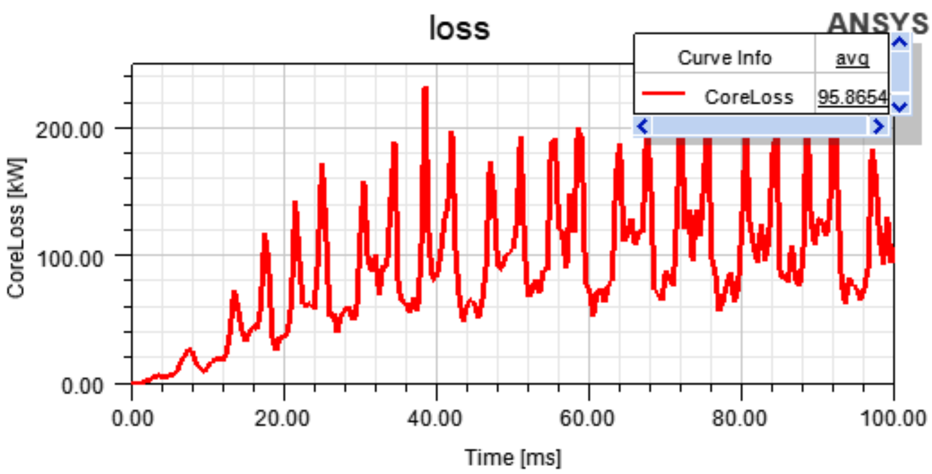

Figure 18. Core loss curve

The studies were obtained by experimental, theoretical calculation and simulation. The results obtained are presented in Table 5 below.

Table 5. Comparison of the results

Parameter	Theorical result	Experimental result	Simulation result
Enductance (H)	3.25	3.31	2.99
Corelosses (kW)	95.03	97.01	95.86
Magnetic Flux (T)	1.60	1.68	1.62

The winding inductance value was found to be 2.99 H, close to the calculated value of 3.31 H. When the energy accumulated in the air gap is integrated and added to the winding inductance, the reactor inductance is calculated as 3.68 H. When the core loss value is examined, it is seen that there is a core loss of for M125-027S 95.86 kW when the average intervals where the reactor is in stable operating mode. Looking at the magnetic flux lines, it is seen that the leakage fluxes are quite high and the magnetic flux values are quite high in the parts of the air gap, as can be seen in Figure 20. As a result, extra losses occur and there is a possibility that the core will reach saturation more easily.

5. CONCLUSION

The capacitive property of long transmission lines causes an unnecessary reactive current to circulate in the system and reduces the quality of the energy that comes with the efficiency of the system. For this reason, reactors are used to provide the compensation process. In the mentioned case, since the size to be damped is capacitive, the reactor type that should be used here is shunt reactor. In this study, the shunt reactor that will be used to increase the efficiency and quality in transmission lines has been designed within the framework of all quality and technical standards and specifications, and the results are evaluated by simulating it. The effect of the reactor core material type on the operating performance was examined and their inductance stability was tested by parametric analysis. The core losses of the reactors designed with these materials and the inductance changes due to current were analyzed. After the design of the shunt reactors was completed, the simulation study was carried out with two different materials in order to observe the results. The method used in the simulation study is the transient regime analysis method. This method offers the opportunity to observe many values that occur in reactor operation. With this method, core losses can also be observed. With the observation of the core losses, it has become possible to evaluate the losses, which is one of the critical values in the reactor operation. One of the advantages of the transient analysis method is the observation of the reactor state as a time-dependent variable. The values obtained as a result of the simulation studies in the designed core models, it has been observed that the number of air gaps left in the core decreases with the increase in the inductance value. With the increase in the number of windings occurring in the winding and the increase in the amount of copper used, it is seen that the losses increase accordingly with the increase in the resistance value. When the core losses are examined, it is seen that they are close to the desired values. When the data obtained are compared with the data obtained from previous studies on this subject, it reveals the effect of the results obtained in this study on productivity and the accuracy of the method used.

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