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Research and Analysis of Ferromagnetic Circuits of A Special Purpose Transformer

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Abstract — *The article considers global issues of voltage transformation and the method of reducing the loss of transformers. We offer to increase the voltage on transformers 10% more than usual, and increase the efficiency of the transformer.*

Keywords — Transmission, the primary types, vicinity, compressor station, generators, voltage, emissions, hydroelectric power stations, alternating.

Introduction

The main energy resources of the country at present are natural reserves of combustible minerals and hydraulic resources. In the vicinity of these energy sources, in most cases, electrical stations are located [1]. On them, the primary types of energy are converted into electrical energy produced by alternating current generators at voltages of 6-35 kV. The manufacture of generators for a higher voltage is difficult and practically impractical. But at such voltages, economical energy transfer is only possible for nearby consumers. To transmit electricity to greater distances of the order of hundreds of kilometers, higher voltages are needed [2].

Materials and methods

At this power, the higher the power line voltage, the lower the current strength should be, and with it the voltage drop in the line and the energy loss on heating the wires decreases, if the line resistance is considered a constant value. Thus, increasing the voltage of the transmission line makes it possible, with the same relative losses, to transmit energy over longer distances. For this reason, they strive to apply increasingly high voltages to the transmission line [3].
One of the important elements of the electrical system is transformer substations. The main elements of a transformer substation are: transformers, switchgears, control devices and auxiliary facilities. By the type of conversion of electric energy from one voltage to another, substations are divided into step-up and step-down.

Step-up substations are usually built directly at power plants (hydroelectric power stations, thermal power plants) and are used to connect the power plant with the electric system and transfer electricity to consumers with high voltage. The voltage on them is 10.5-15.75 kV. Rises to 110-220kV and higher depending on the configuration of the system, remoteness of consumers and economic feasibility.

Result and discussion

In the calculations, we use the standard formula for calculating currents:
Transformer T1:
Current in the line L1:

$$X_{\text{Ë}3} = X_{\text{Ë}3,1} = X_{\text{óä.}} \cdot l \cdot \frac{S_{\text{á.}}}{U_{\text{á2.}}^2} = 0,755 \cdot 5 \cdot \frac{16}{35^2} = 0,049\,\text{î.å.},$$

$$X_{\text{Ò}3} = \frac{U_{k\%}}{100} \cdot \frac{S_{\text{á.}}}{S_{\text{í.ò.}}} = \frac{10,5}{100} \cdot \frac{16}{16} = 0,105\,\text{î.å.},$$

$$X_{\text{Ò}3,1} = \frac{U_{k\%}}{100} \cdot \frac{S_{\text{á.}}}{S_{\text{í.ò.}}} = \frac{10,5}{100} \cdot \frac{16}{16} = 0,105\,\text{î.å.},$$

$$X_{\text{Ò}2} = \frac{U_{k\%}}{100} \cdot \frac{S_{\text{á.}}}{S_{\text{í.ò.}}} = \frac{6,5}{100} \cdot \frac{16}{2,5} = 0,416\,\text{î.å.},$$

$$X_{Ò2,1} = \frac{U_{k\%}}{100} \cdot \frac{S_{á.}}{S_{í.ò.}} = \frac{6,5}{100} \cdot \frac{16}{2,5} = 0,416\,î.å.,$$

Current in the line L2:

$$X_{ðåç.} = \frac{X_{Ë3} \cdot X_{Ë3,1}}{X_{Ë3} + X_{Ë3,1}} + X_{Ò3} + X_{Ò3,1} + \frac{X_{Ò2} \cdot X_{Ò2,1}}{X_{Ò2} + X_{Ò2,1}} =$$

$$= \frac{0,049 \cdot 0,049}{0,049 + 0,049} + 0,105 + 0,105 + \frac{0,416 \cdot 0,416}{0,416 + 0,416} = 0,442\,î.å.$$

Current in the line L3:

$$R_{Ë\,3} = R_{Ë3,1} = r_{Ë\,3} \cdot l \cdot \frac{S_{á.}}{U_{á2.}^{2}} = 0,648 \cdot 5 \cdot \frac{16}{35^{2}} = 0,042\ o.e.,$$

$$R_{Ò3} = \frac{\Delta P_{êç}}{S_{í.ò.}} \cdot \frac{S_{á.}}{S_{í.ò.}} = \frac{86}{16000} \cdot \frac{16}{16} = 0,0054\ o.e.,$$

$$R_{Ò3,1} = \frac{\Delta P_{êç}}{S_{í.ò.}} \cdot \frac{S_{á.}}{S_{í.ò.}} = \frac{86}{16000} \cdot \frac{16}{16} = 0,0054\ o.e.,$$

$$R_{Ò2} = \frac{\Delta P_{êç}}{S_{í.ò.}} \cdot \frac{S_{á.}}{S_{í.ò.}} = \frac{26}{2500} \cdot \frac{16}{2,5} = 0,066\ o.e.,$$

$$R_{Ò2,1} = \frac{\Delta P_{êç}}{S_{í.ò.}} \cdot \frac{S_{á.}}{S_{í.ò.}} = \frac{26}{2500} \cdot \frac{16}{2,5} = 0,066\ o.e.,$$

Calculation of means of protection for HV and HH lines, and choice of wire section

$$R_{ðåç.} = \frac{R_{Ë3} \cdot R_{Ë3,1}}{R_{Ë3} + R_{Ë3,1}} + R_{Ò3} + R_{Ò3,1} + \frac{R_{Ò2} \cdot R_{Ò2,1}}{R_{Ò2} + R_{Ò2,1}} =$$

$$= \frac{0,042 \cdot 0,042}{0,042 + 0,042} + 0,0054 + 0,0054 + \frac{0,066 \cdot 0,066}{0,066 + 0,066} = 0,065\,î.å.$$

Line protection products are selected by comparing the passport data with the calculated values according to the following conditions: by voltage:

$U_{n.} \geq U_{p}$; current:

$I_{nom.} \geq I_{p}$

The choice is made taking into account the installation location and purpose of the switching devices in the circuit.

Conclusion

Step-down substations are designed to convert the primary voltage of the supply network to a lower secondary voltage, at which electricity is transmitted to consumers connected to this substation. They come with one secondary voltage of 6-10 or 35 kV and two secondary voltages of 6-10 or 35kV. At the first substations, two winding transformers are installed, and at the second three winding transformers. The voltage of 35kV is used to power consumers remote from the substations, and the voltage of 6-10kV is used to power consumers located near the substation. Switching the branches of the windings of power transformers (switching devices) are designed to regulate the voltage at a given point in the electric circuit in which the power transformer is installed. Voltage regulation is achieved by changing the number of turns of the windings of the power transformer.

On-load tap-changers are designed to regulate a power transformer under load. Regulation is carried out by changing the transformation ratio by switching the branches of the transformer winding.

The switching device is driven by a motor drive, which makes it possible to use manual, remote and automatic control. The motor drive is mounted outside the transformer tank and is included in the on-load tap-changer package.

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