SELECTION OF THE OPTIMAL METHOD FOR CALCULATING SHORT-CIRCUIT CURRENT IN ELECTRICAL EQUIPMENT

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Annotation

The article considers three methods of calculating short circuits in electrical equipment, based on which the use of the first method in calculations is the most optimal option, and in cases where the data of electrical equipment is incomplete and the first and third recommended methods can be used to approximate the calculation of short circuit current.

Keywords: short-circuit current, short-circuit calculation methods, periodic components, prefabricated bus, maximum current protection, differential protection.

ВЫБОР ОПТИМАЛЬНОГО МЕТОДА РАСЧЕТА ТОКА КОРОТКОГО ЗАМЫКАНИЯ В ЭЛЕКТРООБОРУДОВАНИИ

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Аннотации

В статье рассмотрены три метода расчета коротких замыканий в электрооборудовании, исходя из которых использование первого метода в расчетах является наиболее оптимальным вариантом, а в случаях, когда данные электрооборудования неполны и могут быть применены первый и третий рекомендуемые методы. используется для приближенного расчета тока короткого замыкания.

Ключевые слова: ток короткого замыкания, методы расчета короткого замыкания, периодические компоненты, сборная шина, максимальная токовая защита, дифференциальная защита.

INTRODUCTION

During the operation of power stations and power lines, various types of short circuits and short circuits occur, causing the operation of electrical equipment or power system to malfunction.

Many faults in alternating current intermediate substations result in short-circuits between the phases and the ground. The main causes of damage include insulation damage, wear, overvoltage, service errors of service personnel (disconnection of the circuit breaker under voltage, supply of voltage in the presence of a short circuit, etc.).

All damage occurs and occurs as a result of defects and imperfections of the devices, improper installation, incorrect design, unsatisfactory and improper maintenance of the device, malfunction of the device. Various short circuits are a dangerous process that can damage the electrical system. In the event of a short circuit, the power supply of the source, transformer or lines will be interconnected.

As a result of the increase in current during a short circuit, the amount of voltage in the elements of the power system decreases. This in turn leads to a voltage drop at all points on the power line. Maximum current protection, differential protection is used to protect electrical equipment from short-circuit currents.

Methods

In electrical equipment with a voltage of up to 1 kV, short-circuit current has a slightly larger value, so their electrodynamic and thermal resistance is one of the main factors in the selection of electrical equipment and wires. Different methods of calculating short-circuit current are used in electrical devices of this type.

It is necessary to determine the short-circuit current of the bus with a voltage of 0.4 kV at the traction substation. Based on the data provided, we test the short-circuit current of a 0.4 kV bus in three different ways and compare them.

Data provided: Connection diagram of TMZ 630/10 coils $I_к^{(3)} = 10$ кА Y/Y_0 – 12. $u_к = 5{,}5\%, \Delta P_{кт} = 7{,}6$ кВт$, \Delta P_{си} = 1{,}3$ кВт.

Synchronous motor: PH / SH = 132/162 kW / kVA, IH = 247 A, IP = 4.5 · IH, 0.4 kV voltage cable AVVG 3150, L = 85 m.

The first method of calculating short circuits in electrical equipment is defined as:

a) for high accuracy of calculation, the complete elements of the circuit are assumed to be active and inductive resistances, and if the circuit resistances consist of the same active or inductive resistances, the total resistance of the circuit is assumed to decrease by not less than 10%;

b) the effect of short-circuit current in synchronous compensators, synchronous and asynchronous motors with a capacity of more than 100 kW is taken into account;

c) all sources of electric power are phase-compatible;

g) the periodic components of the short-circuit current are taken to be constant, ie during a short-circuit the voltage remains in the nominal state and at the same time the power is infinitely large;

d) the specified units are used in the calculation of the short-circuit current and the unit of measurement of the resistance of the short-circuit circuit is taken as milliOhm (mOhm);

e) the rated voltage is assumed to be 5% higher than the rated network (0.23; 0.4; 0.69 kV).

The calculation diagram shows the network parameters. That is, the voltage of the upper side of the transformer (Ikz, F, L), the rated power of the transformer, the wiring diagram of the windings and the network parameter U <1000 V (line length, cross-sectional area of the wire, etc.) are indicated.

1. The value of the three-phase short-circuit current component of the short-circuit point 1 is determined as follows:

$$I_{K1}^{(3)} = \frac{U_b \cdot 10^3}{\sqrt{3} \cdot \sqrt{r_{1\Sigma}^2 + X_{1\Sigma}^2}} = \frac{0,4 \cdot 10^3}{\sqrt{3} \cdot \sqrt{10,1^2 + 14,48^2}} = 13,1 \text{ кА},$$

2. The shock current of a three-phase short circuit

$$i_з = \sqrt{2} \cdot 1,11 \cdot 13,1 = 20,53 \text{ кА}.$$

3. Two-phase short-circuit current at point 1 short-circuit

$$I_{K1}^{(2)} = \frac{U_b \cdot 10^3}{\sqrt{(2 \cdot r_{1\Sigma})^2 + (2 \cdot X_{1\Sigma})^2}} = \frac{0{,}4 \cdot 10^3}{\sqrt{20{,}2^2 + 28{,}96^2}} = 11{,}3 \text{ кА},$$

4. Single phase short circuit current

$$I_{K1}^{(1)} = \frac{\sqrt{3} \cdot U_b \cdot 10^3}{\sqrt{(2 \cdot r_{1\Sigma} + r_{0\Sigma})^2 + (2 \cdot X_{1\Sigma} + X_{0\Sigma})^2}} = \frac{\sqrt{3} \cdot 0{,}4 \cdot 10^3}{\sqrt{57{,}5^2 + 125{,}16^2}} = 5{,}03 \text{ кА},$$

5. Current flowing through a synchronous motor

$$I''_{\text{кд}} = \frac{E''_d \cdot 10^3}{\sqrt{3} \cdot \sqrt{R_\Sigma^2 + X_\Sigma^2}} = \frac{1{,}05 \cdot 0{,}38 \cdot 10^3}{\sqrt{3} \cdot \sqrt{29{,}71^2 + 81{,}16^2}} = 2{,}67 \text{ кА}$$

6. The second short-circuit current at short-circuit point

$$I_{K2}^{(1)} = \frac{\sqrt{3} \cdot U_b}{Z_{\text{кт}}} = \frac{\sqrt{3} \cdot 380}{153{,}4} = 4{,}29 \text{ кА}.$$

The second method of calculating short circuits in electrical equipment allows the following:

a) ignoring the magnetization of the transformer;

b) ignoring the saturation in the magnetic system of the electric machine;

c) selection of the transformer conversion factor in accordance with the rated average voltage. The following nominal average voltages can be used for this: 37; 24; 20; 15.75; 13.8; 10.5; 6.3; 3.15; 0.69; 0.525; 0.4; 0.23 kV;

g) to take into account that the sum of the total currents of asynchronous and synchronous motors during a short circuit is more than 1% of the initial value of the periodic current generator.

In the second method of calculating the short circuit in electrical equipment, as in the first method, the short-circuit currents at points 1 and 2, the current flowing through the synchronous motor, the single-phase short-circuit current and the three-phase short-circuit current are arcs and arcs determined separately for the processes.

The third method of calculating the short circuit in electrical equipment up to 1 kV allows to determine the minimum and maximum values of the short-circuit current:

a) a short circuit may occur at a greater distance from the generator;

b) it is assumed that the value of the active resistance of the circuit and the source voltage do not change during a short circuit;

c) the contact resistances of the various elements in the circuit at the point of short circuit are not taken into account;

g) the effect of capacitance and active conductivity of the passive element in the short circuit is not taken into account.

In the third method, too, short-circuit currents are determined based on conditions such as the two methods described above.

Comparison of short circuit current calculation

Method 1.		1 3,1	2 0,5	11, 3	5,0 3	2, 67	4 ,29
etho d 2.	The bow is not taken into account	1 5,6	3 3,0	13, 5	5,3 1	2, 65	4 ,29
	The bow is not taken into account	1 0,6	1 5,4	10, 7	3,0 8	2, 31	3 ,11

Method 3.	1 5,5	3 3,5	13, 4	5,3		4 ,08

The reliability of the calculation of short-circuit current in electrical equipment with a voltage of 1 kV and above depends on taking into account the total resistance of the short-circuit circuit and how accurately it is evaluated.

From the data given in the table above, it can be seen that taking into account the arc resistance has a significant effect on the magnitude of the short-circuit current. The value of three-phase, two-phase and single-phase short-circuit current, taking into account the arc resistance, reduces the short-circuit current by 32%, 20% and 27.5%, respectively. The value of the three-phase short-circuit pulse current, taking into account the arc resistance, is 53% smaller than the value excluding the arc resistance.

The first method proposed considers the resistance of the arc through the sum of the total transient process resistances. As a result, the calculation of the short-circuit current is simplified, but the value of the short-circuit current is 24%, 5.2% and 63.3% smaller than the three-phase, two-phase and single-phase short-circuit current, respectively, calculated in the proposed second method.

From the first and second methods of calculating the short-circuit current, it can be seen that the total current in the electrical device increases from 17.4% to 20.3% from the component of the initial current in the busbar.

The proposed third method does not take into account a number of factors that affect the magnitude of the short-circuit current, so this method is used to determine the maximum value of the short-circuit current.

From a comparison of the short-circuit current calculations, it can be seen that the value of the short-circuit current calculated by the third recommended method is approximately equal to the value of the short-circuit current determined by arc resistance in the second recommended method.

Conclusion

In conclusion from the above, it is preferable to calculate the short-circuit current at voltages up to 1 kV and above 1 kV by the second recommended method when there is complete information on electrical equipment. This leads to a reduction in the number of accidents that occur in the power supply system.

However, in cases where the data of electrical equipment is incomplete and in order to approximate the calculation of short-circuit current, the first and third recommended methods can also be used.

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