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Graph-analytical method of load mode analysis of ferromagnetic current stabilizer

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Abstract. In this paper we consider the application of graph-analytical method for the analysis of the load regime of ferromagnetic current stabilizer. It is proved that under active load the current of the ferromagnetic stabilizer and magnetic flux are related by the ellipse equation where the axes coincide with the axes of coordinate system. The advantage of the proposed method is that it is possible to use an experimentally obtained characteristic.

1 Introduction

When analyzing the circuit of ferromagnetic current stabilizer (Fig.1) for complex load it is convenient to use graph-analytical method by solving algebraic equations of the system. Let's assume that we know the characteristic $X_м=f(Z_м)$ of current stabilizer circuit which can be determined based on the magnetization curve of the ferromagnetic element and the characteristic of the compensating capacitance. [1-8].

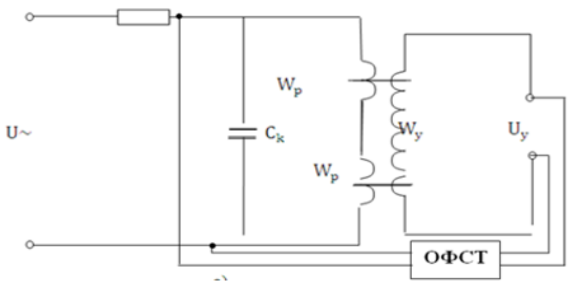

Fig. 1. Schematic diagram of a ferromagnetic current stabilizer

For an active inductive load

$$u = L_H \frac{\omega_{ct}}{dt} + r_H i_{ct} + 2W\frac{\alpha\phi}{dt} \qquad (1)$$

Given that $$Z_c = \frac{1}{m}\frac{d^2x^2}{d\tau^2}$$

$$y = Y_m \cos(\tau + \varphi) \qquad (2)$$

$$x = X_m \sin\tau \qquad z_{фэ} = Z_{mфэ}\sin\tau$$

after introducing the normalized values we have

$$Y_m^2 = (\delta^2 + \gamma_H)Z_{mct}^2 + X_m^2 + 2\gamma_H Z_{mct} X_m \qquad (3)$$

If $\gamma_H = 0$ $\qquad Y_m^2 = \delta^2 Z_{mct}^2 + X_m^2 \qquad (4)$

or

$$\frac{Z_{mct}^2}{\frac{z_{mct}^2}{\delta^2}} + \frac{X_m^2}{Y_m^2} \qquad (5)$$

From this it can be seen that under active load, the current of the ferromagnetic stabiliser and the magnetic flux are related by the equation of an ellipse whose axes coincide with the axes of the coordinate system. On the other hand, these quantities are related by the circuit characteristic of the ferromagnetic current stabiliser. Thus, by superimposing the ellipse on the circuit characteristics of a ferroresonant current stabiliser, the operating mode can be determined. Abscissa of intersection point of ellipse with circuit characteristic shows operating current and ordinate of flux in the core of the ferromagnetic element (fig.2) [9-14].

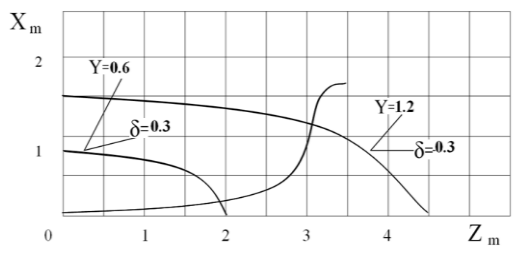

Fig. 2. DependenceXm=f(Zm).

If γ≠0, Zm, Xm are also related by the equation of the ellipse where the centre coincides with the origin. The axis of the ellipse has some angle with respect to the axis of coordinates. Using previously discussed methodology, let's write equation (3) in following form.

$$\frac{Z_m^2}{\frac{Y_m^2}{A}} + \frac{X_m^2}{\frac{Y_m^2}{C}} \qquad (6)$$

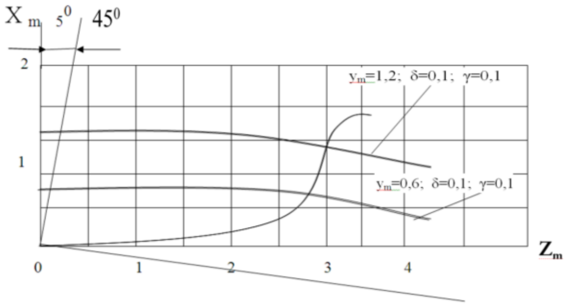

Fig. 3. Dependencies Xm=f(Z .m)for the case γ≠0

Here

$$A = (\delta^2 + \gamma_H^2)\cos^2\alpha + \sin^2\alpha + 2\gamma_H \sin\alpha\cos\alpha \qquad (7)$$

$$C = (\delta^2 + \gamma_H^2)\sin^2\alpha + \cos^2\alpha + 2\gamma_H \sin\alpha\cos\alpha \qquad (8)$$

$$tg\alpha = \frac{2\gamma}{\delta^2 + \gamma_H - 1} \qquad (9)$$

α is rotation angle of ellipse axes,

Z_m, X_m - new coordinates.

Fig.3 shows ellipses for different values of input voltage at inductive nature of load and relationship Zm=f(Xm) of ferromagnetic current stabilizer circuit. Here α has a negative sign which means that the coordinate system of axes of an ellipse is rotated clockwise. [15-22]

When the nature of the load is active-capacitive, the circuit equation of state is as follows:

$$\frac{du}{dt} = \frac{i}{c} + R\frac{di}{dt} + 2W\frac{d^2\phi}{dt^2} \qquad (10)$$

From where

$$Y_m^2 = (\delta^2 + \gamma^2)X_m^2 + X_m^2 + 2\gamma Z_m X_m \qquad (11)$$

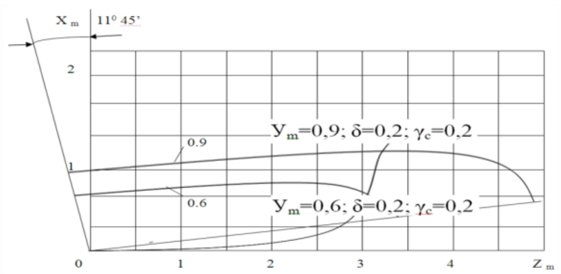

Fig. 4. Dependencies Xm=f(Zm) for the case γ≠0

Further investigation of dependence (11) has shown that expressions similar to (6), (7), (8), (9), differing only by signs before coefficients γn and γ. Angle of rotation of ellipse axes has positive sign (fig. 4). Thus, the advantage of the analysis by graph-analytical method is that it is possible to use experimentally obtained characteristic of the device.

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