THE INVESTIGATION OF THE DRY FURNACE TRANSFORMER ON THE HEATING

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ABSTRACT

The needed attention is not paid to the problem of the optimal calculation and the projection of the dry transformers in the literature nowadays. Moreover, the dry transformers of given size have the set of the advantages in the comparison with the oil-immersed one: explosion safety, the comfortable exploitation, and also the cost of dry transformers in the economic relation is insignificantly more, than the cost of oil-immersed ones.

Keywords: furnace, dry transformer, oil-immersed, heat exchange, loading

I. INTRODUCTION

The calculation and the optimization of dry transformers have the specific peculiarities in the comparison with the oil-immersed ones. Firstly it is connected with problem of the heat exchange. Very few works dedicated directly to the problem of the calculation and the investigation of heat processes in dry transformers in soviet and foreign references.

L.M. Shnizer's technique is the most spread at the calculation of the dry transformers nowadays [1]. L.M.Shnitser considers the heat process in dry transformers, taking into consideration the heat exchange between surfaces and the cooling in canals. The dependence is suggested between the temperature excess and specific heat loadings:

$$\theta = 0{,}2 \cdot q^{0{,}89} \quad (1),$$

where θ is average temperature excess, hail;
q is heat flux density, Vt/m^2.

The coefficient, which is less than unit, taking under consideration the canal geometry is introduced for the internal surfaces (in cooling canals). The suggested dependences have empiric character and differ by the relatively low precision. Set of the works, appeared later, can be considered as the further developing of the method of heat calculation, suggested by L.M.Shnizer. These are works of Sh.I.Lapidus, G.B.Fridman and others.

The heat calculation presents the independent problem, when it is used for the estimation of the available construction. However, the other approach is also possible, which is opposite, when on the assumption of the estimation of heat mode, the geometry and specific transformer loadings are chosen in order to obtain the more satisfactory construction. It is obvious, that the second point of view is more acceptable at the optimal projection.

II. BODY OF THE TEXT

The dependences, suggested in [2] are taken by me for the obtaining of the heat flux from open surface of the winding and from surface of the ventilation canal:

$$q = 9{,}8 \cdot \theta^{1{,}1} \quad (2)$$

$$q = 4{,}9\left[1 - 0{,}11\,(\frac{\delta}{h})^{-0{,}32}\right] \cdot \theta^{1{,}1} \quad (3)$$

Where δ is canal width, mm;
h is canal weight, mm.

Any construction and transformer also should correspond to the definite technical demands. The following values will be considered as given ones at the projection of the transformer:

1) Transformer power S;
2) The voltage of the lowest side U_1;
3) The voltage of the highest side U_2;
4) The scheme of the winding unite;
5) The admissible overheating for the given class of the isolation;
6) The isolated spaces and sizes of isolated constructions;
7) The losses in cuprum $P_{k.z.}$ and losses in steel $P_{x.x.}$ for the optimal variant shouldn't be higher, than values of the corresponding UNST.

In calculation process it is need to definite the optimal values of conductor sizes x_1 x_2, y_1,y_2, the current densities Δ_1 and Δ_2, rode diameter d, winding height h, induction B, winding overheating θ, short circuit voltage $U_{s.c.}$ and choose the material and constructive carrying out of the winding.

As the task of the transformer projection as any optimization task has more unknowns, than the number of the limiting equations, then the part of them is given before the beginning of the calculation, the part is considered as the independent variables.

The core diameter d, the calculative temperature of the overheating θ, short circuit voltage $U_{s.c.}$ are considered as the independent variables.

The minimum of the criterion function of the calculative inputs $З_р$=f (d, θ,$U_{s.c.}$) is chosen as the criterion of the variant optimality. According to [4] the function of the calculative inputs has the form:

$З_р = З_т + З_с + З_п + З_н$, where

$З_т$ is the calculative price of the transformer with amortization deductions;

$З_с$ is calculative cost of the additional power, needed for the loss covering in the transformer in the period of maximal loading in the system;

$З_п$ is cost of the electroenergy loss in the transformer;

$З_н$ is inputs on the compensation of the reactive power.

The solution of the equation is put in the base of the finding of the criterion of optimality

$$h = f(d, \theta, U_{s.c.}), \qquad (4).$$

The h_0 is found for d_o, θ_o and $U_{k\theta}$. All optimal parameters and transformer characteristics are simply defined at known d , θ, $U_{s.c}$ and h: the number of the turns, the sizes and cross-sections of winding wires, current densities, losses in cuprum and steel, weights of cuprum and steel, the values of criterion functions of losses, weights of active materials and calculative inputs.

All above mentioned characteristics and parameters are taken on print. Further by the way of discrete variation of the possible values of diameter d, overheating temperature θ and voltage $U_{s.c}$

$$d_0 \le d \le d_{\max};$$
$$\theta \le \theta \le \theta_{\max}; \qquad (5)$$
$$U_{s.c0} \le U_{s.c} \le U_{s.c\max}.$$

The region of the possible constructive carrying-outs of the transformer is defined. The choice of the optimal variant is done by the projector by the way of the graphic or table finding of the minimum of criterion function of calculative inputs,

The calculation of dry transformers of III size by power 1000 and 1600 kVA was carried out with the use of the given one.

As the conclusions on the investigation results of the transformers of both powers are practically coincide, then for the comfort all graphics further will be given only for the transformer of the power 1000kVA.

The two more competitive variants were considered in the process of the calculation and investigation of the transformer:

1) the winding of lowest voltage has been carried out from pure tire;

2) the winding of lowest voltage has been carried out from metallic ribbon, moreover the ribbon width is equal to the winding height; further this winding we will call the roll one.

The winding of highest voltage for both variants is the manylayered one from the rectangular wire.

As it was mentioned above, the minimum of criterion function of calculative inputs is chosen as the criterion of the optimality. The graphs of calculative inputs are presented on the fig.1. The graphs of the calculative inputs in the function on the temperature $З_р = f(\theta)$ at the optimal values of the diameter of the core rode and constant value of the voltage d = $d_{опт}$ and different economic coefficients β and K_T (β is ratio in made; K_T is calculative cost of the cuprum to the cost of the steel of the transformer in rub./kg) are presented on the fig.1. The winding HH has been carried out on 1 variant, the winding material is cuprum. It has been seemed, that at such definition of the task, it is very important to know indeed the values of these coefficients. From the graphs it follows, that economic coefficients influence not only on absolute value, and mainly on the position of the minimum of the criterion function of the calculative inputs.

The range of the work overheating temperatures changes from 60°C till 110°C at the change of β from 2 till 3,5 and K_T from 0,7 till 1,1. The minimum of the criterion function shifts to the region of more high temperatures with the increase of the economic coefficients. Consequently, it is need to increase of work temperature (current density) at higher transformer cost, at low cost of active materials it is need to chose the mode with low current densities, as in this case the cost of electroenergy losses becomes to prevail under the construction cost.

From the point of view of economy of dry transformer such problem as the use of the cuprum, aluminum in the capacity of the winding material or their joint use presents the interest, i.e. the winding of lowest voltage carried out from the cuprum, the winding of highest voltage is carried out from aluminum. In the set of literature sources it is said, that aluminum as the winding material is totally competitive with cuprum. The new conclusions aren't obtained by us in principle. As it follows from the fig.2. the construction with windings from aluminum, mixed windings and finally from cuprum becomes more profitable for the transformer of power 1000kVA. The results don't change at the different constructive carrying-out of the windings. Probably, that this conclusion is seemed the right one for the all set of dry transformers of the given size.

At the comparison of the two types of the windings on "1" and "2" variants, the second type of the winding is seemed more profitable on the calculation inputs, on 5% less and on heat mode (role material excludes the possibility of the creation of local overheatings).

III. CONCLUSIONS

1. The suggested technique can be used on the step of the draft projection for the calculation of dry transformers of new series.

2. At the projection of technically rational and economical transformers it is need to know the indeed values of economic coefficients "β" and "K_T" in criterion

function of calculative inputs and the more possible transformer loading.

3.The aluminum as the winding material for the transformers of given size is more profitable than cuprum iexcept specific and special cases.

4. The winding type from role cuprum (aluminum) is more perspective and it is need the more detail consideration

REFERENCES

1. *L.M.Shnizer*. Teplovoi process v sukhom transformatore. Moskva, “Electrichestvo”, N4, 1948.(in Russian).
2. *Z.I.Kazim-zade, N.U.Rustamov.* Methodika rasheta sukhogo transformatora na nagrev pri ustanovivshemsa regime. Moskva, “Electrotechnika”, N3, 1969. (in Russian)
3. *K.K.Balashov.* Transformatori s aluminievimi obmotkami. “Vestnik electroteknicheskoi promishlennosti”, N5, 1958. (in Russian)
4. *N.D.Kutavin.* K opredelemiu optimalnikh razmerov trekhphaznikh obmotochnikh transformatorov. Tomsk, Izvestia TPI, T: 130,TGU, 1964. (in Russian)