OPTIMAL DESIGN OF LOW POWER TRANSFORMERS WITH ALUMINUM WINDINGS

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ABSTRACT

The article discusses the optimal design of low-power transformers with a focus on reducing material consumption. Using modern engineering approaches and optimization methods, the presented work seeks to determine the optimal parameters and geometry of a low-power transformer to achieve a reduction in material consumption without losing the efficiency and reliability of the power supply system. This research could contribute to the development of more compact and energy-efficient low-power transformers with applications in a variety of applications, including aircraft and other technical systems.

Keywords: low power transformer, power supply system, aircraft, winding material, aluminum, electromagnetic calculation, no-load current, voltage drop, thermal calculation.

INTRODUCTION

In aircraft (aircraft), high-frequency low-power transformers are widely used in power supply systems (PSS), including direct current converters (DC-DC converters), alternating current inverters (AC-AC inverters) and as power sources for secondary power supply systems [1] . For example, they are used to convert direct voltage received from main generators or on-board batteries into alternating voltage with the required parameters to power aircraft electrical power systems (APS), such as lighting, control systems, communications and other electronic devices[2].

High-frequency low-power transformers in aircraft must meet special requirements, such as high efficiency, reliability, compactness and low weight [3]. Their design and parameters must be optimized to work with a specific frequency used in the aircraft's solar power system.

LITERATURE REVIEW

In famous works Balyan R.Kh., Obrusnik V.P., Kiryukhin Yu.A. The problem of geometric optimization of low-power transformers is solved using a variant method using a computer. The bulkiness, lack of clarity and other known disadvantages of this method forced researchers to look for simpler ways to determine the parameters of the optimal geometry of transformers.

In the studies of Belopolsky I.I., some issues of the theory of transformers at 400 Hz are considered, and the basics of calculation and design of low-power transformers for radio engineering and aviation devices are also described in detail [4]. The difference between designing by this method and other methods is the clarity and simplicity when calculating low-power transformers, while copper conductors were used as the material for the windings.

To correctly select the material for the transformer winding, it is necessary to conduct a comparative analysis of the operating parameters of aluminum and copper and determine the extent of their differences. Particular attention should be paid to those parameters that cause the most concern, since they are the most significant for the operation of transformers.

Table 1. Main characteristics of copper and aluminum

Parameter	Aluminum	Copper
Temperature coefficient of linear expansion, x10 $^{-6}$ /°C	21-2 3	16.4-16.6
Thermal conductivity, W/m·°C	218	406
Specific resistance, Ohm·mm ^{2} /m	0.026-0.028	0.017-0.018
Tensile strength, N/mm ^{2} (soft grades)	79-108	197-276

The calculations are based on the design method of high-frequency low-power transformers by I. I. Belopolsky, while the formulas take into account the features of aluminum as a winding.

To identify the advantages of a low-power high-frequency transformer with aluminum winding materials, we will compare it with a transformer with copper windings similar in electrical quantities and design.

We will make a comparison based on winding data, electrical quantities, overall dimensions, and masses of materials of the active part.

METHODS

When comparing data from a low-power transformer with aluminum windings and copper windings, the following conclusions can be drawn:

1. The coefficient of performance (COP) in a low power transformer with copper windings is more efficient.

2. Aluminum has a lower mass, which can be important when designing a transformer with limited spatial parameters.

3. The surface temperature rise, maximum temperature rise, volume-average temperature rise and maximum temperature of aluminum wires are slightly higher than copper wires, which means a higher operating temperature for aluminum windings.

CONCLUSION

Thus, a transformer constructed using copper wire has some advantages such as higher efficiency, less energy loss and greater thermal stability. However, a transformer with aluminum conductor may be preferable in cases of limited space and winding weight requirements.

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