Optimization Design of the Spacing and Goose Neck Height of Radiator

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Abstract——**The aim of this paper is to present a simulation to optimization the structure of radiator, in this paper the spacing of radiation fin and goose neck height are considered. The simulation is designed to predict their influence on the heat transfer efficiency based on CFD software. A best structure of radiator can be developed according to the simulation results and provide guidance for the practical application of engineering.**

Keywords-spacing; goose neck height; radiator; heat transfer efficiency

I. INTRODUCTION

Low loss, large capacity and good heat dissipation characteristics of the oil-immersed transformer are still the main product in the power grid. The natural oil circulation of transformer has both of the above characters but also has low noise, can avoid "oil flow electrification" etc; it is more and more applications and concerns. The direct consequence of adopting oil natural oil circulation cooling is increase of temperature between copper and oil, so transformer cooling problems become more and more prominent.

For ensuring rapid development of society and industry, power system adjusts energy structure actively, replacing with large capacity and high parameters of power generation and transformation. Therefore, the load of transformers will have been in-creasing. If transformers were overheated for a long time, not only transmission losses of power system would rise beyond rated conditions, but transformers would lose efficacy in severe cases and then lead to more serious power accident[1].

II. MODEL

This paper focus on the radiator of SZ11-240000/220kV transformer, the type is PC2500-26/520.

TABLE I. THE PARAMETERS OF TRANSFORMER AND RADIATOR.

Type	Parameter
Type of transformer	SZ11-240000/220kV
Loss of no load	140kW
Loss of load	535kW
Tank size	7840mm(length)×2260mm(wide)×4050mm(height)
Radiator	PC2500-26/520
Hot spot temperature	80℃
The heat radiating area of tank	81.2m2
The heat radiating area of radiator	1748.4 m2 (36.96×40)

Boundary conditions: (1) Air side: inlet temperature is 30℃, inlet velocity is 0.1m/s; (2) Transformer cooling oil: inlet temperature is 80℃, inlet velocity is 0.01m /s, inlet density is 871kg/m3, kinematic viscosity is 11×10-6m2/s[2]; (3) Wall boundary conditions is convection and radiation coupling boundary.

III. THE INFLUENCE ON HEAT TRANSFER EFFICIENCY BY THE SPACING OF RADIATION FIN

Defined heat transfer efficiency as the heat exchange capable of radiator, study the best heat transfer effect [3].

$$Heat\ transfer\ efficiency = \frac{heat\ transfer\ with\ any\ spacing\ of\ radiation\ fin}{heat\ transfer\ with\ 45mm\ spacing\ of\ radiation\ fin}$$

When the spacing of radiation fin is 40mm, 45mm, 50mm, the result is shown in fig 1.
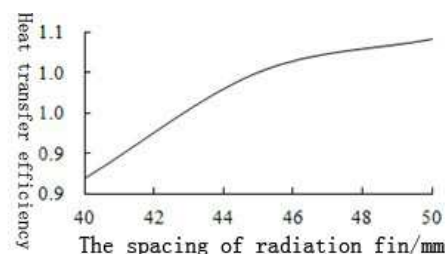

FIGURE I. THE CURVE OF HEAT TRANSFER EFFICIENCY CHANGED WITH THE SPACING OF RADIATION FIN.

As it shown in fig 1, with increase of the spacing the heat transfer efficiency showed an upward trend and the margin rise rapidly at first and then become slowly. When the spacing

of the radiation fin is 40mm and 50mm, the heat transfer efficiency is 0.87 and 1.05.

When the spacing of radiation fin is small, so did the air gap of radiation fin, heat exchange environment is poor, Thus this become the main reason for poor heat transfer. When the spacing of radiation fin is 45mm, the internal resistance of transformer cooling oil is more uniform in the piece radiator of radiator, as shown in fig 2, causing the temperature of the cooling oil flow drops largely. When the spacing of radiation fin is 50mm, the distribution of cooling oil is unequal, there is more cooling oil within the oil channel of nearby transformer, result in high temperature over there. As there is large resistance far away from the transformer the oil flow is reduced accordingly, it's radiating more quickly, therefore, the temperature is lower. But when the spacing of piece radiator is 50mm, still can ensure a better cooling effect.

Fig 2 is the pressure distribution of piece radiator with different spacing. The figure show, when the spacing is 43mm, the internal pressure of piece radiator is more evenly.
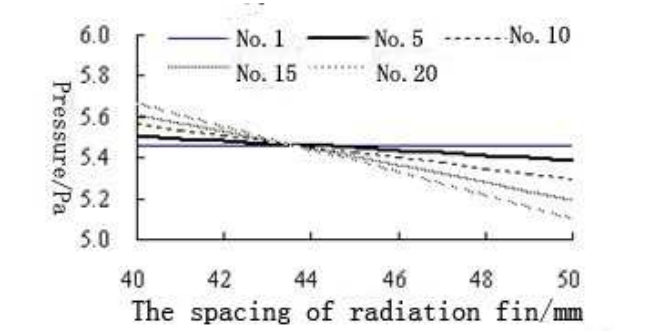

FIGURE II. THE PRESSURE DISTRIBUTION OF RADIATION FIN WITH DIFFERENT SPACING BETWEEN RADIATION FIN.

Based on the analysis above, take the power consumption and heat capacity into account, the best spacing of radiation fin is 45~50mm.

IV. THE IMPACT OF THE GOOSE NECK HEIGHT ON HEAT TRANSFER EFFICIENCY

Affected by the structure of transformer, part of radiator were design with the type of goose neck, as it shown in fig 3, in order to study the influence of goose neck height on the heat transfer efficiency, different height of goose neck were set.
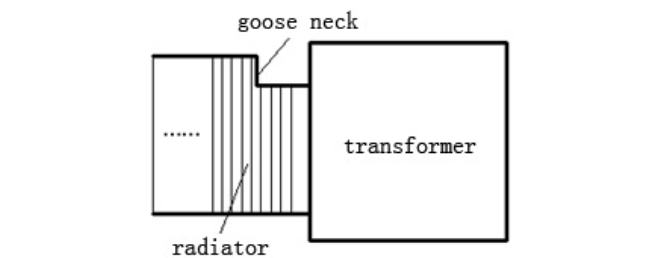

FIGURE III. RADIATOR STRUCTURE SCHEMATIC DIAGRAM WITH GOOSE NECK.

In order to characterize the influence of goose neck on heat transfer efficiency, defined heat transfer efficiency as the heat exchange capable of radiator, study the best heat transfer effect.

$$Heat\ transfer\ efficiency = \frac{heat\ transfer\ with\ any\ height\ of\ goose\ neck}{heat\ transfer\ without\ goose\ neck}$$

When the height of goose neck is 300mm, 500mm, 800mm, and the result were shown in fig 4
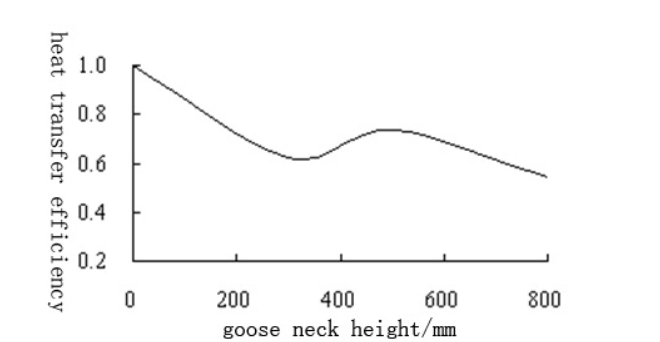

FIGURE IV. THE CURVE OF HEAT TRANSFER EFFICIENCY CHANGED WITH THE HEIGHT OF GOOSE NECK.

As shown in fig 4, radiator with the type of goose neck, heat transfer efficiency decrease sharply with the growth of the height of goose neck. When the height of goose neck is 300mm, 500mm, 800mm, the heat transfer efficiency is 0.62, 0.74, and 0.54. Thus, radiator with goose neck has a bad effect on heat transfer efficiency.

The phenomenon of the velocity of the first four radiation fin is higher than the rest of radiation fin occur, due to the appearance of goose neck, as it shown in fig 5, in the figure, radiation 1 represent the first four radiation fin, radiation 5 represent the radiation fin in the middle, radiation 10 represent the radiation fin at last. While the first four radiation fin with a high speed, not only cut down the residence time of the transformer cooling oil stay in the radiator, this will reduce the heat dissipation effect of the first four radiation fin, but also make more transformer cooling oil distribution in the first four radiation fin, lead to less transformer cooling oil flow into the rest radiation fin, thus the heat transfer were sharply decreased. So the phenomenon of radiator with goose neck has a bad heat transfer efficiency is present.
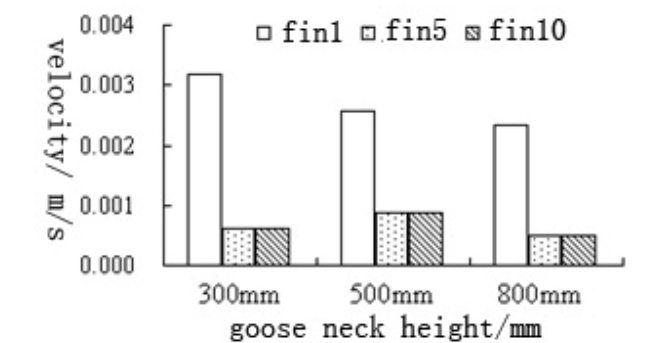

FIGURE V. VELOCITY DISTRIBUTION OF DIFFERENT GOOSE NECK HEIGHT.

V. CONCLUSIONS

This paper have used a wide range of models to attempt to accurately predict the influence of spacing of radiation fin and goose neck height on heat transfer efficiency. As it shown in the simulation under certain conditions with the increase of the spacing of radiator the heat transfer efficiency increase at first, but with the growth of the spacing of radiator, its slow down shown by simulation, the best spacing of radiation fin is 45~50mm. And the radiator with the type of goose neck presents a bad heat transfer capability.

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