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Thermal analysis of aircraft servo motors for cooling fin design

In this study, different cooling fin designs were made to optimize the natural cooling of aircraft servo motors without an air flow. Thermal analyzes of these designs were carried out using the finite element method under the same motor heating conditions. In addition, the effect of the length of the cooling fins and material differences were also examined. The results of this study can be taken into account, especially when designing high torque, hot servo motors.

Introduction

We will examine the geometry and material effect of the fins on the motor body in the dissipation of the heat (friction in mechanical parts, current in winding wires) in aircraft servo motors. The analyzed aircraft servo motor has the same characteristics for all designs and makes the same thermal emission for each experiment.

Thermal loss, 420 W
Winding temperature in the stator, 90°C
Ambient temperature, 25°C
H, 5W/m^{2}K

Due to the detailed geometry of the servo motor, a cross-sectional volume of 30 mm at a depth of 30 mm was investigated from a uniformly distributed 90º slice of the body in order to examine its thermal dissipation more efficiently. This geometry is shown in figure 1.

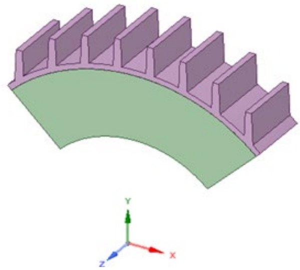

Fig. 1. Aircraft servo motor section geometry created for thermal analysis with the finite element method

Mathematical Model

Mathematical models were created in order to perform thermal analysis of the created geometries with the finite element method. An example mathematical model for a model in experiments is shown in figure 2.

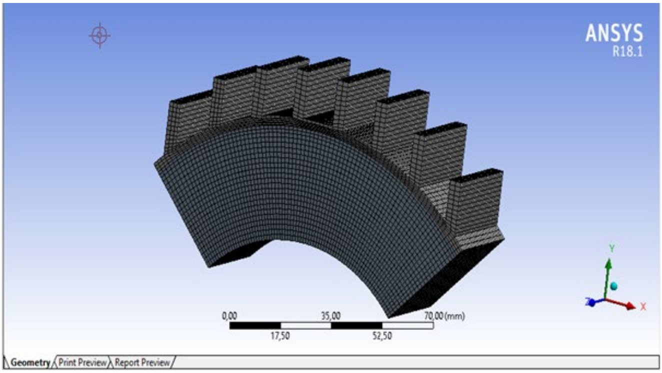

Fig. 2. The geometry of the servo motor cross-section for which the mathematical model was created using the finite element method.

Experiment Setup

Transferring the data to be used for thermal analysis to the program was done as in Figure 3.

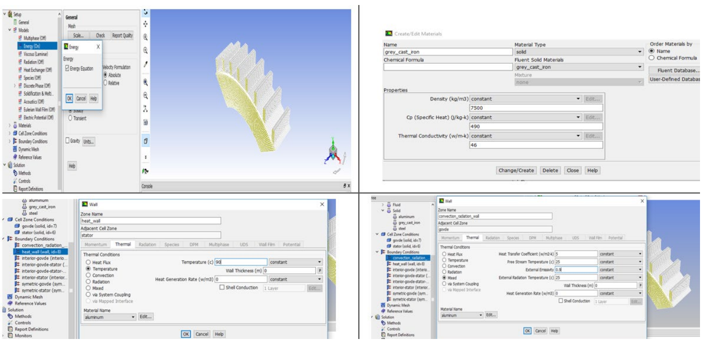

Fig. 3. Setup Stage

The geometries used in the thermal analysis are shown in Figure 4. Five different fin design geometries were tested. However, for the 1st design, the experiment was repeated on the same geometry but by changing the material properties. The image (square form) of design 4 from the thermal analysis results is as in figure 5. In Figure 5 it is possible to determine the temperature of different parts of the geometry. According to these analyzes, the temperatures of the extreme points of the fins are shown in Table 1. However, the difference between the warmest and coldest parts of the fins is shown in Table 1 as DeltaT.

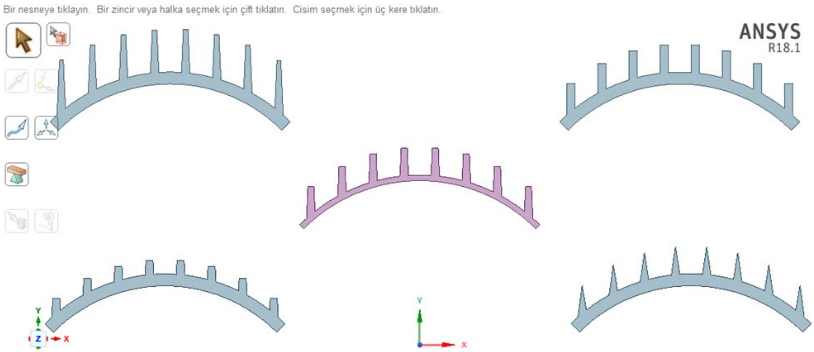

Fig. 4. The geometries which used in the thermal analysis

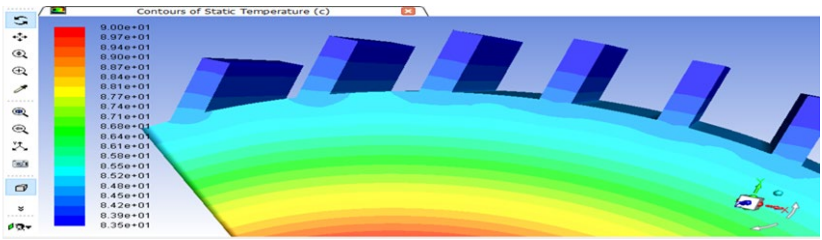

Fig. 5. Thermal analysis results of design 4 (square form)

Table 1.

Results of thermal analysis experiment

Model	Material	Height of Colling Fin	Geometry of Colling Fin	Tmin °C	DeltaT
Design1	Grey Cast Iron	x	Trapezoid	83,6	1,4
Design2	Aluminum	x	Trapezoid	84,6	0,5
Design3	Grey Cast Iron	x	Triangle	83,6	1,6
Design4	Grey Cast Iron	x	Square Form	83,5	1,3

Design5	Grey Cast Iron	2x	Trapezoid(Tall)	68,8	12,7
Design6	Grey Cast Iron	x/2	Trapezoid(Short)	85,9	0,4

Comparisons that can be made in this analysis are as follows:

Comparison of aluminum vs. gray cast iron, comparison of fins of different geometric shapes, comparison of different fin sizes

Conculussion

1. Considering the results of the analysis, aluminum is recommended from a thermal point of view, but strength requirements and other reasons are different criteria for material selection.

2. When we look at the comparison of Design 5 and Design 6, it is seen that DeltaT is high in long fin and low in short fin. It has been shown that the cooling effect of the fin height is high in the environment where there is no air flow.

3. Different geometries (square, triangular fin) did not show a significant difference in terms of cooling in the absence of air flow, but in case of fan cooling, it is recommended to consider the results by performing flow analysis.

References

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