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COMPUTER-AIDED DESIGN SYSTEMS OF RADIATORS

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Abstract. *The basic types of cooling radiators. A review of optimal algorithms in the design of cooling radiators. Software solution for this problem.*

Keywords: cooling radiators; computer-aided design.

Introduction

In recent years, using systems that automate the design process of a particular element is increasing. This significantly reduces the design time.

Cooling radiator – frequently used element in many devices, especially those that work with large amount of heat (such as LED lighting, where it is necessary to cool the LEDs). Therefore, the development of computer-aided design for radiators is very crucial for today.

Types of cooling radiators

There are several types of radiators (Fig. 1) [1]. Of these, the most widely used are plate, ribbed and pin. The simplest is the radiator plate, which is a rectangular or circular metal plate thickness from 1 to 8 mm (Fig. 1*f*).

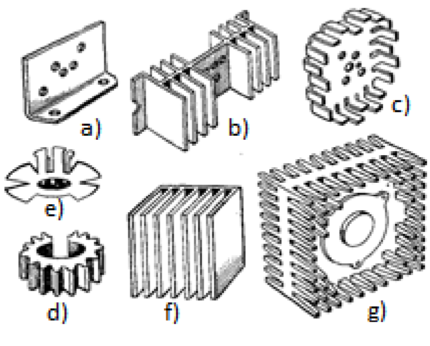

Fig. 1. Cooling radiator design: *a* is plate, *b* is with longitudinal ribs, *c* is with staggered ribs, *d* is the wing, *e* is star, *f* is ribbed, *g* is pin

Plate radiators should be used for the scattering of small capacity. To reduce the space occupied plate radiator gives different configuration. For the removal of a large amount of heat, radiator plate is not suitable because of excessive increase of its size and low efficiency. The main advantage of the radiator plate - simplicity of manufacturing.

Of complex structures,ribbed radiators are more common (Fig. 1*b*–*f*). They may be vertical or horizontal arrangement of ribs have a circular or rectangular shape. Rectangular finned radiators can be both one-way and two-way ribbing.

Pin radiator (Fig. 1*f*) is more complicated to manufacture than ribbed, but it is more effective in their work. Pin radiator is made by casting or milling. This type works more efficient with horizontal location pins.

Choice of one or another type of radiator and its design is determined in each case by various factors: power dissipation, the structural requirements for electronic devices, operating conditions of device, etc.

The benefits of this type of cooling has low cost of manufacture, durability of (there are no fans that can fail), quiet operation.

Disadvantage is the large size of the radiator for cooling power diodes.

If we consider the production of LED lamps, there are most commonly used finned radiators following configurations (Fig. 2).

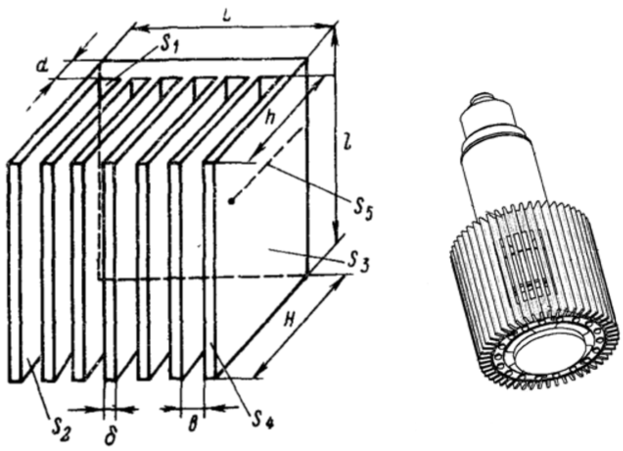

Fig. 2. Configuration finned radiators

These radiators have the following parameters:
–*L* is the width of the radiator;
– *l* is length of the radiator;
– *b* is the distance between the ribs;
– *h* is the height of the ribs;

– d is thickness of the base plate;
– δ is thickness of the rib;
– n is the number of edges.

In the first case, the diodes are attached to the base radiator, in the second – on the vial circle whose length is equal to L.

After selecting the desired configuration finned radiator can proceed for the task of calculating the parameters of the radiator.

Statement of the problem by optimizing the dimensions of the radiator volume and mass

Required to calculate the optimal size by weight and, therefore, at a cost of ribbed radiator for the diode (*s*), with a power dissipation of P.

Input values:
– the ambient temperature;
– material of the radiator (its coefficient of thermal conductivity λ);
– the blackness which of coating;
– insulation gasket between the radiator and the diode;
– thermal diode data: transition temperature, the thermal resistance junction-to-case, the thermal resistance case-to-radiator, power dissipation.

Algorithmic support

There are many different methods for calculating the parameters of the ribs. For example, in [1] presents a simple method of calculating the size of the radiator for simplified formulas. This method does not allow obtaining an optimum size and weight radiator. Also in [2] provides a method for calculating the optimum size has fins, and we still have to optimize the size to get the minimum weight edge.

Since we are interested in the minimum weight edge, then pose the problem of determining the contour edges. In general, the problem is formulated in such a way: to determine the contour edges, which for a given heat flow and thermal head would limit the minimum area (minimum edge weight) (Fig. 3).

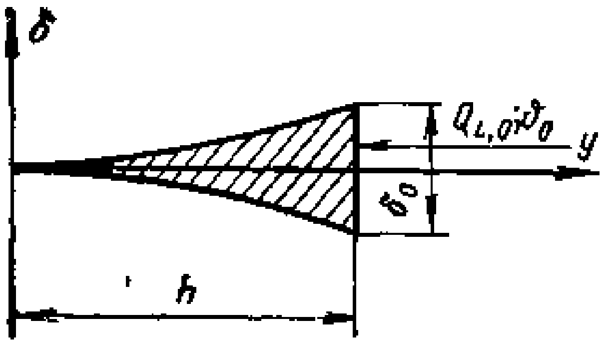

Fig. 3. Edge with minimum area and weight: h is the height of the ribs; $Q_{L,o}$ is ribs heat flow; δ_o is thickness of the rib; v_o is temperature difference

Using a method for calculating the optimum size has fins, and we still have to optimize the size to get the minimum weight edge [2] we will take these results:

$$\begin{cases} h = \dfrac{1}{\alpha}\dfrac{Q_{L,o}}{v_o}; \\ \delta_o = \dfrac{1}{\alpha\lambda}\left(\dfrac{Q_{L,o}}{v_o}\right)^2; \\ S = \dfrac{1}{3\alpha^2\lambda}\left(\dfrac{Q_{L,o}}{v_o}\right)^3, \end{cases} \quad (1)$$

where α –heat transfer coefficient; λ –coefficient of thermal conductivity.

Therefore, we got parameters optimized for minimum mass parameter.

Next, we write the algorithm for calculating the size of the selected radiator. Before the actual calculation is necessary to select the proper configuration of the radiator. To do this, the lighting calculation we get the dimensions of the board on which are arranged diodes, if the diodes are arranged between the ribs, then we need to impose restrictions on the distance between the ribs, possible restrictions on the height of the rib width, etc.

Since the area of the profile rib height, width interdependent values, then combining the restriction to one of these parameters, we obtain different optimal values for the other parameters. We need to fix some value to some of them. This algorithm is presented that we have a fixed number of ribs, changing which we are working on fin parameters.

Software for the task

To solve this problem we use the following linear algorithm:

1. Determine the temperature of the body:

$$t_b = t_t - PR_{j-c},$$

where t_t is transition temperature; P is power dissipation; PR_{j-c} is the thermal resistance junction-to-case.

2. Find the difference in temperature between the body and the heat sink for the diode of this type insulating spacer:

$$\theta = PR_{c-r},$$

where R_{c-r} is the thermal resistance case-to-radiator;

3. For known values of t_b and θ determine the average surface temperature, the temperature differ-

ence between the radiator and the environment and the average temperature [1].

4. Based on the design requirements, receive equal length radiator L. Next, we find the coefficient of heat transfer by convection α_c [1].

5. Determine the value of the radiant heat transfer coefficient α_r [1].

6. Find a common heat transfer coefficient:

$$\alpha = \alpha_c + \alpha_r.$$

7. Determine the heat transfer surface S_p [1].

8. Based on the initial fixed number of edges (n) in the selected type ribbed radiator, find the area of the profile of one edge.

$$S = \frac{S_p}{n}.$$

9. Find the value of the heat flow per unit length of the base edge $Q_{L,o}$ of formula optimal area of the profile edges, optimized weight.

$$Q_{L,o} = \frac{\sqrt[3]{3\alpha^2\lambda}}{\vartheta_0}.$$

10. Find the optimum height ribs and rib spacing from equation (1).

11. Find the distance between the ribs based on the required width of radiator or desired width based on the distance between the ribs of the formula:

$$L = (n-1)(b+\delta) + \delta.$$

Conclusions

The result was a radiator for optimum (optimized in order to obtain the minimum mass of the heat sink) thermal conditions. Thus, the resulting algorithm allows you to perform calculations for parameters ribbed cooling radiator for any elements quickly.

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В. М. Синєглазов, Д. А. Свинаренко. Системи автоматизованого проектування радіаторів

Розглянуто основні типи охолоджуючих радіаторів та оптимальні алгоритми проектування радіаторів. Запропоновано програмне рішення поставленої проблеми.

Ключові слова: охолоджуючі радіатори; автоматизоване проектування.

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В. М. Синеглазов, Д. А. Свинаренко. Системы автоматизированного проектирования радиаторов
Рассмотрены основные типы охлаждающих радиаторов и оптимальные алгоритмы проектирования радиаторов. Предложено программное решение поставленной задачи.
Ключевые слова: охлаждающие радиаторы; автоматизированное проектирование.

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