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Application reynolds analogy in the study of temperature change in wall length of specific channel nasa-0021

Abstract. The work of the wind power plant in the winter in countries with severe weather condition is fraught with very serious consequences. There are frequent multi-day snow storms (storms) that lead to skidding sleet exposed surfaces of the unit with the subsequent formation of a dense snow-ice shell. For large frost (20-35 ^{0}C) frozen bearings, resulting in wind power plant goes down up to destruction under the pressure of the wind. Therefore it is important to have the technology, its production, its experience to develop promising new wind power plants, including those able to work in adverse weather conditions. A simple and reliable measure is the thermal protection element rotating windmill. For studying of regularity of heat exchange in a cavity of the airfoil NASA 0021 profile with an air stream running on it at a rotary motion of the wind turbine theoretical basics of processes of heat exchange in a cavity were covered.

Keywords: wing profile NASA-0021, friction tension, dimensionless coordinate.

Introduction

In this paper we considered the change in temperature channel wall airfoil NASA - 0021 with the running stream of warm air. The flow of warm air, which flows through the interior of airfoil NASA - 0021 serves as an internal heat source, thereby preventing the formation of ice on the exterior wing surface [1]. To get sufficient heat to estimate the change in temperature on the surface of an airfoil at the entrance and at the exit of the warm flow into the channel (and is based on what this work). Knowing the value of the temperature in all areas of the walls of an airfoil can estimate the amount of heat given off to maintain a temperature above 0 0C. This makes it possible to determine the costs of heat for thermal protection of an airfoil under severe weather conditions.

Method of research

The heat transfer from airfoil NASA - 0021, heated by warm air flowing from the inside, is described by two equations [2]

$$q_{wв} = \alpha_{wв} F_{1в} (T - T_{wв}), \tag{1}$$

$$q_{wн} = \alpha_{wн} F_{2н} (T_{wн} - T_{\infty}), \tag{2}$$

where, the subscript "b" refers to the inside of the task and the "h" - outside, and $q_1 = q_2$. Because of the smallness of the thickness of the walls the flow channel can be taken $F_в = F_н = F$, $T_{wв} = T_{wн} = T_w$. Here, the temperature T, as well as medium speed expenditure u_{cp}, is a medium enthalpy temperature

$$T = \frac{\frac{1}{Cp}\int_S \rho Q i dS}{\int_S \rho Q dS} = \frac{1}{SCp}\int_S i dS; \quad i = \mathrm{CpT}, \tag{3}$$

as Q = const, ρ = const. Thus determined temperature constant channel cross section and changes only the cross section of the section, wherein the linearly due to the constancy of the internal and external conditions

$$\mathrm{T} = \mathrm{a} + \mathrm{bz} = \mathrm{T_0} - (\mathrm{T_0} - \mathrm{T_1})\overline{\mathrm{z}}, \tag{4}$$

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where $\bar{z} = \frac{z}{l}$ - the dimensionless coordinate directed along the length L of the test element of the wing. The average temperature along the channel warm air equals

$$\overline{T} = \int_0^1 T d\bar{z} = \frac{T_0 + T_1}{2} . \qquad (5)$$

Because the heat transfer conditions along the length of the channel are constant and the parameters Q, S, V, $d_э$ constant of problem, the channel wall temperature varies according to the same laws (4) and (5)

$$\left.\begin{aligned} T_w &= T_{w0} - (T_{w0} - T_{w1})\bar{z}, \\ \overline{T}_w &= \frac{T_{w0} + T_{w1}}{2} \end{aligned}\right\} , \qquad (6)$$

unlike T and $\overline{T}$ a constant value ΔT . It is interesting to note that the constancy of the temperature differences (including $T_{WB} = T_{WH} = T_W$)

$$T - T_\omega = T_0 - T_{\omega 0} = T_1 - T_{\omega 1} = const$$

can write the equation (1) through the medium temp erature. Really

$$T - T_w = \frac{T_0 - T_{w0}}{2} + \frac{T_1 - T_{w1}}{2} = \overline{T} - \overline{T}_w , \qquad (7)$$

equations (1) and (2) are the specific heat q_{WB} and q_{WH} passed through unit surface area of the blade, as T, T_{WB}, T_{WH} features of $\bar{Z}$ and differ from each other by a constant value. The total amount of heat released blade environment, we find by integrating (1) and (2) by

$$\frac{\tau_a}{u_{cp}} \int_0^1 (T - T_w) d\bar{z} = \frac{\tau_н}{V} \int_0^1 (T_w - T_\infty) d\bar{z}$$

$$q_{wн} = \alpha_{wн} F_н (\overline{T}_w - T_\infty) = q_2 = q_0 . \qquad (8)$$

Subsequently, in certain cases, and will operate with quantities $\overline{T}$ and $\overline{T}_w$. If they are known, then determine T_{W0} and T_{W1} is easy.

The two equations (1) and (2) do not allow us to find the values of the three unknown $\alpha_в$, $\alpha_н$, T_W. Therefore, these two equations must be supplemented by one or condition equation. This condition can be obtained using the Reynolds analogy, the assumption of negligible impact of the viscous sublayer in turbulent flow plate. Then, the expression takes the form

$$q_{wн}(x) = \tau_{wн}(x) Cp \frac{T_w - T_\infty}{u_\infty} . \qquad (9)$$

Although Reynolds analogy has been developed for the case of longitudinal flow over a smooth surface of the plate (exterior problem), it (analogy) is applicable to the turbulent fluid flow in the channel (internal problem). The total amount of heat transferred from the channel will power

$$q_{wв} = \tau_{wв} Cp \frac{T - T_w}{u_{cp}} F \qquad (10)$$

the shear stress at the wall and a flat, smooth surface on the inside of the channel, respectively, and are denoted $\tau_{wн}$ and $\tau_{wв}$.

Due to steady airflow around airfoil NASA-0021 turbulent flow in a narrow range of angle of attack can be considered a process of heat transfer, subject to the relationship (10), sending the coordinate "x" along the perimeter of the wing

$$q_{wн}(\Phi) = \tau_{wн} Cp \frac{T_w - T_\infty}{V} F , \qquad (11)$$

An exemplary flow diagram of airfoil is shown in figure 1 [3].

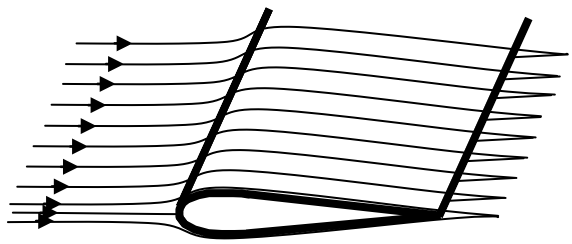

Figure1 – Diagram of steady airflow around airfoil NASA – 0021.

Based on equations $q_{WB} = q_{WH}$ and (7) can be written

$$\frac{\tau_в}{u_{cp}} (T - T_w) = \frac{\tau_н}{V} (T_w - T_\infty) , \; q_1 = q_2 , \qquad (12)$$

where the letters "b" and "h" denotes the quantities related to the internal and external challenges $\tau_{w\text{в}} = \tau_w = \tau_{\text{в}}$, and $\tau_{w\text{н}} = \tau_w(\Phi) = \tau_{\text{н}}$, respectively $q_{w\text{в}} = q_{\text{в}}$ and $q_{w\text{н}} = q_{\text{н}}$. Since $T(\bar{z})$ and $T_w(\bar{z})$, here q_1 и q_2 are the specific amount of heat per unit length of the blade. The total amount of heat released in the blade environment, we find, if we integrate the last equality. As a result, we obtain

$$\frac{\tau_{\text{в}}}{u_{cp}}(\overline{T} - \overline{T}_w) = \frac{\tau_{\text{н}}}{V}(\overline{T}_w - T_\infty) = q_1 = q_2 = q_0, \quad (13)$$

that allows you to find the average temperature of channel

$$\overline{T}_w\,\overline{T}_w = \frac{\overline{T} + \frac{\tau_{\text{н}}}{\tau_{\text{в}}}\frac{u_{cp}}{V}T_\infty}{1 + \frac{\tau_{\text{н}}}{\tau_{\text{в}}}\frac{u_{cp}}{V}} = \frac{\overline{T} + \Omega T_\infty}{1 + \Omega} \quad (14)$$

Because of the parallel changes in T и T_w along the channel will have $T - T_w = \overline{T} - \overline{T}_w = \kappa$, where "k" constant, known in each experiment. This makes it possible to determine the temperature of the channel wall at its inlet T_{w0} and outlet T_{w1}, thereof formulas

$$\left.\begin{aligned} T_{w0} &= \frac{T_0 - T_1}{2} + \overline{T}, \\ T_{w1} &= \overline{T}_w - \frac{T_0 - T_1}{2} \end{aligned}\right\}. \quad (15)$$

Conclusions

Given the theoretical basis of heat transfer, proposed an analytical method for the determination of thermal and thermal parameters of an airfoil NASA - 0021.

The conclusions are valid for all cases of heat Airfoil NASA - 0021 with the oncoming flow, if its internal cavity, in which warm air is flowing, and has the shape of NASA - 0021. This airfoil may be made of any material and have a certain wall thickness, which should be regarded as a flat plate, the thickness Δ, and can be defined as the average heat flow and average temperature of the surface of an airfoil NASA - 0021. This is an important factor in the thermal protection of an airfoil wind units.

Based on the temperature at the inlet to the channel cavity, heat given, it is possible to determine the temperature profile along the plane of the wing, which must exceed 0 ^{0}C.

The results and the development of his methods of analysis will be useful for the design work for the establishment of industrial designs wind turbine airfoil having NASA - 0021.

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