Proceedings of the Iowa Academy of Science

Volume 35 | Annual Issue

Article 46

1928

Cooling by Evaporization in Moving Air

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COOLING BY EVAPORIZATION IN MOVING AIR

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There is present no satisfactory theory for the wet and dry bulb hygrometer in moving air and these experiments were started with idea of getting more information about the effect of the rate of evaporation and the shape of the covered bulb on the lowering of temperature. So far in this investigation only the cylindrical shape has been used. Only a section of the cylinder is covered with moistened muslin and with constant air velocity and humidity, the rates of cooling are compared when the covered section makes different angles with the air stream.

The difference in temperature is measured by means of a multiple junction copper-constantan thermocouple. To determine the rate of evaporization a current is sent through a heating coil embedded in the muslin until there is no difference in temperature between the muslin and the moving air.

The cylinder used is two cm. in diameter and six cm. long. A section equal to one-fourth the circumference is cut out and evaporization takes place from the cooling element inserted in this space. Readings are taken for four different orientations of the cooling element with respect to the direction of the air stream. The cylinder is mounted in a wind tunnel nine inches in diameter and five feet long. An electric fan is used as a blower and so far the experiments have been carried out at only one velocity, which was found to be approximately three meters per second.

A wet and dry bulb hygrometer is placed at the outlet of the wind tunnel for comparison and to determine if the temperature and humidity remain constant.

Table

Orientation	0°	90°	180°	270°
Temperature difference °C	10.1	8.82	8.95	8.70
Temperature difference °C	10.3	9.75	9.82	9.62
Rate of evaporation in watts	1.05	0.72	0.84	0.77

The results show that the cooling effect is the largest when the element is perpendicular to the air direction which is called 0° orientation. One would expect that the cooling effect at 180°

orientation would be more nearly the same as that for 0° than is shown by the results.

The depression of the wet bulb temperature of the wet and dry bulb hygrometer is evidently an average value for the cooling on the different parts of the surface and further study of the effect of the shape of the cooling surface may lead to a better agreement between the theory and experiments for the wet and dry bulb hygrometer.

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HEAT FLOW IN A FINITE CYLINDER WITH VARIABLE SURFACE TEMPERATURE

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If heat be supplied at a constant rate to a liquid which is kept at uniform temperature throughout by stirring, and if this liquid lose heat according to Newton's law of cooling, we get

$$\frac{d\Theta}{dt} = \frac{\beta}{C} - \alpha\Theta. \qquad (1)$$

for the differential equation from which to obtain the temperature, Θ, as a function of time. $\beta/_c$ is the rate of heat supply divided by thermal capacity and $\alpha\Theta$ the rate of cooling. The surrounding medium is assumed to be at zero temperature. This equation is equally valid if the liquid be replaced by a solid of very high diffusivity. Equation (1) assumes the thermal capacity of the liquid to be independent of temperature.

Equation (1) when integrated subject to the condition that $\Theta = \Theta_0$, when $t = 0$, gives

$$\Theta = \Theta_\infty - (\Theta_\infty - \Theta_0)\, e^{-\alpha t} \qquad (2)$$

where

$$\Theta_\infty = \frac{\beta}{C\alpha}$$

It is seen from (2) that the temperature approaches asymtotically the value Θ_∞ as t approaches infinity.

Let us now immerse a small solid cylinder, of small thermal capacity in comparison to the liquid, in the liquid. It is required to find the temperature of any point of the cylinder at any time t. We assume the initial interior temperature of the cylinder uniform throughout and equal to Θ_1.