RESEARCH NOTE

EVALUATION OF "MYLAR" PLASTIC FILM AS A SURFACE FOR A SOLAR-HEAT COLLECTOR

Mylar plastic film was used to cover the collecting surface of the experimental laboratory solar-heat collector, as shown in figure 1. The objective was to determine the performance of this type of surface by observing the temperature increases obtained, and, with this information, to calculate the economic advantage or disadvantage of this type of collector surface as compared to a standard sheet-metal-surfaced collector.

Measurements were made of ambient temperature, heat-collector exhaust temperature, incident solar energy, and airflow rate. The rate of airflow through the collector was determined by measuring, with a micromanometer, the air-pressure difference across the fan and correlating this information with the manufacturer's performance curve for this fan. The fan was coupled to a 3′ × 3′ drying bin, which was filled with parchment coffee to varying depths to provide a series of airflow rates. Experimental trials were normally conducted during the forenoon, on cloudless days, so that a gradually varying solar-energy input was provided. Temperature increases in the collector were plotted against incident solar energy for four different airflow rates, with the following relationships obtained:

$$\text{For } V = 6.7 \text{ c.f.m./ft.}^2, \quad dt = 0.0960\, R$$

$$\text{For } V = 10.0 \text{ c.f.m./ft.}^2, \quad dt = 0.0647\, R$$

$$\text{For } V = 10.4 \text{ c.f.m./ft.}^2, \quad dt = 0.0601\, R$$

$$\text{For } V = 15.2 \text{ c.f.m./ft.}^2, \quad dt = 0.0432\, R$$

V is the airflow rate, in c.f.m. per square foot of collector area; dt is the temperature increase of the air as it passes through the collector, degrees F., and R is the incident solar energy, B.t.u./hr.-ft.^{2}

The results obtained with the plastic-covered collector are compared with those obtained from the uncovered collector in the graph of figure 2. The performance curves for the uncovered collector are based on the relationship:

$$dt = 0.108\, R\, (1 - e^{-8.08/V})$$

It can be seen that for high airflow rates, the plastic-covered collector offers no advantage over the uncovered collector, but for lower airflow rates,

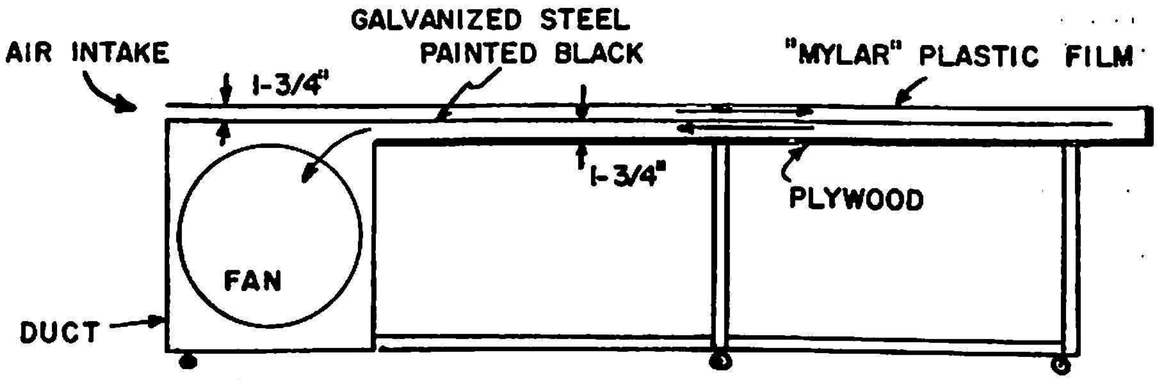

FIG. 1.—Cross-section view of solar-heat collector.

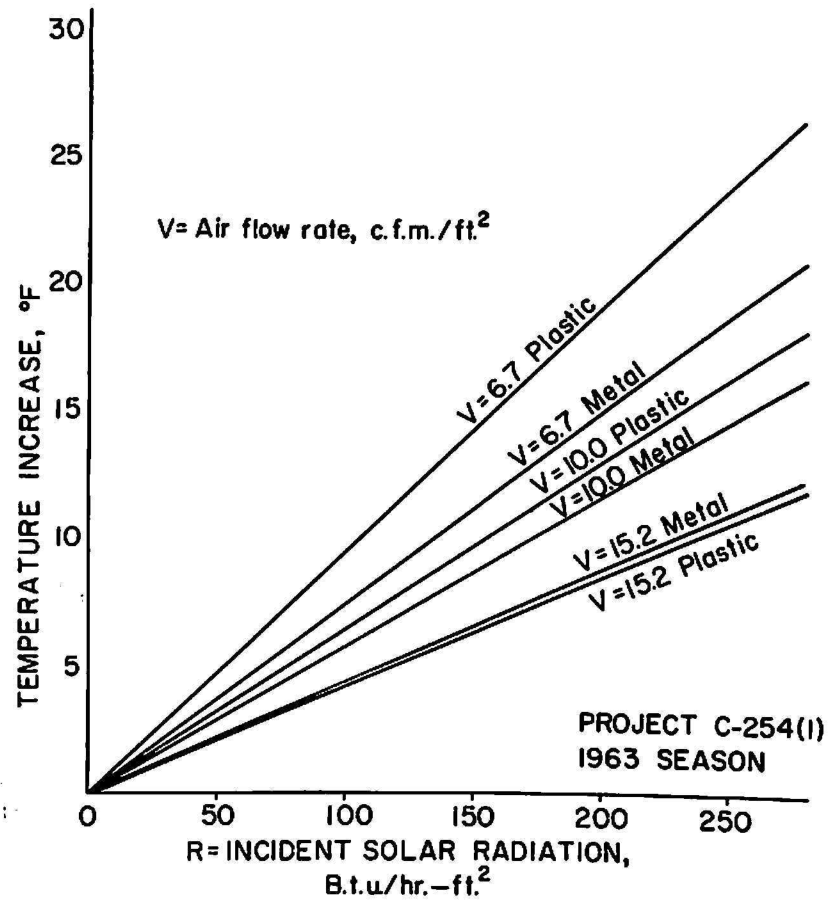

FIG. 2.—Comparison of performance of plastic-covered and metal-surfaced solar-heat collectors.

the plastic-covered collector provides considerably higher temperature increases. The airflow rates most probably encountered in actual practice will be in the range of 3 to 8 c.f.m./ft.², therefore the relative performance of the two types of collectors should be compared in this range.

At an airflow rate of 6.7 c.f.m./ft.², the uncovered collector provides a temperature increase of 0.0756 R. The difference in temperature increases in the two types of collectors can be calculated to be $0.0960\,R - 0.0756\,R = 0.0204\,R$.

By assuming a specific heat for air of 0.24 B.t.u./lb. °F, and a density of 0.07 lb./ft.^{3}, we can determine the difference in energy converted to heat by the two types of collectors to be:

$$6.7 \text{ c.f.m./ft.}^2 \times 60 \text{ min./hr.} \times 0.24 \text{ B.t.u./lb. °F.} \times 0.07 \text{ lb./ft.}^3 = 6.75 \text{ B.t.u./ft.}^2 \text{ hr. °F.}$$

and $6.75 \text{ B.t.u./ft.}^2 \text{ hr. °F.} \times 0.0204\,R \text{ °F.} = Q = 0.138\,R \text{ B.t.u./ft.}^2 \text{ hr.}$

When $R = 300 \text{ B.t.u./ft.}^2 \text{ hr.}$,

$Q = 41.3 \text{ B.t.u./ft.}^2 \text{ hr.}$

and when $R = 200 \text{ B.t.u./ft.}^2 \text{ hr.}$

$Q = 27.6 \text{ B.t.u./ft.}^2 \text{ hr.}$

The extra heat Q provided by the plastic-covered collector can be assumed to have a value of 2.5 cents per kilowatt-hour, corresponding to minimum local electric rates. The economic advantage of the plastic-covered collector, in terms of R, is calculated to be:

$$0.138\,R \text{ B.t.u./ft.}^2 \text{ hr.} \times 0.025 \text{ \$/kw.-hr.} \times 2.93 \times 10^{-4} \frac{\text{kw.-hr.}}{\text{B.t.u.}} = 1.01\,R \times 10^{-6} \text{ \$/ft.}^2\text{-hr.}$$

The cost of Mylar film is 3.66 ¢/ft.^{2}. Other material and labor costs for its installation would increase its cost to about 10 ¢/ft.^{2} Assuming a value of $R = 200$ B.t.u./ft.^{2}-hr. for 6 hours a day, the value of additional heat returned per day by the plastic-covered collector would be:

$$1.212 \times 10^{-3} \text{ \$/ft.}^2\text{-day} = 0.1212 \text{ ¢/ft.}^2 \text{ day}$$

Consequently, 83 days of operation would result in an additional heat return valued at 10 ¢/ft.^{2}, about equal to the additional cost of the plastic-covered collector compared to the metal-surfaced collector.

Since the normal coffee-processing season would include approximately 100 days of dryer operation, and Mylar plastic film has an expected life of 5 years, the plastic would pay for itself 6 times over.

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