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Lewis Research Center

Survey of Coatings for Solar Collectors

Four high-performance, solar-selective coatings have been investigated. Two of these, black copper and black nickel, were previously known to be solar selective; the solar selective properties of the others, black chrome and black zinc, were discovered at the NASA Lewis Research Center. The general broad solar-selective characteristics of all four coatings are very similar.

Research investigations of black chrome were made to determine the preparation method which would produce the optimum solar-selective properties of maximum absorption across the visible spectrum and minimum emittance in the infrared.

When black chrome is used as a solar-selective coating on steel, the steel is first plated with nickel, both to produce low emittance and also to prevent the steel from rusting, since the black chrome provides no such protection. If black chrome is plated on aluminum, the aluminum either is first plated with nickel, after zincating, or is plated directly with chromium, prior to plating with black chrome. Optimum solar selective properties of black chrome require some tailoring of current and time for the plating solution being used. As an example, plating the black chrome over dull nickel for one minute at 1937 amps/m^2 (180 amps/ft^2) with Harshaw Chromonyx* produced excellent results.

The second new solar selective coating discovered is black zinc. This solar selective coating is produced from a high zinc electroplate by subsequent conversion with a chromate dip. As an example, the zinc can be conveniently electroplated from Harshaw NEOSTAR-AFA* at 430 amps/m^2 (40 amps/ft^2).

Measurements have also been made of the reflectance of the previously known solar selective coatings of black copper and electroplated black nickel. The reflectance measurements form the basis for calculation of visible absorptance and infrared emittance. The measured reflectance of the black chrome, black zinc, black copper, and black nickel are shown in the figure, together with the nonselective coatings of black paint and black ceramic enamel.

* Trade name
Harshaw Chemical Company
Cleveland, Ohio

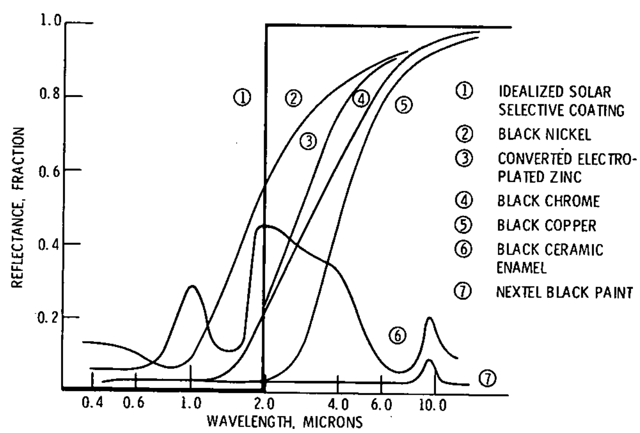

Figure 1. - Reflectance of coatings for solar collectors.

Comparative costs of coating solar collectors with these various selective and nonselective coatings were determined by obtaining, from processors established in the coating industry, quotations for coating a lot of 500 panels. Quotations were in agreement within approximately 15 percent between processors and included handling, surface preparation and coating material costs. The results are shown in Table 1 together with the characteristic values of absorptance, as integrated over the solar spectrum, and of the infrared emittance. Some of the coatings, such as the alkyd enamel, have a material cost which is a large fraction of the total applied cost, while others, such as ceramic enamel, have a processing cost which is a large fraction of the total applied cost.

As an additional component of the evaluation of the various coatings for solar collectors, limited amounts of data have been assembled on the durability of coatings. This information on durability has been summarized in Table 2.

Ceramic enamel is more solar selective than organic enamel, but neither is as solar selective as black chrome, black copper, black zinc or black nickel. Ceramic enamel is matched only by black chrome in durability and wide availability. Ceramic enamel and organic enamel have

(continued overleaf)

TABLE 1

Cost of Coatings for Solar Collectors

Coating	Cost $/ft²	Absorptance α	Emittance ε
ALKYD Enamel	.50	0.9	0.9
Ceramic Enamel	.50-.60	0.9	0.5
Black Chrome	.70-.80	0.9	0.1
Black Copper	.50 (base metal not included)	0.9	0.1
Black Zinc	.70-.80	0.9	0.1
Black Nickel	No quotations	0.9	0.1

TABLE 2

Durability of Coatings for Solar Collectors

Coating	Durability
ALKYD Enamel	Limited at high temperature
Ceramic Enamel	Eminently stable
Black Chrome	Stable
Black Copper	Patinates with moisture
Black Zinc	Not completely defined
Black Nickel	Destroyed by moisture

approximately the same cost, and both are currently slightly lower in cost than black chrome, black copper or black zinc. Black nickel is not readily available from electroplaters, and, because of that, realistic cost comparisons are not possible.

Notes:

1. The information contained in this Tech Brief was first published in NASA report TM-X-71730, "Survey of Coatings for Solar Collectors," by Glen E. McDonald.
2. Further information on the use of black chrome as a solar selective coating is available in the following report:

   NASA TM-X-3136 (N75-12329), Refinement in Black Chrome for Use As A Solar Selective Coating

   Copies may be obtained at cost from:

   Technology Application Center
   University of New Mexico
   Albuquerque, New Mexico 87131
   Telephone: 505-277-3622
   Reference: B75-10067
3. Specific technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B75-10067

Source: Glen E. McDonald
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(LEW-12510)