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SURVEY OF COATINGS FOR SOLAR COLLECTORS

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SURVEY OF COATINGS FOR SOLAR COLLECTORS

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Four high-performance, moderate-cost, widely available 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 other two--black chrome and black zinc--were discovered at the NASA Lewis Research Center, Cleveland, Ohio. The general broad solar selective characteristics of all four coatings are very similar.

The most intensive investigation of solar selective coatings conducted at NASA-Lewis has been made on black chrome in order to determine the preparation method which would produce its 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 is first plated with either nickel, after zincating, or plated directly with chromium, prior to plating with black chrome. The optimum solar selective properties of black chrome are obtained by plating the black chrome over dull nickel for one minute at 180 amps/ft^2 using Harshaw Chromonyx (ref. 1).

The second new solar selective coating discovered is black zinc. This solar selective coating is produced from a high zinc electroplate by susbsequent conversion with a chromate dip. The zinc is conveniently electroplated from Harshaw NEOSTAR-AFA at 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 figure 1, together with the nonselective coatings of black paint and black ceramic enamel.

Comparative cost of coating solar collectors with these various selective and nonselective coatings was 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 do include handling, surface prepreparation and coating materials cost. 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, a limited amount of data has been assembled on the durability of coatings. This information on durability has been summarized in Table 2.

Summary

Ceramic enamel is more solar selective, (i.e., has high solar absorptance in combination with low infrared emittance) 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 approximately the same cost, and both are currently slightly lower in cost than black chrome, black copper or black zinc. Black nickel is relatively unavailable and, because of that, realistic cost comparisons are not possible.

Reference

1. McDonald, G. E.: Refinement in Black Chrome for Use as a Solar Selective Coating. NASA TM X-3136.

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

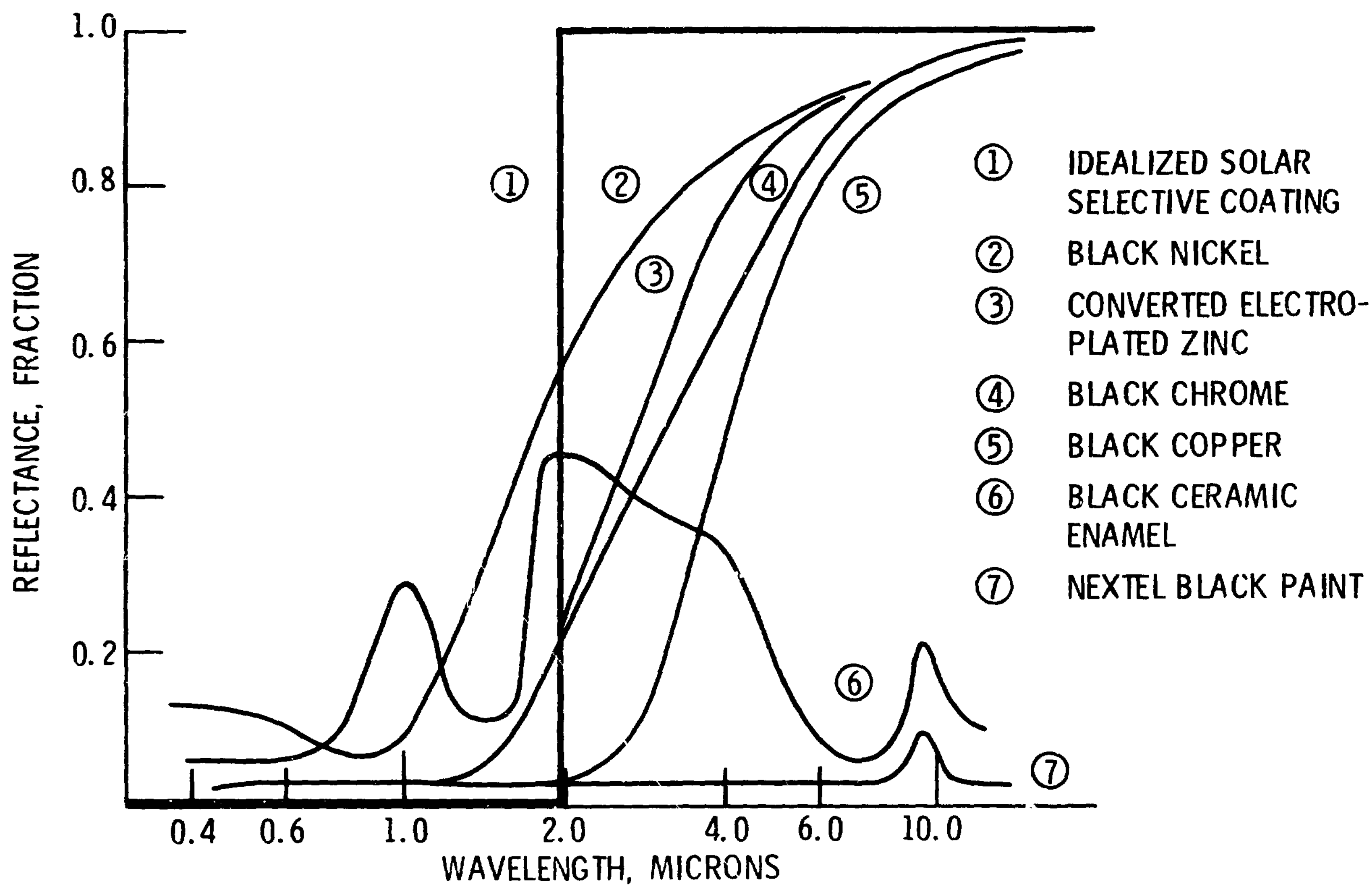

Figure 1. - Reflectance of coatings for solar collectors.