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SELECTIVELY ABSORBING COATINGS

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Résumé.- Quelques revêtements pour absorbeur sélectif ont été produits par galvanisation et conversion chimique d'une couche appliquée en surface sur une plaque métallique. Du chrome noir a été obtenu par galvanisation d'oxyde de chrome sur des sous-couches de cuivre (fer ou bronze) nickelé, et du cuivre noir (oxyde de cuivre) a été préparé au moyen d'hydroxyde de sodium et persulfate de potassium. La réflectance du spectre de ces recouvrements a été analysé et leur application à des collecteurs solaires a été discutée. On a de même fait des recherches sur la stabilité à l'humidité, les changements de température et la déformation mécanique de ceux-ci.

Abstract.- Some selective absorber coatings were produced by electroplating and by chemical conversion of a surface layer on the metal plate. Black chromium was obtained by electroplating chromium oxide onto nickel coated copper (iron or brass) substrates and black copper (copper oxide) was prepared by means of sodium hydroxide and potassium persulphate. The reflectance spectra of these coatings have been investigated and their applications on solar collectors were discussed. Stability on humidity, temperature changes and mechanical deformation have been investigated.

1. Introduction.- Most optically efficient selective solar absorber coatings combine high solar absorptivities with low thermal emissivities. The selective absorption of such coatings is due to the presence of a surface layer which absorbs approximately the whole solar spectrum while it almost does not permit infrared frequencies reemission.

2. Selective absorber coatings.- Several selective absorber coatings are produced by electroplating and by chemical conversion of a surface layer on the metal plate. Black chromium is obtained by electroplating chromium oxide onto nickel coated copper (iron or brass) substrates. Black copper (copper oxide) is prepared by means of sodium hydroxide and potassium persulphate.

Visible and infrared spectral reflectance is measured using spectrophotometers (Perkin-Elmer) with adequate reflectance attachment. Figure 1 shows some results obtained from measurements of reflectance of black chromium samples. One can see that even small variations in technological processes cause a change in the selectivity of the sample.
Calculations are made to obtain the values of absorptance (averaged over about the total spectrum from 0.3 to 2.5 \( \mu \text{m} \)) and emittance (averaged over a blackbody wavelength distribution for the corresponding temperatures).

The maximum solar absorptance of 0.95 is obtained for black chromium with the minimum emittance of 0.20. This high solar absorptance and low thermal emittance are achieved by controlling the coating thickness through variations in plating time and in current density.

An excellent absorptivity of 0.98 with a very satisfactory emissivity of 0.10 is obtained for black copper samples by varying the duration of chemical reactions (Fig.2). These selective properties are improved as compared to those reported in literature /8/.

The coatings are subjected to a heating test to determine their thermal stability, resistance to humidity and mechanical deformation. The test results indicate that there are no significant changes in these properties under the conditions that may be expected in applications. Black chromium samples show better thermal stability than black copper samples; however, the latter have the advantage of being produced more readily and in a simpler way.

The efficiency curves of flat plate collectors are determined using the Hottel-Whillier-Bliss equation. The usual values of collector's parameters are taken /7/. Figure 3 shows collector efficiency as a function
of $\Delta T/G$ ($\Delta T$ is the difference between outlet fluid temperature and ambient temperature, $G$ is the rate at which solar radiation is incident on the collector surface per unit area) for black chromium, black copper and black paint absorber. It can be seen that the efficiency of a collector with selective coating is much better than that of a collector with black paint. The efficiency of a black copper collector is about 3% higher than of a black chromium collector.

Fig.2.- Reflectance as a function of wavelength for black copper samples.

Fig.3.- Efficiency curves of flat plate collectors.
3. Conclusion.— The produced black chromium and black copper samples have a high solar absorptance and low thermal emittance. The test results indicate that black chromium shows better thermal stability, higher resistance to humidity and mechanical deformations than black copper samples, but the production of black copper absorber is more simple.

References

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