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Methods for Determination of the Thickness of Metallized Cadmium Coatings

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METHODS FOR DETERMINATION OF THE THICKNESS OF METALLIZED CADMIUM COATINGS

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Statement of Problem

To study various methods, particularly non-destructive, of measuring the thickness of metallized cadmium on a non-magnetic base metal.

History of the Problem

For the past several months the Metallurgical Department has been measuring the thickness of cadmium coatings on steel cold traps and other similar equipment. Because of the magnetic property of steel, it was possible to use a Magnegage. This instrument was calibrated to measure the thickness of non-magnetic cadmium coatings on steel. The tests were non-destructive, sufficiently accurate, rapid, and simple.

Since the Magnegage could only be used with magnetic materials, it seemed advisable to study possible methods for measuring the thickness of cadmium coatings on non-magnetic base metals, particularly copper.

Preparation of Test Specimen

All samples prepared for the investigation were sand blasted before they were sprayed with 1/8" cadmium wire using a Metco gun. Difficulty was encountered in the sand blasting as the pressure of the blast warped the thin flat specimens and made the surface wavy but not deeply pitted. Since the metallized coating is held to the base metal purely by a mechanical bond, the base metal needs deep, sharp pits for good adhesion. This difficulty was partially overcome by silver soldering the copper sheets onto heavy steel plates before sand blasting.

All methods were checked by preparing a microsection adjacent to the test area and measuring the thickness by use of a filar micrometer eye piece.

Experimental

Part A - Three six-inch square copper sheets (.052" thick) were sprayed with 11.5, 9.4, and 8.0 feet of cadmium wire. The microsections showed the thickness of cadmium to average .035", .029", and .017" respectively.

The following methods were tried as possible methods for determining the thickness of the coating:

Micrometer Method

The method was possible because the bond between the cadmium plate and the copper was very poor allowing the cadmium to be peeled off the copper. The results were obtained by measuring the total thickness with a micrometer, pulling off the cadmium coating, and then measuring the copper, the difference in readings being the thickness of the cadmium. The results were as follows: for the 11.5' of wire the thickness of the cadmium was found to be .035" - .039"; for the 9.4' of wire the thickness of the cadmium was found to be .026" - .029"; for the 8' of wire the thickness of the cadmium was found to be .021" - .023".

Magnegage Method

An attempt was made to use the Magnegage by placing the test sheets on top of a piece of steel. However, since the copper sheets were not perfectly flat, there was an air gap between the metals that caused erratic results. This method was dropped because of insufficient accuracy.

Chemical Method

This method consisted of chemically stripping the cadmium coating from the copper. The object of the method was to determine the average thickness of the coating by determining the weight of metal on a given area. A specimen was weighed and immersed in ammonium nitrate. The coating was dissolved but the reaction was too slow.

A second sample was weighed and placed in concentrated hydrochloric acid. The stripping was fast, and the copper was not affected. The sample was dried and reweighed. The values were then substituted into the following formula:

$$\frac{\text{Weight of coating (oz.)} \times K_1^{*}}{\text{area (sq. in.)}} = \text{Thickness (in.)}$$

*K_1 is a constant for Cd = 0.201

The results were as follows: for the 11.5' of wire sample the thickness of the coating was .033"; for the 9.4' wire sample the coat thickness was .023" and the coat thickness for the 8' wire sample was .018". These results are lower than the micrometer readings as these are the average thicknesses, while the micrometer readings are maximum values.

Thermal Method

Two of the samples were measured with the micrometer for the total thickness. The cadmium coatings were melted off with a torch. This was possible as cadmium melts at 610° F. while copper melts at 1981° F. The thickness of the copper was then measured and subtracted from the total thickness to give the cadmium thickness. The results were the same as those in the micrometer method.

Part B - In addition to the flat sheets of copper, work was done on a round brass bar 1" in diameter and 3" long. This bar was sprayed with 5' of cadmium wire.

The following methods were tried as possible methods for determining the thickness of the coatings:

Groove Method

Three V shaped grooves were cut at right angles to the axis of the bar with a 60° triangle file. The grooves were just deep enough to expose the brass. A pointed depth gage was used to measure the difference between the surface and the bottom of the groove. The values for the thickness of the cadmium coat were .027", .027", and .013". The low reading was due to the uneveness in the spraying.

The bar was then cross-sectioned near the grooves, polished and prepared for the microscope. The thickness of the cadmium coat as measured by the filar micrometer eye piece was .025", .024", and .016", respectively.

Summary of Test Data

			Test Methods				
Part	Feet of Cd Wire	Base Metal	Micrometer	Thermal	Chemical	Groove	Micro-scopic
A	11.5'	copper	.035"-.039"	.035"-.039"	.033" av.	-	.035"
	9.4'	copper	.026"-.029"	.026"-.029"	.023" av.	-	.029"
	[illegible].0'	copper	.021"-.023"	-	.018" av.	-	.017" av.
B	5.0'	brass	-	-	-	.027"	.025" av.
	5.0'	brass	-	-	-	.027"	.024" av.
	5.0'	brass	-	-	-	.013"	.016" av.

Analysis of the Test Data

The Micrometer

The micrometer method gives only maximum values while minimum values are usually required. It is usable only when the inside of the sample is accessible to the micrometer or when the sample is small enough

to allow the micrometer to encircle the whole sample, and then it must be used with some method of removing the cadmium without injuring the copper base.

The Chemical Method

This method is a laboratory method only, and it has several sources of error that make it less accurate than the microscopic.

The Thermal Method

This method could be used in the field in conjunction with a depth gage or micrometer. However, a large area of cadmium would be removed that would have to be replaced.

The Groove Method

This method could be used in the field to obtain fairly accurate results on cylindrical samples. One advantage is that only a small area is exposed.

Conclusions

1. The investigation shows that for field work on cylindrical samples, the groove method will give reasonably accurate results without undue damage to the coating, and that on flat samples, the thermal method in conjunction with a depth gage, will be satisfactory.

2. No non-destructive method was found for determining cadmium thicknesses on non-magnetic base metals.

3. Whenever possible a test sample should be sent to the Laboratory for microscopic measurements.