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N. Murly

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Technical note

Thickness determination of anodized deposits and electrodeposits by Vickers indentation technique

N. Murly

 Manuscript received 18 December 1972. *The author is in the Metallurgical Engineering Department, Regional Engineering College, Jawaharlal Nehru Technological University, Warangal (A.P.), India.*

Electrodeposit thickness is of prime importance and a test is therefore almost invariably included in specifications. Knowledge of the precise thickness of electrodeposits and anodized deposits is essential in corrosion, abrasion, and wear studies. In the literature there are numerous proposed methods[1-14] for determining electrodeposit thickness, which are neither simple nor rapid compared with the method described here.

Derivation

The standard Vickers indenter consists of a diamond in the form of a square-based pyramid with an included angle of 136° between opposite faces. The impression produced by such an indenter is shown in Fig.1. Where the diagonal, side, and height of the indentation are d, a, and h, respectively, the interrelation between these three can be expressed as:

$h = d \cot 68° . \sqrt{2}/4 = 0{\cdot}1428\, d$

$h = a \cot 68° . 1/2 = 0{\cdot}202\, a$

and hence

$h = 0{\cdot}1428\, d = 0{\cdot}202\, a.$

Where the electrodeposit thickness is t and the dimensions of the diagonal and side before and after the removal of the electrodeposit are d_1, a_1, d_2, and a_2, respectively, the relationship between these can be written as:

$t = h_1 - h_2 = 0{\cdot}1428\,(d_1 - d_2) = 0{\cdot}202\,(a_1 - a_2)$

which is evident from Fig.1.

Experimental

An anodized, dyed aluminium sheet and an electrodeposited nickel-on-brass specimen 4 mm thick were taken. From each of the specimens a 25×25 mm piece was cut. These were mounted on a clear plastic self-setting resin. Four Vickers indentations were made on each of the specimens with 30 and 40 kg loads, respectively. Using 3/0 and 4/0 emery papers these were fine ground and later subjected to disc polishing for controlled removal of dyed anodized film and electrodeposit. Conventional ultrafine magnesia, suspended in water, was used as an abrasive for both the specimens. Disc polishing was continued in stages until the anodized film and electrodeposit were completely removed. This was best judged visually by colour difference.

Measurements

Measurement of the diagonals and sides of the indentations was made by a Filar micrometer eyepiece, which is accurate to ±0·001 mm.

In some cases there was difficulty in measuring the dimensions of the indentation because it was barrelled. This was overcome by using smaller loads. Empirical corrections for the barrelling effect proposed by Crow[15] were used and compared.

Results and discussion

For each impression both the diagonals and sides were measured and the mean of each was tabulated. The measurements were carried out on each impression before and after the removal of the anodized and electrodeposited layer. The subscript (1) indicates the dimensions of the impression made on the electrodeposited layer and the subscript (2) indicates the same dimensions after its removal. The dimensions of the impressions are given in Table 1.

It is evident from this table that the results agree to three significant figures. It is also clear that the resultant thickness measurements based on the sides are slightly higher than those based on corresponding diagonal measurements. This may be due to the uncertainty of the side measurements arising from some barrelling of the indentations.

Advantages of the method

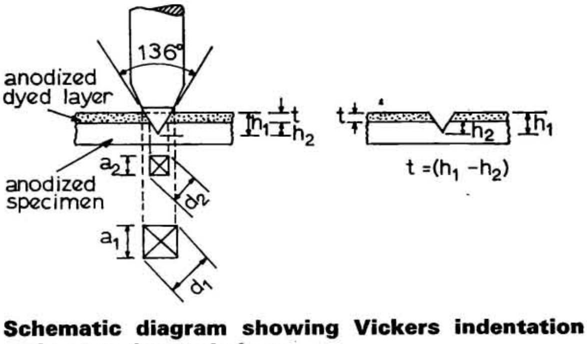
The advantages of this method are:

(i) it is simple and rapid

(ii) local thicknesses of the electrodeposits and anodized films can be determined

(iii) the thicknesses of electrodeposits and anodized films less than 3 μm can be measured very easily and accurately, because indentations are easy to measure accurately.

The method is relatively non-destructive. The degree to which the test is destructive to the finished part depends



1 Schematic diagram showing Vickers indentation and measuring technique

Table 1 Dimensions of the impressions

Drum reading d_1	d_2	t_d, mm	d_1/d_2	Drum reading a_1	a_2	t_a, mm	a_1/a_2
Anodized aluminium specimen							
749	612	0·0268	1·22	529	433	0·0265	1·22
738	599	0·0271	1·23	522	424	0·0271	1·23
729	591	0·0269	1·23	523	421	0·0282	1·24
737	598	0·0271	1·23	521	422	0·0273	1·23
Nickel-plated brass specimen							
796	671	0·0244	1·186	562	474	0·0243	1·185
792	670	0·0238	1·182	560	473	0·0240	1·183
793	673	0·0234	1·178	561	475	0·0237	1·181
789	669	0·0234	1·179	558	473	0·0235	1·179

t_d=thickness calculated on the basis of diagonals
t_a=thickness calculated on the basis of sides

upon the size of the indentation. Obviously, the smaller it is the less harmful it will be. The indentations at low loads are virtually invisible. Local thickness determination can be made without impairing the final use of the article.

Limitations

The method does have some limitations. In certain cases, the end point at which the coating is polished away would be difficult to detect, e.g. for a coating of nickel on steel or where the deposited metal and base metal are the same colour.

Local thickness determination on curved surfaces may be somewhat difficult, but by making some corrections it is possible to determine this thickness.

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