The phenomenon is now being investigated in greater detail.

L. Grunberg
D. T. Jamieson
D. Scott

Lubrication and Wear Division,
National Engineering Laboratory,
East Kilbride.

R. A. Lloyd

Department of Scientific
and Industrial Research,
Isotope Applications Unit,
Wantage.

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METALLURGY

Fatty Acids and Adhesion of Electrodeposited Metals

The deleterious effect of grease on the substrate on the adhesion of electrodeposited metals is well known, but quantitative data are sparse. A systematic study of the influence of monolayers of adsorbed surface-active agents on the adhesion of electrodeposits is in progress in this laboratory, and this communication reports the initial results obtained from the fatty acid series.

The adhesion was measured in the manner described by Williams and Hammond[1], with the test-pieces made of copper. The ends of the specimens to be plated were polished to 1μ diamond powder, electropolished in 50 per cent phosphoric acid and treated to have a monolayer of the fatty acid under test[2]. The acids used were the even-numbered acids of the series $CH_3(CH_2)_nCOOH$, where $n = 4$–16. The specimens with the monolayer were plated with nickel from a conventional Watts type solution at a *p*H of 4, temperature of 40° C., and a current density of 20 amp./sq. ft. until a deposit of at least 0·1 in. had been produced. After plating, the specimens were tested in a Denison tensile testing machine. To provide a reference point, a series of specimens was tested using the exact procedure outlined except that no fatty acid was used.

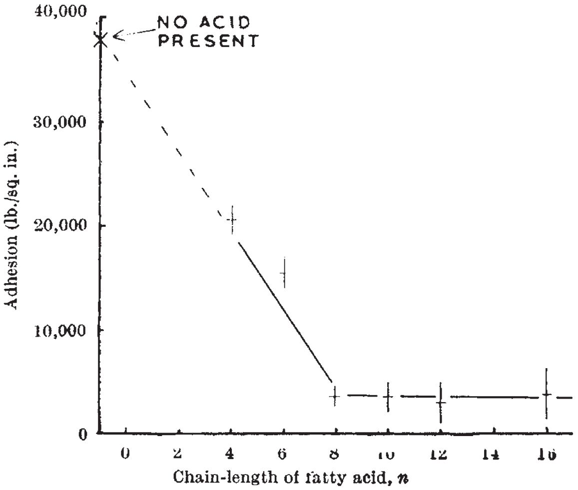

Fig. 1. Adhesion of electrodeposited nickel as a function of fatty acid chain-length

The results are shown in Fig. 1. They were reproducible for each acid, and when the experiment was repeated with caprylic acid ($n = 6$) the adhesion values were within a few hundred pounds per sq. in. of each other. The adhesion appears to be independent of the chain-length of the fatty acid when n is greater than 8 or 10; as n decreases below this value the adhesion progressively increases. This increase can be explained either by the increased desorption of the shorter-chain acids resulting in the nickel being discharged directly on the copper lattice, or by a decrease in the long-range forces between copper and nickel as the distance increases. It is impossible to distinguish between these alternatives at this stage, but it may be pertinent that there is no evidence of epitaxis.

P. A. Brook

Department of Metallurgy,
The University,
Nottingham.

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Fatigue Straining of Copper Whisker

Brenner[1] has shown that copper whiskers can be strained elastically to as much as 2·8 per cent in tension. I have found that similar whiskers remain elastic in cantilever bending at static strains up to 4 per cent corresponding to a stress of 470 kgm./mm.$^{-2}$ in a whisker of $< 110 >$ orientation.

When plastic deformation occurs it is by 'kinking', as has been described by previous workers[2] with other materials. The 'kink' formed is a bend of radius of curvature of the order of the thickness of the whisker; it is produced suddenly, with release of the elastic strain in the rest of the whisker. It can be shown that this behaviour is to be expected from a cantilever bent by a 'hard' device, if it is of a material that has clearly defined upper and lower yield points and yield extension. These phenomena are very pronounced in copper whiskers[3].

I have performed experiments to see whether the behaviour of copper whiskers under repeated straining differs from that under static conditions. The experiments were performed in cantilever bending with the whisker encased in diphenyl carbazide glass[4] and deflected by a 'hard' probe. The whiskers were grown by hydrogen reduction of cuprous iodide[5].

Since the static strain at which kinking occurs varies very much from one whisker to the next, it was not possible to test whiskers in cyclic loading at a known fraction of the static kinking strain. Instead, whiskers that were less than about 3μ thick, straight and optically smooth, were selected and were then tested as follows.

A whisker was bent to a strain, S ($\simeq$ 1 per cent), which it was thought very likely to be able to sustain elastically. The bending-probe was then removed, and the whisker examined for permanent bending. If there were none, the probe was then made to vibrate so that the maximum strain in the whisker fluctuated between 0 and S at 900 c./s., the test being observed stroboscopically. After 10^6 cycles of vibration the probe was stopped and removed. If no permanent deformation had taken place, a static strain of $(S + \Delta S)$ ($\Delta S \simeq 0{\cdot}3$ per cent) was applied, and the whole procedure repeated, the vibrations being this