

Title: Studies on hydrogen co-deposition during electrode position of metals with particular reference to chromium

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Abstract: The hydrogen embrittlement characteristics of steel during electrode position of chromium, have been evaluated by the electro permeation technique – the first report with special reference to chromium deposition.

Electro permeation characteristics of standard, high-sulphate and sulphate-cryolite electrolytes, have been investigated over a polarizing current density (c.d) range of 165 to 1080 mA.cm⁻² and temperature range of 30° to 50° C. The maximum coverage of hydrogen observed was typical of each electrolyte and did not vary systematically with the c.d. or temperature, as in the case of an acid or alkali and limiting c.d. was responsible for such a behavior. High temperature – high ratio and tetra chromate chrome solutions were similarly studied.

The permeation rates of widely different deposits – crack free to highly cracked and mirror bright to dull – have been explained in terms of (i) crack nature; (ii) physical appearance and (iii) degree of packing (coarse/fine grained). Further, the difference in the ability of fine and big cracks to ‘block’ or ‘favor’ hydrogen entry respectively has been interpreted in terms of the concepts on ‘mechanism of chromium deposition’ put forward by Gerischer and Kappel and ‘micro throwing power’.

A majority (70%) of chromium deposits possess medium or high ‘porosity’ enabling easy de-embrittling by baking the plated specimen, as observed in practice.

The diffusion coefficient, D for hydrogen in steel was evaluated by three methods and they agree with the reported values.

From the decay curve the hydrogen retained by the chromium deposit is estimated and is found to vary from 2-7 cm³ per 100 gm of deposit for crack free deposits to 20-54 cm³ for highly cracked deposits (100 gm. Of chrome deposit considered).

A preliminary ‘strike’ in chromium plating confers enhanced embrittlement to the steel.

In salvaging work, presence of a previous chromium layer effectively blocks the hydrogen entry during subsequent chromium plating and thus reduces significantly the risk of embrittlement of the substrate.

Polarisation of steel in pure chromic acid introduces large quantities of hydrogen into the cathode, compared to the chrome baths and the films formed are highly porous and hence can be degassed by banking.

Studies in four types of nickel electrolytes indicate that they confer insignificant embrittlement. The D values are in conformity with the values obtained in chromium electrolytes.

Chromium deposition over nickel undercoat shows that thin deposits up to 20 microns enhance the permeation rate and 34 to 58 microns thick deposits lower the hydrogen entry by 25%, compared to chromium plating without an undercoat.

Electrode position of copper from cyanide electrolytes is similar to chromium deposition, from hydrogen permeation view point. The D values agree well with the values obtained in chromium and nickel electrolytes.

As low as 1.5 micron thick copper undercoat is capable of blocking completely the hydrogen entry during subsequent chromium deposition.