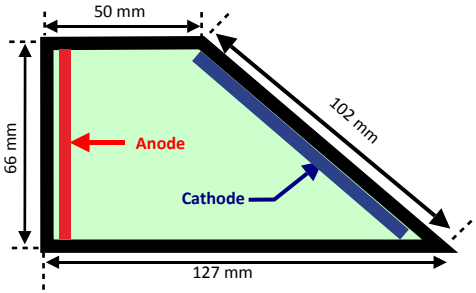
THE HULL CELL & ITS IMPORTANCE IN ELECTROPLATING

By Dr. T. S. Krishna Ram

The Hull cell is a specially designed trapezoidal test cell used for carrying out practical & qualitative plating tests on electroplating solutions. The cell is designed so that the cathode is at a pre-defined angle to the anode (as shown below in Fig .1) to produce a range of varying current densities. The current densities produced in the Hull cell are above and below those that would be used under normal production parameters. This allows any potential problems in the plating solution (e.g. lack of additive) to be observed before any problems are seen on the production line.

Cathode size: 100 x 75 mm
Anode size: 75 x 50 x 7.5 mm
Solution Volume: 267 ml



The current distribution is based upon the formula:
$i = I\ (5.1 - 5.24 \log_{10} X)$ where
i = current density (A/dm^2)
I = total current (ampere) and X = distance from high current density end of panel

The Hull cell - the trapezoidal container, holds 267 ml of plating solution under test. This shape allows one to position the test panel at an angle to the anode. As a result, the deposit is plated at different current densities that can be measured with a Hull cell ruler, which is a little over six inches long and one to two inches wide and used to calculate current densities, conversion of temperature, etc. The solution volume allows for a quantitative optimisation of additive concentration: 1 gram addition to 267 ml is equivalent to 0.5 oz/gal in the plating tank. A 2 g or 2 ml addition to the 267 ml cell equals an addition of 1 oz/gal in the operating bath.

In metricated countries the cell is usually operated with a volume of 250 ml so that a 2 g or 2 ml addition to the cell will correspond to an addition of 8 g or 8 ml per litre of process tank solution.

The Hull cell produces a deposit that is a true reproduction of the electro-plate obtained at various current densities within the operating range of a particular system; it allows experienced operators to determine multiple process parameters, including:

- Approximate bright range.
- Approximate concentration of primary bath components, such as metal and electrolyte.
- Approximate concentration of addition agents.
- Presence or absence of metallic and organic impurities.
- “Covering power” - the lowest current density at which plate is deposited.
- “Throwing power” - metal distribution.
- Effects of temperature variations.
- Effect of pH variations.

Hull cells can do far more than help to get you out of trouble. Properly used, they can prevent problems. You can use them in routine daily maintenance, establishing operating parameters, and in considering modifications or improvements of a plating process.

Fig 2: Hull Cell Panel

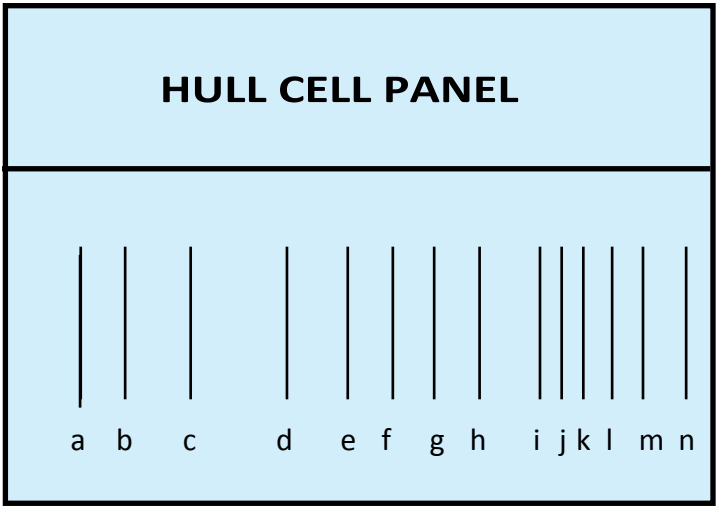


Table 1: Current Density A/dm²

Position of Hull Cell Panel														
Current Applied in Amps	a	b	c	d	e	f	g	h	i	j	k	l	m	n
1	5	4	3	2	1.5	1.25	1	0.75	0.5	0.4	0.3	0.2	0.1	0.05
2	10	8	6	4	3	2.5	2.0	1.5	1	0.8	0.6	0.4	0.2	0.10
3	15	12	9	6	4.5	3.75	3	2.25	1.5	1.2	0.9	0.6	0.3	0.15

The Hull cell is a time saver. Hull-cell panels are inexpensive when compared with experimenting in a production tank plating actual parts. You can introduce variables quickly and safely in the small tank represented by the cell. And you can see the results of several different tests at the same time, as it accurately duplicates all the variables present in a production-plating tank size, shape, width, depth and time parts are exposed to the process.

Table 2: Details for Plating Test

No	Type of Plating	Anode	Anode Bag	Cathode	Air Agitation	Heating
1	Acid Copper	OFHC* Copper	Polyester or Nylon	Polished Brass/Bronze	Yes	Yes
2	Cyanide Copper	OFHC* Copper	Polyester or Nylon	Polished Brass/Bronze	—---	—---
3	Nickel	Pure Nickel	Polyester or Nylon	Polished Brass/Bronze	Yes	Yes
4	Cadmium	Pure Cadmium	Polyester or Nylon	Polished Brass	—---	—---
5	Tin	Pure Electrolytic Tin	Polyester or Nylon	Polished Brass	—---	—---
6	Cyanide Zinc	Pure Zinc	Polyester or Nylon	Steel	—---	—---
7	Acid Zinc	Pure Zinc	Polyester or Nylon	Steel	—---	—---
8	Alkaline Zinc	Pure Zinc	Nil	Steel	—---	—---
9	Chromium	Lead/Tin#	Nil	Bright Ni plated on polished Brass	—---	Yes
10	Electro-polishing	Titanium	Nil	Aluminium	—---	Yes
11	Acid Gold	Titanium	Nil	Bright Ni plated on polished Brass	Yes	Yes
12	Cyanide Gold	Titanium	Nil	Bright Ni plated on polished Brass	Yes	Yes

Note: *OHFC Copper: Oxygen Free High Conductivity Copper
Lead/Tin alloy: 10% Tin and 90% Lead alloy

Larger Hull cells with volumes up to 1000-ml can be equipped with heaters and agitation. The larger size allows more precise evaluation of baths. It is preferred for testing Chromium plating baths.

A hanging Hull cell can be suspended in an operating tank anywhere a rack of parts can be hung. Capable of reading from 0 to 50 amps, the cell hangs on a cathode bar below the solution and is an excellent tool for finding:

a) “Dead” areas,

b) Poor electrical contact,

c) No current, reduced current and

d) Other conditions.

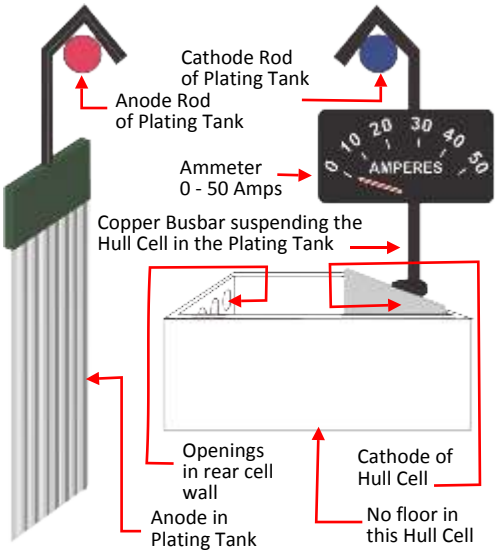


Fig.3: Hull Cell suspended in Tank

The following accessories are required along with the Hull cell:

Rectifier: A 220-volt, 50-cycle, single-phase electronic rectifier in 0-10 amperes, direct current with 6 volts, with very little “ripple” & built-in timer up to 30 or 60 minutes.

Hull cell Ruler: Usually supplied as a “freebie” by the supplier of the plating chemicals. It is probably the most useful support tool for tank-side or laboratory testing. It is a little over 150 mm long and 25 or 50 mm wide (depending on how much information is being offered).

Abrasive Paper: 60- to 80-grit paper; apply uniform pressure to abrade along the bottom half inch of the entire ampere range of the Hull cell cathode panel.

Air supply: A fish-aquarium bubbler is quite adequate to agitate 267 ml & even up to 1000 ml of solution.

Alligator clips: These assure more positive contact in the electrical circuit.

Agitator: A glass stirring rod and a strong and patient arm will work.

Anodes: Anodes that are metallurgically as close to as possible to those used in production tank.

Anode Bags: Cloth, nylon or whatever used in the operating system.

Cathode Panels Standard panel size is 7 by 10 cm. Polished brass panels protected by plastic sheet are used for nickel plating and other tests listed in Table 2.

Conclusion:

One can store a set of Hull cell panels plated from a new bath, which are used to compare and understand:

a) the level of additives to be introduced in the working bath to improve brightness.

b) defects in the working bath when it is experiencing problems.

Most of the plating chemical suppliers will supply a Hull cell Ruler to study the working baths for addition of additives, brighteners, levelers etc. With experience one can use this cell for trouble-shooting of plating baths.

Trouble-shooting data-sheets, with details and diagrams or pictures of Hull Cell Panels demonstrating problems that may be experienced, are generally supplied by plating chemical suppliers. Or one can prepare Hull cell panels by introducing the impurities into a new bath, plating the panels and preserving them for later comparison and identification of defects/impurities in the working bath.

A competent plater can successfully use a Hull cell for the correct addition of brighteners and additives in addition to trouble-shooting of the bath.

With experience the Hull cell can provide much more information than just the appearance of the coating. Bending the bottom high current density corner can yield data on stress and ductility. Heating and quenching can give indications of levels of adhesion. Indeed it is possible to carry out comparative tests on cleaning systems with judicious use of the Hull cell. The more the technique is used, the more useful it becomes as the skills of the operator improve.

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References:

1) The Investigation of Electroplating and Related Solutions with the Aid of the Hull Cell by Walter Nohse (1966)

2) Hull Cell by Walter Nohse (Sep 1966)