Production Advantages of Hard Chromium Plating Using Close Anode to Cathode Spacing

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ABSTRACT

The purpose of this paper is to take a comprehensive look at the advantages of close anode to cathode spacing when chromium plating aircraft components. This method of chromium plating, called at various times, reversible rack plating, innovative plating, and conforming anode plating, has been poorly explained and therefore, often misunderstood. As a result, very few aircraft rework or manufacturing facilities are taking advantage of this simple, efficient process.

The Naval Air Rework Facilities at Cherry Point, North Carolina and Pensacola, Florida converted several hard chromium plating tanks to the close anode to cathode spacing arrangement approximately three years ago. Since that time, both facilities have gathered information comparing this system to the conventional, tank anode boxing method, previously used. Significant production advantages were realized with the close anode to cathode spacing.

Close anode to cathode spacing, as it pertains to this paper, shall be defined as a system for hard chromium plating that reduces the space between the anode and cathode to a distance of approximately 0.5 to 1.0 inch (1.3-2.5 cm). Conforming lead mat anodes (see Figure 1) are fabricated for each part. The voltage is measured at the part and is held constant at approximately 4.5 volts. The close spacing between the anode and cathode reduces resistance, increasing the current density. A current density of 430-750A/ft² (43-75 A/dm²) is typical at 4.5 volts when using this system. A conventional 30 oz/gal (225 g/l) chromic acid, 0.30 oz/gal (22.5 g/l) sulfuric acid plating solution is utilized, operated at a temperature of 140°F (60°C). Parts may be fixtured on a reversible rack (see Figure 2) or plated using in-tank conforming anodes.
HARD CHROMIUM PLATING has been a major part of aircraft rework for decades. The production efficiency of the operation has, however, improved very little over the years. Most managers look at hard chromium plating as a necessary evil requiring long turn-around times and high reject rates.

TODAYS STRICT ENVIRONMENTAL REGULATIONS and the competitive market place do not allow managers the luxury to continue wasteful practices. The opportunity to produce more chromium plated parts with existing resources (tanks and rectifiers), or the same number of parts using fewer tanks should be very appealing, as should the reduction of costly rejects.

The Naval Air Rework Facilities at Cherry Point, North Carolina and Pensacola, Florida were confronted with these problems several years ago. Existing tanks were old and antiquated, production requirements were increasing and plans for new construction were years away. An engineering evaluation of the existing production situation revealed a gross under utilization of existing tanks and rectifier capacity. The major problems are listed as follows:

- CHROMIUM PLATING PRODUCTION PROBLEMS
  - Production habits were centered around loading and unloading tanks at the beginning of each work shift.
  - Tank space was poorly utilized due to the space needed to box-in parts with tank anodes.
  - Rectifier utilization was consistently under 40% capacity (less than 2000 amps used from a 5000 amp rectifier).
  - Plating rate was less than 1.0 mil (25 μm) on the radius per hour.
  - Parts were often plated out-of-round causing subsequent grinding problems.
  - Parts were many times plated 10-15 mils (250-400 μm) on the radius over finish dimension to compensate for out-of-roundness.
  - A high percentage of chromium plated parts required replating as a result of masking and racking errors.
  - Delays in turn-around time often created problems with the timely repair of aircraft.

INDEPENDENT EFFORTS were made by both Cherry Point and Pensacola to correct the chromium plate production problems. With assistance from the Naval Civil Engineering Laboratory at Port Hueneme, California, a plan was proposed to use existing technology and improved management skills to increase production and reduce waste, without increasing the number of tanks or rectifiers in the plating shops.

Close anode to cathode spacing using conforming anodes was suggested as a major production modification. Reasons for using conforming anodes were given as follows:

- DOES NOT REQUIRE EXPENSIVE PLANT MODIFICATIONS
- EXISTING CHEMICALS ARE UTILIZED.
- ALLOWS MORE PARTS TO BE PROCESSED USING EXISTING TANKS.
- HIGHER CURRENT DENSITY POSSIBLE AT LOWER VOLTAGE.
- MUCH MORE UNIFORM DEPOSITS.
- MASKING TIME REDUCED.
- FASTER PLATING RATE.
- REDUCED NUMBER OF REJECTS.

A list of such advantages will at once make most people associated with chromium plating very skeptical. Ironically, one of the major draw backs to the acceptance of this method within the aircraft community has been the frequent claims of enormous production improvements. One has only to work in a plating shop for a short time to realize that a price must be paid for each improvement. When reviewing the literature concerning close anode to cathode spacing, there seemed two distinct view points concerning the system; those that were totally in favor and those that were very skeptical.

An effort was made to review some of the claims and concerns voiced over the years about this method of chromium plating, in an attempt to resolve these differences. The following is a list of statements and concerns frequently voiced when discussing the possible use of close anode to cathode spacing in a production shop. The authors will follow each statement with the information obtained from production use of the process:

1. CLOSE ANODE TO CATHODE SPACING results in cathode efficiencies much higher than would be expected with conventional chromium plating.

This is not true. Cathode efficiencies are a result of bath chemistry rather than anode placement. Two identical parts were plated at the same time in the same tank, one with a conforming anode, the
other using conventional tank anodes. The cathode efficiencies were the same. Cathode efficiencies ranging from 13-16% are typical when using this system.

2. PLATING AT A CONSTANT VOLTAGE DOES not allow current density to be adequately controlled on the parts in the plating tank.

This is not true. It is true that if voltage is held constant in a chromium plating operation, amperage will vary depending on the concentration of the bath, the anode to cathode spacing, and the solution temperature. The typical current density range for hard chromium plating is 430-750A/ft² (43-75A/dm²) as stated in McDonnell Douglas Process Specification P.S. 13102. This current density range is easily held using a 0.5-1.0 in. (1.3-2.5 cm) anode to cathode spacing. Production experience has shown that at 4.5 volts a 0.5 in. (1.3 cm) anode to cathode spacing generates a current density of 575A/ft² (58A/dm²). The current density is reduced to 430A/ft² at 4.5 volts when anode to cathode spacing is increased to approximately 1.0 in. (2.5 cm). Current density can be easily checked on each rack of parts with a hand held D.C. amp meter.

3. THE PLATING RATE USING CLOSE ANODE to cathode spacing is much greater than the rate when using the conventional tank anode system.

This is not true. If the plating is deposited at the same current density, the plating rate using either system will be the same. The major advantage of close anode to cathode spacing is the ability to plate at relatively high current densities using low voltage. This cannot be done with the 4 inch or greater spacing used with conventional tank anode systems. It is true that under production conditions, parts are often plated at a higher current density using close anode to cathode spacing explaining the increased plating rate. As an example, an H-46 rotor head pin (Figure 3) was chromium plated under production conditions using both the conventional boxed anode method and conforming anodes with close anode to cathode spacing. The plating parameters are listed below.

4. THE INCREASED PLATING RATE AND associated benefits of close anode to cathode spacing are negated by the time and expense required in making hundreds of conforming anodes.

This is not true. This was a major concern of the authors when prototyping the close anode to cathode modifications. It was feared that qualified electroplaters would become full time anode makers, resulting in a loss of efficiency. This has not been the case. In fact, very little time is spent on anode manufacturing and repair (estimates are less than two manhours per week). Anodes are
quite durable; many lasting over two years. The time required to manufacture the anodes necessary for start-up was accomplished without significant production delays.

As an example, during the first two weeks of prototyping the close anode to cathode spacing system at Cherry Point, approximately 120 manhours were expended in making 30-35 conforming anodes. Using these anodes, 60% of the chromium workload could be plated. At present, all hard chromium plating is performed at Cherry Point using 50 conforming anodes.

5. MODERN METHODS OF HARD CHROMIUM plating make close anode to cathode spacing obsolete.

This is not true. One of the major advantages of close anode to cathode spacing is the ease in which it can be incorporated into existing hard chromium plating systems. Many aircraft rework facilities use multiple rectifiers per tank to allow separate control of current density on each part being plated. It would be costly and unwise to remove these multiple rectifiers in favor of a single power source. Simple inexpensive bussing modification will allow in-tank conforming anodes to be used with existing multiple rectifiers.

6. CLOSE ANODE TO CATHODE SPACING USING conforming anodes increases the uniformity of chromium deposits.

This is true. Out-of-roundness problems were significantly reduced at Cherry Point and Pensacola after the production shops increased the use of conforming anodes. This was true when plating both outside and inside diameters. As an example, six inside diameter journals on the H-46 helicopter rotor head hub (see Figure 4) required grinding and chromium plating as part of a repair procedure. Internal lead anodes were made allowing a 0.9 in. (2.3 cm) anode to cathode spacing. At 4.5 volts the current density for this part is 389A/ft² (39A/dm²) with a plating rate of 0.8 mil (20.3 μm) on the radius per hour. The hub is plated for seventeen hours during which time 14 mils (355 μm) of chromium is deposited. Out-of-roundness is less than 1.0 mil (25.4 μm) on the diameter after plating. One of the major advantages of the anode arrangement is that all six journals can be plated at once. More than 50 hubs have been repaired without any rejected due to plating.

7. THE QUALITY OF THE CHROMIUM PLATING process cannot be assured when using close anode to cathode spacing.

This is not true. The quality of chromium deposited on aircraft parts cannot be compromised in order to improve efficiency. Quality improved at Cherry Point and Pensacola after the incorporation of close anode to cathode spacing. This can be attributed to the uniformity when racking parts, along with the improvement in current distribution. One very significant aspect was the overwhelming positive response from the electroplaters. The change made their job easier and the results more consistent. The ability to plate more parts allowed additional time for checking masking and racking steps, reducing the number of misplated parts. Most importantly, management recognized the improvements, showing renewed interest in the process. Sustained improvements in productivity and quality would not have been possible without strong management support.

SUMMARY

1. Hard chromium plating using close anode to cathode spacing and a single power source has many useful applications in the aircraft industry.

2. There are many misconceptions concerning the specifics of this system that have resulted in its limited use in aircraft hard chromium plating operations.

3. Tank space and rectifier capacity are under utilized in many hard chromium plating operations.

4. The inability, with conventional tank anodes and a single power source, to adequately control current density on each part in the plating tank, has led to the use of complicated and expensive multiple rectifier systems.

5. Using a single rectifier held at a constant 4.5 volts, with 0.5-1.0 in. (1.3-2.5 cm) anode to cathode spacing, the current density on all parts in the chromium plating tank can be controlled within the range of 430-750A/ft² (43-75A/dm²).

6. Use of conforming anodes in combination with close anode to cathode spacing can reduce utility costs and increase production efficiency without requiring expensive plant modifications.
C-130 LANDING GEAR
BOXED TANK ANODES

DISTANCE ANODE TO CATHODE -- 4-5 INCHES
VOLTAGE -- 7.5 VOLTS
AMPERAGE -- 750 amps
CURRENT DENSITY -- 2 amps/in²
PLATING RATE -- 1.75 mils/hr
PLATING INFO FOR H-46
ROTOR HEAD PINS – 67

TIME – 4 HOURS
VOLTAGE – 4.4 VOLTS (at rack)
AMPS – 600–625
CURRENT DENSITY – 4.4 amps/in²
PLATING RATE – 3.7 mils/hr (on diameter)

TIME – 4 HOURS
VOLTAGE – 4.6 VOLTS (at rack)
AMPS – 700–710
CURRENT DENSITY – 4.9 amps/in²
PLATING RATE – 4.2 mils/hr (on diameter)
HOW TO TELL IF YOU HAVE CHROME PROBLEMS

1. ASK MACHINE SHOP
2. COUNT REJECTS
3. LOOK AT INCOMING TABLE
4. LOOK AT SHIPPING AREA
5. WHAT KIND OF TURN AROUND TIME
6. COUNT NUMBER OF PARTS IN TANK
7. LOOK AT AMP METER ON RECTIFIER
8. ASK HOW MUCH CHROME PLATE OVER PRINT
9. RINSE DOWN BUS BARS, LOOK FOR STEAM
10. ASK THE PLATERS
REASONS NARF CHERRY POINT CONVERTED TO CLOSE ANODE TO CATHODE SPACING

1. OLD OUTDATED SHOP
2. NO ROOM OR FUNDS FOR NEW TANKS
3. WORK LOAD RAPIDLY INCREASING
4. PRODUCTIVITY RAPIDLY DECREASING
5. NEW FACILITY FOUR YEARS FROM COMPLETION
MAJOR ADVANTAGES OF CLOSE ANODE TO CATHODE SPACING

1. RACKING MUCH MORE UNIFORM
2. TANK SPACE BETTER UTILIZED
3. SYSTEM BETTER FOR HEAVY PRODUCTION
4. LOWER VOLTAGE REDUCES HEAT; COOLING UNNECESSARY
5. CONFORMING ANODES ALLOW BETTER CURRENT DISTRIBUTION
6. OUT-OF-ROUNDNESS REDUCED
C-130 LANDING GEAR
CONFORMING ANODES

DISTANCE ANODE TO CATHODE -- 0.75-1.0 INCH
VOLTAGE -- 4.6 VOLTS
AMPERAGE -- 1300 amps
CURRENT DENSITY -- 3.4 amps/in²
PLATING RATE -- 3.2 mils/hr