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**ELECTROFORMED
NICKEL MOLD
INSERTS**

BDX-613-454

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**Prepared by:
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Department 834**

**Final Report
PDO 6984202**

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ABSTRACT

The effects of various concentrations of barium and sulfate ions on the plating ability of solutions were investigated. In addition, stress concentrations and delaminations or voids in electroformed deposits due to current-interruption and different anode types were studied. The optimal states of each variable influencing electroformed deposits are summarized. This investigation was terminated prior to achieving the stated objectives because of other more satisfactory methods.

INTRODUCTION

BACKGROUND

Preformed inserts are frequently used to form part details that cannot be machined conveniently in the cavity of the master mold. Such inserts may be fabricated by several different methods, depending upon the configuration of the part or other considerations.

Electroformed injection mold inserts which had been developed for use in earlier production had proven the feasibility of the electroforming process, and had a potential of saving an estimated \$5000 per tool over use of a carbonyl gas-plating process.

Although electroformed inserts were successfully used in molds during early production, further process refinements or new processes were necessary to improve quality, to reduce flow time, and to provide longer operating life in the mold.

JOINT PLANNING

A joint design/production agency meeting was held at the Bendix Kansas City facility on June 1 and 2, 1966, to review past electroforming developmental work and existing problems, and to discuss possible future efforts to upgrade the quality of electroformed deposits and to reduce flow time and plating costs. Work that had been done at a separate laboratory was discussed, and the previous related work at the Kansas City facility was summarized.

As a result of the ensuing discussion, future development requirements were summarized and the following areas of activity defined.

- Slow plating, using the current nickel sulfamate bath, possibly with greater concentration of nickel sulfamate
- Machining

Edge configuration. (Machinable geometry, with a possibility of changing the mandrel to eliminate difficult plating areas.)

Ring insert

- Cold Back-Fill

Powder

Other plating materials

Amalgams

- Alloy Back-Fill, Warm, Casting
- Flame Spray Plasma, Hot (Initial work on cable groove only.)
- Separation of Insert From Mandrel
 - Nickel flash, with passivation.
 - Paints (Silver, or comparable metals)
 - Passivation only
 - Jack screws
 - Pressure holes
 - Other methods
- Development of Other Plating Processes (Use of various baths, additives, and techniques which might appear promising.)

OBJECTIVES

The principal objectives of the proposed electroform development were as listed and explained below.

- To Improve Reliability (Due to visible voids, delaminations, and stress warping, some previously produced inserts had not been usable.)
- To Increase Tool Life (Internal voids had caused premature failure in some of the previous inserts.)
- To Decrease Lead Time (The plating process used for fabrication of the previous inserts required approximately six weeks.)

The immediate goal was to fabricate six improved mold inserts for a specific use; however, additional foreseeable-future applications were anticipated.

APPROACH

A literature search was begun soon after the joint meeting and preparations were made for the physical investigation. Because of other priorities, however, the work was suspended temporarily. An appropriation request which outlined the proposed phases of the work was submitted, but work on the project was not resumed until January, 1967.

PROPOSED WORK

Previous investigation of a number of electroforming processes indicated that the greatest probability of success would lie in further development of the nickel sulfamate electroforming process. Therefore, the following work was planned.

- Nickel Sulfamate Solution Make-Up, Operation, and Control:
 - Effects of various bath constituents and additives on the tensile stress of the deposit and the throwing power of the solution;
 - Effects of sulfate content (establish a maximum),
 - Addition of barium sulfamate for sulfate reduction, and
 - Effects of barium ions on stress reduction and throwing power;
 - Evaluate anode materials for corrosion, efficiency, surface finish of the deposit and co-deposition of sulfur;
 - Rolled depolarized electrolytic nickel, and
 - Sulfur depolarized electrolytic nickel; and
 - Determine the effects of current-interruption on the quality of the deposit. (examine for possible passivation and/or stratification).
- Tooling and Equipment:
 - Mechanical agitation of solution,
 - Solution pumping,
 - Auxiliary and conforming anodes,
 - Anode to cathode distance variations, and
 - Effects of shielding and robbers on current distribution.
- Back-Fill With Metallic Materials Having Good Adhesion to Nickel and Acceptable Heat-Transfer Properties:
 - Casting a filler in place, and
 - Electrodeposition of copper from a solution having a higher throwing power.
- Separation Methods - Insert From Mandrel:
 - Permanent mandrels (reusable);
 - Surface passivation of nickel alloy steels,

Nickel strike and surface passivation, and

Mechanical methods (thermal shock and vibration techniques).

Expendable mandrels:

Low temperature melting point alloys, removed by melting and by chemical dissolution.

EXPERIMENTAL WORK

The effects of anodes and current-interruption upon stress concentrations and delaminations or voids in the electroformed deposits were investigated, and the effects of barium and sulfate ions on the throwing power of the solution were determined. Both rolled depolarized and sulfur depolarized anodes were evaluated to determine the effects on solution throwing power and the surface finish of the deposits and the extent of voids or delaminations therein. The results of those experiments, as briefly described below, enabled the composition and balance of the plating solution to be established.

STRESS

Several different sulfate ion concentrations were used in determining the effect of sulfate ion concentration upon deposit internal stress. The sulfate was removed by addition of barium sulfamate to the solutions. The lowest internal stress was obtained at a zero sulfate ion concentration.

THROWING POWER

Throwing power is the ability of a solution to plate uniformly on irregular surfaces. Various ratios of sulfate and barium sulfamate were tried. The best throwing power was obtained with a barium sulfamate content of approximately 1000 parts to one million parts of solution. That ratio also produced the lowest internal stresses.

EFFECTS OF ANODE DEPOLARIZATION

Sulfur depolarized (SD) and rolled depolarized (RD) nickel anodes were evaluated for appearance of the deposit, sulfur content in the deposit, and plating efficiency. The anodes were about equal on the first two counts; however, SD anodes were superior in efficiency.

EFFECTS OF CURRENT-INTERRUPTION

The effects of interruption of the plating current upon deposit stratification were investigated by subjecting coupon samples to current interruptions of one, five and fifteen seconds and one and five minutes. No separable plating layers were found in any of those samples.

CONCLUSION

Since initiation of this project, more reliable and efficient methods of producing mold inserts have been introduced. Because of those advances, further development plans for this project were abandoned.

Work was in progress on the solution pumping phase of the work and experiments had been conducted for two pumping conditions when the project was terminated. None of the samples had been evaluated for plating quality and uniformity of the deposits. The first experiments were conducted on simulated mandrels. If results from the simulated mandrels had been found satisfactory, similar experiments with production mandrels would have followed.

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