PowerTrain

Cutting Tool News

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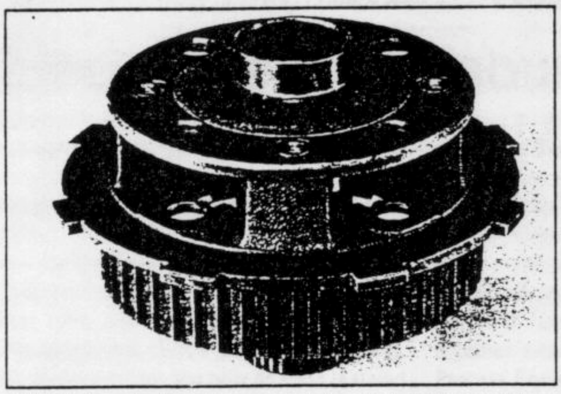
Electrochemical deburring results in the sweet smell of success

Livonia engineers, faced with a challenging deburr operation, identified an electrochemical deburring process that appeared promising—but it had some drawbacks. By focusing Ford and vendor resources, the problems have been eliminated and the resultant process is capable, safe, and robust.



AX4S front planetary carrier. Note the notches milled in the pinion gear shaft holes.

The part in question was the AX4S front planetary carrier (cast iron and SAE 1010 steel). In Oct. 1993 two design changes were incorporated to increase oil flow to gear areas: an oil slinger groove was bored into the ID of the cast iron plate; and notches were milled across the pinion gear shaft holes in both plates. Working with product design engineers, Process Engineer Don McRoberts recognized that edge burrs would result. He began investigating deburring processes.

After ruling out several mechanical deburring processes, McRoberts found an electrochemical deburring process which was based on a proprietary electrolyte. The ethylene glycol-based electrolyte had been developed to minimize the formation of free hydrogen (Lower Explosive Limit, abbreviated LEL, is 5%).

Early in this project, Process Equipment Company bought the rights to the proprietary electrolyte process from the original owner. Working together, Ford and Process Equipment Company engineers recognized three significant drawbacks of the process: 1) it produced a noticeable ammonia odor; 2) tooling (cathodes) lasted only 8,000 parts; and 3) the electrolyte solution was difficult to maintain and expensive to replace.

Early in 1995, Ken Stacherski succeeded McRoberts and Faraday Technologies (experts in electrochemical machining and electroplating) was brought in to consult on the process problems. After some sleuthing, it seemed that the ammonia odor, the poor tool life, and the electrolyte maintenance problems could be attributed to the proprietary electrolyte:

- The formation of ammonia happened by design in lieu of hydrogen formation.
- The electrolyte is very corrosive to copper and copper-based alloys, so the cathode had to be constructed from stainless steel. The relatively high resistance of stainless steel caused the cathode to heat up which in turn resulted in formation of additional ammonia. This reaction was detrimental to cathode life.
- Nitric acid and water were added daily to the electrolyte to maintain pH between five and six. In spite of these measures, engineers felt that the electrolyte chemistry would eventually deteriorate and the system would have to be dumped and recharged at a cost of about $12,000 (6 bbls in the system at $2,000 per bbl).

The team of engineers investigated sodium chloride ($NaCl$) and sodium nitrate ($NaNO_3$) electrolytes and found that they offered advantages in terms of reduced odor, tool life, and ease of electrolyte maintenance. Importantly, both electrolytes were being used in industrial operations and the

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Letter from the editor

This issue begins the second year of publishing ***Cutting Tool News***. Our mission is to communicate tooling information throughout ATO. Often engineers at different locations face similar manufacturing challenges. By highlighting innovative tooling and machining processes we hope to promote communication between engineers working on like processes.

From your many comments and anecdotes—many of you tell us that you are using it as a tool and resource—it appears ***Cutting Tool News*** is achieving its objectives.

We would like to express our sincerest gratitude to the many individuals who contributed to the development and writing of articles. Ford salutes your desire to improve processes and your willingness to share information with other engineers.

Ed Exner, *ATO Tool Analyst*

Indy Cutter Grind focuses on resolving tool problems

Indianapolis Cutter Grind personnel are working to solve tooling problems and help manufacturing meet quality and production goals by hosting weekly tooling meetings. Their efforts have dramatically changed the attitude toward Cutter Grind which is now viewed as a valuable resource for tooling help.

All plant employees are invited to bring their tooling problems and concerns and ideas to the Friday afternoon meeting which lasts for about 90 min. Hourly and salary personnel from Cutter Grind, Production, Tool Engineering, and other departments strive to eliminate machining problems by applying the appropriate resources to tooling issues. Generally this means soliciting a Cutter Grind operator or a Tool Engineer to visit the production floor and work with Process Engineers, tool setters and maintenance to analyze and solve the problem.

Cutter Grind Supervisor Bill Sorter and Cutter Grinder Bob Eyster check the setup on a Walter Helitronic 44, used for regrinding hobbing cutters with a CBN wheel.

Prior to initiating the quality team approach, Cutter Grind did not always have the best reputation: Cutter Grind personnel rarely visited the shop floor; production blamed tooling problems on Cutter Grind; and at times operators threw up their hands and just tolerated tooling problems.

Brief Case Studies

Bill Sorter, Cutter Grind Supervisor, explains that "operators don't live with problems like they used to. Now, when a tool breaks, operators are encouraged to bring it to Cutter Grind. We repair the tool and send someone back to the floor to help troubleshoot the process." Here are a couple problems that were brought up and eventually solved at weekly tooling meetings.

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Electrochemical deburring

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concentration of free hydrogen formed was only 0.01 to 0.03% (the high end of this range equals one-twentieth of the LEL of 5.0%). NaCl was selected as the electrolyte and the system was re-engineered. Design of Experiment was complete by midsummer 1995 and the recent machine runoff was successful (5,000 parts, zero failures). As of this writing, the new process is slated for production by the end of 1995.

What have been the benefits of re-engineering the electrochemical deburring process?

- **Operator welfare.** Hydrogen formation is well below the LEL and no ammonia is formed.
- **Electrolyte maintenance.** The process stabilizes at a pH between 11.25 and 11.50 and does not need to be adjusted. Twice monthly, evaporated water is replaced and a refractometer is used to check NaCl concentration. NaCl is added as needed. A byproduct of the electrochemical reaction is iron hydroxide particles (1/2 to 1 µm) which are removed by a magnetic separator.
- **Electrolyte cost** is a fraction of the cost for the proprietary electrolyte.
- **Tool life.** The stainless steel cathode was replaced by brass which is more conductive and produces less heat. Uptime has been 100%, and 20,000 parts have been deburred without a cathode failure.
- **Robust.** To ensure robustness, the system was built mostly of stainless steel to withstand the corrosive affects of salt water.

In reviewing the events leading up to the new electrochemical deburring process, Stacherski points out that "this project might not have turned so well had we not put together a team of experts from Ford and Process Equipment and Faraday."

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Process Engineer Ken Stacherski points out one of two plates that require deburring in the AX4S front planetary carrier.

Electrochemical deburring

The planetary carrier is suspended in an electrolyte solution. The carrier is the anode. Critical surfaces are masked (bearing journal surfaces and ID of the pinion holes) to prevent them from reacting. The part rests such that the burred edges rest very close to, but not in contact with, the cathode. When current is applied to the cell, iron atoms in the anode give up electrons—they are oxidized—and iron ions go into solution in the electrolyte where they react to form iron hydroxide. The oxidation half-reaction is: $Fe \rightarrow Fe^{2+} + 2e$

$E^{\circ} = -0.44$ V (standard potential)