2007 NCAT Defense Manufacturing Excellence Award Nomination

Nominator

Dr. Charles L. Ryan
Vice President, Technology
National Center for Manufacturing Sciences (NCMS)
3025 Boardwalk
Ann Arbor, MI 48108-3230
(734) 995-4905 direct
(734) 995-1150 FAX
chuckr@ncms.org email

Category Small team/group from small business company

Project Nominee **No-Mask Tooling for Chromium Electroplating**

Project Team

George Cushnie – Advanced Tooling Corporation (industry champion)
Randy Taylor – Advanced Tooling Corporation
Jeremy Smith – U.S. Army, Corpus Christi Army Depot
Bryan Pilgrim. – U.S. Navy, North Island Naval Aviation Depot
Paul Chalmer – NCMS (program manager)
Anita Tolen – NCMS

SUMMARY

Chromium electroplating imparts wear resistance to metal surfaces. It is essential for building and maintaining crucial aircraft parts like landing gear journals and pistons. But the conventional chrome plating process is slow and expensive. Parts must first be masked so that only the desired areas are plated, a time-consuming task that must be performed by skilled artisans. Chrome in a standard plating setup is deposited slowly and unevenly, requiring extensive machining to bring parts back into tolerance. The extra labor contributes significantly to the overall turnaround time and cost of aircraft refurbishment.

This project demonstrated the ability of a new development, "no-mask" tooling, to eliminate labor for masking, and to achieve much faster plating times and more uniform chromium deposits. The quality improvement and cost savings were so dramatic that no-mask tooling was adopted for standard production while the project was still underway.

More Detailed Description of the No-Mask Tooling Project

The Department of Defense (DoD) uses hard chromium plating extensively during maintenance of aircraft, ships, and weapon systems. Hard chromium plating provides superior wear resistance for a wide variety of surface geometries. Although there has been considerable effort over the past several years to develop alternative processes that can match its performance and flexibility, hard chromium plating is not likely to be superseded in the foreseeable future for many critical applications.

Usually, chromium is only plated onto certain portions of steel engine parts, for example, where metal-on-metal contact occurs during use. Depositing a layer of chromium on such a surface prevents wearing of the steel parts in these areas. To prevent unwanted deposition of chromium on other areas of the parts, these surfaces are masked with plastic, wax, metal or plastic tapes, or by other means. The masking and subsequent unmasking are labor-intensive aspects of the chromium plating process. Personnel assigned to masking must be well trained and experienced; typically the best platers in the shop are used for this task.

For refurbishment of used parts, chromium is typically plated to an average thickness that is several times the amount required in the finished part. This is necessary because the chromium coating resulting from conventional DoD methods is non-uniform. In order to achieve the required minimum thickness over the entire surface, the parts must be over-plated, and then machined to a uniform, specified dimension. Thus, the conventional DoD hard chromium plating process involves hours of preparation time for masking and fixturing the parts, plus long plating times, as well as subsequent cleanup time to remove the masking and to machine the finished part back into tolerance.

At DoD facilities plating times for parts typically run from one to five days, with some parts requiring up to seven days of tank time. As a result, DoD plating facilities have installed

multiple chromium plating tanks to meet their production requirements. Plating procedures include use of elaborate racking and fixturing above the tanks forcing employees to lean over the plating tanks with direct exposure to chromic acid fumes. Platers performing these tasks are required to wear respirator equipment but it is uncomfortable and restricts movement. In addition to the imposed health hazard, the various metal-to-metal connections most DoD shops use to attach racks to tank busing causes an electrical current drop resulting in lower plating rates.

The goal of the project was to create "no-mask" anodes, a relatively new concept for chromium plating, and apply them in actual operation in DoD facilities. With no-mask tooling, the masking operation is eliminated. The masking is incorporated into the tool itself, as an acid-resistant plastic that fits tightly around the part to be plated. The tooling also incorporates an anode configured to the specific part shape, which greatly improves the speed and uniformity of the chromium metal deposit. The details of the geometry, including the curvature of the edges of the masking sections, and the overall shape (which determines the flow path of the electrolyte during plating), are critical to the performance of the tool.

During this project, no-mask anodes for hard chromium plating aircraft parts were developed and implemented. These particular parts were selected because they are produced in high volume, with long plating cycles, involving labor-intensive masking and machining, and typically having relatively high reject/rework rates.

The project involved several stages of prototype no-mask tooling design, followed by fabrication and extensive testing. A final set of production tooling was then supplied and employee training was performed. By the end of the project, the new tooling developed during the course of the work had been incorporated into the each of the facility's hard chromium plating operations.

Deliverables

Almost from the day it was launched, the Hard Chrome project had begun to assist two key DoD metal finishing facilities in meeting critical production requirements and saving money:

- Corpus Christi Army Depot (CCAD). No-mask anodes for hard chromium plating eight aircraft parts were developed and implemented. These particular helicopter parts were selected because of their production frequency and because they are difficult to plate (i.e. significant reject/rework rate). CCAD has since expanded use of the technology to cover 80% of their hard chrome production.
- NAVAIR Depot North Island. The no-mask technology was applied to two critical F-18 landing gear parts. The tooling was immediately implemented into full production use. North Island is in the process of expanding use of the technology to other critical landing gear parts.

Benefits Realized

Key benefits derived from the project include:

- **Cycle Time:** The processing time for these aircraft parts was reduced by an average of 57%. Cycle time benefits were derived mainly from reduced masking and plating times.
- **Cost Avoidance:** An annual cost avoidance of $2,039,705 was achieved due mainly to the elimination of masking labor and a major reduction of rejects/rework.
- **Availability:** The new tooling increases existing chrome plating tank capacity by 50% (achieved as a result of average reduced plating tank residence time for the selected parts). This benefit is particularly important since tank capacity was previously insufficient; occasionally causing impacts to the overall CCAD and North Island production rates.
- **Proliferation of New Technology:** In addition to continued expanding use of the no-mask technology at CCAD and North Island, the technology is now being implemented at Warner Robins ALC and Anniston Army Depot where it is expected to have major impacts on production rates and costs.

DoD Leverage Through Cost Sharing

This project provided $504,000 in CTMA funding matched by industrial cost share of $1,387,400 for a total project value of $1,891,400.

BIOGRAPHIES

Participants:

Advanced Tooling Corporation

- George Cushnie has over 25 years of experience in metal finishing. He has owned and operated a hard chrome plating company and has consulted extensively for DoD, other government agencies and private industry. He managed projects at multiple Navy plating facilities (NADEPs and Shipyards) involving the installation of conforming anode hard chrome plating systems. Mr. Cushnie has managed projects for developing short-term repairs and long-term modernization plans for the plating shop at Corpus Christi Army Depot as well as numerous projects involving technology demonstration and validation at DoD and commercial plating facilities. He has served as the technical manager of the National Metal Finishing Resource Center since 1995. He has authored three books on electroplating topics and more than 50 published articles and papers. He is an active member of the National Association of Surface Finishing, where he serves on the education and communications committee. Mr. Cushnie holds a Bachelors degree in oceanography and two Master in engineering.

- Randy Taylor has over 30 years experience in hard chrome, sulfamate nickel and cadmium electroplating, and other metal finishing processes with respect to tooling and anode design/fabrication, process set up and plating. Prior to his role as President of ATC, Mr. Taylor was Process Engineering Manager for Plating at Southwest United Industries, Tulsa, OK and Founder and President of Plating Perceptions, Inc., Twinsburg, Ohio. Mr. Taylor has designed and built both conforming and no-mask

conforming anodes, fixtures and plating support equipment for landing gear and hydraulics systems components for the following military and commercial aircraft: YF- 22, B-2, B-1, C-17, F4, F14, F15, F16, F18, F111, F104, S2A, A6, EA6B, C-1, C-2, C-5A, C130, CH47, CH53, B52, B-1, B-2, KC135, A10, 727, 737, 747, 757, 767, 777, 777LR, L1011, DC8, DC9, DC10, MD11, MD80, A300, A320, A330, A340, A380, Lear Jet, Hawker, Canadair. Mr. Taylor has additional career experience in metal finishing for automotive, mining and oil drilling industries and is certified operator for Brush (Stylus) plating, HDI testing, Electroless Nickel plating. He served in the U.S. Navy from 1971 through 1979 and is a combat veteran.

Corpus Christi Army Depot

- Jeremy Smith is currently the Branch Chief for the Chemical Process Branch in the Materials & Process Engineering Division in the Directorate of Quality Assurance located at the Corpus Christi Army Depot. Mr. Smith has 19 years of metal finishing experience in DoD aviation overhaul, and holds a Bachelor of Science degree in Chemistry from the University of Texas at San Antonio, and a Master of Science degree in Environmental Science from Texas A&M University Corpus Christi.

North Island Naval Aviation Depot

- Bryan Pilgrim began working at NAVAIR North Island in 1997 as a member of the F/A-18 Landing Gear Team where he was responsible for engineering investigations, gear failures and support of Naval Aviation Depot overhauls and repairs. By 1999, Mr. Pilgrim was leading this team and expanding his responsibilities with the U.S. fleet and international customers. In 2004, he led the AirSpeed initiative for the NAVAIR Depot Components Branch that implemented Lean Manufacturing practices to reduce cost and cycle time. Currently, Mr. Pilgrim is a George Group trained Master Black Belt for Naval Aviation using Lean Six Sigma tools to attack variation in transactional and production arenas. Mr. Pilgrim was in the U.S. Coast Guard from 1982 to 1986. He was previously employed by Lockheed Martin in a position involving nuclear material and production and subsequently transitioned into the Atlas Centaur Rocket Program. Mr. Pilgrim's education includes a Mechanical Engineering degree from San Diego State University.

NCMS

- Paul Chalmer, Senior Program Manager, led the program planning, schedule, and management activities.

- Anita Tolen, Administrative Assistant, provided team administrative support.