Approved for public release; distribution is unlimited.

HOUSING DEVELOPMENT FOR PLASMA ELECTRODE POCKEL CELLS

R. L. Stubenhofer

Published January 1995

Final Report
R. L. Stubenhofer, Project Leader

Project Team:
M. G. Chapman
L. G. Cook
R. F. Davis
D. L. Frey
F. N. Rogers
C. J. Schumacher
J. R. Speer

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Contents

<i>Section</i>	<i>Page</i>
Abstract.....	1
Summary.....	1
Discussion.....	2
Scope and Purpose.....	2
Activity.....	2
Housing, KCD Part Number 1470373	3
End Plate, KCD Part Number 1470374.....	4
Insulator, KCD Part Number 1470375, and Vacuum Adapter, KCD Part Number 1470378	4
Conclusion	4
Accomplishments	4

Illustrations

<i>Title</i>	<i>Page</i>
1 Original Pockel Cell Design.....	5
2 Manufacturing Drawing of the Pockel Cell Housing	6
3 Completed Pockel Cell Housing.....	7
4 Manufacturing End Plate Drawing.....	8
5 Completed End Plate With O-Rings.....	9
6 Manufacturing Insulator Drawing	10
7 Completed Insulator.....	11
8 Manufacturing Vacuum Adapter Drawing.....	12
9 Completed Vacuum Adapter, Front View.....	13
10 Completed Vacuum Adapter, Back View	14

Table

<i>Number</i>	<i>Page</i>
1 Pockel Cell Components.....	3

Abstract

The ability to produce metal machined products with deep pockets and thin walls is a critical feature of the Kansas City Plant. Lawrence Livermore National Laboratories' upgrade of the NOVA Laser in preparation for the National Ignition Facility (NIF) offered the opportunity to exercise and maintain this capability on a limited scope project. Their purpose was to evaluate the feasibility of replacing the current PEPC (plasma electrode pockel cell) housings with aluminum structurally robust housings and associated hardware. When completed, the National Ignition Facility will provide other alternatives for nuclear testing to maintain the enduring stockpile. The NOVA laser is the precursor to this development.

Summary

This project was undertaken to maintain the capability to machine deep-pocket, thin-walled features in large metal parts. This was a capability which was not being fully exercised under the existing Production Capability Assurance Program (PCAP). Lawrence Livermore National Laboratories (LLNL) had requested that the Kansas City Division (KCD) provide support for the development of the design and machining of a prototype Pockel Cell Electrode for the NOVA Laser upgrade. This project was done in conjunction with the planned development of the National Ignition Facility (NIF). The KCD designed and produced three metal and three plastic products from an existing all ultra-high molecular polyethylene plastic design. The metal parts were fabricated to eliminate the stress and inaccuracy in the plastic parts. KCD also specified and ordered high-strength magnets for use in the assembly. The project successfully met all the goals required by the original scope of the project.

Discussion

Scope and Purpose

The purpose of this project was to evaluate the feasibility of fabricating metal housings for plasma electrode pockel cell (PEPC) applications in support of the National Ignition Facility (NIF) program at Lawrence Livermore National Laboratories (LLNL). The project developed prototype fabrication processes of the pockel cell switch. The NIF will provide an alternative to nuclear testing for maintaining the enduring stockpile. Two sets of hardware were delivered to the NOVA laser facility for evaluation.

Activity

The NIF program required PEPC housings that are thin wall, structurally robust, creep resistant, cost effective, and compatible with cold cathode plasma generation. This project evaluated the feasibility of fabricating a metal housing to meet those needs using key process technologies at the Kansas City Division (KCD). The technical approach defined, fabricated, and evaluated a prototype housing representative of the materials, size, shape, and thickness required to function as a plasma housing in conjunction with permanent magnets.

LLNL has proposed a National Ignition Facility to support the goal of achieving laser-driven fusion ignition and gain. NIF capabilities encompass significant defense applications including nuclear weapon physics research, weapons effects testing, instrumentation/diagnostics development for nuclear testing, and exploration of advanced weapon concepts.

A key technology for NIF is the development of a large aperture high-energy electro-optical

switch that is cost effective and can be sized to serve as a building block for a multielement array of switches required by the system. LLNL has constructed a single element demonstration switch that uses conducting plasma as the electrodes and ultra-high molecular weight polyethylene for the housing (Figure 1). (All figures appear following the text.) The best structural solution was fabricating a metal housing that would meet the physical and functional requirements of a cold cathode plasma system.

This project evaluated the feasibility of metal plasma housing fabrication in support of the National Ignition Facility and its defense program objectives. KCD had the key engineering expertise and process technologies necessary to concurrently engineer and fabricate a unique hardware prototype for this feasibility evaluation. Exercising of key mechanical process technologies by this project maintained KCD's nuclear weapon competence for machining deep-pocket, thin-walled metal products.

This project concentrated primarily on the metal machining of deep-pocket, thin-wall sections of aluminum. Existing projects in the metal machining areas were not supporting the capability. This project also exercised the process of manufacturing several plastic-based parts. All the product was fully inspected by Precision Measurement. This aided in their capability by providing objects of greater size than normally inspected in that area and required complete programming on a quick turnaround basis.

The list of parts which were manufactured for this project is shown in Table 1.

Table 1. Pockel Cell Components

Part Name	KCD Part No.
Housing	1470373
End Plate	1470374
Insulator	1470375
Cap	1470376
Retainer	1470377
Vacuum Adapter	1470378
Magnet	1470379
Pockel Cell Assembly	1470380

The housing, end plate, and retainer were made from metal; the magnets were purchased; and the balance of the parts was a variety of plastic products. A final assembly drawing was generated to show the interrelation of the products. This was requested by LLNL near the end of the project, but we were able to support this requirement.

A complete set of drawings was created at KCD from the existing plastic pockel cell drawings provided by LLNL to redesign the product. This required extensive conversations with the LLNL engineer to take a prototype design and make it match the needs of the customer.

Product was shipped to the customer at LLNL and is currently being evaluated for feasibility.

Housing, KCD Part Number 1470373

The housing was the cornerstone piece of the project and the driver for the redesign from the plastic currently in use at the NOVA laser facility. As stated, the existing plastic piece tended to deform during manufacturing and in standard use. This caused a problem for the laser beam to compensate for this deflection. The LLNL engineer had determined that an aluminum housing could potentially replace the plastic housing. This would eliminate the

deformation and provide a more robust cell design. The concern was that the aluminum would not perform in the same manner as the plastic during the ultimate application.

The housing was manufactured in the Heavy and Precision Shapes Machining Department. The housing was started from a solid block of 6061-T6 aluminum, approximately 24 x 24 x 6 inches, weighing over 80 pounds. After removal of the center section and creation of a rough cross opening, the block was placed on a 5- axis mill; and with two different machine setups, the final product was machined. Four pieces were started with the intention of yielding two. Inspection was completed on the first piece while the second piece was in process. The second and third pieces were completed to the print definition, thus eliminating the need to manufacture the fourth piece. Thread tapping and counter sinks were added after the milling operation was completed.

The housing was started from plate stock in the final heat treat condition of 6061-T6 with the initial intention of heat-treating after the first roughing operation to relieve stresses and stabilize the flatness. The heat treat was not required, which was unusual given the size and large amount of material being removed during the initial machining process. Typical processing would have included the heat treat for resulting warpage.

A numerical control tape was generated for the milling process which required extensive editing on the mill to generate the final configuration. The editing was a normal process in any first-run program; however, this was complicated by the complexity of the product and the intention to reduce the number of setups and fixture changes. A fixture was ordered to allow complete machining of the housing with a minimal number of setups and fixture changes during

the process. A top plate was repositioned several times, but the only major change to the fixturing occurred when the housing had to be turned over for the machining on the other side.

Due to the complexity of this product, future product of this type should probably be manufactured in a model shop-type environment where the machinists can do their own setup and design tooling as the process is defined. Manufacturing this in a production environment for only four pieces was extremely costly from a tooling standpoint. However, this did exercise the critical skill capability.

The product drawing and a picture of the final product are shown in Figures 2 and 3.

End Plate, KCD Part Number 1470374

The end plate was also manufactured from 6061-T6 aluminum. The complexity of this part was not comparable to the housing except for the O-ring grooves and the flatness requirements. The end plate was started from 6061-T6 like the housing and also did not require heat treatment to maintain flatness.

Fixturing for this part was simpler than for the housing. One fixture was made, and after the first side of the end plate was machined, the fixture was modified on the mill to accommodate the processing on the other side. Four parts were started and four parts yielded to the final assembly.

The product drawing and a picture of the final product are shown in Figures 4 and 5.

Insulator, KCD Part Number 1470375, and Vacuum Adapter, KCD Part Number 1470378

The insulator and vacuum adapter were both made from an ultra-high molecular weight polyethylene as specified by LLNL. This material was special ordered for this project. The machining of this product posed no significant difficulties except for the thin wall on the insulator. The 0.148-inch wall thickness was thin enough that over the 16.65-inch length the walls tended to bow in at the center, making the part appear to be out of tolerance to the ± 0.010 -inch requirement. Restraint was allowed for the inspection of the part which showed that the product met the drawing requirements.

The product drawings and completed parts are shown in Figures 6 through 10.

Conclusion

The project intent of maintaining capability of deep-pocket, thin-wall machining was met and maintained by this project. In addition, the knowledge gained from this project on machining large pre-heat treated items plus the technology of machining the plastic portion of this project added to the capabilities at KCD. LLNL was pleased with the efforts expended at KCD and has determined this facility as an acceptable site for future work in the National Ignition Facility arena.

Accomplishments

The deep machining endeavor that was one of the primary drivers for this project was maintained. In addition, KCD supported the NIF Nova Laser Upgrade project with quality hardware that has generated additional directive work now and in the future.

Figure 3. Completed Pockel Cell Housing

Figure 5. Completed End Plate With O-Rings

Figure 6. Manufacturing Insulator Drawing

Figure 7. Completed Insulator

Figure 8. Manufacturing Vacuum Adapter Drawing

Figure 9. Completed Vacuum Adapter, Front View

Figure 10. Completed Vacuum Adapter, Back View