MAY 23 1968

Date Issued: June 7, 1967

Report Number Y-DA-1730

MASTER

UNION CARBIDE CORPORATION
Nuclear Division

Y-12 PLANT

Contract W-7405-eng-26
With the U. S. Atomic Energy Commission

SPARK DISCHARGE MACHINING METHOD
FOR PREPARING URANIUM ALLOY SPECIMENS
FOR X-RAY ANALYSIS

C. M. Wiedemann

Metallurgical Development
Co-op Student
University of Florida

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission: (1) Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (2) Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report. As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor, prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

This document is
PUBLICLY RELEASABLE

3 Steele
Authorizing Official

Date: 8/21/06

Oak Ridge, Tennessee

April 21, 1967

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission: (1) Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (2) Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report. As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor, prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

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, makes 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.

Report Number Y-DA-1730

Distribution:

J. L. Cadden

S. G. Campbell

C. P. Coughlen/W. G. Rains

J. R. Cullipher

R. L. Ludwig

W. K. Whitson, Jr.

C. M. Wiedemann

W. J. Yaggi (Y-12RC)

ABSTRACT

Spark-discharge machining methods were applied in making small (0.1 inch by 0.1 inch by 1 inch) specimens for Debye-Scherrer X-ray analysis of the effect of varying quenching rates on uranium alloys. A Servomet Spark machine and an accessory rotating chuck was used to point the specimens. Afterwards, an electropolish was used to remove the damaged surface layer. The method is fast, produces quality specimens, and requires a minimum of operator skill.

SUMMARY

A standard method for making uranium alloy specimens for Debye-Scherrer X-ray analysis was developed. The method employs spark-discharge machining to taper small, square metal rods which are then electropolished to remove the disturbed surface layer of metal remaining after the machining process.

The chief advantages of this method are:

1. Relative speed of producing specimens.
2. Once the initial setup is made, little attention is required.
3. Distortion of the specimen is slight.
4. The results are easily reproducible.

INTRODUCTION

Formerly, samples for Debye-Scherrer X-ray studies were made by pointing small (0.1 inch by 0.1 inch by 1 inch) metal rods by mechanical grinding and electroetching. The rods were tapered by a grinding step which deeply disturbed the surface layer of metal and necessitated the etching process to remove it. The possibility of the grinding operation overheating the sample and distorting the original quenched structure prior to X-ray examination was a factor to consider. Electroetching had a tendency to round the points and pit the specimens, thus rendering them unfit for X-ray analysis. It was slow and needed constant observation to produce a usable specimen.

A method was needed that would produce a specimen in less time and require less operator skill to perform as well as reduce the possibility of structural damage to the specimen.

A method of making specimens using spark-discharge machining with a subsequent electropolishing operation was developed. The amount of distortion that spark-discharge machining produced and the amount of metal that the electropolishing solution removed was investigated.

DESCRIPTION OF THE DEVICE

The method developed uses a Servomet Spark Machine made by Metals Research Ltd., Cambridge, England. This device uses an electrical spark to erode the workpiece into a desired geometry. The voltage-amperage characteristics of the spark can be changed to one of seven different energies which range from coarse to very fine. "Coarse" and "fine" refer to the amount of metal removed by the spark. A servo motor attached to the tool holder moves the tool closer to or farther away from the workpiece to maintain the voltage-amperage characteristic called for by a particular range setting. A timer connected to the energy range switch allows the machining to start on a set range with the machine automatically switching itself every four minutes to a finer range. After four minutes on the very fine setting, the machine automatically turns off.

Spark Machine Set Up

Figure 1 shows the machine set up to point specimens for X-ray diffraction work. It consists of a servo-driven tool holder, a tungsten tool, and a chuck driven by a flexible cable. A tungsten tool is used because erosion is much less compared to brass or copper tools. The less the erosion of the tool the sharper and smoother the point on the specimen. The tool holder is positioned to hold the tool at an approximate 10-degree angle to the longitudinal axis of the chuck (Figure 2) and the tool itself is positioned at a slight angle (approximately 2 degrees) to the vertical axis of the tool holder (Figure 3). The angle that the tool holder makes with the chuck axis denotes the degree of taper of the point on the specimen; whereas, the angle of the tool in relation to the vertical axis of the tool holder allows the servo mechanism to operate efficiently.

Preparation of Uranium Alloy Specimens

The specimens are readied for use in the Servomet Spark Machine by cutting 0.1-inch by 0.1-inch by 1-inch-long rods from heat-treated plate stock. The rods are cut out of the plates on a Micro-Matic Precision Wafering Machine made by Micromech Manufacturing Corporation which uses a diamond-impregnated brass cutoff wheel 0.020-inch thick by 6-inch diameter. By slowly feeding the plates into the cutoff wheel, very little mechanical and thermal damage is done to the surface of the rods.

Figure 1. SERVOMET SPARK MACHINE SET UP TO MAKE X-RAY DIFFRACTION SPECIMENS.

Figure 2. ROTATING CHUCK AND TOOL HOLDER SHOWING ANGLE BETWEEN TOOL AND THE AXIS OF ROTATION OF THE CHUCK.

Figure 3. TOOL HOLDER AND TOOL SHOWING ANGLE OF TOOL TO THE DIRECTION OF SERVO MOVEMENT.

Machining Procedure

The apparatus as shown in Figure 1 is in the up position; during the machining operation, it is lowered into the dielectric tank. The actual machining procedure is as follows:

1. The specimen is placed in the jaws of the chuck and tightened.
2. The apparatus is lowered into the dielectric tank.
3. The mode switch is turned to the "Plane" position, which starts the chuck rotating.
4. The Range Selector Switch is turned to "1."
5. The High Tension Switch is set to the ON position.
6. The Servo Switch is set at the ON position.
7. The Timer Switch is pushed to activate the timer, which starts the machining operation.

For this particular operation two machining cycles are sufficient to produce a fine needle point on a specimen. Figure 4 illustrates a specimen in the as-machined state.

Electropolishing Procedure for Uranium Alloy Specimens

After machining, the pointed specimens are electropolished to remove the damaged surface layer of metal. Metallographic examination of several samples has indicated that the spark machining process damages the surface to a depth of one-half mil or less as shown in Figures 5 and 6. To remove this damage, an electropolish is used which consists of:

118 g CrO_3 in 100 ml of H_2O
400 ml of Acetic acid

A stainless steel beaker contains the electrolyte and also functions as the cathode for the electropolishing operation. The polishing is done at 20 volts (open circuit) and room temperature. It has been found that a 15-second immersion in the solution will remove approximately one mil on the specimen's diameter. On the basis of this, all specimens are electropolished one minute to insure removal of all disturbed metal.

Figure 4. SPECIMEN IN THE AS-SPARK-MACHINED CONDITION.

D209-1

250X

Figure 5. CROSS SECTION OF SPARK MACHINED SPECIMEN
SHOWING DEPTH OF SURFACE DISTORTION.

D209-2

250X

Figure 6. CROSS SECTION OF SPARK MACHINED SPECIMEN
SHOWING DEPTH OF SURFACE DISTORTION.

Conclusions

The method developed shows several important advantages over the grinding and electroetching process. The time and operator skill required is significantly reduced. The use of machines with automatic feeds and timed sequences results in an easily reproducible process. The spark-discharge machining step eliminates the objections of thermal damage and an unknown depth of mechanical distortion to the specimen caused by hand grinding. The possibility of thermally damaging the specimen by spark machining is small since it heats a very small part of the surface of the specimen and because the dielectric fluid quickly carries away the heat of the sparking operation. Spark-discharge machining damages the surface layer of metal to a known depth; whereas, in the hand-grinding method, the depth of distorted metal was entirely dependent on the skill of the operator. The general appearance of the specimens made by spark machining is improved. The electroetching method required several hours to remove the material from the rod to the desired point. It also required that the operator watch the etching process constantly and remove the specimen from the etchant repeatedly to check the progress. This, however, did not always produce a usable specimen because of pitting and rounding of the specimen's point. The spark machining process allows the operator to start the machining operation and not check it until the cycle is complete. The electropolishing operation needs only a few minutes of an operator's time to perform. Starting with a square rod, the time required to spark machine and electropolish a specimen is approximately one-and-one-half hours. This time includes two machining cycles, the electropolishing operation and the set-up time for both the spark machining and electropolishing operations.