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TECHNOLOGY - HANFORD PROCESSES

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FINAL REPORT
PRODUCTION TEST 105-389-P
GRAPHITE SAMPLE BORING FROM
PROCESS CHANNELS

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BY

J. B. COLE

TECHNICAL DIVISIONS

JULY 10, 1951

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GRAPHITE SAMPLE BORING FROM PROCESS CHANNELS

By

J. B. Cole

Pile Engineering Section
Pile Technology Division

July 10, 1951

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RICHLAND, WASHINGTON

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FINAL REPORT
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GRAPHITE SAMPLE BORING FROM PROCESS CHANNELS

INTRODUCTION

The study of radiation damage to the graphite moderator is largely dependent upon the availability of graphite samples from the moderator itself. Because of the varied temperature-flux history and complicated structure of the piles, it is impossible to study the problem from the laboratory standpoint alone. The samples of greatest interest are those taken from the sections of the moderator which have received the greatest damage. However, a comprehensive study requires samples from all sections of the graphite moderator. It is desirable that these samples be solid in order that physical and dimensional measurements of all types may be made. Solid samples enable thermal conductivity measurements and the gradients of damage across tube blocks to be measured. To provide such samples, it was necessary to design some device which would cut solid samples from any location in the pile through the process channels. The graphite core borer was designed specifically for this purpose. The objective of this Production Test was to test the operation of the core borer and evaluate the results of its performance.

SUMMARY

A total of forty-nine graphite core samples have been bored from process tube blocks in the Hanford piles to date. These results indicate that core boring is an entirely practical operation. Because of the additional value of solid graphite samples over powder samples, core boring will supplement and replace much of the bore scraping used in obtaining powder samples.

A direct means of measuring graphite expansion is made possible by core boring. The radial expansion of a graphite tube block may be measured as shown in Figure 1. Core lengths are combined with the bore diameter to give the over-all expansion of the tube block. These measurements will serve to check expansion data based on X-ray measurements.

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TUBE BLOCK EXPANSION

①③ - CORE SAMPLE LENGTH

② - BORE DIAMETER (MEASURED WITH ELECTRONIC BORE GAGE).

④ - ORIGINAL BLOCK HEIGHT $\pm .003$ IN.

① + ② + ③ - ④ = EXPANSION OF GRAPHITE BLOCK

FIG. 1

DETAILS

The testing of the core borer for this Production Test involved the cutting of six samples from B or D Piles. Because of the urgency of obtaining data on the affects of overboring for new pile design, the core borer was used first at DR Pile on April 10, 1951.⁽¹⁾

The location and number of samples bored from the piles are as follows:

100-DR Pile, April 10, 1951⁽¹⁾

Tube channel 2569-DR - 4 samples
Tube channel 2580-DR - 4 samples

100-DR Pile, May 9, 1951⁽³⁾

Tube channel 2560-DR - 7 samples
Tube channel 2581-DR - 10 samples

100-B Pile, May 15, 1951⁽²⁾

Tube channel 1856-B - 3 samples

100-H Pile, May 22, 1951⁽⁴⁾

Tube channel 1191-H - 5 samples
Tube channel 2766-H - 10 samples
Tube channel 1196-H - 6 samples

All samples were bored vertically upwards from the process tube blocks.

The average cutting time per core was about 5 minutes. As shown above, the samples were cut from new and old piles alike, subjecting the core borer to graphites of various hardnesses.

Only three of the six samples scheduled to be bored from 100-B Pile were cut. The freezing of the drive cylinder in the lower bearing was responsible for the malfunctioning of the borer. A change of bearing material from Oilite to Teflon plastic has alleviated this difficulty.

DESCRIPTION

The graphite core borer consists of a cutting head 1.700 inches in diameter fastened to multiple lengths of handle extensions 1.500 inches in diameter

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and 6 feet long. See Figure 2. This assembly passes into the pile through a process channel 1.744 inches in diameter. When fully assembled with all four lengths of handle extension, the assembly is 26 feet long. This enables the borer to cut samples a little beyond the half-way point from either face of the pile. Any number of extensions may be used to obtain the desired length. To the last extension is fastened a T-handle assembly which is used to control the azimuth of the borer. A 3/8 inch drill motor fastens to the drive shaft at the T-assembly. A flexible air hose from the air compressor is coupled to the borer airline at the T-assembly. And the two elevating cams, located in the borer head, are controlled by handles in the T-assembly.

OPERATION

The boring operation requires six pieces of equipment; the core borer, a drill motor, an air compressor, a vacuum cleaner, a locking stand and a suspension cable assembly. The core borer is the assembly which is inserted in the pile and does the actual boring of the graphite sample. The drill motor provides the force necessary to rotate the core saw. The air compressor provides the compressed air which forces the core saw into the cut and the vacuum induced force to withdraw the core saw and sample from the cut. The vacuum cleaner is used to remove the graphite dust during the boring operation. The locking stand is used to lock the core borer in place to prevent it from rotating or translating. The suspension cable assembly provides the support on which the core borer is suspended as it is inserted and withdrawn from the pile.

A typical boring operation is accomplished in the following manner:

1. The process tube is removed from the process channel.
2. The core borer is aligned with the process channel by positioning the work area crane in line with the process channel. The borer is suspended from the crane on a taut cable.
3. The core borer is inserted in the pile process channel to the desired location and locked in place with the locking stand.
4. The vacuum cleaner hose is inserted in the other end of the process

FIGURE 2. - CORE BORER

- channel to within approximately one inch of the end of the core borer.
5. The air compressor is connected to the air line and four to five pounds of pressure is applied to the borer.
 6. The drill motor is connected to the drive shaft and power is applied until the air flow indicator registers a change, indicating the core saw to be fully extended into the graphite cut.
 7. The elevating cam handles are then actuated to force the core borer head against the wall of the channel to insure maximum travel of the core saw and a complete cut through the graphite block.
 8. The compressor valves are positioned to provide the vacuum which withdraws the core saw and sample from the cut.
 9. After disconnecting the drill motor and releasing the lock stand, the core borer is withdrawn from the pile. The vacuum induced force remains applied to the air line while the core borer is being withdrawn.
 10. Pressure is again applied to the air line forcing the core saw out so the sample may be removed and placed in a storage container.

DESIGN AND CONSTRUCTION

The core borer was fabricated in accordance with Hanford Works Drawing No. SK-1-710, and revisions thereto. Because of the rather extreme bowing in some of the process channels in the older piles, the core borer had to be made flexible enough to conform to this bowing without binding in the channel. At the same time the assembly had to be rigid enough to support the drive shaft, two cam shafts and air line. This was accomplished by breaking the handle assembly into four 6 foot lengths and using semiflexible joints to couple them together. The joints are a coarse threaded coupling type as shown in Figure 2. In addition to these requirements the joints had to be strong enough to withstand the weight of the 26 foot assembly when supported at the ends only.

In designing a drive for the core saw, it was necessary to provide both a rotary force and a thrust force to the core saw, each of which could be controlled independently. This was accomplished by a revolving piston and cylinder arrangement. See Figure 2. The revolving drive cylinder is rotated by an

electric drill motor through a shaft and bevel gear arrangement. The core saw screws to a base which is the piston part of the arrangement. The rotary force is transmitted from the drive cylinder to the piston by a keyway. The piston contains the key and the drive cylinder the keyway. The thrust force is applied to the core saw by air pressure. A small, electric motor-driven air compressor provides the necessary air pressure to the base of the drive cylinder through a copper tubing air line. The air pressure forces the piston outward. A very exacting fit is required between the piston and drive cylinder to maintain the necessary air pressure.

In withdrawing the core saw and sample from the cut, a vacuum is applied to the piston. This is accomplished by manipulating the compressor valves to make it operate as a vacuum pump.

In designing the bearings for the drive cylinder it was necessary to provide bearings that would operate dry and still serve as an air seal. Lubricants could not be used because of the possibility of leakage into the pile. Oilite bearings were initially used, but were replaced by ones made from Teflon plastic. The Teflon proved superior to the Oilite showing no tendency to gall or wear, yet producing an excellent air seal. An Oilite bearing has proved satisfactory for use on the drive shaft.

The design of the core saw has been more critical than any other part of the core borer assembly. A great variety of core saws were made and tested. To obtain a core sample of maximum diameter, approximately 0.400 inches, in a relatively short cutting time, less than 60 seconds, it was necessary to design a saw with the thinnest practical wall thickness. Saws with wall thicknesses from .092 inches to .010 inches were made and tested. To produce a saw with very thin wall thickness, .010 to .020 inches, that would not deform when the teeth were flame hardened, required a special non-deforming oil hardening die steel. A wall thickness of .015 inches has been adopted using this steel.

After experimenting with many saw tooth designs one with six teeth was adopted. The teeth are chisel pointed with a .005 inch variation in height between

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alternate teeth. This arrangement gives the proper depth of cut and unit pressure to produce a refined graphite chip size, necessary for proper chip removal. The teeth are cut to provide .015 inches external clearance, and no internal clearance.

A maximum hardness of 63 to 65 Rockwell is obtained by heating the teeth with a flame to 1475°F., dull red, and quenching in oil. The teeth must be sharpened with the same care and precision as a tool bit. Due to the extreme abrasive qualities of pile graphite, a core saw requires rather frequent sharpening. In KC graphite as many as twenty-five cuts may be made with one saw. Four or five cuts in the harder GBF graphite, and one cut in irradiated GBF graphite are all that are necessary to dull a saw.

After testing in the pile it became evident that some positive means of indicating when a cut was completed should be incorporated into the core borer. Since the core saws vary in sharpness and cutting speed with use, a fixed cutting time is not reliable in determining when a cut is completed. Variable graphite hardness also added uncertainty to the length of time required to make a cut. These conditions resulted in the loss of some cores because the cutting time was too short. In other cases time was lost because the cutting period was longer than it needed to be. An air flow indicating device was developed which satisfactorily solved the problem. The core borer was modified to incorporate this device by providing an air port in the wall of the drive cylinder, so that when the piston and saw were in the extended position the port was uncovered allowing air to escape. This escape of air increased the flow from the compressor causing the flow indicator to register a change. A pressure regulator prevents loss of pressure to the piston when the air port is uncovered, thereby insuring a complete cut.

CONCLUSIONS AND RECOMMENDATIONS

From both operational and research standpoints the data provided by graphite cores will make valuable contributions to the solution of expansion problems. It is recommended that a core sampling program be carried out in accordance with the Pile Graphite Monitoring Program. (5)

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