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CONTINUOUS CHAIN DRILL BIT DEVELOPMENTS

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ABSTRACT

Under DOE's Geothermal Well Technology Program, the Continuous Chain Drill Bit, in which fresh cutting surfaces are cycled into place without removing the bit from the hole, is under development by Sandia Laboratories. Fixed head bit testing has optimized cutting surface diamond patterns, developed adequate bit hydraulics, and solved the apex problem thru application of Stratapax[R] cutters in the bit nose. Prototype chain drill testing has demonstrated structural integrity, identified some hydraulic erosion and cycling mechanism problems, and confirmed superior drilling rate and lifetime performance to commercial diamond bits when drilling hard abrasive rock.

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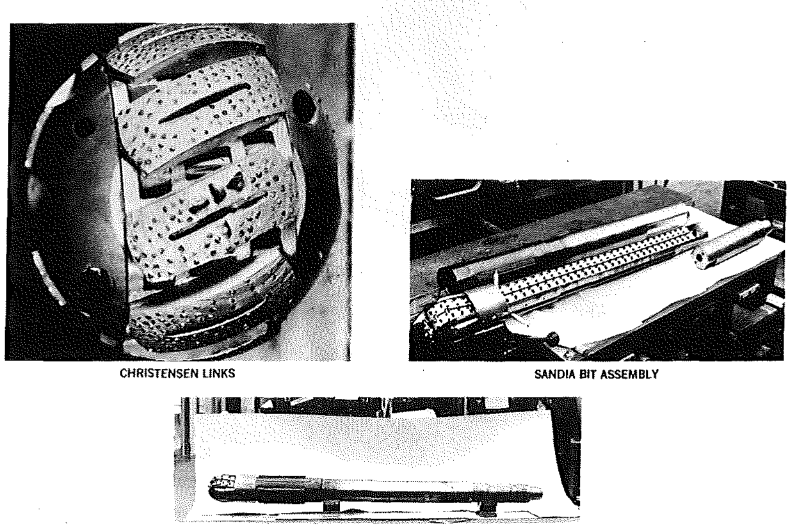
CONCEPT

A continuous Chain Drill Bit prototype is shown in Figure 1. The cutting structure consists of natural and synthetic (Stratapax[R*]) diamonds set in a tungsten carbide matrix. The four Stratapax[R] cut the center of the hole. The cutting structure is attached to links of a continuous chain. Five links constitute the cutting surface. There are sufficient links to replace the cutting surface 15 times before making a trip.

Drilling fluid pressure is used to cycle the chain downhole. To cycle, the bit is pulled off the bottom and the mud pumps are turned off. The pressure drop activates a spring, piston and pawl mechanism. The spring drives the piston to a reset position which engages the pawl in the chain. The rise in pressure from the restart of the mud pumps drives the piston, pawl and chain to a new drilling position, thus exposing five new cutting links.

CHAIN DRILL PROTOTYPE



CHRISTENSEN LINKS

SANDIA BIT ASSEMBLY

FIRST CHAIN DRILL PROTOTYPE

Fig. 1

*Trade name of General Electric Company

Drilling is done by a combination of bit load and rotation as in conventional rotary drilling

FIXED HEAD BIT DEVELOPMENT PROGRAM

The cutting structure design and bit hydraulics evolved in the fixed head bit development program, Figure 2. Ten fixed head bits that

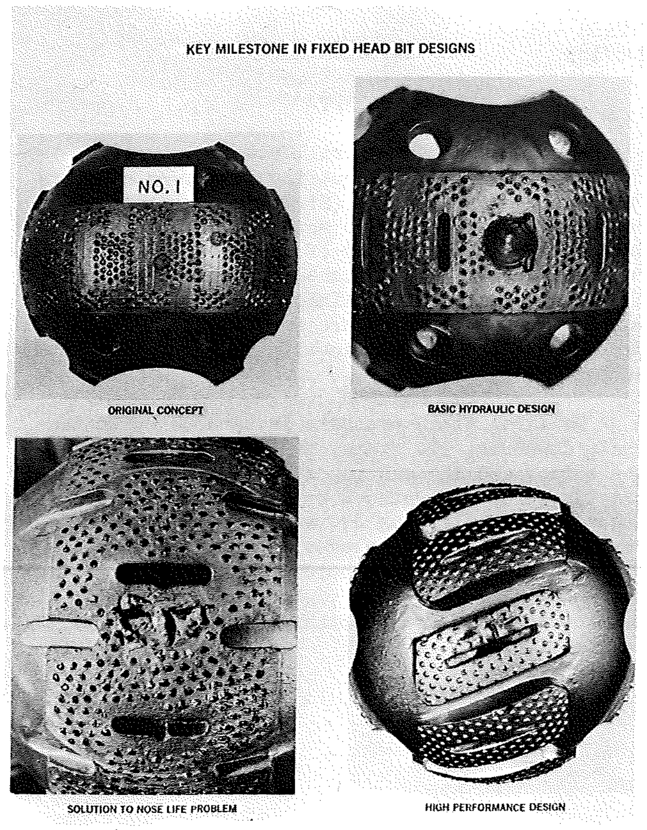


Fig. 2

employed eight different diamond configurations were built by Christensen, Inc. to Sandia's specifications. These fixed head bits were tested at the Reed/Terra Tek Drilling Research Laboratory. Christensen provided consulting services on the eighth fixed head bit design. This design has been incorporated into the present chain link design. A conventional hard rock diamond bit provided comparative rate and lifetime performance data.

*Development of improved Stratapax[R] bonding procedures and optimization of cutting surface rake angle was accomplished under funding from DOE's Division of Oil, Gas, Shale and In Situ Technology.

The final cutting structure design employs several unique design features:

1. Stratapax[R] are used in the nose of the bit.* This eliminated the nose area as the life limiting factor and increased the instantaneous penetration rate for a fixed bit load.

2. A modular hydraulics design was incorporated which significantly improved bit cooling and cleaning. An increase in drilling life while drilling with a higher bit load resulted.

3. A lighter-than-normal balanced diamond set was incorporated. Uniform wear rate and a load of 120 pounds per diamond (equivalent to 15,000 pounds maximum bit load) were the design criteria. This resulted in fewer diamonds per square inch (compared to conventional bits) which increased penetration rate for a given bit load with little loss in bit life.

Test results of the fixed head bits are summarized in Figure 3.

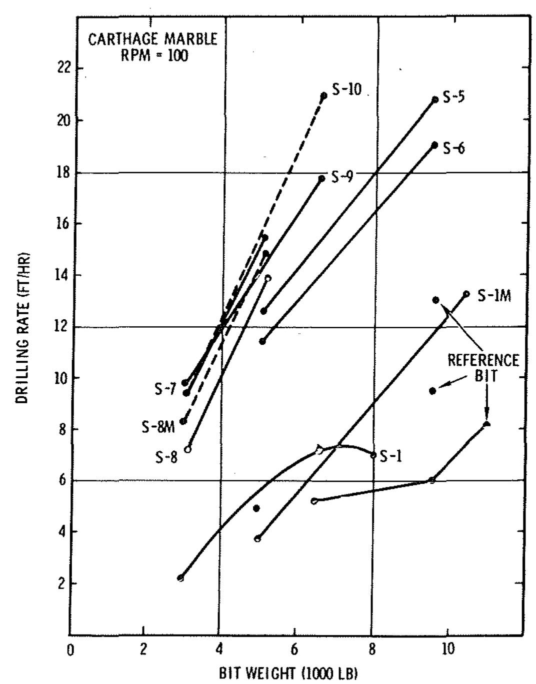


Fig. 3

CHAIN DRILL PROTOTYPE

A prototype 4 3/4 in. diameter chain drill was designed and fabricated at Sandia. This bit was tested at the Reed/Terra Tek DRL utilizing Christensen-built chain links. Chain links of an alternate design have been built by NL Hycalog and are being prepared for evaluation.

Testing of the prototype was done at room temperature and atmospheric pressure in Sierra White Granite at 100 rpm. Bit loads were varied to maintain a 4 ft/hr penetration rate. Testing was terminated when the required bit load exceeded 15,000 pounds.

The prototype bit was tested in September 1977. The footage drilled versus bit load for all tests is shown in Figure 4.

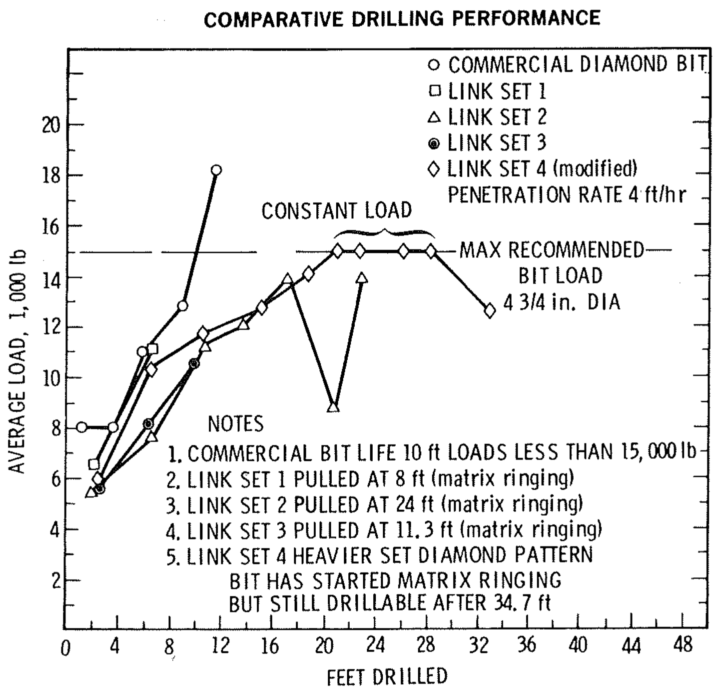


Fig. 4

The diamond cutting surfaces for links No. 1, 2, and 3 were specified to be identically set. Insufficient diamond coverage in Link Set No. 1 and No. 3, however, resulted in early ringing of the matrix causing reduced drilling performance. Link Set No. 2 performed best of the first three link sets, but ringing also terminated this test. Additional diamonds were added to Link Set No. 4. Performance of these cutting surfaces was outstanding.

Some fluid erosion problems were noted but these can be easily corrected with harder materials and increased openings of the fluid entry holes. The chain cycling mechanism was overly sensitive to fluctuations in drilling fluid pressure. Current emphasis is directed at improving the reliability of the mechanism. Overall, the chain bits out drilled the control bit by about a factor of two on the average with generally lighter bit loads.

ECONOMIC COMPARISONS

Using the depth versus time data generated in the prototype drilling test series, minimum cost per foot calculations have been made. A summary of these calculations is presented in Figure 5 which shows footage cost savings relative to a conventional bit versus starting depth.

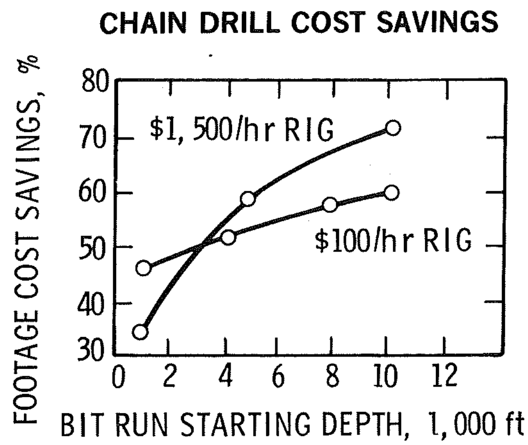


Fig. 5

The chain drill offers appreciable cost savings on all conditions considered.

CONCLUSIONS

1. The chain drill structural design has been proven adequate in laboratory testing.

2. The diamond set chain links have achieved notable penetration rates and lifetimes.

3. Fluid erosion is not considered a problem.

4. The chain cycling mechanism has been demonstrated but improved performance is needed.

5. Based on laboratory data, economics of the system appear attractive.

The cutting structural design has features that could improve conventional diamond bits, such as:

1. Stratapax in the nose area of the bit.

2. Modular hydraulic design.

3. Minimum diamond set pattern to obtain increased rilling rates and uniform wear rates.