DESIGN OF A DRILL TO WORK IN A FLUID FILLED HOLE

by

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ABSTRACT

Since core quality rather than hole closure limits the maximum depth capability of a dry hole, we are constructing a modular drill compatible with a dry drill to work in a fluid.

Use of standard industrial equipment such as sludge pumps and well screen keep the cost of this drill relatively low. Because of its robust nature, this drill should also be able to penetrate subglacial material.

Results of the test this summer in Greenland wil be presented.

Suggestions for drilling fluids and their relation to personnel, environment, and core quality will be considered.

INTRODUCTION

Since core quality rather than hole closure limits drilling depth man open hole the logical solution is to add fluid to compensate for overburden pressure. The fluid also aids the drilling process by enhancing chip removal and damping vibrations in the drill.

The current drill design is based on incorporating pumping and filtering mechanisms in an existing dry drill design. Core size has been increased to 13 cm so a greater volume of ice can be retrieved in each sample.

An instrument package has been incorporated in the drill to monitor drilling progress and will be upgraded to provide a feed back loop that will assure smooth penetration control (Hancock, 1988).

Selection of a drilling fluid is still underway since chlorinated hydrocarbons are toxic as well as potential sources of contamination for many of the ice chemistry analysis. See Appendix A for selection criteria.

In 1984, a practical limit to open hole drilling was reached in the 200-300 m range. Beyond that depth the ice becomes brittle, largely due to high bubble pressure in the ice. One can only go so far in perfecting the drilling process before solutions become too costly.

Addition of a hole fluid to compensate for the overburden pressure helps by decreasing the defiance of basic physical laws. Additionally chip removal is done gently rather than by the brute force technique of spiral auger flites. Another benefit is the lubrication provided between ice core and barrel as demonstrated by tests this past summer in Greenland.

Past experience drilling in ice saturated by water has demonstrated that current dry electromechanical drills will work in an ice/water slurry and recover good quality core. Extrapolating to a diesel fuel/ice clurry thus becomes a reasonable choice. All that is needed is to pump less than 10 % by volume of chips into a filter where the excess fluid is extracted and returned to the drill hole.

Rather than worry about pumping slurries of narrow viscosity ranges, a pump that can handle a wide range of viscosities was selected. In addition a pump that works in the long axis of the drill makes design much easier. Hence selection of a progressive cavity Moyno pump becomes the choice. This pump handles anything from air to peanut butter as well as chunks of material with no clogging or damage. The only penalty is a power requirement approaching 1,000 W to overcome friction caused by deforming the stator. Pump and drill operate in the same rotation speed range of 60-150 rpm. Since the drill produces about 4 liters of chips per minute a 40 l/min pumping range is desirable which suggests an outer diameter of 16 cm. Thus the selection of 13 cm core size.

The filtering mechanism is borrowed form the water well industry. Johnson stainless steel well screens with a gap of 0.2 mm filter out sand and clay size particles with no pressure drop across the screen. This screen is robust, straight and sufficiently strong to be incorporated directly in the drill with no added support structure.

Tests in the field and test wells have shown that both the pump and screen perform as expected. The pump will handle ice chunks and the screen filters the finest snow particles with no evidence of any particles passing through.

A schematic of the drill appears in Figure 1 giving general locations of components. Core barrel and screen length can be varied to suit the application. Maximum length of each is approximately 5 m which seems adequate for drilling to 3,000 m.

A high pumping rate and open system design allows drill design to proceed without need for seals of any kind. A few leaks are acceptable. Likewise the motor and gear reducer sections are allowed to fill with fluid. Tests of 100 hrs operating in DFA has shown no degradation of motor performance.

Mechanical portions of this drill are perhaps easiest to design. The addition of a navigation package is one of the design features of this drill necessary to keep track of drilling processes once drill depth has reached a point where the thumb on cable method is no longer adequate. A presentation of the capabilities of this package and suggestions for future updates will be presented later in this symposium.

Good penetration control is essential to good core quality. At depths beyond 1,000 m we feel that a feedback loop will be necessary to balance weight on bit, penetration rate and torque to drill head. Because of cable elasticity, current wisdom suggests accomplishing all this on the drill rather than trying to work it through a winch driven system. The exact method is unclear yet.

Drilling deep core will also require taking oriented core for physical properties studies. By monitoring drill orientation with a fluxgate magnometer and relating that to drill barrel position through an angular transducer, the process is straight forward. Marking the core will be accomplished by marking one of the core dogs.

Currently a 1,000 m winch is used to work with this drill. This winch weighs 700 kg complete and can be moved with two skidoos. Thus core can be drilled into new scientifically interesting areas without the need for heavy support equipment.

A 15 kW Lister diesel generator set turbocharged to provide sealevel power to 20,000 ft was used this past summer with no failures. This was coupled to a 15 kw permanent magnet Dc motor through auto transformers, a bridge rectifier and a choke. The system is capable of pulling over 1,000 kg without any evidence of weak links.

The cable, supplied by Cortland Cable of New York has four # 18 power conductors and three # 24 signal conductors. A 5,000 kg strength member is consistent with a working load of up to 500 kg or 1/10 the breaking strength. Since the wires are all spark tested to 3,000 VDC and sliprings rated to 1,000 VDC there are no anticipated weak points in a system designed to work at 560 VAC.

To compensate for increased cable length, voltage is stepped up to a maximum of 560 VAC for transmission through the cable. Toridal transformers located above the drill reduce the voltage to make it compatible with the motor windings. After stepdown the AC is converted to DC and run through on inductor to improve the quality. Reversing switches are also incorporated as part of the downhole instrument package.

RESULTS

As expected, 13 cm core is more robust and generally superior to 10 cm core. This is largely due to having more volume to resist forces generated by drilling and relief of the overburden pressure. Because of the efficiency of the core dogs little additional force is required to break the core at the end of a drilling run.

The 13 cm diameter core is easy to handle and work with provided length is kept to the 1 m range. There is less likelihood of core breakup during processing and it appears there is enough core to support two investigators with one core thus reducing drilling requirements considerably.

Tests in the PICO test well and pumping and filtering tests performed in the field have demonstrated the ability of the pump and filtering mechanisms to perform their tasks. The drill and screens now can be scaled up to a length that will allow retrieval of three meter cores first then six meter cores. As always more testing is required but to date there are no surprises.

CONCLUSION

13 cm core is a reality in dry or wet versions. The question now is how deep and should we consider 15 cm core ?

ACKNOWLEDGEMENT

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REFERENCES

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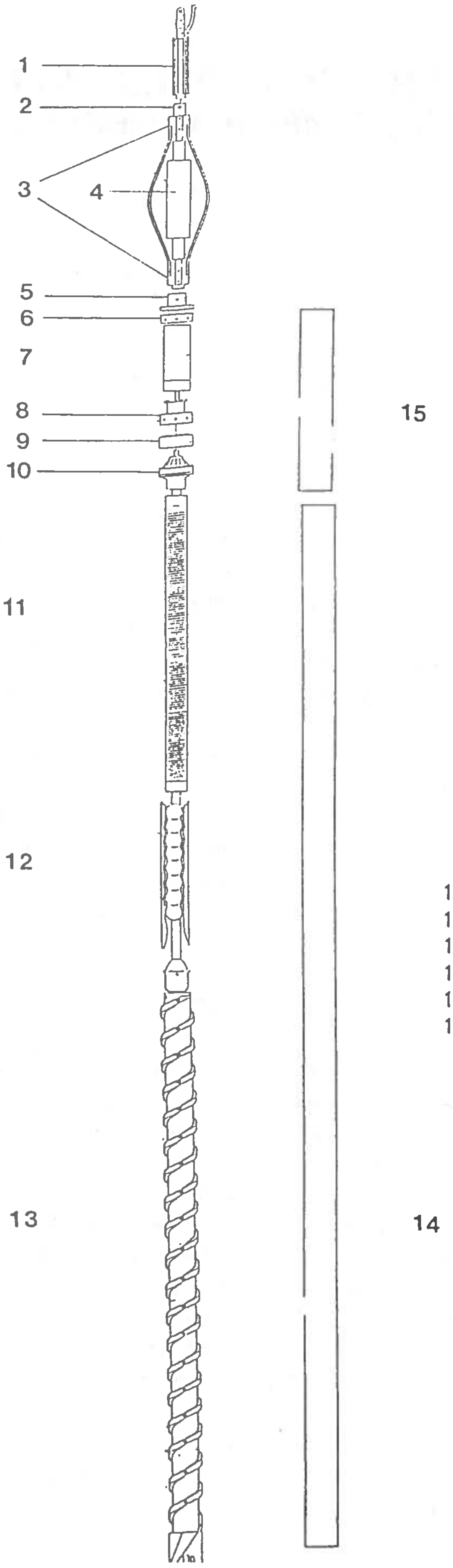

Fig 1.

1 slip ring
2 anti torque tube
3 sliders
4 instrumentation package
5 antitorque support
6 motor tubing end
7 motor
8 4" drill adaptor
9 input side flange
10 gear reducer
11 Johnson well screen
12 Moyno pump
13 inner barrel
14 outer barrel
15 outer can