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OPERATIONAL CONSIDERATIONS OF THE U.S. DEEP CORING ICE DRILL

M. A. WUMKES

Polar Ice Coring Office, 208 O'Neill Building, University of Alaska Fairbanks, Fairbanks, Alaska 99775-1710, U.S.A.

Abstract: The development of the 13.2 cm (5.2 inch) U.S. deep coring ice drill has required new approaches to the drill operation and handling. Large diameter cores 6 m (20 feet) long have dictated a change in the scope of not only the drill handling but core handling as well. A drill handling system has been designed and refined to accommodate these large cores. New drilling fluids have re-defined operational procedures in regards to safety and environmental concerns. These new drilling fluids have also forced investigators to incorporate recycling procedures due to the high costs of the drilling fluid. These and other factors are discussed as related to drilling operational requirements.

1. Introduction

The development of the 13.2 centimeter (cm) ice coring drill for use in a fluid filled bore hole has required that the drill and core handling operations be re-evaluated. (KOCI, 1989) In the past, drills produced cores of approximately 10 cm diameter. Cores of this size, as well as the drills designed to retrieve them, could easily be handled by hand in the field. Increasing the core diameter allows a more extensive sampling and analytical protocol to be adopted while allowing an archive sample nearly the volume of the 10 cm core.

Utilizing the larger core diameter of 13.2 cm provides additional advantages and disadvantages in regard to drill design and operation. The increased diameter makes the ice core more robust and durable. The increased core diameter creates handling problems due to the weight of a 13.2 cm core in lengths of up to 6 m (approximately 20 kg per m). Handling of the drill sections by hand is no longer a viable option. A drill and core handling system needed to be designed and developed in order to safely handle the drill components and operate the ice core drill.

2. Drilling Fluid

Initial design constraints begin with the choice of drilling fluid. Recent deep drilling projects involving U.S. investigators have favored the use of kerosene mixed with a densifier, usually perchlorethylene (PCE) or trichlorethylene (TCE) as a drilling fluid.

Recent health and environmental considerations have caused a re-examination of possible drilling fluids in an effort to locate a fluid that would pose a reduced health risk as well as address environmental responsibility. The drilling fluid chosen was n-butyl acetate. (GOSINK *et al.*, 1991)

The use of n-butyl acetate does away with the need for a densifier. The temperature density curves for laboratory grade n-butyl acetate closely match the curves for ice thus making it a desirable fluid for preventing bore hole closure due to overburden pressure and plastic deformation. It does, however, have characteristics that need further consideration. Some common seal and o-ring materials are chemically attacked by exposure to n-butyl acetate. All drill components must be closely examined for materials compatibility before being incorporated into the drill design. Fortunately, butyl acetate is a common industrial solvent and several readily available materials lend themselves well to use with butyl acetate. Most o-rings, seals and gaskets are easily replaced with compatible substitutes.

The cost of purchasing and transporting enough drilling fluid for a larger diameter core is also an important factor in consideration of an over-all drill operation. The higher cost makes it necessary to recover and recycle as much of the drilling fluid as possible. This factor was carefully considered in the operational approach of the drill handling and drill fluid recovery system. Increasing environmental concerns dictate even closer examination of operational priorities and protocol.

3. Chip Handling

As a result of the desire to recover large diameter core in lengths of up to 6 m, conventional drill handling procedures had to be re-examined. The kerf of ice that is removed during the coring process is nearly the same volume as the core itself. If 6 m core lengths are desired, an equivalent chip retaining capacity must be incorporated into the drill design. Also involved is the volumetric increase of ice as chips are produced by the cutting process. As observed at GISP2, a screen volume of approximately 1.5 times that of the core volume is necessary.

The GISP2 drill uses a modified well screen to capture the ice chips produced as a result of the coring operation. The chips are pumped into a screen section where the drilling fluid can flow back into the bore hole and the chips retained in the screen for transport to the surface. The chips are removed from the screen section at the surface by using an electric vibrator.

A key element in the chip handling process is the coupling mechanism used to connect drill string components. It allows workers wearing protective clothing to efficiently make the connections and disconnections of the various drill components quickly and safely. The coupling is very rigid, minimizing the tendency of the drill string to wander. It has a positive safety latch mechanism which prevents loss of drill string components if the coupling is not seated or not tightened properly due to ice or chip slurry. Also incorporated in the design is an adequate chip path that allows quick and efficient screen cleaning. The coupling design used on the GISP2 drill was produced by Larry V. Kozycki of the Geophysical Institute machine shop at the University of Alaska-Fairbanks. The chips are caught in a large hopper beneath the drill platform. A 15 cm auger transports the chip slurry out to an area where the chips are centrifuged to recover any butyl acetate trapped in the slurry. The centrifuging of the chip slurry recovers approximately 95% of the butyl acetate contained in the chips. This recycled butyl acetate is then re-used in the bore hole. This recycling procedure has more than paid for the equipment necessary for this process.

4. Drill Handling

The use of butyl acetate as a drilling fluid accentuates the need for ergonomically sound system design because of the requirement of wearing not only heavy Arctic clothing but also respirators and protective gear (Fig. 1). Design options must consider ease of operation while wearing these types of protective clothing.

The GISP2 drill is approximately 27.5 m in length and weighs 730 kg when configured to take 6 m long cores. The core barrel assembly and screen sections are all approximately 6 m in length and weigh 90 kg of more each. These sections must be assembled and disassembled in the course of each drilling run. Drill components of this

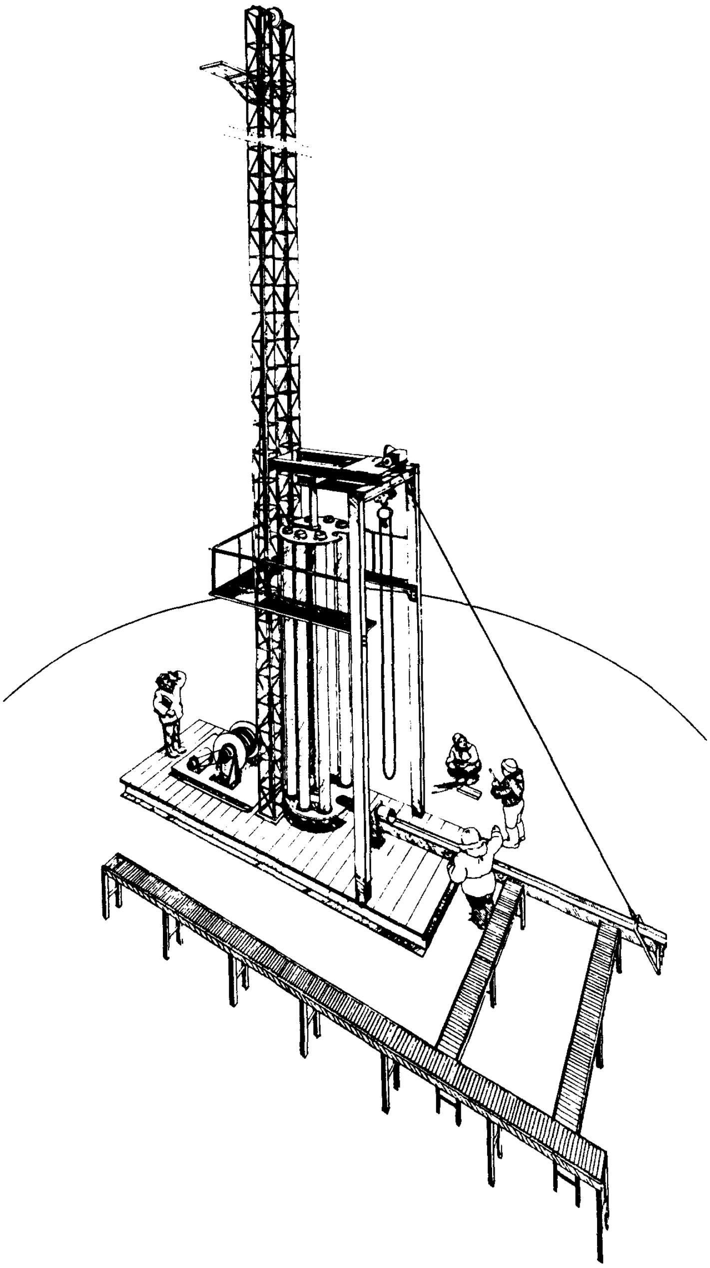

Fig. 1. PICO 13.2 cm ice core drill handling system.

size and weight cannot be handled without the use of proper drill handling equipment.

To deploy a drill of this length and weight it was necessary to develop a method to handle the drill components safely and efficiently. The procedure of dismantling the drill string while hanging in the hole was discussed but rejected because of the high risk of dropping drill parts in the bore hole. The production of a 3000 m ice core would entail hundreds of connections and disconnections of the drill components. A revolving carousel type storage rack was developed to handle the drill string. This allowed the drill to be handled in a vertical mode with the advantage that core removal and screen cleaning could take place after the drill was re configured and making the return trip down hole for the next coring run.

The carousel was designed to have eight storage positions for drill components. This allows two sets of screens and core barrels to be available so rapid turn around at the surface could take place. The components that need servicing could be quickly changed out at the surface and any servicing including screen cleaning and core extraction could take place while the reassembled drill was being sent down for another run.

The only drill component that requires handling in a horizontal position is the core barrel assembly containing the ice core. After the core barrel assembly is disconnected from the drill and placed in the carousel it is placed in a horizontal tilt table which lowers it to a horizontal position. The core barrel assembly is then disassembled and the core pushed out into a 6 m long core tray where final inspection and logging can take place. After core removal the core barrel assembly is reassembled and raised back into a vertical position where it can be placed back in the carousel. This can all be accomplished while the drill string is going down for another coring run.

5. Safety

As the size of the coring drill increases, so too does the risk of handling heavy drill components. The need for protective clothing against cold and butyl acetate adds to the importance of adequate safety procedures in the drilling process.

As a result of the added clumsiness of the protective gear, every effort was made to reduce the number of hand movements necessary that would put the drilling crew at risk of injury. The need for a protective respirator complicated the important need for the drill crew to communicate with the drill operator. To overcome this problem, small FM communications radios were used. These radios utilized an ear microphone that acted as both microphone and earphone. This allows hands free communication during the procedures when both hands are needed to make drill connections.

Every activity during the assembly and disassembly process must be announced and responded to during drill operations. The use of these radios makes safe operations possible.

6. Testing

The design of deep coring devices for recovering ice cores from fluid filled holes has been an evolutionary prospect. It is this evolutionary nature that brings importance to the need for adequate pre-field testing. This is especially true for developing the operational procedures necessary to implement a deep coring program. Not enough emphasis can be placed on the need for adequate testing and modification periods to further refine and polish drilling technique. Drill design is only a portion of the deep drilling process. It must be complimented with well thought out and proven techniques to avoid difficult and costly field solutions to design changes that are easily solved when not in the field.

7. Conclusion

The proper design of a deep coring drill is only a portion of a deep coring program. The development and implementation of proper, safe and efficient operating procedures is just as important as design considerations. Proper testing must be done to enable affordable solutions to design changes without seriously impacting field operations. It has been proven at GISP2 that many drill operation requirements can be addressed in a safe and effective manner despite the large size and complexity of the coring drill.

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