

# ANTI-TORQUE SYSTEMS OF HOT-WATER ICE-CORING DRILLS WITH POSITIVE DISPLACEMENT MOTOR

Hot-water drilling is the fastest method of drilling through ice, with penetration rates typically ranging from 40 to 60 m/h, and in some cases reaching as high as 200 m/h. Currently, hot-water drilling is being actively used to observe ocean cavities beneath ice shelves, study internal ice structures, measure temperature and deformation within the ice, and clean access subglacial lakes. In general, hot-water drill drills are full-face (non-coring) drilling tools that can only produce meltwater and the borehole itself. To recover ice cores from desirable depths, specialized hot-water ice-coring drills can be used in combination with a full-scaled hot-water drilling system. However, the recovered cores suffer from water circulation issues (Liu et al., 2021).

In an attempt to overcome this limitation, mechanical hot-water core drills with a positive displacement motor which has been proposed (Das et al., 1992; Koci, 1994). These systems can be used to recover core samples not only from the clean ice but also from debris-rich basal ice, subglacial till, and bedrock. The preliminary laboratory tests have shown a high potential for the use of mechanical hot-water core drilling technology for ice coring (Liu et al., 2020). The main challenge of this technology is the reliable design of an anti-torque system to prevent the upper, non-rotating part of the drill from spinning in a large, irregular borehole. The robustness of the anti-torque system is essential, as failure of this component could lead to the twisting and breakage of the hose in the absence of a hydraulic swivel.

In order to design a more reliable and efficient anti-torque system, two different structures are designed for comparison. The first one is to control a part of hot water through an electromagnetic valve, allowing it to be sprayed out centripetally through small nozzles to form anti-directional jets to balance the torque generated during mechanical drilling. The other part of hot water is used to maintain mechanical drilling with a positive displacement motor. The flow rate of the jets is automatically controlled based on the feedback from the encoder that measures the rotational speed of the upper part of the drill. The second one is to design multiple rectangular blades on the surface of the motor or other components that do not rotate with the drill bit to increase the resistance generated during rotation, in order to balance the torque generated during mechanical drilling. The report presents estimations of the torque required for drilling ice and bedrock as well as maximum holding torque for both designs, to choose the suitable structure for further testing.

**Primary author:** YANG, Yang (Jilin University)

**Co-authors:** TALALAY, Pavel (Jilin University); FAN, Xiaopeng (Jilin University); ZHANG, Nan (Polar Research Center, Institute for Polar Science and Engineering, College of Construction Engineering, Jilin University); GONG, Da (Polar Research Center, Institute for Polar Science and Engineering, College of Construction Engineering, Jilin University); WANG, Ting (Jilin University); HONG, Jialin (Jilin University); Mr WANG, Liangyu (Jilin University); Mr ZHENG, Xianhe (Jilin University); Mr ZHANG, Xu (Jilin University)

**Presenter:** YANG, Yang (Jilin University)

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