

**DWS70**

**Water-cooling Electromagnetic Eddy Current Brake**

# **Operational Instruction**

## 一、Features And Structure

DWS70 eddy current brake is designed for use as an auxiliary brake of onshore or offshore rig with rating drilling depth of 7000m. It can be supplied with drawworks package or supplied as a separately matching unit for an existing rig on oilfield.

### 1. Technical Specifications

Torque	110000N.m
Drilling depth(with 4½" drill pipe)	7000m
Principle of operation:	induction eddy current braking
Number of coil:	4
eddy current brake resistance of each coil(AT20℃):	10.722 Ω
Coil insulation:	Class H
Exciting power	23Kw
Exciting current(4coil parallel connections):	80A
Cooling water required:	560L/min
Max temperature of outlet water	
(at the temperature of intake water 42℃):	78℃
Weight:	11000kg

## 二、Electrical Equipment

The wind-cooling electromagnetic eddy current brake is composed of three parts, i.e., the main body of brake, silicon controlled rectifier and switch for driller.

### 1. Main Body of Brake:

It is composed of two basic parts, which are shown as Figure I. One is the static part and called stator; the other is the rotary part and called rotor. There is certain gap, which is called working gap, between the stator and rotor. The main body of the brake of the wind-cooling vortex brake adopts the form of external armature structure, which is to say that its rotor rotates outside the stator.

The stator of the brake is composed of magnetic pole and exciting coil. The magnetic pole is a part of the magnetic circuit and made of electric steel whose magnetic permeability is high and coercive force is small so as to meet the requirement for big useful braking torque while tripping and small useless braking torque while hoisting. The exciting coil, which is fixed at the magnetic pole and electrified at work, is the circuit part of the brake and forms an entirety with the magnetic pole to become the stator. Because the brake will generate a large amount of heat in action, the exciting coil is adopted with fire-resistant electromagnetic lines and corresponding insulating materials to ensure the coil to still have good insulating performance at high temperature.

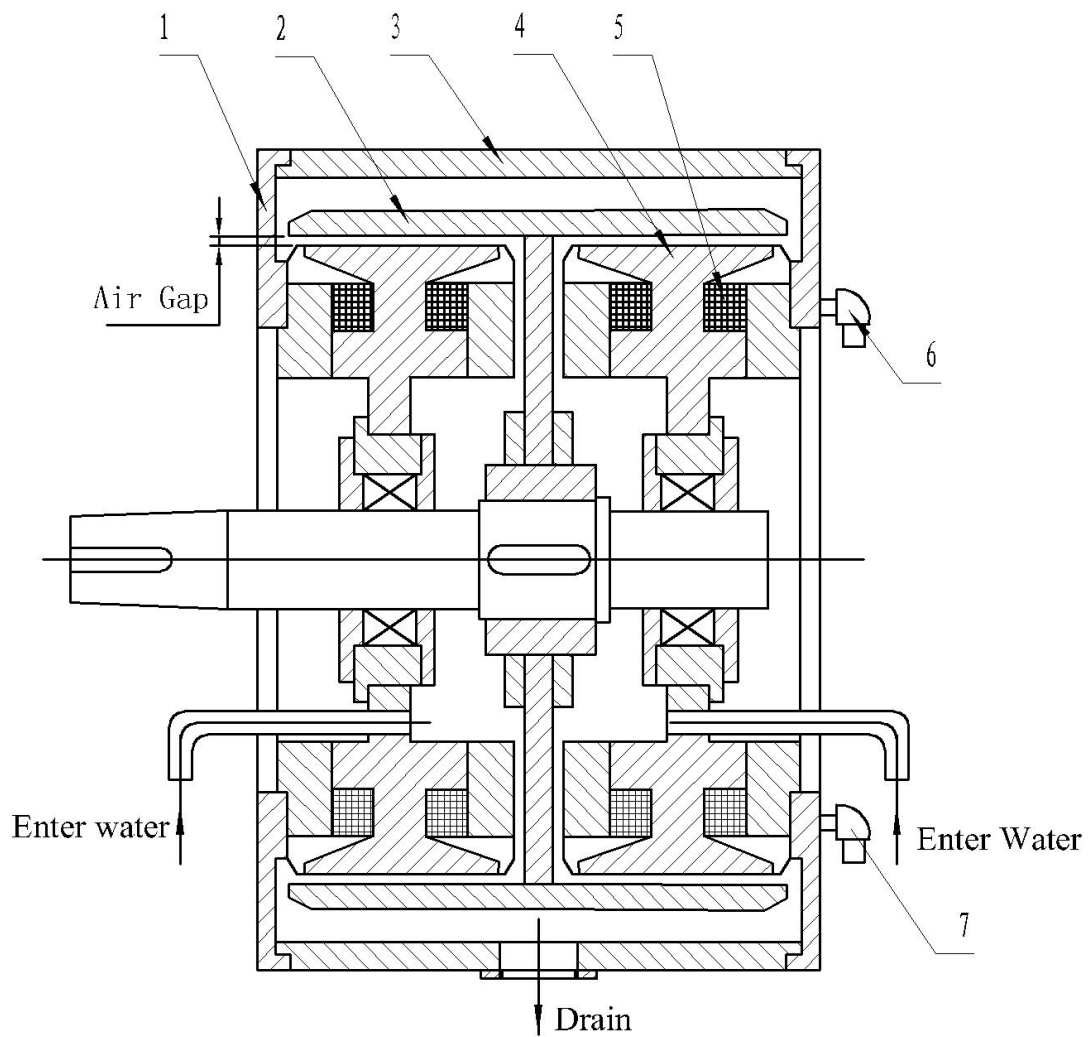


Figure I Structural Schematic Electromagnetic eddy current brake

1. End Cover 2. Rotor 3. Base 4. Stator 5. Exciting Coil  
6. Upper Breather 7. Lower Breather

The rotor of the brake connects with the winch barrel spindle through claw clutch or tooth clutch, is driven by the winch barrel, and rotates with the barrel at the same speed. The rotor is not only a part of the magnetic circuit but also a part of the electric circuit, and is made of the electric steel. The magnetic pole of stator, working air gap and rotor compose a complete magnetic circuit of the brake.

## 2. Silicon-controlled Rectifier:

It is composed of rectifying transformer and silicon-controlled half-controlled bridge rectifier circuit. And it is used to transform the AC voltage supplied by the AC generator of the drilling machine or AC network into adjustable DC voltage so as to supply the adjustable DC current to the exciting coil. Considering the requirement for the indicators with respect to the setting accuracy of tripping speed, stability of regulating system and dynamic quality in transient process is not high while using the wind-cooling electromagnetic eddy current brake in tripping operation, the relatively simple closed-cycle regulating system can meet the requirement of the drilling technique. Through adjusting the DC current of the exciting coil, the braking torque of the brake can be regulated so as to change the lowering speed of the drilling tool.

## 3. Switch for Driller:

It is actually a set of adjustable differential transformer and composed of iron core, coil and regulating gear, etc. Transform the change of the position of the iron core into the change of AC signal voltage as the given signal voltage through bridge-type rectification to control the angle of current flow of silicon controlled rectifier so as to attain the purpose of changing current and voltage,

On the two sides of the housing there are four breathers to remove condensed water in the four stainless steel guards and two grease fitting to lubricate the bearings.

The end of the output shaft has a diameter of (of 7.5inch), and a taper of 8:77 The overall dimensions of the brake are:

Length:	1346mm(53" )
Width:	1860mm(73" )
Height:	1860mm(73" )

## 三、Cooling System

The eddy current brake and the drum of the drawworks share the use of the water cooling system. to provide the cooling water by a water pump.

The cooling water passing through the brake flows back to a water tank of 40m<sup>3</sup> volume for the purpose of heat release. The brake needs 560L/min of cooling water in order to ensure the water temperature at inlet and outlet of the eddy current brake within the specified range. The

flow chart of the cooling system is shown in Fig .2.

The requirement for the water quality is that water contains Lower Minerals(PH value less than 7-7.5).That is similar to the requirement for the cooling water used in the water jackets of internal-combustion engines.If the water does not conform to the requirements,it should be treated with chemicals,For offshore application the brake can be equipped with a specially designed seawater cooler.

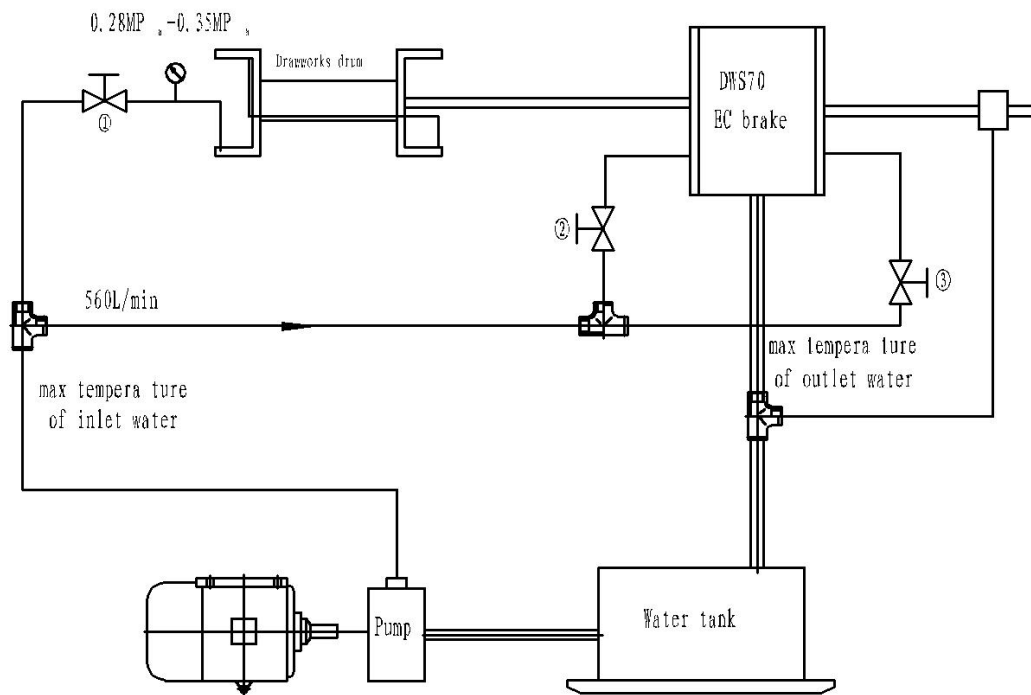


Fig2 water cooling system

Notes:

1. Open the valve①.
2. Close the valve②Adlust the valve③to an output of 280L/min  
then open the ②up to an out put of 560L/min.
3. fasten the stems of the valve ②and③to the valve bodies and remove the nand-wheel.
4. the brake' s outlet water pipe shall be unblocked to prevent the water from entering the bearings.

#### 四、 Installation

The brake has a support with itself. It can be directly installed to the drawworks of 7000 meters. When used for other rigs, this support should be replaced. At the end of the brake shaft, there is a tooth-clutch which is connected with the drum shaft. Warning. It is unnecessary and impermissible to use overrunning clutch, as the rotor of the brake must rotate synchronously with drum shaft in two different directions in order that the rotor can be cooled off by the water flowing through it.

The cooling water from the brake passes through a funnel and returns to the water tank. Some distance needs to be kept between the funnel and outlet to ensure free discharge of water. For lack of return water pump in a position the water tank should be installed somewhat below the cooling water level in the eddy current brake so that the cooling water can flow back automatically. Each side of the brake has a 1 ½ " overflow tube. The tubes should not be blocked up to prevent the internal water level from rising and bearings from rusting.

#### 五、 Operational Principle

Electromagnetic eddy current brake is also called the electromagnetic eddy-current brake. It is a kind of non-frictional energy conversion device which transforms the huge mechanical energy generated during the tripping of drilling tool into electric energy, and then transforms the electric energy into heat energy. This kind of energy conversion and strong braking process is completed through the principle of electromagnetic induction but not through the friction type or other formed frictional force, so the brake has no any wearing parts. water-cooling vortex brake performing absorption and exchange through aqueous medium.

When the brake is at work, electrify the DC current into the exciting coil, and then there will be magnetic fluxes connected between the rotor and stator, which makes the rotor exist in a closed loop circuit in the magnetic field. The magnetic lines of force generated by the magnetic field form a closed loop circuit through magnetic pole → air gap → armature → air gap → magnetic pole. Shown as Figure II, while tripping, the winch barrel rotates, and the rotor rotates in the magnetic field established by the stator through clutch drive at the same speed. In this magnetic field, the distribution of the magnetic lines of force is relatively dense in the tooth part (the part of salient pole) of the magnetic pole, however, the distribution of them is relatively sparse in the slot part (the part of inter-tooth space) of the magnetic pole, therefore, along with the relative motion of the rotor and stator, the magnetic flux at each point of the rotor will be in a certain situation of continuously repetitive changes. In other

words, the magnetic conductance of the rotor along the circumference of the working air gap is unequal due to the tooth part and slot part of the magnetic pole, if pulsating magnetic field established in the space, the induced electromotive force will emerge on the rotor according to the principle of electromagnetic induction, and under the action of this induced electromotive force, the vortex will be generated in the rotor. The vortex and stator field interact to generate electromagnetic force whose direction is determined by the left-hand rule, this force is along the tangent direction of the rotor and reverse to the rotation direction of the rotor. The torque formed by this force to the axle center of the rotor is called electromagnetic torque, i.e., the braking torque of the electromagnetic eddy current brake stopping the barrel from rotating. By means of regulating the handle position of the switch for driller, the drill operator can adjust the exciting current, change the braking torque, and thus accomplish the purpose of controlling the lowering speed of the drilling tool.

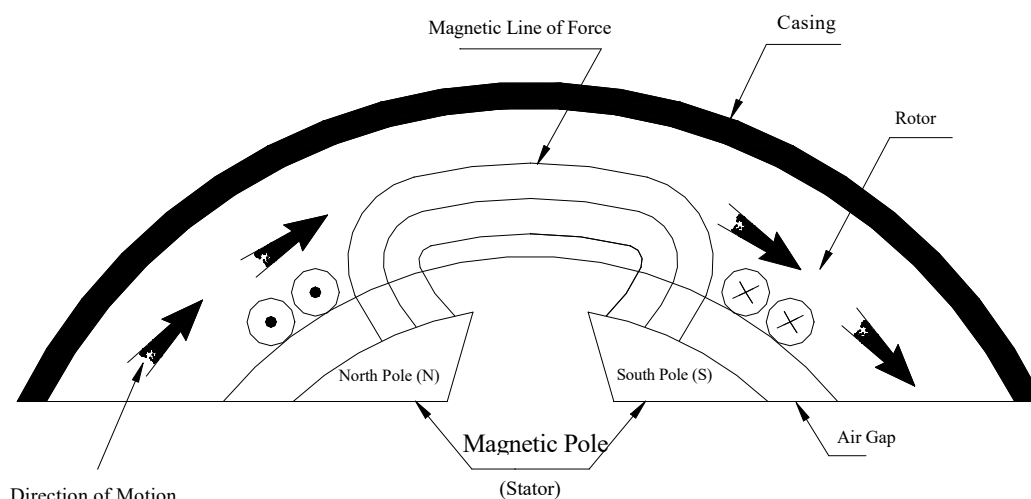
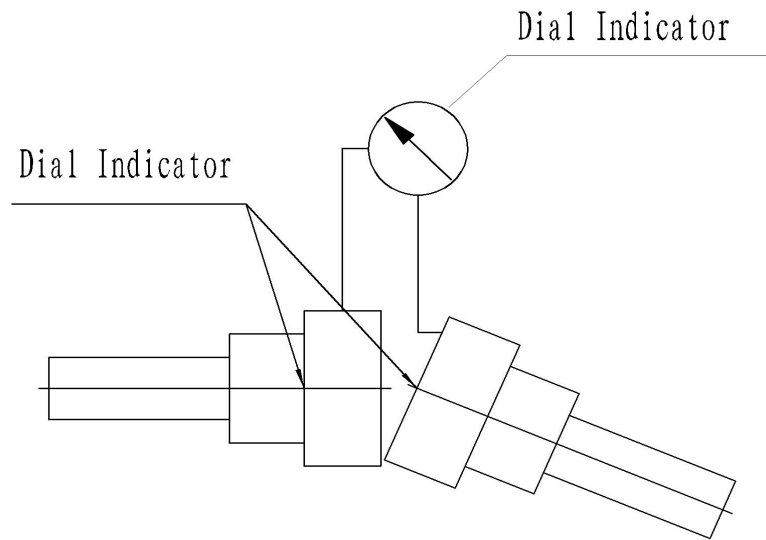


Figure III Operational Principle Schematic of  
Electromagnetic eddy current brake

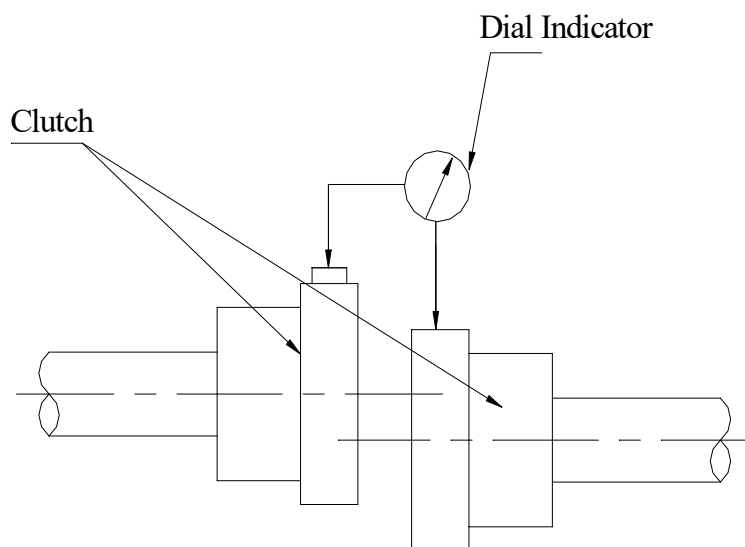
## 六、Installation and Adjustment

1. After unpacking the electromagnetic eddy current brake, first check whether the three parts, i.e., the main body of the brake, silicon controlled rectifier and switch for driller, are undamaged; whether the rotor of the main body of the rotary brake can rotate smoothly, the operation of the claw clutch or tooth clutch is flexible, whether the components and wiring of the silicon controlled rectifier are loose, and the components and parts are damaged; and whether the rotation of the control handle of the switch for driller is mobile. Subsequently,

perform installation, wiring and adjustment on the basis of exterior inspection qualified.



Angular Error Adjustment



Level Error Adjustment

Figure IV Spotting of Electromagnetic eddy current brake Axle and Barrel Spindle



2. Hoist the main body of the vortex brake on the winch base and mount it in the place of the original water brake. Use claw or tooth clutch to connect between the brake axle and winch barrel spindle. At the time of installation, the strict spotting of the axes of the vortex brake axle and winch barrel spindle must be ensured, and their right-alignment error shall not be more than 0.25mm. In accordance with the method shown as Figure IV while spotting, use the dial indicator to check the angular error and level biased error, and perform adjustments between the brake and bottom plate with spacer under the aid of four forcing-off screws on the bottom plate of the vortex brake. At the time of field installation and regulation, if there is no dial indicator, the steel board rule and plug gauge can be used to carry out tests, and the indicating needle can also be used to check their bouncing amount in four radial directions along the circumference against the end plane of the clutch. If the centers of the vortex brake axle and winch barrel spindle are not spotted or have quite big errors, the bearing load will be increased, which will cause the bearing to be worn at early stage till damaged and discarded as useless. Besides the center height of the vortex brake must be ensured to be uniform with the one of the winch barrel, the clutch must be ensured to have a gap of 15~19mm in the meantime that it is in disjuncture. The installed clutch shall be able to move freely, which ensures the clutch can be operated smoothly at the time of juncture and disjuncture without any jam and blockage.

3. Mount the silicon controlled rectifier in the switching house for the winch or the air compressor house, and be sure not to mount it in the open air in order to prevent it from the damages affected with damp and heat. If the vibration in the mounting place is relatively serious, take vibration-proof measures, such as padding with rubber, etc.

4. Mount the switch for driller (controller for driller) on the air-controlled box of the winch or in the place for the drill operator to operate the switch conveniently, and fix it with bolts without any looseness. The operation of the switch for driller shall be flexible, and ensure automatic return-to zero and power turn-off.

5. Wiring: the wiring shall be performed strictly in accordance with the diagram of electrical principle. Before wiring, first check the insulation resistance to ground whose value must be more than 1 M $\Omega$  of the exciting coil of the vortex brake and the machine winding of the ventilator with a 500V MEG meter, and the measured normal insulation resistance will be infinitely great in general.

6. Adjustment of circuit

(1) According to the requirements of the diagram of electrical principle and wiring diagram, strictly check whether the wiring is correct, after confirming the wiring has no any errors, switch on the power source and

conduct adjustment.

(2) The loads on the DC output terminals S1(+) and S2(-) of the silicon controlled rectifier are not to connect the exciting coil of the vortex brake but a 500W & 200V incandescent bulb as fictitious load first.

(3) Switch on control power supply and pull switch K<sub>1</sub>. The major loop is disconnected and the AC electromagnetic contactor ZC is disconnected.

a. Observe whether the indicator light HD (red) lightens, and check whether the AC input voltage 220V or 380V is normal.

b. Use oscilloscope to observe whether saw-tooth wave emerges at both ends of capacitance C<sub>11</sub>.

c. Use dual-beam oscilloscope or common oscilloscope to observe the trigger waveform, let the detecting head contact G<sub>1</sub>-Z<sub>11</sub> and G<sub>2</sub>-X<sub>22</sub>, the pulse waveform shall be normal, and the pulse shall not be lost.

(4) Switch on the power source of the major loop, and press the button QA<sub>1</sub> down. The contactor ZC is switched on, and the indicator light LD (green) is lightened.

a. Use dual-beam oscilloscope to observe the waveform between the DC output terminals S1 (+) and S2 (-) as well as between the control electrode and negative electrode of the silicon controlled rectifier, and the trigger waveform and DC output waveform shall be observed at this point.

b. Pull the given signal switch on the panel to “Internal” (namely given by local machine).

Adjust the given electrical equipment W<sub>1</sub> from zero to be increased gradually, and the DC output voltage of the major loop will increase along with the increase of the given signal (the changes of the output voltage can be seen from the DC voltmeter, oscilloscope and the bulb as fictitious load clearly).

c. Pull the given signal switch on the panel to “External” (namely given by switch for driller).

This kind of changes can also be seen from the DC voltmeter, bulb and oscilloscope clearly.

And pay attention to observe whether the system is stable during the adjustment.

(5) Switch the DC output terminals S1 (+) and S2 (-) of the silicon controlled rectifier in the exciting coil of the vortex brake, the 200V & 500W incandescent bulb as fictitious load used for adjustment is still to be connected in parallel with the DC output terminals of S1 (+) and S2 (-) and not necessary to be removed. Set the given signal zero, then switch on the control power supply K<sub>1</sub> and the major loop ZC respectively, adjust the given signal voltage W<sub>1</sub>, and the current of the exciting coil of the vortex brake increases from zero to maximum 84A gradually along with the increasing given signal. The changes of the DC voltage and

current can be observed from the DC voltmeter, ammeter, incandescent bulb and the waveform of the oscilloscope connected with the DC output terminal clearly.

During the adjustment, conduct “internal-control” and “external-control” adjustments respectively, and pay attention to whether the system is stable at any moment. If the system is not stable enough and shows oscillations, adjust the feedback potentiometer to make it stable.

So far, the installation and adjustment of the wind-cooling electromagnetic eddy current brake has been completed and the brake can be put into operation at once. Please notice that after each move of the brake, the content of the above (5) Wiring and (6) Adjustment of circuit must be repeated. Don't ignore it and lower guard and become careless.

## 七、Trouble Shooting

1. Bearings damage –Short circuit between magnetic pole, resulting from iron powders produced by scratches or impacts of the rotor and stator surfaces.

### Cause

- (1) Excessive uncoaxality between the brake drum shaft.
- (2) Lack of adequate lubrication in the bearings.
- (3) Too high water level in the brake chambers leads to deteriorated sealing condition of the bearings.
  - a. The inlet water flow is too large.
  - b. The outlet pipe is blocked up.
  - c. Back pressure at the outlet is too high.

### Remedy

- (1) Adjust the shaft position.
  - (2) Do maintenance according to the bearing service instructions.
  - (3) Control the water flow to keep it at 560L/min. The diameter of the outlet pipe should not be less than 3" , and the level difference between brake chamber and water tank should be enough. The outlet pipeline for returning to the water tank should not be too long. Do not connect the broken outlet pipe with the funnel.
2. The air gap is worsened –The air and the iron oxide are poor magnetic conductor. Slightly increasing the air gap or surface deposit rust layer would considerably decrease the magnetic flux which pass through the rotor and magnetic poles.

### Cause

Owing to using cooling water of high salt content or high PH value (7.0-7.5), larger amount of rusty and scale layers form on the rotor and magnetic pole surfaces. Using salty cooling water would cut short the service life of the brake by 2-3 years.

## Remedy

- (1) Keep using clear cooling water as possible.
- (2) Put on rust chemicals into water.
- (3) The right air gap is 1.10-1.30mm. If the air gap has increased to 1.6-2.5mm, the brake is subject to overhaul.

Note: Before measuring the air gap, remove the rusty and scale layers. When the air gap is up to 1.8mm, the brake moment would reduce to half.

## 3. Troubles caused by overheat of the brake

- (1) Enlargement of the rotor inside diameter causes the air gap to increase.
- (2) As the coil resistance increases, the current passing the coil would decrease.

Because the magnetic flux is proportional to ampere turns, the magnetic flux is decreased accordingly.

- (3) Buckling caused by deformation of the rotor makes the air gap increase locally.

## Cause

- (1) The inlet water flow is less than 560L/min
- (2) The amount of water in cooling system is inadequate.
- (3) The brake runs at a load beyond the rating, so the outlet water temperature is higher than 78°C.
- (4) The overheated rotor is not adequately cooled.

## Remedy

- (1) Increase the inlet water flow to the recommended value.
  - (2) Increase the cooling water in the tank or increase the tank's volume for use in very hot area, the volume should be increased properly.
  - (3) As the rotor runs, slow down the flow speed of the cooling water.
4. One or more than one coils damaged---The magnetic flux decreases.

## Cause

- (1) The voltage applied to the coils is too high.

The brake coils are connected improperly.

The condensate accumulated in the coil chambers damages the coil insulation.

## Remedy

- (1) Use the tight rectifier.
- (2) Connect the terminal lead of coils according to the requirements specified in the drawing.
- (3) A. If the path between the coil chambers and the breather is blocked, clean the breather.  
B. Too much water drain age out of the breather shows the sealing of the coil guard is poor, so in this condition, an overhaul is needed.

C. Eliminate the trouble of the water cooling system.

5. Wrong polarity of the coils— The magnetic fluxes which are produced by the two coils mounted on the stator may strengthen or weaken each other depending upon the direction of the current flow. The improper coil connection would reduce the moment of force.

Cause

Improper wiring

Remedy

Change the connection of coils, check the polarity with compass.

## 八、 VI. Electrical Control

When the electromagnetic eddy current brake is at work, the exciting coil must be electrified with DC current. In general, the drilling machine is energized by AC generator or AC electric network, in order to transfer AC voltage into adjustable DC voltage, we adopt DC silicon-controlled power feeding equipment, make partial modifications and supplements on the basis of the original electric circuit, and adopt the single closed-loop system with current feedback only.

The major loop is adopted with single-phase or three-phase half-controlled bridge rectifier circuit. The control system is composed of the signal given, current regulation, trigger, current shift and DC regulated power supply, etc. This kind of system has a high accuracy of regulation and rapid reaction, and is easy to be stabilized and adjusted. The given signals are divided into the internal control, which is generated by the potentiometer on local panel, and external control, which is generated by the switch for driller installed on the driller's air-controlled table. During tripping, the drill operator operates the switch for driller and transforms the angle variance of the handle of the switch for driller into the voltage variance as the given signal voltage through bridge-type rectification. This kind of non-contact switch for driller is convenient and flexible with good linearity and without contact wear, and the value of the given signal is relatively visual and convenient for the drill operator to grasp.

Once the given signal voltage is changed, the phase of the silicon-controlled trigger pulse is changed, and thus the DC output voltage and DC current of the exciting coil will also be changed along with it, and the braking torque is regulated. Consequently, to attain the purpose of freely controlling barrel speed and lowering speed of drilling tool and make the drilling tool situated on the turntable or pipe slips smoothly dependent upon the vortex brake.

The power feeding equipment is adopted with transformer to coil in, which not only meets the requirement of the output voltage but also forms security isolation between the power source and silicon-controlled

components. There are capacitance and voltage dependent resistor as the excess voltage protection at the incoming line of the silicon-controlled components, and each silicon-controlled component also has capacitance-resistance absorption installation.

## **九、 Use and Maintenance**

1.Inject enough Li-base lubricant into the bearing chamber on both sides of the brake, and make sure at least 2/3 of the bearing chamber is filled with the grease injected by grease gun. Grease should be applied once a week generally under normal operational conditions.

2.Apply enough machine oil to the sliding and rotating part of the claw or tooth clutch to ensure the lubrication of the parts including the claw and spline, the inner and outer gear rings and the shifting fork so as to keep the clutch operating smoothly with reliable “disjuncture” and “juncture”.

3. Switch on the power and keep the silicon controlled rectifier and switch for driller in operation.

When the above preparation is made, the vortex brake will be available for tripping operation with the switch for driller (controller for driller). The lowering of drilling tool can be slowed down to your satisfaction and carry out the tripping without using the main brake. One thing worth mentioning is to catch the brake crank during the tripping to ensure the safety.

During the process, the electro magnetic vortex brake should be maintained regularly to guarantee the normal operation and extend its service life. The maintenance includes the following procedures:

1.Check if the fixing bolt of the vortex brake is loose, including the bolt between the brake and the winch base and the fastening bolt of the vortex brake. Fasten it in case it gets loose.

2.Inject enough Li-base lubricant into the bearing chamber on both sides of the brake before each tripping.

3. The breather at the upper part of both sides of the brake is designed for the ventilation when the coil is heated or cooled. And the breather at the lower part of both sides is for discharge of the condensate water when the coil is heated or cooled. Any ponding should be prevented to avoid the damage to the coil. Avoid any damage during the installation for house moving. Timely clear away the rubbish in the breather to keep it clean and straightway.

4.Regularly inject machine oil into the claw or tooth clutch, the shifting fork should never be loose, check if “disjunction” and “junction” are in the right position.

5.When water is used improperly,corrosion will occur on the rotor or stator surfaces,which increases the air gap resulting in decreasing the braking moment.For considering the gas size,remove the rusty trace and

scales at first. The increase in air gap will fail to provide effective paths for magnetic flux so that the performance of the conductor in induction of eddy current will be impaired.

The radial air gap value of a new brake is within 1.10-1.30mm

6. For the adjustment steps of the cooling system in operation, see the description in Fig.2.

7. Keep the silicon rectifier clean and avoid rain, moisture and insolation under the sun, protect the components or electrical equipments from any damage and make sure it works with safety and reliability.

8. Keep the switch for the driller clean and keep the handle flexible for operation, protect the handle from any damage caused by any mechanical force during the moving of the drilling machine, and make sure it works with safety and reliability.

9. Regularly check each cable if it is pressured or damaged and in good isolation. Replace it at once in case the isolation is found to be damaged, especially the cable with the adaptor, check if the isolation of the adaptor is safe and reliable, and adopt proper measures in case of any abnormal situation to ensure the safety of personnel and equipment.

10. For storage and transportation of the eddy current brake or when it will lie idle for a long period of time for some reason, some preventive action should be taken to prevent the rotor from sticking to the stator surfaces owing to scale, salt deposits and corrosion, etc. Both bearings should be filled with lithium-base grease during storage. If the water that did not conform to the specified requirements had been used in running, it is necessary to have a wash with new fresh water conforming to the requirements. In order to prevent scale, deposits or corrosion inside the chamber of the brake, it shall be sprinkled with kerosene, diesel oil or the similar by inserting a gun with spray nozzles through six check holes (1" tube thread) on the surfaces of both sides. Warning: do not sprinkle oil-base substance on coils and breathers to prevent insulation of coils from deterioration or damage.

**WARNING: When eddy brake working, it shall be cooled completely and must ensure water flow from overflow port, otherwise, it may be damaged and electric coil may be injured for excessive heating.**