

Pressurized consistometer

1 The high temperature high pressure consistometer is designed and manufactured in strict accordance with the API specification 10 requirements. It is used to simulate the downhole high temperature high pressure state and test the cement slurry thickening time and to determine the operation time.

2. The structure and principle of high temperature high pressure consistometer

High temperature high pressure consistometer is made up of autoclave, magnetic driver, pneumatic hydraulic pipeline system, temperature control instrument and heater, kettle cover lifting equipment, electrical control equipment, slurry cup, blade, potentiometer used for measuring consistency, cooling system and surface. The autoclave is made by high strength steel, and can bear high temperature and pressure. The pressure in the kettle is provide by a pneumatic high pressure pumps, conduction oil in the consistometer transit through tank, oil filter and the valves and then be pressed into the kettle by compressed air. Then pressurized by the high pressure pump, and provide initial pressure.

The maximum working temperature is 315°C, the maximum working pressure is 275 MPa, and there is a 2500W inside the kettle. Three pen recorder and instrument are linked together which can record the temperature inside the kettle and the thickening-time curve of slurry in the slurry cup. The slurry cup is drove by magnetic driver, rotate with the constant speed of 150 r/min.

High temperature high pressure consistometer is equipped with two J type thermocouples which are used to measure the temperature of cement slurry and oil. Temperature regulator shows the temperature determined by thermocouple and it can set and control program to pressure control program by pressure regulator booster and constant pressure, temperature and pressure in the kettle that is simulated cementing operation homework underground temperature and pressure

The high pressure return pipe line is equipped with one-way oil filter which is used to filter out various impurities and cement particles. High pressure pipeline is equipped with blasting slice which can stand 310 Mpa pressure. This is the last protection device which is used to protect the whole high pressure system, when blasting slice broken, oil will be pushed to fuel tank in immediately.

The slurry cup has a large volume hat. This is because, the cement slurry inflates seriously in the high temperature testing, and that will produce the overflow phenomenon. This hat is used to capture seal lax in test, prevent cement slurry spilling and kettle body and oil being polluted.

When testing the cement slurry's consistency, put the cement slurry into the slurry cup which is drove by the magnetic driver. Fix potentiometer and driving gear shafted on the blades well. The cement slurry rotates relative to blade; the blade is resisted, that deforms the spring on the potentiometer. Consistency is proportional to torque. Along with the increase of spring torque and pointer rotation angle, potentiometer resistance and voltage also will increase. so the reaction of the potentiometer shows the voltage value, it not only shows the size of the spring torque, also reflect the value of slurry consistency. After the experiment, turn on the cooling water button to cool kettle body and tank. This can remove potentiometer and plasma cup timely after the high temperature and high pressure experiment (The temperature should be dropped to under 100 °C before the open the cover if the temperature is over 100°C). And make axe body cooling down as soon as possible, so as to be convenient for the next experiment.

3. The type of high temperature and high pressure consistometer

(1) The basic type pressurized consistometer

It is equipped with a threepenrecorder and can record the curve of consistency changing with the temperature and time. The temperature is set and controlled by the temperature controller. And pressure regulator control program to boost and consist the pressure.

(2) Upgrading type pressurized consistometer

It is equipped with numerical control, and connects with computer. It can use the computer to set the warming time and pressure. And it can be controlled by computer to test and use printer to print out the graph.

(3) Smart type pressurized consistometer

Increase the man-machine interface, and connect with internet communication and other related.

4 the installation and debugging of pressurized consistometer

Before installation, turn on the air, water and power in the laboratory, the power cord should

be able to pass through the 30 A current safe. When voltage is 220V, wire diameter must be greater than 6 mm².

Electromagnetic route, such as electromagnetic valve, electromagnet, can not be turned on the power in no-load (which means no iron core) state to avoid the electromagnetic valve from burning. Remember to close the heater when return oil after the experiment, if not, heater will still work that can cause very big lampblack, destruct the oil, and even burn heater. This kind accident, will bring to a lot of trouble to maintenance work, and it must be avoided.

5 the application of pressurized consistometer

(1) Potentiometer calibration

Potentiometer must be calibrated by load potentiometer correction device and do the calibration according to the methods API specification 10 and GB10238 provided and the procedure is as follows:

Add 50 grams, 100 grams, 150 grams, 200 grams, 250 grams, 300 grams, 350 grams, 400 grams of Jordan farmar in turn, knocking the calibration table slightly with screwdriver handle after each Jordan to overcome the error caused by mechanical friction. Write down each voltage value which is correspond to a Jordan farmar, but usually correction the following two points is ok.

The relationship of consistometer with the equivalent torque

The equivalent torque	Jordan farmar	consistometer
520	100	22
2080	400	100

The operation steps of consistency testing experiment

Before the experiment, turn on the power, and turn off the other electric switch.

Put the slurry cup on the stand, put the prepared slurry onto the slurry cup, repeatedly beat the cup to remove the air. Screw on the bottom cap and the slurry is full of the cup when some cement spilled from the hole in the bottom cap. Loose the bottom cap, and crew on the enter plug. Then crew on the bottom cap.

Put the slurry cup into the kettle; rotate the cup until the cup bottom pin is inserted to the two

holes in turning plate; remove the hook; open motor switch to see if the swinging of blades shaft. The blades shaft should not have a lot of shaking. If shaking seriously, the slurry cup will be scraped in the experiment. And it is necessary to check and place slurry cup once again.

Put the potentiometer into kettle with hook. The potentiometer electrode piece must be aligned with the kettle contact electrode. If potentiometer is placed in right, the slider on the blade shaft should be holding-on with the bottom of the potentiometer connected piece of notch. The top of blade shaft should level with the potentiometer top, and then observe the voltmeter. It should have voltage instructions, and the pointer should not have big rocking, and the instructions is smooth.

Screw on the kettle cover; tighten with hands or rubber hammer. It should not to twist too tight or too loose. If it is too loose, oil will spill out from the upper of kettle, and if it is too close, the metal sealing ring life will reduce, and it is difficult to finish open the cover after the experiment.

Insert the thermocouple into the kettle vertically; twist into the lock nut. Don't tightened and reserve a few screws. Pick up the thermocouple, so as to let out the air inside the kettle in the process oil-taking.

Open air source (intake valve), began to compress the air. The compressed air press the oil in the oil tank to pass through the high pressure oil valve and go to the kettle. The air inside the kettle is gradually ejected, when oil flow into the kettle. The oil will spill out from the locked nut when the kettle is full. Immediately lock nut at this moment.

Open pump switch, the high-pressure pump begin to work, according to the API specification requirements, when the pressure meet the initial pressure required, closed pump switch.

According to the standard requirement, set the temperature, time parameters, operation warming, boost pressure program and make the thermostat into the program control state. Open the heater, and at the same time open the timer, alarm switch and recorder. The consistometer at this time should be in working condition. During this time, the experimenter should be on duty, and watch experiment phenomenon, find the problem to treatment in time. Watch and record the slurry initial consistency, namely the maximum consistency between 15 and 30 minutes.

When the slurry consistency comes to 100 Bc, alertor alarms, the timer displays the time which is the thickening time of cement slurry. Turn off the heater, timer, motor, timer alarm and direct voltage and stop to run the program.

Close the air intake valve, open air-release valve. When all the air is drained, open the high pressure valve and release the high pressure slowly. When pressure drop to zero, open return oil valve and the compressed air will get into the kettle and press the oil back the oil tank. When you hear sound of gas release, the oil return finishes, and then close the oil return valve. If the temperature is more than 100°C, open the cooling water first to cool the device and open the kettle cover until the temperature is dropped to under 100°C. Loosen the internal thermocouples and lock nut. Using a soft cloth to cover the kettle cover center hole and to avoid oil and gas jetting. When residual air is drained, take out the thermocouple, unscrew the kettle cover, remove the potentiometer and slurry cup. Pour out the cement slurry cup, clean the cup, blade, diaphragm, bottom cover and plug. And then grease for the next time use. Finally close all switch and valves.

6 the maintenance of pressurized consistometer

After the experiment

(1) High pressure kettle: Check the kettle metal O type sealing ring, clean part of the cement particle in the o-rings above and between kettle cover and o-rings contact. Keep the o-ring and base clean and it can be reused for many times. If o-rings are scratched or damaged, it must be replaced. Sufficiently lubricate the o-ring before change, and open and close it with special tool, so as not to scratch the metal surface.

(2) Potentiometer: After the experiment, clean potentiometer, spring, and resistors. Clean the potentiometer, and grease high temperature grease on the surface of it to protect it from oxidation.

(3) Slurry cup: after the experiment, all the slurry cup parts must be thoroughly cleaned and checked; Check the wear patterns of slurry cup bottom plug, for example if the internal taper seat is damaged beyond the wear rang, the blades shaft will rub slurry cup wall or can not rotate flexibly. If the blade is damaged, it should be replaced with new blade. Record the blade weight before the first time we use. Record the weight again after 20 times experiment. if the second weight is less than 20% of the first weight, replace the blade, and eventually grease all parts.

Monthly maintenance

(1) Potentiometer: the potentiometer must be broke and cleaned completely, if there is any obvious damage, the parts damaged must be replaced according to the following procedure.

The replacement of resistor disc

- a. Take down the resistor disc; be careful not to damage the resistor rank.
- b. Put into a new resistor disc vertically and resistor ends should be the same length with contact pieces outside overlapping.
- c. Inset the resistor into the rank firmly, and the upper surface of the resistor must be horizontal.
- d. Using a hardwood to polish upper surface of resistors winding gently, this can ensure the pointer to slide smoothly.
- e. Turn the pointer with hand to ensure the pointer rotating smoothly and contacts well. And the pointer slide between the contact pieces without acerbity feeling, if need, bending the pointer to adjust the contact.
- f. Adjust the pointer stop arms position on the center axis; make sure the pointer sliding between contact pieces and all the screws being tightened.

Change of calibration spring: install a new spring, potentiometer axis anticlockwise, spring taut, and restart the correction.

(2) Magnetic drive device

The magnetic drive device can eliminate the problems such as leakage, pollution, seal and heat. Maintenance must be in a no metal clean desktop, use a special tool to take it out from the consistometer.

Carbon bearing: Clean the cement particle on bearing inside and outside diameter, if carbon bearing surface have obvious scar, or the wearing diameter is damaged seriously, replace the carbon bearing.

Copper bearing: Clean the cement particle on bearing inside and outside diameter, if the wearing diameter is damaged seriously, replace the carbon bearing.

Clamp ring: if its bottom is damaged, replace it.

(3) High pressure filter

If the oil-return is slow, take down the filter, and roast it with alcohol burner and clean it well. It also can be cleaned with ultrasound.

Check for every half-year

a. Thickening oil and low pressure filter

If the thickening oil become dirty, run it off and change the low pressure filter.

b. Drive motor

The rotation is 150 ± 15 r/min which is required in the API specification; the motor rotation can be adjusted and can be calibrated with tachometer.

Check for every year

a. Change the high pressure filter, rupture disk, high pressure relief valve seat and rob, air to kettle valve seat and rob.

b. Pump: dismantle and clean

c. Oil tank: clean and wash

d. Heater: check insulation and leakage; Ground/shell insulation, bad heater insulation can produce severe consequences, and at the same time bad insulation will cause heater doesn't work properly.

Trouble shoot

a. Equipment can't charge

Cause: 1. insurance tube is burned 2. The main source switch trip

b. Abnormal/wrong temperature reading

Cause: 1. thermocouple damaged 2.terminal damaged/rust/aging 3. Check the thermocouple connect and components

Solution method: 1. change thermocouple connect 2.change thermocouple

c. Drive motor abnormal

Cause: 1. insurance is burned 2. Motor or motor control board is damaged 3. Connect 4. Switch is damaged

d. Heater system error

Cause: 1. the heater is no-voltage/insurance is burned 2. switch is damaged 3. The heater power supply is short circuit 4. The heater is short circuit to the earth 5. Solid state relay is damaged 6. Thermostat is damaged.

e. Pressure system error

Cause: 1. can't be pressurized 2. Pressure control valve can't be opened or it is discoverable 3. Kettle cap is discoverable 4. Rupture disk is damaged 5. Driving air pressure is low or no 6. The oil level is too low in the oil tank 7. Air-operated solenoid valve is damaged.

f. The kettle cap locks the kettle body, hard to remove

Cause: 1. Screw grease is not good 2. There is some foreign body in the seal ring 3. The kettle cap is too tight.

Solution method: cool the kettle cap; beat the cap handle slightly with rubber hammer, and screw on the kettle cap.

g. Pump work abnormal

Cause: 1. the pump piston is locked by air 2. The pump valve has impurity.

Solution method: increase the air drive power; decrease the pump circuit speed 2. Maintain the pump.

h. The recorder is unstable or abnormal

Phenomenon 1: The read of consistency come to 0 suddenly.

Cause: 1. potentiometer resistor disc is damaged 2. The potentiometer is separated from the drive block or the potentiometer has no contact with the kettle contact pin. 3. The potentiometer bear is polluted by the cement 4. The wire on the top of the drive pan of potentiometer is loose 5. the potentiometer cut pin has been broken.

Solution method: 1. maintain the potentiometer 2. Check the contact disk of potentiometer.

Phenomenon 2: the read of consistency comes to 100 suddenly

Cause: contact pin and the kettle have short circuit.

Phenomenon 3: the recorder pointer is intermittently and it rocks seriously

Cause: 1. the slipping resistor disk of potentiometer is irregular, there is cement and pollutant on the resistor disk which makes the voltage is intermittently.

2. The slipping rotational arm of potentiometer is loose and lack of flexibility.
3. The output signal and potentiometer is changed. There is cement or oxidation layer between the resistors and disk which make the connect undesirable.
4. The potentiometer wearing is dusty and can't move.
5. The location pin of potentiometer is loose.
6. The slurry cup shaft is bended, blade rub with the slurry cup wall.
7. The slurry cup shaft is damaged, and the blade scrapes with the bottom plug.
8. The blade scrapes with the rubber diaphragm, because the diaphragm is installed wrongly, so the reaction is absolutely when the pressure is increased.
9. The cement is not sieved, stir is not enough, and there are cement block in the slurry.