Cryopump knowledge lecture

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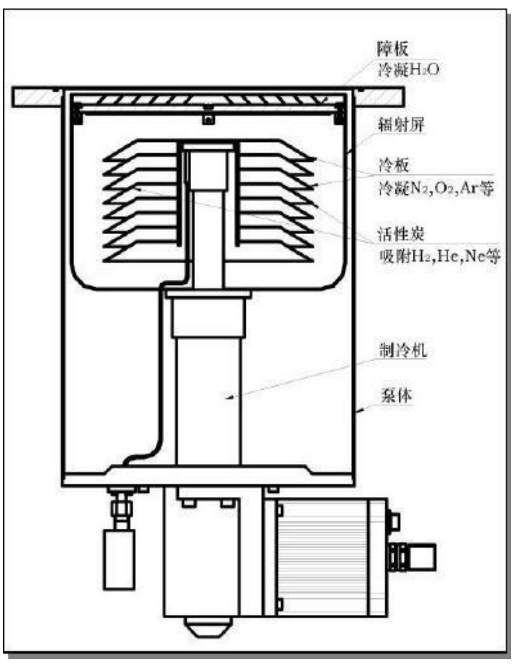
I. Structure and working principle of low-temperature vacuum pump

1. The structure of low temperature pump



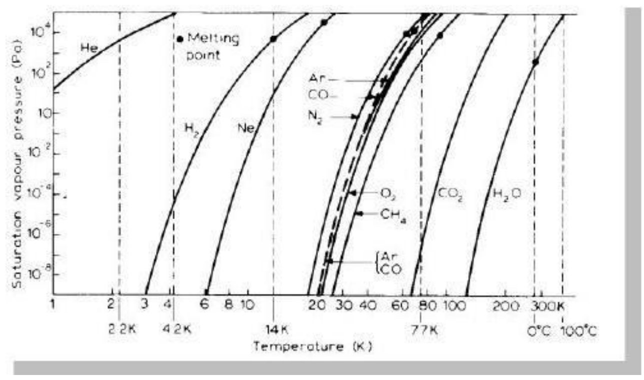
Cryogenic pump is also called low temperature vacuum pump, cold pump, condensate pump. The cold source of the cryogenic pump can be cryogenic liquid (liquid nitrogen or liquid helium), or it can be a cryogenic refrigerator. The cryogenic pump is introduced here. The cryogenic pump's cryogenic machine generates refrigeration at two temperature stages, respectively cooling two cryogenic surfaces, on which the pumped gas is cooled.

The first stage of the chiller, which usually operates in the range of 50K to 70K, is used to cool the outer cold plate. This external cold plate acts as a radiation shield for the cooler plate and also cools the louver (baffle) at the pump entrance. When water vapor hits the baffle plate, it is frozen on it, much like the liquid nitrogen trap freezing water vapor.

The second stage of the refrigerator, the coldest stage, usually operates between 10K and 20K, and is used to cool the cold plate near the inside, which freezes N2, O2, Ar and other gases that pass through the shutters. Gases that cannot be frozen at this temperature are adsorbed by activated carbon located inside the cold plate.

2. Working principle of cryogenic pump

1) One of the pumping mechanisms of cryogenic pump: low temperature condensation



The figure above shows the cryogenic pump's ability to reduce pressure in the vacuum chamber to very low levels. It represents the relationship between the equilibrium pressure above the low temperature deposit layer and the low temperature deposition temperature. For example, water boils at 373K at 760Torr pressure. The vapor pressure is 4Torr at 273 Kelvin freezing temperature. If the ice is cooled further to 150K, the equilibrium vapor pressure will be 4 x 10^{-8} torr. If the temperature is at the first stage of the refrigerator, the pressure will be less than 10^{-10} torches. It can also be seen from this figure that for N2, if the cold plate temperature is less than or equal to 20K, the pressure will be less than 10^{-10} torr.

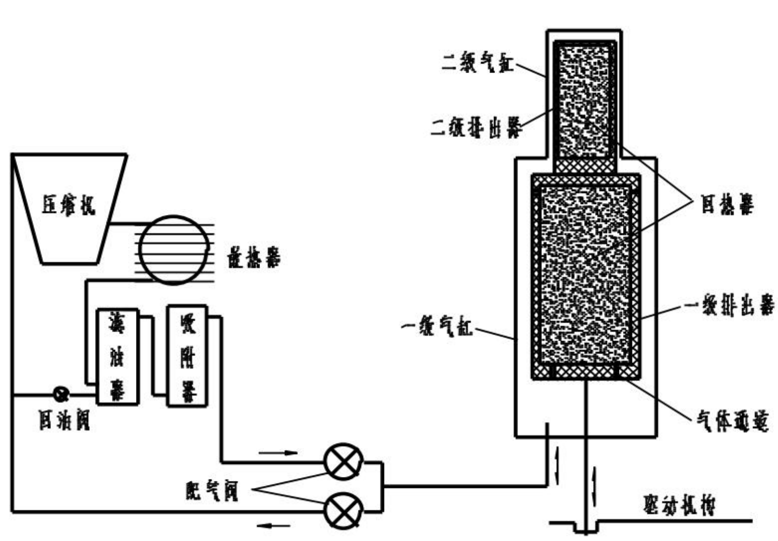
2) Low temperature pump pump principle of two: low temperature adsorption

Low temperature condensation alone is not enough. The equilibrium steam pressure of Ne, H2, He and other gases at 20K is too high to be condensed on the surface of light at low temperature. Therefore, activated carbon is used to absorb these gases. Activated carbon is used as adsorption material because of its large surface area and because it is easily desorbed at room temperature during the regeneration process. The equilibrium pressure of hydrogen adsorbed on activated carbon depends on the activated carbon temperature and the amount of hydrogen adsorbed. As the adsorbed hydrogen increases, the adsorption becomes condensation on the surface of the activated carbon. However, the pressure remains constant when the thickness of the condensate layer increases. Activated carbon has great hydrogen extraction capacity. If the refrigerator keeps 1 gram of activated carbon at 15K, it can hold 280SCC of hydrogen in 10-6 support. The maximum amount of gas that a cryopump can absorb (the pumping capacity) refers to the pumping capacity of a particular type of gas, that is, the volume of gas that the cryopump can remove before being re-pumped.

3. Working principle of low temper ature refrigerator

Cryogenic pump with small cryogenic refrigerator is used by the Giford - McMahon cycle, the use of Simon expansion principle (that is, adiabatic discharge) to refrigeration.It is mainly composed of cold head unit, compressor unit, control unit, metal connect ion hose and so on.Among them, the control unit is generally installed in the compressor unit, forming a whole.Its working medium uses helium gas to circulate in the system. The following is the main schematic diagram of its operation.

The high purity helium gas is compressed in the compressor to produce high pressure helium gas, which is cooled by the heat exchanger, separated from the oil steam through the oil gas separator, and further purified in the adsorbent. At the beginning, the driving mechanism keeps the primary and secondary ejectors at the bottom of the cylinder while opening the intake valve. The high pressure gas enters the heat chamber volume above the primary ejector and the primary regenerator. The pressure of the primary regenerator and heat chamber volume increases. When the pressure is balanced, the first-stage ejector moves upward from the bottom of the cylinder to push out the gas entering the hot chamber and enters the first-stage cold chamber after cooling by the first-stage regenerator. When the ejector moves to the top of the cylinder, the intake valve is closed, and the exhaust valve is opened. At this time, the high pressure gas in the primary cold chamber is discharged to the low pressure part, and the primary cold capacity is generated. Part of the gas is heated by the primary regenerator and enters the low pressure chamber of the compressor. After compression, it becomes high pressure gas. Part of the gas enters the secondary cold chamber by the secondary regenerator and changes heat through the cold head to generate the secondary cold capacity. When the first and second stage ejector is moved to the bottom of the cylinder, the exhaust valve is closed. In this way, over and over again, the whole system can work continuously, continuously producing cooling capacity. The cold quantity produced is output by the cold head to form a cold source.



II. Characteristics and application of cryogenic pump

1. The characteris tics of low temperature pump:

1) Cryogenic pump is a positive displacement vacuum pump, no need to work before the pump;
2) The cryogenic pump needs regeneration;
3) Cryogenic pumps have different pumping speeds and pumping capacities for different gases.

2. The advantages of cryogenic pump

1) High limit vacuum degree

A standard cryogenic pump, its limit vacuum degree can reach 10-7Pa, if necessary, can be achieved without the addition of other auxiliary pumps -9 Pa, and in theory, even up to 10- 11Extrem ely high vacuum above Pa.These are unmatched by other high vacuum methods.

2) High pumping speed

High pumping speed is an important characteristic of cryogenic pumps.Under the condition of the same caliber, the pumping speed of the air, molecular pump is about 2/3 of the cryogenic pump.Although the diffusion pump is comparable to it, but after the addition of cold plate, its ability is greatly reduced, and can only be equivalent to about 2/3 of the low temperature pump.

The most important point: the cryogenic pump has a super high pumping speed for water, which is much higher than other vacuum pumps.In most cases, water vapor is the main load of the vacuum system. The high pumping speed of the cryogenic pump allows the vacuum to be built faster than other vacuum pumps, which can greatly improve the product output.

3) Real clean

Cryogenic pump is a real clean oil-free high vacuum pump with high pumping speed. It uses low temperature cold plate to condenses and adsorb gas to obtain and maintain vacuum. In the vacuum area, there are no moving parts, no oil, and all are clean and pollution-free.This point is incomparable to other vacuum pumps.

Cryogenic pumps generally do not occur these problems.Because they do not use fluids, reflux is not possible under any circumstances.

In addition to the oil return from the diffusion pump itself, another common source of pollution is the oil vapor from the former mechanical vacuum pump.The switching pressure of the cryogenic pump is 2 to 10 times the s witching pressure of the diffusion pump. The low vacuum tube used for pre -pumping is viscous fluid, so that the oil vapor of the low true empty pump will not produce backflow.

Cryogenic pumps do not have the problem caused by the contamination of the pump oil.In the manufacturing of many films (especially infrared coatings that can be produced chemically in combination with the pump oil), the pump oil becomes contaminated and turns to mud, which can quickly reduce pump efficiency, increase production time, and even cause film quality problems.In order to prevent this kind of problem, people often change the oil, but the frequent change of fuel consumption and effort, increase the maintenance cost and downtime.If you use a cryogenic pump, you do not have this problem.

The cryogenic pump has a high switching pressure.This has two major benefits: (1) reduced pumping time; And (2) there is no oil return.

4) Low operating cost

Whether investing in new equipment or upgrading existing equipment, expect a return on investment in reduced costs (labor, materials, utility, depreciation, etc.), increased production, and revenue.What is the return on investment if you change from a diffusion pump or other pump to a cryogenic pump? For example, a 500mm cryogenic pump pumps water vapor at a rate of 30,000 L/s, equivalent to an 800mm diffusion pump, without the use of a cold trap.A set of film equipment can save 40,000 yuan to 80,000 yuan per year due to the purchase of liquid nitrogen.At the same time, it can also save various costs caused by the purchase, storage, treatment and transportation of liquid nitrogen.In addition, the cost of routine maintenance and accidental damage to the liquid nitrogen level control system is eliminated.The elimination of the cold tr ap while maintaining the maximum pumping rate for steam also reduces the pumping resistance and therefore increases the pumping rate in the chamber.

Compared with diffusion pumps, cryogenic pumps can solve some other cost problems.Diffusion pumps require continuous supply of cooling water. If the water supply is interrupted, the pipeline will be damaged, the recirculation pump will fail, and even the c ooling pipe of the diffusion pump itself will be blocked, or the maintenance personnel will fail to realize it and cause accidental injury.In particular, the absence of cooling water will cause the diffusion pump to produce "backflow", which will contamina te the vacuum treatment chamber, and the diffusion pump flow will cover the plated products, targets, tools and chamber walls.Once contaminated, the vacuum chamber must be painstakingly cleaned, reassembled, and leak detected, all of which must be acceptable before starting up again.

Other common causes of diffusion pump backflow are vacuum leakage, operator error, loss of power supply, excessive air flow, and failure of the preceding pump.In each case, the diffusion pump exhaust nozzle will be damaged, res ulting in oil vapor backflow.While some effective maintenance can ameliorate these failures, each approach costs money and none is simple.

Cryogenic pumps save electricity. Compared with the diffusion pump, the low temperature pump can greatly reduce the power consumption, especially the large diameter pump. In terms of pumping speed, cryogenic pump only needs 1/3 energy consumption to achieve the same effect as diffusion pump. For example, using two 800mm diameter diffusion pump/booster pump coating system, the annual power consumption of 290,000 degrees (calculated by 300 working days), use two 500mm diameter low-temperature pump, pumping speed is better than two 800mm diffusion pump, and can save 200,000 degrees of electricity, 120,000 yuan.

The cryogenic pump works, and the front pump rests.When the diffusion pump works, the former vacuum pump needs continuous and stable operation (vacuum degree 0.1-0.5 support), that is, the diffusion pump can not work alone.When the cryogenic pump works, th e front pump will be turned off after providing the initial vacuum (only a few minutes).From the beginning of pumping air until the chamber reaches the switching pressure (usually 0.2 -0.5 support), the front stage pump works, and the later time the cryogen ic pump works independently.The short opening time of the front stage vacuum pump can save electric energy, reduce maintenance and reduce noise.

5) Safe and reliable

There are no moving parts in the vacuum chamber. Interference from the outside or particles from the vacuum system will not affect the work of the cryogenic pump.In addition, when the vacuum suddenly fails, the cryogenic pump will not be affected by any am ount of gas entering the cryogenic pump, so it will not be damaged in the case of the implosion of the true empty tube.At the same time, because the temperature of the cryogenic pump has a certain "inertia", it can effectively protect the vacuum chamber in the case of sudden power outage, so as not to be affected by the plating workpiece.

6) Easy to use

Cryogenic pump does not require installation orientation: because the cryogenic pump does not require high directionality, it can be installed above the pump port, down the pump port, horizontally or at any Angle required by the chamber.And the diffusion pump in most cases need to pump mouth upward vertical installation.This installation allows high vacuum to be achieved in the vertical direction of the chamber, but the true space at the end of the horizontal direction of the chamber is affected, and the effective pumping rate will be reduced from 70% to 60%.This reduction in pump speed results in extended cycle time and reduced production.

7) Long life of cryogenic pump.

Because it has few moving parts and operates at low speed.Through daily maintenance, the normal service life of cryogenic pump can reach 50 ~ 60 thousand hours, and some even more than 80 thousand hours.

3. The shortcomings of cryogenic pump

1) Need cooling time (preparation time);

2) Need to regenerate;

3) High acquisition cost.

4. Low temperature vacuum pump application field

Cryogenic pumps are suitable for those wishing to obtain 10^{-1}Pa to 10^{-9} P a vacuum , especially suitable for applications requiring clean oil-f ree and/or rapid pumping, such as:

◆Vacuum exhaust equipment

◆Sputtering coating equipment

◆Evaporation coating equipment

◆Ion implantation equipment

◆Molecular beam epitaxy equipment

Industrial vacuum coating using the above equipment, such as: semiconductor and integrated circuit preprocessing, optical coating, solar cell plate, optoelectronic device and vacuum electronic device manufacturing, flat panel display device coating

◆Electron beam equipment

◆Space analog device

◆High energy physics research equipment

◆Accelerator beam tube

◆Surface analysis device

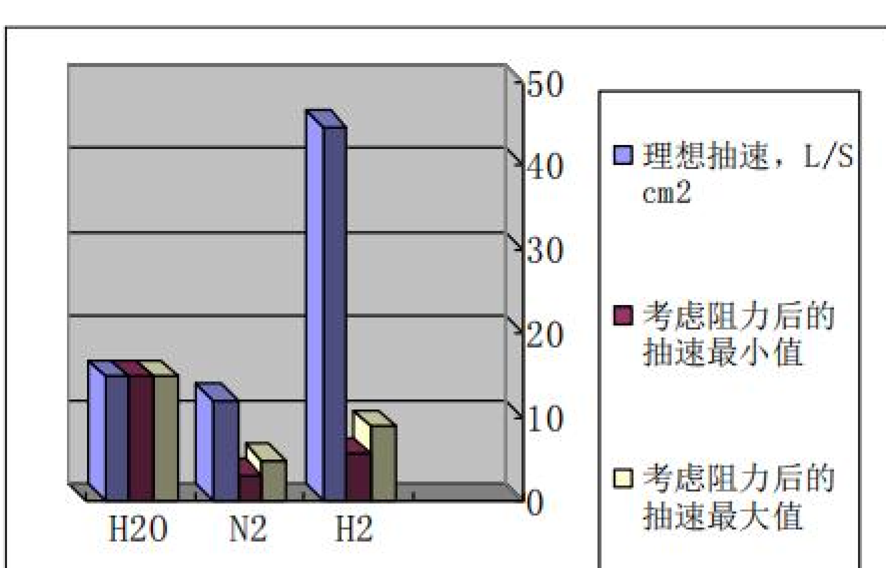
III. Three, the selection of low temperature pump

Cryogenic pump manufacturers of cryogenic pump models are not quite named, there is no unified regulation, but its specifications are basically based on the caliber to determine.For the selection of cryogenic pump, the main consideration is: pumping speed, the vacuum range used, the most large flow of gas, pumping capacity, refrigerator heat load, etc.

1. Pumping speed (pumping speed)

Cryogenic pump designers are generally most interested in pumping speed. The gas flows into the vacuum pump due to its therm al energy (equal to kinetic energy), and the following relationship can be obtained: The average velocity of the gas entering the pump opening is equal to the gas constant times the temperature divided by 2 π times the square root of the molecular weight of the gas, so that the ideal pumping rate for the cryopump is equal to the average velocity times the area of the pump through which the gas can flow.

$$v = \sqrt{\frac{KT}{2\pi m}}$$



Since most vacuum systems operate at room temperature, we assume that the ideal velocity is based on room temperature. The speed of such a molecule is determined only by its molecular weight. The lighter gas has a higher velocity. The molecular weight of hydrogen is 2, and the pumping speed through the opening area per square centimeter is 44.6L/S. Water has a molecular weight of 18 with an ideal extraction speed of 14.9 L/S cm^2, while nitrogen, the heaviest in this group, is 28 with an ideal extraction speed of 11.98 L/S cm^2.

The ideal pumping speed is achieved if all the gas molecules that hit the head of the pump are frozen on the shutter.In fact, water reaches this point, and almost all of the water molecules that hit the pump stick to the Venetian Venetian instead of bounci ng back.Like N2 Some of the molecules bounce back and the rest pass through and freeze on the inner cold plate. To effectively block radiant heat from reaching the inner cold plate, the cryogenic pump has entrance louvers that allow approximately 40% to 25 % of the air molecules (O 2 And N2) flows through it and ice freezes on the cold plate.In this way, on N 2 The net pumping speed is 25%-40% of the ideal pumping speed or 3.0 -4.8L /S CM^2 , Ne, H^2 , He has to travel a more tortuous road to reach the active ca rbon site, as a result, only about 12%-20% of H^2 reaches the pump port surface. The molecules are adsorbed at low temperatures, and the rest will bounce back, so H^2. The net extraction speed is about 12%-20% of the ideal extraction speed or 5.6-8.9L /S CM^2.

2. **Working vacuum range of cryogenic pump**

The typical working vacuum range of cryogenic pump is 1×10^{-3} -1 $\times$ 10^{-9} Pa.The gases in this range are free molecular flow zones, which means that they usually move from one wall to another without colliding with eac h other.The pumping velocity is constant in this region.Enter more than 1 x 10^{-3} as the pumping pressure increases. In the transition area of the bracket, the pumping speed increases. Compared with the diffusion pump, the low temperature pump has the characteristic of increasing the pumping speed in this area, while the pumping speed of the diffusion pump decreases.

3. Maximum flow and argon pumping problem

Thr oughput or Ma x. Thr oughput means " ma xim um flow rate" of cryoge nic pum p, referring to the ma xim um mass pum ping spee d of a cryogenic pum p f or a certain gas (the ma xim um mass flow rate of a gas allowed into the vacuum pum p), exceeding this am ount will caus e the tem perature of cryogenic pump refrigeration machine to rise to more than 20K and cannot work.

The maximum flow rate and the "switching value" indicate the gas flow rate that the cryogenic pump can tolerate during the operation of the cryogenic pump and when the main valve is just opened.They mean the same thing.Because it is common to let argon into the studio when the sputtering platform is working, and it may cause the temperature rise of the cryogenic pump to be too high because of the argon flow rate, we often specify the maximum argon flow rate of the cryogenic pump.

The maximum flow: (1.5-3) Q

Q is the refrigerating capacity of the refrigerator at 20K (watts)

4. Pumping capacity of cryogenic pump (pumping capacity)

Cryogenic pump can gather a large amount of solid water, air, argon, nitrogen and oxygen, and then evaporate defrosting.When these frost layers are formed, the pumping speed of the pump rarely decreases and the cooling temperature changes very little. As t he frost layer increases to a certain extent, the pumping speed and temperature will change significantly.Water is concentrated on the barrier until half of the barrier area is blocked off (for example, a Φ200 caliber low temperature pump can condense 300 grams of water vapor into ice).Solid nitrogen and argon are concentrated in the outer layer of the cryogenic plate up to a few centimeters, usually this thick.

The degree is limited only by not being able to touch the radiation screen.(For example, a Φ200 diameter pump concentrates 1 ㎝ of air or argon outside the cryoplate, which is 1200 standard litres.This pump is specially used for sputtering platform, and its cryogenic plate is larger.Another pump of the same caliber has a value of only 350 standard liters).The amount of hydrogen that can be absorbed is the hydrogen equilibrium pressure gathered when the hydrogen pumping rate is reduced by 50% (1×10 for a section)-6 To determine that when other gases are pumped to increase the temperature of the low temperature plate, the amount of hydrogen can be absorbed will be reduced.

Extraction capacity is the maximum amount of a particular gas that can be removed (retained) by the cryogenic pump and is expressed in TRR • L, mbar • L, or std • L.Pumping capacity is determined by the following factors:

1) Half of the flow area is covered by the pumping steam from the barrier plate;

2) The thickness of condensed nitrogen and argon outside the cold plate is too large;

3) The adsorption array is close to saturation.

Of these three factors, adsorption tends to reach saturation first, because the amount of adsorption is smaller than the amount of condensation compared to condensation. So the extraction capacity is mainly determined by adsorption (the main factor is the performance and amount of the adsorbent).

Usually pumping capacity refers to the amount of gas extracted when the pumping speed drops to half of the initial pumping speed. At this time, the cryogenic pump needs to be regenerated. In fact, it is often regenerated when the vacuum degree is not good enough and the refrigeration temperature exceeds 20K.

5. Heat load of refrigerator in cryogenic pump

When no heat load is applied to the refrigerator used in the cryogenic pump, the minimum temperature of the second stage is about 10K and the minimum temperature of the first stage is 35K. As the applied heat load increases, the temperature at each stage increases.For example, adding a heat load of 9W to a refrigerator will make the temperature of the cold head reach 20K, and adding a heat load of 17W to the first stage will make the temperature reach 77K.We set the nominal temperature of the low temperature cold plate as about 12K and 60K-65K in the normal working time.In this way, there is a certain margin for the heat load from the vacuum chamber that is not taken into account in advance or the heat load that is increased due to the large gas flow rate. The cooling capacity of the above refrigerating machines is 5W/12K and 12W/60K, respectively.The heat load of the cold plate comes from the following three aspects:

1) Heat radiation from the vacuum chamber;

2) Heat of condensation given off by gases being cooled from room temperature and frozen at low temperatures;

3) Heat conduction of the gas in the cavity.

The thermal conductivity of air (which is basically constant at more than 1 torr pressure) decreases rapidly when the pressure is reduced below 1 torr.At pressures below 1 x 10 -3 Heat transfer due to heat conduction can usually be neglected (this area of g as is in the molecular flow area).In the cryogenic world, it is called an adiabatic vacuum.Compare the thermal conductivity of this time with the general thermocouple vacuum gauge, which operates from 1 × 10-3 It is based on the change of the heat conduction coefficient within the range of 1.

Radiant heat is the main heat load of the cryogenic pump. There are two requirements for the cryogenic pump to withstand radiant heat: first, as much as possible reflects the radiant heat from the vacuum chamber; Second, cryogenic pumps should be able to absorb radiant heat that is difficult to reflect off. Some very clean electropolishing vacuum chambers have very little radiant heat to the cryogenic pump, but in most cases the radiant heat is almost equal to the black body radiation after the absorption of water vapor on the wall of the vacuum chamber.

Because radiant heat is a function of temperature to the fourth power.If there is a high temperature heat source that generates radiation to the cryogenic pump in the vacuum chamber, it is easy to make the heat load of the cryogenic pump too large, so the water cooled baffle is used to shield the high temperature heat source and the cryogenic pump in the vacuum chamber.The cryogenic pump cold plate should be well polished and can reflect radiant heat in the cooling process, but once the thin layer of water condenses on the cryogenic surface, it will make the surface become a thermal black body surface that absorbs heat radiation.

The heat load due to gas condensation in a cryopump is usually small, but an exception is when the cryopump is used to extract argon in a sputtering platform.Most of the heat load from condensing argon is borne by the cooler stage.It takes about 0.7W to condense 1 torl/s of argon.The secondary temperature of the refrigerator rises with the increase of argon flow rate.Since it is usually necessary to hold hydrogen on activated carbon at the same time, the flow setting of the cryogenic pump should be based on the standard that the temperature of the cryogenic plate is not greater than 20K (then the flow rate is the maximum flow rate). In general, the pressure is 1×10^{-3} when the flow is set If higher argon pressure is required in the sputtering coating process, a throttle valve will be installed in front of the cryopump to reduce the operating pressure to 1 x 10^{-3} on entry to the pump port The bracket.

6. The selection of cryogenic pump steps

When choosing a cryogenic pump, mainly follow the following steps:

1) Calculate the pumping speed required by the system and select the corresponding pumping speed of the cryogenic pump;
2) According to the flow rate of a certain gas at work, check whether it exceeds the allowable conduction of the cryogenic pump;
3) According to the system of exhaust gas, calculate the regeneration cycle of the cryogenic pump, to see whether it meets the requirements of the process;
4) Check whether the heat source affects the cryogenic pump when the system is working, and improve the structure if necessary.

IV. The use of cryogenic pump

1. When can you open the main valve and use the cryogenic pump to pump air?

According to the capacity of the refrigerator in the specific cryogenic pump, the maximum allowable switching value of the cryogenic pump can be measured, which is the performance parameter of the cryogenic pump.The larger the secondary cooling capacity of the cryogenic pump is, the larger the switching value of the cryogenic pump is.The empirical value of the switching value is:

(20 --45) x Q (tores • liters)

Q is the refrigerating capacity (watts) of the refrigerator at 20K

In addition to being related to the secondary cooling capacity, the switching value is related to:

1) Primary cooling capacity

2) The size of the secondary cold plate

3) The structure of the barrier plate (whether it is well shielded)

The user should decide when to open the main valve?Dividing the switching value marked by the cryopump by the volume of the vessel being pumped is the switching pressure, the degree of vacuum at which the main valve can be opened.For example, when pumping a 100-litre studio with a cryogenic pump with a switching value of 150 torl, the switching pressure is:

150 torre • L /100 L = 1.5 torre

In other words, when the vacuum chamber reaches a vacuum degree of 1.5 torr or more, it can open the main valve and pump air with the cryogenic pump. In practice, the general switching pressure is: 0.2- 0.5 torches, that is, (2×10^{-1}- 5×10^{-1} Tot)High switching pressure (main valve opens early), making the vacuum chamber pumping time shorter, but will make the cryogenic pump pumping time shorter before re-entry.

2. Working procedure of cryogenic pump system

1) Pre-vacuum pumping

Before starting the cryogenic pump, the vacuum in the chamber of the cryogenic pump must be pre -pumped to the starting pressure. The starting pressure of the general manufacturer's cryogenic pump is 5Pa. If the customer starts the cryogenic pump at a time higher than the starting pressure in order to save time, the cooling time of the cryogenic pump will be longer.

When helium and hydrogen gas are present in the system, the starting pressure needs to be 0.5Pa, if you need to produce less than 10 in the vacuum chamber -7Pa limit pressur e, then you need 10 to start -2 T he starting pressur e of Pa.

In ultra-high vacuum applications, the cryogenic pump and vacuum chamber must be baked, and the cryogenic pump must be equipped with a safety valve, (the manufacturer has installed a safety valve for each pump. Note: when disassembling or moving the cryoge nic pump, we must ensure that the safety valve is not touched, otherwise the vacuum degree will not go up, so we need to reinstall the safety valve.)

In order to pre-vacuum, it is necessary to close the high vacuum valve and start the mechanical pump connected to the vacuum interface of the cryogenic pump front stage. When the internal pressure of the cryogenic pump drops below its starting pressure, the vacuum valve of the front stage is closed, and the cryogenic pump is started as described above. If it is started under high pressure, the cooling time will be longer, and the low temperature will occur when the pressure is relatively high.

It takes about 12 hours to prepump a new pump because the activated carbon in the cryogenic pump permeates water vapor.

Note: If you do not add pipe to the front stage to cool the well, the front stage pressure is not allowed to drop below 3Pa. In addit ion, the oil vapor from the front stage pump can flow back into the cryogenic pump and be condensed or adsorbed. If the activated carbon is contaminated by oil, the adsorption matrix cannot be regenerated.

When the cryogenic pump reaches the starting pressure, the front stage vacuum valve should be immediately closed to prevent oil backflow, and then the front stage pump is used to pump the vacuum chamber to reduce the pressure required.

2)Bake

In order to meet the requirements of ultra high limit pressure sometimes need to bake, and bake to reduce to reach below 10 -7Pa press ure require d for the desire d time, in order to bake hopefully have at least 10-2 P a starting pressure.

Baking time and tempe rature depend on the required limit pressure, usually vacuum chamber baking temperature is 200 ℃ - 300 ℃, baking time is 24 hours, usually with heating belt around the pump body to bake, its high vacuum flange temperature should not exceed 100 ℃, the motor temperature should not exceed 60℃.

If baking is required, it is necessary to prevent overheating of the internal components of the cold head. Temperature detection equipment such as two sets of diodes can be used. If the diode is used for measurement, the hi gh temperature trip relay should be connected to the power supply of the heating belt, so as to cut off the heater before the primary and secondary cold head reach the maximum temperature0C below, to take into account the delay and error of the relay and temper ature detector.

Due to the release of a large amount of water vapor between the first baking, so the front pump should be kept on, so as to avoid water vapor condensation on the adsorption array. When operating the front pump, it is necessary to open the gas ballast valve to avoid water vapor condensation in the pump.

3) Start and cool down

Start the cryopump with the following procedure:

◆ In ensuring cryogenic pumps and compressors installed correctly, under the condition of low temperature pump drainage to the start-up pressure, before the high vacuum valves and piping valve in the closed state.

◆On compressor water supply,

◆ Connected the compressor power, to ensure that the pressure to start at this time.

◆On your track records can record the value of the compressor operating at high pressure and low pressure, and then during the cooling cycle time interval record low temperature pump the instructions of the thermometer, also want to record the time it takes to reach the lowest temperature, low temperature pump of low temperature pump cooling time can be found in the index and specifications, these information can help us out so the barrier.

4) Operation monitoring

Hotline for 18757617999

◆ Do not overload the cryopump by exceeding its entry pressure. In addition, the pump will heat up and release adsorbed gas due to startup. If the overload is serious, the cryopump may not resume operation and require you to close the high vacuum valve and re-pre-vacuum.

◆ To keep the pressure of the vacuum chamber under 0.5 Pa to avoid from the outer wall of low temperature pump its condensation heat conduction.

◆ When pumping nitrogen, oxygen, nitrogen and hydrogen compounds and water, the temperature of the cryogenic pump must be 230C- 250C, and when pumping mainly helium, the temperature cannot exceed 180C.

◆ Monitoring compressor pressure ga uge in the operation of the compressor, high pressure table in commonly 1.7 2.0 Mpa, the low pressure table is in commonly 0.4 0.7 Mpa, sometimes there will be some deviation, average pressure difference between 1.0 1.4, there is no problem, if not balance in the operation of pressure is not up to standard, then you need to fill gas.

◆ When secondary temperatures began to increase, and the limit of the vacuum chamber pressure began to rise, the cryogenic pumps have to regenerate, born again after cooling can run long.

in the running process shall ensure that from the compressor to th e temperature of the low -temperature pump high pressure metal hose can't more than 350C, if the metal tube temperature is highe r, please check the cooling water.

5) Pump dangerous gas

Suggestion: Do not use cryogenic pumps or any adsorption type pumps to pump toxic gases including oxygen and hydrogen.

Cryogenic pump is an adsorption type of pump, it stores process gases rather than continuous removal or release process gases, so dangero us gases will be concentrated in the pump, in the case of regeneration or failure of the power supply or compressor, the pump will be hot, and dangerous gases will be released at very high concentrations.For this reason, we recommend that cryogenic pumps not be used to pump combustible and explosive gases, which, if ignited outside, will lead to serious consequences.

If your cryogenic pump is exposed to toxic, flammable, explosive and corrosive gases, ensure that the pre -pumping and regeneration system has a properly sealed exhaust system to which the relief valve must be connected to avoid exposure of the preceding pump and any adsorption well to dangerous gases during regeneration.

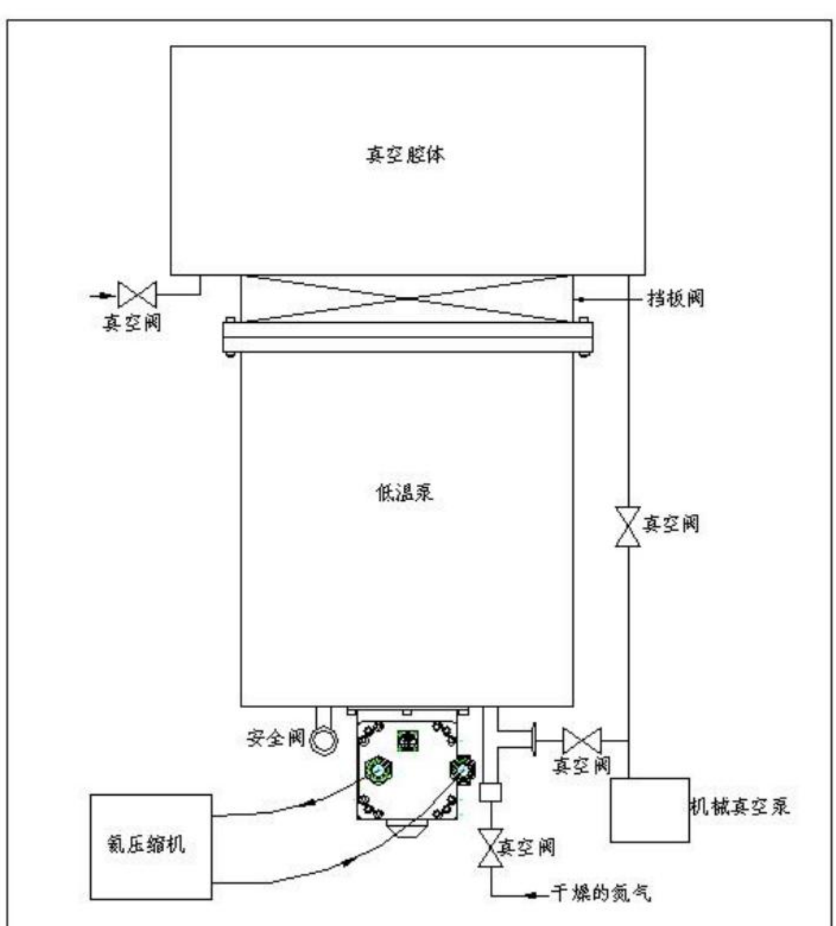
If the gas is spontaneous or explosive, then you should ensure that the cryopump does not have devices that could generate sparks, such as electric heating, ionization or conductance gauges or electronic temperature detectors. The regenerative cryopump should use the exhaust method rather than the electrical regeneration method.

Before and during regeneration, the cryopump should be flushed with dry inert gas for approximately 15 minutes to dilute the concentration of the dangerous gas to a safe level.

Mechanical pumps and any filters or cold Wells should also be rinsed with inert gas during operation and prior to maintenance to avoid hazardous gas buildup in the pump passenger.

When necessary, the cryogenic pump for oxygen pumping shall not pump gas containing more than 21% oxygen.When pumping hydrogen, the temperature of the cryogenic pump should not exceed 18K.

The hotline for 18757617999



典型低温泵安装

BWOKA. ting@bwokai.com

3. Regeneration of cryogenic pumps

Cryogenic pump in continuous work for a certain time, the cold surface of the sediment layer thickened, pumping speed down, the need for regeneration to restore it to the original state.Regeneration is carried out when the pumpin g rate drops by half or when the refrigeration temperature exceeds 20K.Regeneration can be carried out automatically by stopping the machine to make it warm up, or it can be accelerated by filling the cryogenic pump chamber with dry nitrogen or heating the cold plate.Some low -temperature pumps are equipped with automatic regeneration device to facilitate the regeneration operation.

The typical process of low -temperature vacuum pump regeneration: first let the low-temperature condensing plate back to the amb ient temperature, and then vacuum to 5×10 — 2 1 x 10 — 1 Bracket, and finally restart the cryogenic pump to cool the cold array to the proper operating temperature.

Regeneration of the cryopump does not need to be very frequent. A device with a 48-inch vacuum chamber that runs on two shifts and 12 cycles per shift requires only about one cycle every two weeks, or after 120 cycles.

Of course frequent regeneration may be necessary under extreme conditions.For example, plating four f ilms on plastic substrate with a high water vapor load, with a 30-minute cycle, averaged 32 times per day and produced more than 38,000 pieces.

Regeneration is best done in a planned way and can be done regularly at the convenience of the user, typically o n weekends without the supervision of an operator.Even a microprocessor -controlled automatic regeneration system can be used after the shop is closed without interruption of production operation.The entire regeneration cycle, from the pump being separated, shut down, purified and heated to roughing and restarting operation, is completely manual free.

Many cryopump users schedule regeneration early on Monday mornings to get the system ready for the first shift.In some cases, both cryopters may be able to regenerate at the same time.

In what circumstances does regeneration need to be done? This can easily be determined by detecting a rise in the temperature of a cryopump, by looking at a hydrogen vapor pressure thermometer; Or detect if there is a slow rise in t he system's operating pressure.

Advice hotline: 18757617999

Using cryogenic pump, the film quality is better and the yield is higher.This has attracted the majority of optical plating manufacturers and laser products manufacturers almost 100% switch to the use of cryogenic pumps.It can be expected that, due to the competitive pressure and the demand for high -quality optical coating, optical coating companies all switch to the use of cryogenic pumps.

Ⅴ The maintenance of cryogenic pump

1. Daily maintenance of cryogenic pump

◆Compressor and pump at low temperature the pump head pressure is 1.3 to 1.5 MPa, so before the removal of any pressure parts, the first Must first put the gas inside the parts to normal atmospheric pressure.

◆ The compressor and the ac voltage is very dangerous, cryogenic pump use electric shock could be fatal, therefore must cut off power supply when maintenance.

Once installed, cryogenic pump system is almost don't need daily maintenance, must follow the maintenance is running about 18000 hours later, the replacement of the compressor oil adsorber.Preventive maintenance specifications:

◆Record low temperature pump temperature...(every day)

◆Record compressor pressure...(every day)

◆Replacement compressor adsorber...(15000 hours)

◆To replace piston head cold...(as required)

◆To compressor with helium gas...(as required)

Normal irregular maintenance procedures:

◆According to the need for compressor with helium

◆Of low-temperature pump cooling capacity of a significant decline in replace cold piston head

◆ When defiled objects into helium loop, using helium purge compressor and cold head.

2. low temperature pump fault diagnosis, and ruled out

1)Troubleshooting procedures

During the operation of the cryogenic pump sometimes there will be a series of problems, for the convenience of users, you can solve some problems by yourself, but because the cryogenic pump system is full of more than 1.3MPa pressure, so when disassembling any parts must be put to air.

When you find a problem with the cryogenic pump-compressor system, before determining whether the root cause of the problem is the cryogenic pump or the compressor fault, first look at the following simple problem check.

◆Cryogenic pump switched on or not.

◆ Compressor after good power supply are not reflected, to see if the compressor of the thermal protection is on.

◆Whether compressor is flat, because too much may cause the slope of the compressor runtime compressor overheat and stop

◆In the pump is not up to cut into the pressure of low temperature and can't open the high vacuum valve. cryogenic pump whether to regeneration?

◆Compressor of the adsorber after about 15000 hours after the replacement yet? vacuum system is to ensure that the air leakage.

◆Whether cold array by the oil pollution.

◆Metal hose installation is correct.

◆Helium is contaminated.

◆Adequacy of helium.

2) common troubleshooting and measures

故障现象	故障范围	可能原因	建议措施
1. 低温泵最低温度太高或冷却时间太长	a. 低温泵已经抽气至饱和	低温泵需要再生	启动再生器进行低温泵再生
		系统负载太大	更换制冷量更大的低温泵
		开启压力过高	在启动低温泵之前至少预抽到5Pa，泵回温到室温前不要使泵暴露大气中
	b. 活塞与配气阀	活塞坏了	更换新的活塞和配气阀，如有此种现象请与生产商联系
		氦气被污染	按照 2a 的方法确定氦污染，用 5 级氦吹洗系统
	c. 氦气压力太低	氦气系统有漏。平衡压力低于正常值	要对压缩机的安全阀、自密封接头、软管、等所有接头进行捡漏，由于压缩机管路磨损请检查所有管路
	d. 温度显示器	装气压表的由于氢压表功能不正常引起误差	室温下为 5Pa 左右，请与生产商联系安排维修
		装硅二极管的由于它功能不正常	更换新的二极管
			确保二极管的连接正确，安装准确
		铑铁温度计出现问题	重新安装或更换新的
	e. 真空腔漏气（捡漏时要在室温下）	由于安全阀的 0 圈漏气造成	检查 0 圈，清洗密封面并重新安装，还漏则更换安全阀
		信号输出接头漏气	拧紧或重新安装

		高真空阀门或连接管路有漏	检查并消除漏点
	f. 障板或辐射屏	障板或辐射屏与泵外壳相碰	拧紧螺钉确保他们的正确位置
		再生与烘烤时铟片过热损坏	安装新的铟片
		辐射屏被腐蚀或很脏没有光泽	拆下用酒精清洗,
	g. 吸附阵	吸附阵与辐射屏或障板接触	纠正使之不相接触
	h. 软管	软管接错拉	根据说明书接
	i 低温泵过热	有象真空炉的热源	在高阀与热源间安装水冷挡板
	j. 压缩机	氦压力过大	在压缩机的进气口放一些气体
	k. 油吸附器	油吸附器饱和	安装一只新的
	1. 低温泵和压缩机失配	氦泵的进气量大于压缩机的排气量	与生产商联系，安排搭配
2. 低温泵的极限压力不达标	a. 温度太高	见故障 1	同故障 1 处理
	b. 真空室	有漏	对真空室和高阀进行检漏
		放气过大	对真空室和低温泵壳进行烘烤
	c. 低温泵被油污染,（如吸附阵有油请更换吸附阵）	运行时前级泵返油蒸汽	在前级加冷井，长更换过滤介质
		冷阱不起作用	检查冷阱
	d. 制冷机	制冷机运转不规律，有噪音	见故障 2
	e 低温泵	用了不合适的泵	与生产商联系更正
3. 低温泵噪音大，运转缓慢或不规则（正常为 2.4Hz）	a. 氦回路或配气阀污染	氦的供气系统中含有湿气或空气	用 5 级氦气吹洗，确保没有湿气
		氦气中含有油蒸汽	安装一只新吸附器，检查一下自密封接头是否有油，有则需吹洗氦气系统
		油分离器不起作用或回油管被堵塞	与生产商联系
	b. 制冷机	活塞或配气阀损坏	与生产商联系
		配气阀与阀座之间有赃物	清洗，如有划痕与生产商联系
	c. 磁场	制冷机处于超过 300 高斯的磁场中	请增加磁场屏蔽
4. 压缩机停止运转	a. 氦气温度太高	热保护起作用	检查水流量（调节水温使之不超过 25℃）

		压缩机的转向错误	更改输入电源的相位使压缩机有压力差为止
		环境温度太高	环境温度不能超过 40°C
	b.压缩机运行一段时间后空开突跳为OFF位置。	1) 电源缺失或降压 2) 电机绕组有缺陷	1) 检查线路所有相的电压 2) 检查线路上的运行电流
	c.系统空开处于ON位置，但是压缩机在运行几分钟后停机且开关处于OFF位置。	过低的冷却水温造成压缩机启动后由注油孔进入的润滑油流量受到限制。	选择合适的冷却水温度，参考表**1-1**。重新启动压缩机直到可以连续正常运行。
	d.氦气压力太低	压缩机有漏	对压缩机进行检漏
	e.交流电电压	它太低造成高马达电流和高温	检查AC线电压使符合要求
	f.水保护启动	由于某时开机而没有通冷却水	把水保护的蓝色按钮按下去即可

Ⅵ. Examples of cryogenic pump used in vacuum equipment

1. Vacuum exhaust equipment and vacuum treatment equipment

Cathode ray tube, traveling wave tube, magnetron and other electric vacuum device exhaust packaging, used to use diffusion pump, molecular pump or off pump, use low temperature pump after bringing a lot of benefits.Other vacuum treatment devices, vacuum furnaces, vacuum degassing devices, etc., make the effect of cryogenic pump is very good.

Example 1: Cathode ray tubes are often pumped with turbomolecular pumps. Due to the problem of inward explosion, an expensive high -speed valve is needed to isolate the turbomolecular pumps from the vacuum chamber. Oil contamination of the cathode -ray tube is also a problem, since molecular pumps are difficult to be completely oil -free.After replacing the molecular pump with two Φ150mm diameter cryogenic pumps driven by a universal press, the switch from mechanical pump to cryogenic pump is carried out when t he vacuum degree is 1 support, and the cycle time is significantly reduced.The performance of the cathode ray tube has been greatly improved, which is attributed to the elimination of pollution from the vacuum pump system.

Some enterprises use sputtering ion pumps to vent magnetron or traveling wave tube. There is a problem that when heating (generally up to 450 ℃), a large amount of air is discharged from the pumped tube, and the pumping speed of the pump is insufficient.Thi s problem is solved after the cryogenic pump with a water-cooled baffle is replaced.

Example 2: Galanz is the world's largest microwave oven manufacturer. After the enterprise uses 500 caliber cryogenic pump to exhaust the magnetron, the exhaust time is greatly shortened and the cost is significantly reduced.

2. Sputtering coating equipment

Sputtering stations have made extensive use of cryopumps, from the earliest 3-inch to the latest 12-inch line.

Example 3: Titanium, platinum, and gold films are sputtered on a 3-inch sheet on a sputtering device, and the substrate is fixed while being sputtered. The rate of production is 16 sheets per 10 minute cycle.A comparative experiment was conducted between a 1500L/S molecular pump and a 200mm diameter cryogenic pump. The load fixing chamber should be pumped to 5 ×10 before the film is introduced into the sputtering zone － 6 Support. When both the cryogenic pump and the molecular pump pump pump air at 1500L/S, the cryogenic pump can remove water vapor at 4000L/S, while the molecular pump pump pump air at 1500L/S.This difference in steam pumping speed significantly reduces the cycle time by 20%.

Example 4: A large optical coating machine (2.2 m diameter x 2.3 m heig ht) is pumped by three 400mm diameter diffusion pumps. Several of these large coaters are installed on the same production site and the operator needs to work on the ground near the base of the pump.In an attempt to improve the quality of the product, three 250mm diameter cryogenic pumps were used instead of the three diffusion pumps.The cycle time is approximately equal. Note that the port area of cryogenic pumps is only 40% of the diffusion pumps they replace.The product quality is greatly improved by eli minating the pump return oil.An added benefit of the cryogenic pump is that there is no electric furnace to heat, providing comfortable working conditions for the machine operator. The savings in electricity are also great.

Example 5: A company's coating laboratory with cryogenic pump plating optical film, feel the use of cryogenic pump, the film repeatability is very good, that is, make different people to operate, also can achieve high repeatability of the film. The clean vacuum of the cryopump also increa ses productivity.Before the use of diffusion pump, because of the adhesion and hardness is not qualified, in eight coating is once waste, waste rate is reduced to zero after the use of cryogenic pump.

3. Ion implantation equipment

Ion implantation machine has high requirements on the quality of vacuum and is suitable for the use of cryogenic pump.

Example 6: In the loading chamber and discharge chamber, the diameter of 200mm diffusion pump with liquid nitrogen baffle i s used for ion implantation. The diameter of the chamber is 600 × 450mm, and the diffusion pump can reach the required 7 × 10 in 12 minutes − 6 Tote.Reduce this time to 1 minute after installing the cryopump, and reduce the total cycle time from 27 minutes with the diffusion pump to 15 minutes with the cryopump. In other words, the output of the injector was almost doubled.Now, more than 600 cycles are performed each week, and the regeneration of the cryopump occurs automatically on weekends.It can also save a large amount of liquid nitrogen costs every year.

4. Evapor ation coating equipment

Example 7: An evaporation table with a glass bell jar of Φ460×760mm fitted with a 200mm diameter diffusion pump with a water cooled baffle. The system is used to deposit 16 to 50 layers of materials such as zinc sulfide and thorium oxide.The system pressure should be less than 2 x 10 layers before deposition begins — 5 It will take about 34 minutes for the system to reach this value with the diffusion pump in the initial stage.After replacing with a cryogenic pump of 200mm diameter, the pumping time is reduced to less than 20 minutes.The cryogenic pump can maintain half of the pressure lower than the diffusion pump when working.The substitution of the cryogenic pump for the diffusion pump has resulted in a significant increase in production and a significant improvement in film quality.

Ⅶ. Introduction of Zhejiang Bokai Electromechanical Technology Co., LTD

Zhejiang Bokai Electromechanical Technology Co., Ltd. is located in Jinhua Economic Development Zone, Zhejiang Province, is a professional engaged in low - temperature refrigeration products, vacuum products R & D, design, manufacturing, sales and after-sales service as one of the new high -tech enterprises.Bokai's products are widely used in integrated circuit and semiconductor device manufacturing, flat panel display device manufacturing, vacuum coating, vacuum exhaust station, scientific research equipment and scientific instruments (such as superconductivity, new material research, condensed matter physics and surface physics research), product environmental tests, industrial gas treatment and supply and other fields, is the first choice to replace imported products.

The company will adhere to the core technology and products of continuous technical innovation and improvement, adhering to the "integrity-based, quality leading, continuous innovation" concept, for the majority of customers to provide quality products and technical services, with you and your enterprise hand in hand for sustainable development!

DZB series cryogenic pump main perfor m ance indicators:

型号 Model		DZB200	DZB250	DZB300	DZB400	DZB500	DZB550
抽速 Pumping Speeds (l/s)	For H_2O	4200	6500	9000	16000	30,000	36,000
	For Air	1500	2300	3000	6000	10,500	12,0 00
	For H_2	2500	2500	5000	5000	13,000	15,000
	For Ar	1200	1900	2500	5000	8,500	10,000
	For H e	750	1100	2300	2500	3,500	4,200
通导 Throughput （scc/min）	for Ar	700	1200	1500	500	790	790
抽气容量 Capacity （Std.l)	For N_2/Ar	1000	2000	2000	2500	3,200	3,200
	For H_2/ H e	18	25	25	20	20	20
降温时间 Cool Down Time (min)		≤90	≤90	≤90	≤150	≤180	≤180
泵口法兰 Inlet Flange (可根据用户要求定制)		ANSI 6in	ANSI 10in	ANSI 12in	ANSI 16in	ANSI 20in	ANSI 22in
		CF 10in.	CF 12in	CF 14in			
		ISO 200mm	ISO 250mm	ISO 320mm	ISO 400mm	ISO 500mm	/