**Cleaning method of air separation equipment**

1、Air separation equipment and its performance characteristics

1.1 Air separation equipment

Air separation equipment is the air as raw material， through the compression cycle depth freezing method to turn the air into a liquid state， and then after distillation and gradually separated from the liquid air to produce oxygen， nitrogen and argon and other inert gases equipment.

At present， China's production of air separation equipment in various forms， a wide variety. There is the production of gaseous oxygen and nitrogen equipment， but also the production of liquid oxygen and nitrogen equipment. But as far as the basic process is concerned， there are four main types， namely high pressure， medium pressure， high and low pressure and full low pressure process. The production scale of China's air separation equipment has developed from the early production of only 20 m3 /hour (oxygen) oxygen machine to the current production of 20，000 m3 /hour， 30，000 m3 /hour and 50，000 m3 /hour (oxygen) of ultra-large air separation equipment.

1.2 The basic system of air separation equipment.

Air separation equipment can be divided into five basic systems in terms of process flow.

1.2.1 Impurity purification system: mainly through the air filter and molecular sieve absorber and other equipment to purify the air mixed with mechanical impurities， water， carbon dioxide， acetylene， etc.

1.2.2 Air cooling and liquefaction system: mainly consists of air compressor， heat exchanger， expander and air throttle， etc.， which plays the role of making the air deeply frozen.

1.2.3 Air distillation system: mainly consists of distillation tower (upper tower， lower tower)， condensing evaporator， subcooler， liquid air and liquid nitrogen throttle valve， etc. The role of separating the various components of air

1.2.4 Heating and blowing system: regenerate the purification system by heating and blowing.

1.2.5 Instrument control system: control the whole process through various instruments.

2. Surface cleanliness of air separation equipment and its inspection method

2.1 Air separation equipment is prone to combustion

Combustion or even the occurrence of an explosion must meet 3 conditions: a certain amount of combustible materials， the presence of the corresponding amount of oxidant， a minimum of energy security. The most important feature of the working environment of air separation equipment is the oxygen cycle in low or room temperature conditions. Pure oxygen is a strong oxidant， even in the -183 ℃ liquefied low temperature state， as long as the number or concentration of flammable and explosive substances exceed the explosive limit， the medium oxygen due to high-speed transport friction generated by the accumulation of energy to a certain value， it will still explode， resulting in casualties and equipment damage. Therefore， air separation equipment where the media oxygen contact parts， its surface cleanliness requirements are very high， does not allow the presence of mechanical impurities and organic substances such as grease， these substances must be removed.

Air separation equipment grease-free parts of degreasing cleaning is through physical or chemical methods， select the appropriate cleaning agent through a specific cleaning process to clean its surface to ensure that the concentration of organic substances on its surface is controlled below the explosive limit. This is a necessary condition for the safe operation of air separation equipment， and after surface treatment， it has to undergo strict inspection and testing before it can be put into use.

2.2 Types of air separation equipment surface dirt

The indicators for checking the cleanliness of the surface of air separation equipment should include the following four types of substances.

(1) solid substances: such as organic rust inhibitors， wood， paper， fiber， paint and other organic substances; welding slag and spatter， metal chips， welding wire and other metal substances; sand and similar particulate matter， and other substances that may dissolve under working conditions.

(2) Cleaning solution and water

(3) floating rust and oxidation skin

(4) mineral oil and grease

2.3 Surface cleanliness inspection methods

Solid materials， cleaning solution， water and rust marks can be directly inspected visually by eye. Under bright light， eye observation of the surface of the inspected equipment for residual solid material. The presence of solid particles with a diameter (or diagonal) greater than 0.5mm is not allowed， and the sum of solid particles with a diameter (or diagonal) between 0.25-0.5mm should be less than 100 particles/m2， and no fibers， dust or fabric should be present. A single residual fiber whose length shall not exceed 2mm; the presence of residual cleaning solution and water is not allowed， and the surface should be completely dry.

The determination of mineral oil and grease can be divided into direct inspection method and quantitative determination method. Direct inspection method has filter paper wipe method， ultraviolet fluorescence method， water coating test method and drop diffusion method. Quantitative analysis method can be further divided into weight method and oil concentration determination method.

At present， the determination of residual oil on the surface of air separation equipment in China basically uses the oil concentration measurement method， which is the most widely used.

3. determination of the standard oil residue on the surface of air separation equipment

Degreasing and cleaning of air separation equipment is to remove the grease from the surface of the components in order to achieve the standard requirements for the amount of oil residue on the surface. The lower the amount of oil residue specified in the standard， the higher the requirements for equipment cleaning， the cleaning process will be more tedious， labor-intensive， and the cleaning cost will be greatly increased. How should the standard for the measurement of residual oil prohibited on the surface of air separation equipment parts be determined? I think the principle should be to implement ISO9000 to ensure the quality of the product and the absolute safety of the system operation， and at the same time the value of the residual oil should be set reasonably and appropriately.

I think the essence of this reasonable value is the behavior， enrichment and explosive limit concentration of oil and grease in the oxygen medium. Some literature review articles [1] and Mckinley.c [2] and others point out that the lower explosive limit for hydrocarbon mixtures dissolved in liquid oxygen can be taken as 5% (grams of molecules) of methane equivalent. When the concentration of hydrocarbons in the mixture exceeds these limits， it becomes an explosive mixture with special hazards.

This limit concentration also applies to the uniform distribution of hydrocarbons in liquid oxygen in suspended or emulsified form. After conversion 5% grams of molecular methane equivalent is equivalent to 28kg CnH2n/m3 liquid oxygen. Grease in liquid oxygen comes from residual oil scale on surfaces in contact with media oxygen in air separation equipment. The amount of oil richness is different for parts with different specific surfaces， the larger the surface per unit volume， the larger the oil richness. We assume that all the surface residual oil enters the liquid oxygen， and the limit value of the residual oil on the surface of the parts with different specific surfaces can be obtained after transformation (see Table 1).

Table 1 Calculated values of oil residual limits for different product surfaces

Product specific surface area residual oil limit calculation value

Name Specification g/m2μm

Adjustment packing 750#350# 750350 3580 4194

Oxygen cooler 160 175 200

Liquid oxygen cryogenic storage tank 50m3 100m3 42 700014000

As can be seen from Table 1， if the surface residual grease in contact with the medium oxygen in the air separation system is absolutely uniformly dispersed in the liquid oxygen (which is the ideal state in the laboratory)， then the limit grease residual for the explosion is quite high.

What is the actual form of oil on the walls of the apparatus at low temperatures? The article "Performance of oil films on structural fillers at low temperatures" [3] describes the study of the performance of oil films in oxygen and liquid oxygen by Linde， Anton Kissinger and others. Kehart used n-hexadecane as a typical substance for combustion experiments in liquid oxygen. At low temperatures， the n-hexadecane oil film located on the walls of stainless steel tubes solidifies， and when the film thickness is >5 g/m2， a portion of the oil layer is observed to flake off and the solid n-hexadecane oil film formed floats on the surface of liquid oxygen. Although n-hexadecane is transportable at ambient temperatures and flakes off at low temperatures， Kehat was unable to spot oil， so he suggested that oil contamination of about 5 g/m2 would be tolerable in systems using oxygen.