Cryogenic process of air separation

Low temperature process of air separation

Air consists of a variety of gases， of which nitrogen (N2) and oxygen (O2) account for 99.03% of the total sample volume. There are about 78.08% nitrogen， about 20.95% oxygen and about 0.93% argon in the dry air， as well as traces of other gases， such as hydrogen， neon， helium， krypton， xenon and carbon dioxide. Ambient air may contain varying amounts of water vapor (depending on humidity) and other gases produced by natural processes and human activities. Oxygen and nitrogen are produced through the air separation process， which requires the separation of air into its components. Rare gases， such as argon and krypton， can be recovered as by-products of the air separation process.

The separation of air into its constituent gases is accomplished by implementing specific air separation techniques. At present， there are different air separation technologies， each of which aims to take advantage of the different properties of the physical properties between the air components. In other words， the air separation technology is based on the fact that each component gas in the air has different physical properties. Therefore， the air separation is realized by using certain physical properties， such as (I) distinguishing the molecular size of the component gas， (II) distinguishing the diffusion speed difference through some materials， (III) adsorption preference of special materials for certain gases， and (IV) difference in boiling point temperature， etc.

Some of the technologies used today include low temperature， adsorption， chemical processes， polymeric membranes， and ion transport membranes (ITMS). Among these technologies， low-temperature air separation technology is in the mature stage of its life cycle. Therefore， it is the only feasible means among the currently available technologies for large-scale production of oxygen， nitrogen， argon and other air products.

Air separation technology is used to produce oxygen and / or nitrogen， sometimes as a liquid product. Some plants also produce argon， either gas， liquid， or both. All air separation processes begin with compressed air. All air separation plants use non cryogenic technology or cryogenic technology. Air separation plants using non cryogenic air separation technology use a separation process close to ambient temperature to produce gaseous oxygen or nitrogen products. These plants typically produce oxygen of 90 to 95.5 percent purity， or nitrogen of 95.5 to 99.5 percent oxygen free. Air separation equipment can produce more than three times more nitrogen than oxygen， but usually maintain a ratio of 1:1 to 1.5:1.

The low temperature process was first developed by Karl von Linde in 1895 and improved by George Claude in the 1900s. It is used for small-scale production of oxygen to meet the requirements of various industrial processes， such as welding and cutting， and as a medical gas.

Industrial scale cryogenic air separation began in the early 20th century， which promoted the development of metallurgical industry and other industrial sectors that are highly dependent on oxygen， nitrogen and ultimately argon. Low temperature air separation equipment (ASP) is characterized by good product quality， large capacity and high reliability. Despite other emerging air separation technologies， cryogenic air separation technology is still the basic technology for oxygen production. Cryogenic air separation equipment is most commonly used to produce high purity gas products. However， for applications that require a large amount of gas， the use of this technology is limited， usually requiring hundreds of tons of separated gas per day. They can produce gaseous or liquid products.

Low temperature air separation technology uses the difference of boiling point of gas for separation. It is based on the fact that different components of air have different boiling points， and air can be separated into its components by manipulating the direct environment in terms of temperature and pressure. The boiling point of oxygen at 1 atmosphere and 0 °C is minus 182.9 °C， and the boiling point at 6 atmospheres and 0 °C is minus 160.7 °C. The corresponding boiling points of nitrogen are minus 195.8 °C and minus 176.6 °C， and the boiling points of argon are minus 185.8 °C and minus 164.6 °C respectively.

Low temperature separation is the most effective process when any of the three criteria needs to be met， i.e. (I) high purity oxygen (higher than 99.5%)， (II) large amount of oxygen (greater than 100 tons of oxygen / day)， or (III) high pressure oxygen. The low temperature air separator needs more than one hour to start. In addition， since the cryogenic technology can produce such high purity oxygen， the waste nitrogen stream also has available quality. This can increase considerable economic benefits for the process combined with low temperature air separation equipment.

The separation of air into its constituent gases at low temperature involves various processes. These processes need to be combined in cryogenic air separation equipment， the most basic of which are (I) air compression， (II) air purification， (III) heat exchange， (IV) distillation， and (V) product compression. Figure 1 shows these processes.

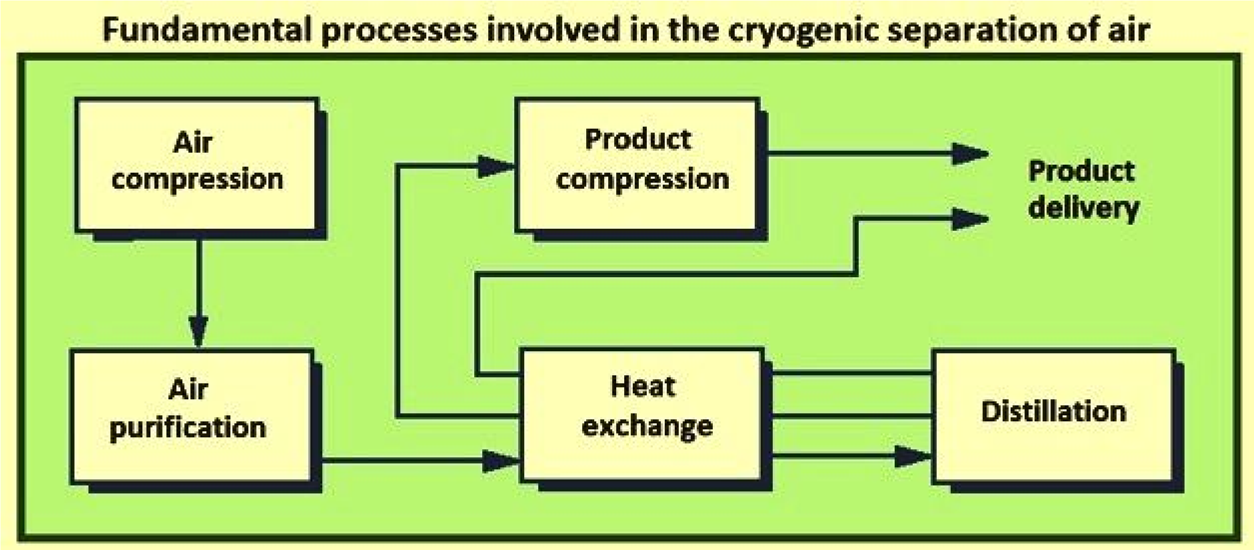

Figure 1 involves the basic process of cryogenic air separation

The cryogenic air separation equipment is based on the cryogenic air separation process. Since its commercialization in the early 20th century， the basic process as an industrial process has been developing continuously. A large number of process configuration changes have occurred due to the desire to produce specific gas products and product combinations as efficiently as possible at various required purity and pressure levels. These air separation process cycles are developing synchronously with the progress of compression machinery， heat exchanger， distillation technology and gas expander technology.

The distillation process is the core of the whole process because it actually separates air into its components. The air products produced have a certain purity， which is defined as the ratio of the quantity of 100% pure air products to the total amount of air products output.

In the distillation process， trays were used. The basic function of the tray is to effectively contact the falling liquid with the rising gas. Thus， the tray provides a stage for (I) cooling and partially condensing the rising gas， and (II) heating and partially vaporizing the falling liquid. Figure 2 shows a typical distillation column with a fractionation tray. This distillation column has only one vaporizer and one condenser. Distillation is achieved by effective liquid gas contact， which is achieved by proper contact between the falling liquid and the rising gas. The purity of the most volatile and less volatile elements is different on each tray. The lower and upper sides of the distillation column are two extremes， which is also the place to obtain pure elements.