Separation and purification of gas mixtures by pressure swing adsorption (PSA) technology has become an important unit operation in the chemical industry in the last twenty-five years. A large variety of binary and multi-component gas mixtures are commercially being separated using this technology. Table 1 provides a comprehensive list of the major applications of the technology [1-3] and Figure 1 shows the year-by-year tally of the number of worldwide patents issued between 1970-1987 [4] with PSA as the key words in the titles. It is apparent that the growth in research and development and commercialization of PSA processes has been rather spectacular in the last two decades and the future of this technology is very promising. The key reason for this outstanding progress is that the PSA technology can provide a very flexible and efficient means of gas separation and it can reduce the energy and cost of separation compared to conventional separation processes like absorption and distillation for many applications. This is particularly important today when international competition is formidable and energy costs are high.

Table 1

Major Applications of Pressure Swing Adsorption Technology

- **Gas Drying**

- **Air Separation**
  Production of 80-95% \( \text{O}_2 \) enriched gas from air.
  Production of 25-50% \( \text{O}_2 \) enriched gas from air.
  Production of 95-99.9+% \( \text{N}_2 \) from air.
  Argon purification from crude argon produced by liquid air distillation.
  Removal of water and carbon dioxide from air feed to distillation columns.

- **Carbon Dioxide - Methane Separation**
  Purification of landfill gas
  Upgrading crude natural gas

- **Carbon Monoxide Production**
  Carbon monoxide recovery from blast furnace and other waste gases from steel industry.
• **Carbon Dioxide Production**  
  Purification of blast furnace flue gas.

• **Hydrogen Production**  
  Hydrogen recovery from steam-methane reformer (SMR) off-gas.  
  Hydrogen and carbon dioxide recovery from SMR off-gas.  
  Production/upgrading of hydrogen from many different hydrogen containing gases.

• **Production of ammonia synthesis gas from SMR off-gas.**

• **Miscellaneous Applications**  
  Separation of normal and iso-paraffins.  
  Helium recovery from diving gas.  
  Alcohol dehydration  
  Ozone enrichment  
  Solvent vapor removal and recovery

Reviews of the vast patent literature on PSA technology can be found elsewhere [1-9]. The purpose of this paper is to discuss the basic PSA process concepts and to describe several practical PSA processes and their relative performance.

**PSA PROCESS PRINCIPLES**

The principle of separation used by the PSA technology is selective adsorption of one or more components of a feed gas mixture on a solid adsorbent so that an adsorbed phase having a composition different from that of the feed mixture is formed when the feed is contacted with the adsorbent. This produces a gas phase enriched in the less selectively adsorbed components of the feed mixture. The adsorbed components are then desorbed by reducing their superincumbent partial pressures to produce a gas enriched in the more selectively adsorbed components of the feed mixture. The desorption process also cleans the adsorbent so that it can be reused. Consequently, a practical PSA process consists of a cyclic sequence of various "adsorption at high adsorbate partial pressure" and "desorption at low adsorbate partial pressure" steps. Hence, the name.

![FIGURE 1.](image)

In a practical PSA process, the adsorption step is usually carried out by contacting the feed gas with the adsorbent in a fixed packed bed or by