Air conditioning

History

earlier forms of air conditioning were invented in Persia (Iran) thousands of years ago in the form of wind shafts on the roof, which caught the wind and passed it through water and blew the cooled air into the building.

The 19th century British scientist and inventor, Michael Faraday discovered that compressing and liquefying a certain gas could chill air when the liquified ammonia was allowed to evaporate. His idea remained largely theoretical.

In 1842, Florida physician Dr. John Gorrie used compressor technology to create ice, which he would use to cool air blown over malaria and yellow fever patients.
He eventually had a vision of using his ice-making machine to regulate environment in buildings. He even envisioned centralized air conditioning that could cool entire cities. Gorrie was granted a patent in 1851 (Patent #8080, USPTO) for his ice-making machine. The technology was attacked by Northern businessmen with the help of religious leaders they got to call the technology blasphemous, in order to protect its business of exporting natural ice to Southern states. When both his partner and he died in 1855, the idea of air conditioning died with him for the time being.

One of the first uses of air conditioning for personal comfort was in 1902 when the New York Stock Exchange's new building was equipped with a central cooling as well as heating system. Alfred Wolff, an engineer from Hoboken, New Jersey
who is considered the forerunner in the quest to cool a working environment, helped design the new system, transferring this budding technology from textile mills to commercial buildings.

Later in 1902, the first modern, electrical air conditioning was invented by Willis Haviland Carrier (1876â€“1950). His invention differed from Wolff's in that it controlled not only temperature, but also humidity for improved manufacturing process control for a printing plant in Brooklyn, New York.
This specifically helped to provide low heat and humidity for consistent paper dimensions and ink alignment. Later, Carrier's technology was applied to increase productivity in the workplace, and the Carrier Engineering Company, now called Carrier (a division of United Technologies Corporation), was formed in 1915 to meet the new demand. Later still, air conditioning use was expanded to improve comfort in homes and automobiles. Residential sales didn't take off until the 1950's. The Royal Victoria Hospital, Belfast, Northern Ireland, is a Landmark Building in building engineering services (built in 1906) and lays claim to being the first â€œAir conditioned Building in the Worldâ€•.

In 1906, Stuart W. Cramer of Charlotte, North Carolina was exploring ways to add moisture to the air in his southern textile mill. Cramer coined the term "air conditioning" and used it in a patent claim he filed that year as an alternative to "water conditioning", then a well-known process for making textiles easier to work. He combined moisture with ventilation to actually "condition" and change the air in the factories, controlling the humidity so necessary in textile plants. Willis Carrier adopted the term and incorporated it into the name of the company he founded in 1907, The Carrier Air Conditioning Company of America.

The first air conditioners and refrigerators employed toxic gases like ammonia and methyl chloride, which resulted in fatal accidents when they leaked. Thomas Midgley, Jr. created the first chlorofluorocarbon gas, dubbed Freon in 1928. The refrigerant proved much safer for humans but is harmful to the atmosphere's ozone layer. "Freon" is a trade name of Dupont for any CFC, HCFC, or HFC refrigerant, the name of each including a number indicating molecular composition (R-11, R-12, R-22, R-134). The blend most used in direct-expansion comfort cooling is an HCFC known as R-22, and is slated to be phased out for use in new equipment by 2010 and completely discontinued by 2020. R-11 and R-12 are no longer manufactured in the US, the only source for purchase being the cleaned and purified gas recovered from other air conditioner systems. Several ozone-friendly refrigerants have been developed as alternatives, including R-410A, known by the brand name "Puron".

Air conditioning applications

Air conditioning engineers broadly divide air conditioning applications into comfort and process.

Comfort applications aim to provide an indoor environment that remains relatively constant in a range preferred by humans despite changes in external weather conditions or in internal heat loads. Some have claimed that comfort air conditioning increases worker productivity but this claim is disputed, one counter argument being that apparent increases in productivity can be explained as resulting from workers perceiving that their employer shows an interest in their welfare. (See Hawthorne effect). What is certain is that comfort air conditioning makes deep plan buildings feasible. Without air conditioning, buildings must be built narrower or with light wells so that inner spaces receive sufficient fresh air. Air conditioning also allows building to be taller since wind speed increases significantly with altitude making natural ventilation impractical for very tall buildings.

Process applications aim to provide an indoor environment suit a process being carried out that remains relatively constant despite changes in external weather conditions or in internal heat loads. Although often in the comfort range it is the process that determines conditons not human preference. Process applications include:

- Hospital operating theatres in which air is filtered to high levels to reduce infection risk and the humidity controlled to limit patient dehydration. Although temperatures are often in the comfort range, some specialist procedures such as open heart surgery require low temperatures (about 18Â°C, 64Â°F) and others such as neonatal relatively high temperatures (about 28Â°C, 82Â°F).

- Cleanrooms for the production of integrated circuits, pharmaceuticals and the like in which very high levels of air cleanliness and control of temperature and humidity are required for the success of the process.

- Facilities for breeding laboratory animals. Since many animals normally only reproduce in spring, holding them in rooms at which conditions mirror spring all year can cause them to reproduce year round.

- Aircraft air conditioning. Although nominally aimed at providing comfort for passengers and cooling of equipment, aircraft air conditioning presents a special process because of the low air pressure outside the aircraft.

In both comfort and process applications not only is the objective to control temperature (although in some comfort applications this is all that is controlled) but other factors including humidity, air movement and air quality.

Rating (SEER)

The efficiency of air conditioners are usually rated by the SEER (Seasonal Energy Efficiency Ratio) rating system. The SEER rating is calculated by dividing the total number of BTUs of heat removed from the air by the total amount of energy required by the air conditioner in watt-hours. The higher the ratio, the more energy efficient the air conditioner.

Looking at it on a power basis, the SEER ratio relates the cooling power of the air conditioner (in BTU per hour) to the electrical power consumption (in watts).
For example if an air conditioner has a cooling power of 5000 BTU/hour, and an SEER rating of 10, then on average it will consume 500 watts of electric power (5000 divided by 10).

Today, it is rare to see systems rated below SEER 9 in the United States, as people there are increasingly using higher efficiency units. In addition some countries set minimum values for energy efficiency, although not always in terms of SEER. (For example, the United States requires new systems to have a minimum SEER rating of 13.) Substantial energy savings can be obtained from more efficient systems. For example by upgrading from SEER 9 to SEER 13, the power consumption is reduced by over 30% (equal to 1 - 9/13). It is claimed that this can result in an energy cost saving of $US 300 per year, depending on energy tariffs, usage and climate. A common misconception held by people is that the SEER rating system also applies to the efficiency of heating systems. This however is not true, as SEER ratings only apply to air conditioning.

Air conditioners (for cooling) and heat pumps (for heating) both work similarly in that heat is transferred or "pumped" from a cooler "heat-source" to a warmer "heat-sink". (Note: This process requires energy input according to the second law of thermodynamics)

Air conditioners and heat pumps usually operate most effectively at temperatures around 50-55 degrees Fahrenheit. Typically when the heat source temperature falls below 40 deg F, the system begins to reach a point called the "balance point", where the system is not able to "pull" any more heat out of the heat-source. Similarly, when the heat-sink temperature rises, the system will also operate less effectively, and the system will not be able to "push" out any more heat typically when the heat-sink temperature reaches about 120 deg F.

Types of air conditioning

Refrigeration cycle

A diagram of the refrigeration cycle: 1) condensing coil, 2) expansion valve, 3) evaporator coil, 4) compressor.

In the refrigeration cycle, a heat pump transfers heat from a lower temperature heat source into a higher temperature heat sink. Heat would naturally flow in the opposite direction. This is the most common type of air conditioning. A refrigerator works in much the same way, as it pumps the heat out of the interior into the room in which it stands.

This cycle takes advantage of the universal gas law PV = nRT, where P is pressure, V is volume, R is the universal gas constant, T is temperature, and n is the number of moles of gas (1 mole = 6.022Ã—1023 molecules).

The most common refrigeration cycle uses an electric motor to drive a compressor. In an automobile the compressor is driven by a pulley on the engine's crankshaft, with both using electric motors for air circulation. Since evaporation occurs when heat is absorbed, and condensation occurs when heat is released, air conditioners are designed to use a compressor to cause pressure changes between two compartments, and actively pump a refrigerant around. A refrigerant is pumped into the cooled compartment (the evaporator coil), where the low pressure and load temperature cause the refrigerant to evaporate into a vapour, taking heat with it. In the other compartment (the condenser), the refrigerant vapour is compressed and forced through another heat exchange coil, condensing into a liquid, rejecting the heat previously absorbed from the cooled space.

Humidity

Refrigeration air conditioning equipment usually reduces the humidity of the air processed by the system. The relatively cold (below the dewpoint) evaporator coil condenses water vapor from the processed air, (much like an ice cold drink will condense water on the outside of a glass), sending the water to a drain and removing water vapor from the cooled space and lowering the relative humidity. Since humans perspire to provide natural cooling by the evaporation of perspiration from the skin, drier air (up to a point) improves the comfort provided. The comfort air conditioner is designed to create a 40% to 60% relative humidity in the occupied space. In food retailing establishments large open chiller cabinets act as highly effective air dehumidifing units.

Refrigerants

"Freon" is a trade name for a family of fluorocarbon refrigerants manufactured by DuPont and other companies. These refrigerants were commonly used due to their superior stability and safety properties. Unfortunately, evidence has accumulated that these chlorine bearing refrigerants reach the upper atmosphere when they escape. The chemistry is poorly understood but general consensus seems to be that CFCs break up in the stratosphere due to UV-radiation, releasing their chlorine atoms. These chlorine atoms act as catalysts in the breakdown of ozone, which does severe damage to the ozone layer that shields the Earth's surface from the strong UV radiation. The chlorine will remain active as a catalyst until and unless it binds with another particle forming a stable molecule. CFC refrigerants in common but receding usage include R-11 and R-12. Newer and more environmentally-safe refrigerants include HCFCs (R-22, used in most homes today) and HFCs (R-134a, used in most cars) have replaced most CFC use.

Evaporation coolers

The aforementioned Persian cooling systems were evaporation coolers. In very dry climates, such affectionately called "swamp coolers" are popular for improving comfort during hot weather. The evaporative cooler is a device that draws outside air through a wet pad. The sensible heat of the incoming air, as measured by a dry bulb thermometer, is reduced. The total heat (sensible heat plus latent heat) of the entering air is unchanged. Some of the sensible heat of the entering air is converted to latent heat by the evaporation of water in the wet cooler pads. If the entering air is dry enough, the results can be quite comfortable. These coolers cost less and are mechanically simple to understand and maintain.

An early type of cooler, using ice for a further effect, was patented by John Gorrie of Apalachicola, FL in 1842, who used the device to cool the patients of his malaria hospital.

A three-stage absorptive cooler exists that first dehumidifies the air with a spray of salt brine. The brine osmotically absorbs water vapor from the air. The second stage sprays water in the air, evaporatively cooling (via absorptive refrigeration) the air. Finally, to control the humidity, the air passes through another brine spray. The brine is reconcentrated by distillation. The system is used in some hospitals because, with filtering, a sufficiently hot regenerative distillation controls airborne organisms.

Absorptive chillers

Some buildings use gas turbines to generate electricity. The exhausts of these are hot enough to drive an absorptive chiller that produces cold water. The cold water is then run through radiators in air ducts for hydronic cooling. The dual use of the energy, both to generate electricity and cooling, makes this technology attractive when regional utility and fuel prices are right. Producing heat, power, and cooling in one system is known as trigeneration.

Power

Air conditioner equipment power in the U.S. is often described in terms of "tons of refrigeration". A "ton of refrigeration" is defined as the cooling power of one short ton (2000 pounds or 907 kilograms) of ice melting in a 24-hour period. This is equal to 12,000 BTU per hour, or 3510 watts (http://physics.nist.gov/Pubs/SP811/appenB9.html). Residential "central air" systems are usually from 1 to 5 tons (3 to 20 kW) in capacity.

The use of electric/compressive air conditioning puts a major demand on the nation's electrical power grid in warm weather, when most units are operating under heavy load. In the aftermath of the 2003 North America blackout locals were asked to keep their air conditioning off. During peak demand, additional power plants must often be brought online, usually natural gas fired plants because of their rapid startup. A 1995 study of various utility studies of residential air conditioning concluded that the average air conditioner wasted 40% of the input energy. This energy is lost, ironically, in the form of heat, which must be pumped out. There is a huge opportunity to reduce the need for new power plants and to conserve energy.

In an automobile the A/C system will use around 5 hp (4 kW) of the engine's power.

The Association of Home Appliance Manufacturers (AHAM) offers a worksheetthat can help you estimate how powerful an air conditioner you need. The worksheet guides you through the measurements needed to calculate the size of the air conditioner, and then it automatically calculates the final answer for you.

Insulation

Insulation reduces the required power of the air conditioning system. Thick walls, reflective roofing material, curtains and trees next to building also cut down on system and energy requirements.

Home air conditioning systems around the world

Domestic air conditioning is most prevalent and ubiquitous in the first-world nations of East Asia (Japan, South Korea, Taiwan, etc.). In this area, with soaring summer temperatures and a relatively high standard of living, air conditioning is considered a necessity and not a luxury. Japanese-made domestic air conditioners are usually window or split types, the latter being more modern and expensive.

In the United States, home air conditioning is more prevalent in the South and on the East Coast, in some parts of which it has reached the ubiquity it enjoys in East Asia. Central air systems are most common in the United States, and are virtually standard in all new dwellings in the state of Florida.

In Europe, home air conditioning remains a rarity, owing to the more temperate climate and social adaptations (for example, it is traditional to take siesta in Spain, and to take long summer holidays in France). Global warming may necessitate more widespread adoption of air conditioning; its lack in homes, in residential care homes and in medical facilities was identified as a contributing factor to the estimated 35000 deaths left in the wake of the 2003 heat wave.

The information above was gathered from the wikipedia site at the following url :
http://en.wikipedia.org/wiki/Air_conditioning