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Air Conditioning
1- Introduction
Principles

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Air-conditioning systems usually provide year-round control of several air conditions, namely, temperature, humidity, cleanliness, and air motion. These systems may also be referred to as environmental control systems, although today they are usually called **heating, ventilating, and air-conditioning** (**HVAC**) systems.

The primary function of an HVAC system is:
(1) The generation and maintenance of comfort for occupants in a conditioned space.
(2) The supplying of a set of environmental conditions (high temperature and high humidity, low temperature and high humidity, etc.) for a process or product within a space.

HVAC Processes

1. **Heating**: the process of adding thermal energy (heat) to the conditioned space for the purposes of raising or maintaining the temperature of the space.
2. **Cooling**: the process of removing thermal energy (heat) from the conditioned space for the purposes of lowering or maintaining the temperature of the space.
3. **Humidifying**: the process of adding water vapor (moisture) to the air in the conditioned space for the purposes of raising or maintaining the moisture content of the air.
4. **Dehumidifying**: the process of removing water vapor (moisture) from the air in the conditioned space for the purposes of lowering or maintaining the moisture content of the air.

5. **Cleaning**: the process of removing particulates, (dust etc.,) and biological contaminants, (insects, pollen etc.,) from the air delivered to the conditioned space for the purposes of improving or maintaining the air quality.
6. **Ventilating**: the process of exchanging air between the outdoors and the conditioned space for the purposes of diluting the gaseous contaminants in the air and improving or maintaining air quality, composition and freshness. Ventilation can be achieved either through natural ventilation or mechanical ventilation. Natural ventilation is driven by natural draft, like when you open a window. Mechanical ventilation can be achieved by using fans to draw air in from outside or by fans that exhaust air from the space to outside.
7. **Air Movement**: the process of circulating and mixing air through conditioned spaces in the building for the purposes of achieving the proper ventilation and facilitating the thermal energy transfer.

Historical review

Obviously, the earliest form of heating was the open fire. The addition of a chimney to carry away combustion byproducts was the first important step in the evolution of heating systems. By the time of the Romans, there was sufficient knowledge of ventilation to allow for the installation of ventilating and panel heating in baths.
Leonardo da Vinci had invented a ventilating fan by the end of the 15th century. Robert Boyle's law was established in 1659; John Dalton's in 1800. In 1775, Dr. William Cullen made ice by pumping a vacuum in a vessel of water.

Thanks to Thomas Edison, the first electric power plant opened in New York in 1882, making it possible for the first time to have an inexpensive source of energy for residential and commercial buildings.

Steam Systems

James Watt developed the first steam heating system in 1770. However, the first real breakthrough in design did not occur until the early 1900s.

From 1900 to 1925, two-pipe steam systems with thermostatic traps at the outlet of each radiator and at drip points in the piping gained wide acceptance.

Hot water heating systems were developed in parallel with steam systems.

During the 1930s, radiators and convectors were commonly concealed by enclosures, shields, and cabinets. In 1944, the baseboard radiator was developed.

Panel heating, another form of heat distribution, was developed in the 1920s.

Early Refrigeration

Early forms of refrigeration included the use of snow, pond and lake ice, chemical mixture cooling to form freezing baths, and the manufacture of ice by evaporative and radiation cooling of water on clear nights.

By the 18th century, certain mixtures were known to lower temperatures. One such mixture, calcium chloride and snow, was introduced for commercial use. This particular mixture made possible a temperature down to –27°F (–33°C). In Great Britain, machines using chemical mixtures to produce low temperatures were introduced.

Mechanical and Chemical Refrigeration

In 1748, in Scotland, Dr. William Cullen and Joseph Black lectured on the latent heat of fusion and evaporation and “fixed air” (later identified as carbon dioxide). These discoveries served as the foundation on which modern refrigeration is based.

In 1851, Dr. John Gorrie, was granted US Patent No. 8080 for a refrigeration machine that produced ice and refrigerated air with compressed air in an open cycle. Also in 1851, Ferdinand Carre designed the first ammonia absorption unit.

In 1853, Professor Alexander Twining of New Haven, Connecticut, produced 1600 lb of ice a day with a double acting vacuum and compression pump that used sulfuric ether as the refrigerant.

Daniel L. Holden improved the Carre machine by designing and building reciprocating compressors. These compressors were applied to ice making, brewing, and meat packing.

In 1872, David Boyle developed an ammonia compression machine that produced ice.

Until 1880, mechanical refrigeration was primarily used to make ice and preserve meat and fish. Notable exceptions were the use of these machines in the United States, Europe, and Australia for oil dewaxing, and wine cooling. At this time, comfort air cooling was obtained by ice or by chilling machines that used either lake or manufactured ice.

History of ASHRAE

The American Society of Heating and Ventilating Engineers (ASHVE) was formed in NewYork City in 1894 to conduct research, develop standards, hold technical meetings, and publish technical articles in journals and handbooks. Its scope was limited to the fields of heating and ventilating for commercial and industrial applications, with secondary emphasis on residential heating.

Years later the Society's name was changed to the American Society of Heating and Air-Conditioning Engineers (ASHAE) to recognize the increasing importance of air conditioning.

In 1904, the American Society of Refrigerating Engineers (ASRE) was organized and headquartered at the American Society of Mechanical Engineers (ASME). The new Society had 70 charter members and was the only engineering group in the world that confined its activities to refrigeration, which at that time consisted mainly of ammonia systems.

In 1905, ASME established 288,000 Btu in 24 hrs as the commercial ton of refrigeration (within the United States). In the same year, the New York Stock Exchange was cooled by refrigeration. In 1906, Stuart W. Cramer coined the term “air conditioning.”

The First International Congress on Refrigeration was organized in Paris in 1908 and a delegation of 26 was sent from the United States. Most of the participants were members of ASRE.

ASHAE and ASRE merged in 1959, creating the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Willis H. Carrier

Willis H. Carrier (1876-1950) has often been referred to as the "Father of Air Conditioning." His analytical and practical accomplishments contributed greatly to the development of the refrigeration industry.

Carrier graduated from Cornell University in 1901 and was employed by the Buffalo Forge Company.

By 1902, he developed formulas to optimize forced-draft boiler fans, conducted tests and developed multi rating performance tables on indirect pipe coil heaters, and set up the first research laboratory in the heating and ventilating industry.

In 1902, Carrier was asked to solve the problem faced by the lithographic industry of poor color register caused by weather changes. Carrier's solution was to design, test, and install at the Sackett-Wilhelms Lithographing Company of Brooklyn a scientifically engineered, year-round air-conditioning system that provided heating, cooling, humidifying, and dehumidifying.

By 1904, Carrier had adapted atomizing nozzles and developed eliminators for air washers to control dew-point temperature by heating or cooling a system's recirculated water.

Soon after this development, over 200 industries were using year-round air conditioning.

At the 1911 ASME meeting, Carrier presented his paper, "**Rational Psychrometric Formulae**," which related dry-bulb, wet-bulb, and dew-point temperatures of air, as well as its sensible, latent, and total heat load, and set forth the theory of adiabatic saturation.

The formulas and psychrometric chart presented in this paper became the basis for all fundamental calculations used by the air-conditioning industry.

By 1922, Carrier's centrifugal refrigeration machine, together with the development of nonhazardous, low-pressure refrigerants, made water chilling for large and medium-size commercial and industrial applications both economical and practical. A conduit induction system for multiroom buildings, was invented in 1937 by Carrier and his associate, Carlyle Ashley.

Comfort Cooling

Although comfort air-cooling systems had been built as of the 1890s, no real progress was made in mechanical air cooling until after the turn of the century. At that time, several scientifically designed air-conditioning plants were installed in buildings. One such installation included a theater in Cologne, Germany. In 1902, Alfred Wolff designed a 400-ton system for the New York Stock Exchange. Installed in 1902, this system was in operation for 20 years. The Boston Floating Hospital, in 1908, was the first hospital to be equipped with modern air conditioning. Mechanical air cooling was installed in a Texas church in 1914.

In 1922, Grauman's Metropolitan Theater, the first air-conditioned movie theater, opened in Los Angeles. The first office building designed with and built for comfort air-conditioning specifications was the Milam Building, in San Antonio, Texas, which was completed in 1928.

Variable air volume (VAV) designs rapidly became the most popular type of HVAC system for offices, hospitals, and some school buildings.

Although energy-efficient, VAV systems proved to have their own set of problems related to indoor air quality (IAQ), sick building syndrome (SBS), and building related illness (BRI).

Solutions to these problems are only now being realized.

Reference:

Principles of heating ventilating and air conditioning a textbook with design data based on the 2017 ASHRAE handbook fundamentals by Sauer, Harry J. Howell, Ronald Hunter Coad, William

Thank you very much