Control of Rate of Biochemical Reactions

In the field of biochemical control, industrial air conditioning has been applied to many different and well-known products. All problems involving fermentation are classed under this heading. As biochemistry is a subdivision of chemistry, subject to the same laws, the rate of reaction may be controlled by temperature. An example of this is the dough room of the modern bakery. Yeast develops best at a temperature of 80 F. A relative humidity of at least 75 percent is maintained to hold the surface of the dough open to allow the carbon dioxide gases formed by the fermentation to pass through and produce a loaf of bread, when baked, of even, fine texture without large voids.

Control of Rate of Crystallization

The rate of cooling of a saturated solution determines the size of the crystals formed. Both dry- and wet-bulb temperatures are of importance, as the one controls the rate of cooling, while the other, through evaporation, changes the density of the solution.

In the coating pans for pills, gum, and nuts, a heavy sugar solution is added to the tumbling mass. As the water evaporates, each separate piece is covered with crystals of sugar. A smooth, opaque coating is only accomplished by blowing into the kettle the proper amount of air at the right dry- and wet-bulb temperatures. If the cooling and drying are too slow, the coating will be rough and semi-translucent, and the appearance unsightly; if too fast, the coating will chip through to the interior. Only by balancing temperature, relative humidity, and volume of air to the sugar solution, can the proper rate be obtained and a perfect coating assured.

Control of Temperature for Close Machining Tolerances

Where tolerances must be held within 2 or 3 ten-thousandths of an inch, as in the manufacture of precision instruments, tools, and high quality lenses, temperature variations may cause expansion and contraction of material to an extent that will seriously affect the quality of the work. This type of work usually requires close temperature control to assure accuracy and uniformity of the product.

Usually the temperature level with respect to the product is not as important as controlling the temperature within close limits. For this reason, conditions are usually selected for comfort below the sweat range.

Control of Dew Point for Protection of Polished Surfaces

In the manufacture of certain metal articles, the presence of fingerprints, tarnish, or *etching* cannot be tolerated in the finished article. If these articles are manufactured under conditions of effective temperatures that will cause the hands to perspire, an unsatisfactory product will result. The salt and acid contained in body perspiration, when deposited on the highly polished article, can show corrosion and rust within a few hours if examined under a microscope.

It is therefore important to maintain temperatures and relative humidities (dew point) low enough to prevent sweating of the hands. In addition, the manufacture of polished surfaces usually requires a better-than-average job of air filtering to avoid abrasion of the surfaces.

Control of Humidity for Reduction of Static Electricity

The presence of static electricity is often detrimental to the satisfactory and economical processing of many light materials, such as textile fibers and paper. It is also extremely dangerous where explosive atmospheres or materials are present. Fortunately, this hazard is minimized by increasing the relative humidity to at least 55 percent, if the material being processed is not damaged thereby.

It must be borne in mind that for successful elimination, the air that actually comes in contact with the material in the machine must be at a relative humidity of 55 percent or more. As some machines consume a great deal of power, which is converted directly into heat, the temperature in the machine may be considerably higher than the temperature adjacent to the machine where the relative humidity is normally measured. In such cases, the relative humidity in the machine will be appreciably lower than that elsewhere in the room, and it may therefore be necessary to maintain a room relative humidity of 65 percent, or even more, to maintain the desired humidity.

Control of Conditions for Material Test Laboratories

Laboratories having controlled conditions of temperature and humidity are common, not only for the purposes of scientific research, but also for routine testing and for quality production control. A control of temperature and humidity within fairly close plus or minus limits is usually required. Laboratories designed for scientific research may require control of conditions over a wide range, whereas the routine testing laboratory or quality control laboratory will usually be designed to maintain the ASTM Standard Conditions of 50 percent relative humidity and 23 C (73.4 F) temperature. For further information, see Chapter 24.

CALCULATIONS

The methods for determining the heating and cooling loads for the various industrial processes are similar to those outlined in Chapters 25 and 26 of the 1961 Guide And Data Book. Some factors affecting heating or cooling requirements are given in Table 1. Because of the large number of motors and heat producing units usually found in an industrial application, it is particularly important that operating allowances, for the latent and sensible heat loads, be definitely ascertained and used in the calculations to determine the total design load.

BIBLIOGRAPHY

H. A. Mosher: When is complete air conditioning of the modern factory advisable? (*Heating, Piping and Air Conditioning*, June 1945, p. 305; July 1945, p. 385).

N. N. Wolpert: Air conditioning design conditions for various industries (*Heating and Ventilating*, May 1949, p. 70; June 1949, p. 73; July 1949, p. 79; August 1949, p. 102).

N. N. Wolpert: Air conditioning design data for commercial applications (*Heating and Ventilating*, February 1950, p. 68).

F. F. Stevenson: Industrial air conditioning (*Heating, Piping and Air Conditioning*, May 1948, p. 100; June 1948, p. 94).

J. F. Salsburg: Industrial air conditioning (*Heating, Piping and Air Conditioning*, July 1948, p. 88; October 1948, p. 93).

E. E. Herbacek: Photo studios need conditioning for both processing and comfort (*Heating, Piping and Air Conditioning*, June 1949, p. 85).

CHAPTER 24

PRECISION MANUFACTURING, LABORATORIES AND TESTING

PRECISION MANUFACTURING: Machine Shops, Gage Rooms, Instrument Assembly, Drafting Rooms, Blackout Plants, Mining, Motion Picture Studios, Optical Goods, Abrasives; LABORATORY AND TESTING FACILITIES: Design Conditions, Hours of Operation, Thermal Loads, Air Distribution, Fume Hoods, Exhaust Systems, Supply Air Intake Locations, Supply Systems

THIS chapter will discuss the application of air conditioning for: (1) precision manufacturing processes, and (2) laboratories, for both research and testing.

PART I: PRECISION MANUFACTURING

Precision manufacture requires the making of parts with very small variations of size, and the assembly of such parts regardless of when or where they were made. Air conditioning for precision manufacture thus requires great constancy of the given conditions of temperatures, humidity and cleanliness. Typical applications are for industries making the following products: watches, gages, instruments, meters, electronic parts, missile-space vehicle components, gear-cutting machines, aviation engines, printing machinery, optical goods, photographic developing equipment, and laboratory testing apparatus.

Another class of industrial situations concerns the efficiency of personnel. Air conditioning can provide improvement of working conditions in factories, as it does in offices, operating rooms, drafting rooms, studios and the like. In some cases air conditioning is needed for cleanliness, precision, and work efficiency. Some of the following industries use air conditioning for one reason, some for both.

Machine Shops

Modern technological developments have increased the demands of manufacture so that precision work is more necessary than ever before, and uniformity in such work demands closer control of temperature and humidity conditions. Many precision parts can be economically manufactured only under controlled conditions of temperature, humidity and cleanliness. Accurate control of coolant temperatures, for machining processes, is also employed. An example is the large gears used for marine propulsion, some of which take 17 days for hobbing. Parts may be assembled into machines at various assembly plants distant from the plant which manufactured them. Parts may be used for replacement in every corner of the world, and they must be interchangeable. Air conditioning for maintaining constant temperature, humidity and cleanliness of air has been the answer to these many problems of precision manufacture in machining operations and assembly rooms for a wide variety of products.

Gage Rooms

Precision manufacture depends also upon gages. The Bureau of Standards recommends a temperature of 68 F for gage calibration rooms. The primary gages are laboratory instruments only, and the art of making these has been developed to a high state of perfection. Gages are sensitive to changes in conditions of temperature, humidity and cleanliness during their manufacture and use.

Primary gages must be maintained under constant conditions for use as standards against which secondary gages are periodically checked. Secondary gages have to be manufactured under the same constant conditions, but, as they are used in various places where manufacturing processes are utilized, they are accurate only to the degree that constant conditions are maintained in the manufacturing processes. Secondary gages should be stored in air-conditioned rooms.

Gage rooms are generally located as enclosed rooms completely inside the plant structure. This is of particular value when winter humidification is desired. The degree of accuracy of control that should be specified and the refinements of gage room construction that should be recommended are matters of economic evaluation. Control of temperature to plus or minus 2½ F deg and control of humidity to not more than 60 percent at the control instrument location is usually obtainable from conventional refinements and with the availability of a year-round source of heat. The frequently used specification of plus or minus 1½ F deg and plus or minus 5 percent rh at the control instrument location requires more sensitive controls and suitably responsive equipment. A specification of plus or minus 1 F deg and plus or minus 2½ percent rh at the control instrument location increases the requirements of control accuracy, equipment responsiveness and usually requires refinements or room construction and/or some degree of temperature control of the surrounding air. Control of temperature to plus or minus ½ F deg and humidity to plus or minus 1½ percent (as frequently recommended for major primary gage rooms) requires special control instrumentation, modulation of equipment response as well as refinements of room construction and control of the surrounding temperature. It should be noted that operating costs as well as first costs rise with the accuracy of control that is specified.

In many industries, where the problem is primarily that of comparing gages, an average temperature of 75 F is frequently used in place of the 68 F standard. In other cases, the ASTM standard conditions of 50 percent relative humidity and 23 C (73.4 F) temperature are used as the design and optimum operating values.

Instrument Assembly

Instruments are judged by their accuracy, and the parts from which they are made demand extreme accuracies. Many parts have to be nearly frictionless, making polished surfaces important.

The temperatures usually employed in this field are between