HUMIDIFICATION IN TEXTILE MILL

IMPORTANCE OF RH AND TEMPERATURE:
The atmospheric conditions with respect to temperature and humidity play very important part in the manufacutring process of textile yarns and fabrics. The properties like dimensions, weight, tensile strength, elastic recovery, electrical resistance, rigidity etc. of all textile fibre whether natural or synthetic are influenced by Moisture Regain.
Moisture regain is the ratio of the moisture to the bone-dry weight of the material expressed as a percentage.
Many properties of textile materials vary considerably with moisture regain, which in turn is affected by the ambient Relative Humidity (RH) and Temparature. If a dry textile material is placed in a room with a particualr set of ambient conditions, it absorbs moisture and in course of time, attains an equilibrium.
Some physical properties of textile materials which is affected by RH is given below:
Strength of COTTON goes up when R.H.% goes up
Strength of VISCOSE goes down when R.H.% goes up
Elongation %ge goes up with increased R.H.% for most textile fibres
the tendency for generation of static electricity due to friction decreases as RH goes up
At higher levels of RH , there is also a tendency of the fibres to stick together
Temparature alone does not have a great effect on the fibres. However the temperature dictates the amount of moisture the air will hold in suspension and , therefore, temperature and humidity must be considered together.
PSYCHROMETRY:
psychrometrics is the study of the thermodynamic properties of air and water vapour mixture or simply the study of solubility of moisture in air at different temperatures , the associated heat contents and the method of controlling the thermal properties of air. There are various properties of moist air, they are
Dry bulb temperature
wet bulb temperature
dew point temperature
relative humidity
specific voulme
enthalpy etc.
DRY BULB TEMPERATURE:
This is the temperature of air-moisture mixture as registered by an ordinary thermometer.
WET BULB TEMPERATURE:
It is the temperature of air-moisture mixture as registered by a thermometer where the Bulb is covered with the wetted wick.
DEW POINT TEMPERATURE:
This is the temperature of air at which moisture starts condensing when air is cooled.
SPECIFIC HUMIDITY:
This is the weight of water vapour present in unit weight of dry air.
RELATIVE HUMIDITY:
This is the ratio of the mass of water vapour to the mass of dry air with which the water vapour is associated to form the moist air. Relative humidity is a measure of how thirsty the air is at a given temparature.
At 100%, the air is completely saturated. At 50%, the air holds one-half of what it could hold if saturated at the same temperature. The thirstier the air, the lower the percentage and the more it can rob fibres of moisture.
SPECIFIC VOLUME:
It is the volume per unit weight of air.
ENTHALPY:
It is the total heat contained in unit weight of air, taking the heat content of dry air at 0 degree centigrade. Enthalpy includes both the sensible heat and latent heat contained in the air.
SENSIBLE HEAT AND LATENT HEAT:
Sensible Heat is any heat that raises the temperature but not the moisture content of the substance. This is our regular and familiar every day heat. Because it raises the temperature it can be detected by the senses, and this in fact, is why it is called Sensible Heat.
Latent Heat is the tricky one. When we talk of Latent Heat we mean 'Latent Heat of Vaporisation'. It is that heat required to transform a liquid to vapour. Take water for example. Water can be heated to its boiling point of 100oC. If more heat is added at this point the temperature of the water does not increase. The water continues to boil and becomes steam. So where does all the heat go? Well, the heat goes into changing the water into steam. The latent heat of vaporisation in this instance is the heat required to change water from liquid at 100oC to vapour at the same temperature.

TYPICAL AIR-CONDITIONING PROCESSES:

SENSIBLE COOLING / HEATING:

Involving a sensible change in the temperature of air with the specific temperature of air with the specific humidity or moisture content of air remaining the same. This process is shown as a horzontal line in Psychrometric chart as no moisutre has been added or removed from the air and the humidity ratio remains the same.
The heat required to bring this change is shown below

H = G(h2-h1)
H = (Q/V)(h2-h1)
Where,
H is the rate of heat flow, kcal/h
G is the mass rate of flow of air, kg/h
Q is the volume rate of flow of air, meter cube / h
h1,h2 are the enthalpy before and after heating, kcal/kg
V is specific volume of air, meter cube/ kg

COOLING AND DEHUMIDIFICATION:

This is a process invoving reduction in both the dry bulb temperature and the specific humidity.
If air is cooled to temperature below its dewpoint, condensation of moisture occurs.
This condensation
continues as long as the air is being further cooled. By noting the enthalpy of air before and after cooling, we can determine the heat to be extracted or the tonnage of refrigeration required for cooling air continuously.

COOLING AND HUMDIFICATION:

This is a process involving reduction in DRY BULB Temperature and increase in specific humidity.

HEATING AND DEHUMIDIFICATION:

This is a process where there is an increase in DRY BULB temperature and reduction in speccific humidity.

LATENT HEATING:

This is a process where there is only an increase in specific humidity. This is a process of steam injection.

HEATING AND HUMIDIFICATION:

This is the process where there is an increase in both DRY BULB temperature and specific humidity.

EVAPORATIVE COOLING:

This is a process of cooling and humdification but with no change in the enthalpy of air during the process.
This is the process through an air-washer using recirculated water for spraying. This is the most commonly used humidification system in a textile mill.

ADIABATIC SATURATION OR EVAPORATIVE COOLING:

In this process air comes in direct contact with water in the air washer.There is heat and mass transfer between air and water. The humidity ratio of air increases. If the time of contact is sufficient, the air gets saturated. Latent heat of evaporation required for conversion of water into water vapor is taken from the remaining water.When equilibrium conditions are reached, water cools down to the wet bulb temperature of the air.In general it is assumed that, the wet bulb temperature and before and after the process is the same.
If the air washer is ideal, the dry bulb temperature and wet bulb temperature of the air would be eqaual.

If a process is adiabatic, heat is neither added or removed from the system

Dry bulb temperature of the air goes down in the process and the effect of cooling is due to the evaporation of some part of the water. That is why it is called EVAPORATIVE COOLING.
The sensible heat is decreased as the temperature goes down but the latent heat goes up as water vapour is added to the air.The latent heat required by the water which is evaporated in the air is drawn from the sensible heat of the same air.Thus it is transformation of sensible heat to latent heat. During this process the enthalpy of air remains the same.
If humidity ratios of saturated air and of the air before saturation is known, then the difference between the two would be the amount of water vapour absorbed by unit weight of dry air.
The amount of water sprayed in the air-washer to maintain misty condition can be as much as 200 times the quantity of water absorbed by the air during summer time.

AIR CONDITIONING PROCESS FOR THE TEXTILE INDUSTRY:

Air is drawn in and is passed through the air washer, it gets saturated adiabatically. Since it is not saturated 100%, the dry bulb temperature of the saturated air will be 1 degree greater than WBT.

When this air is admitted into the conditioned space, it gets heated due to the heat load of the room.
During this heating process the air does not lose or gain any moisture as latent heat load is absent.
The air displaces an equal amount of air in the room which is pushed outside the room.
If we know the heat load of the room, we can easily calculate the rate of flow of air, G, which is the air circulation rate necessary to give the required relative humidity, from the following formula.

$G = H(h2-h2)$

where,

G-mass flow rate of dry air, KG/h

H-total heat of air,Kcal/h

h1-enthalpy of supply air, Kcal/kg

h2-enthalpy of outgoing air,Kcal/kg

The air circulation rate is generally expressed in cubic meters per hour and not in terms of mass flow rate. (h2-h1) can be calculated from the initial and final temperatures. Therefore

$H = (Q/V) * Cp * (DB2-DB1)$

Where,

Q-rate of air flow,metercube/h

Cp- specific heat of air

V-specific volume of air,metercube/kg

DB1- supply air DBT,degree centigrade

DB2- leaving air DBT,degree centigrade

However in practice, the air washer does not continuously supply air of 100% RH. The efficiency of air washer falls. It is considered satisfactory, if the difference between DBT and WBT of air after the air washer is 1 degree centigrade.
The following equation can be used for practical purposes.

$(DB2-DB1) = ((3.39 H)/Q)+0.52$

Once the relative humidity to be maintained is decided, the quantity (DB2-DB1) is fixed. In other words, once the inside relative humidity is fixed, the minimum dry bulb temperature in the condition space is determined by the wet bulb temp. of the outside air. It is not possible to go below this DBT unless refrigeration is used.

Why refrigeration is required?

Let us assume that WBT of outside temp is 35 degrees. If the RH% to be maintained in the department is 60%, then DBT of the conditioned space should be 43.5 degrees. Whatever we do , we cannot reduce this temperature as long as we are maintaining a RH OF 60%. Underthis circumstance, refrigeration plant is required to bring down the WBT of the air inside, so that 60% RH can be maintained at lower DBT depending on the refrigeration capacity.

HUMIDIFICATION SYSTEM:

Humidification system without chilling helps to maintain only the RH% without much difficulty. They can be classified generally as either unitary or central station. Central system is the most widely used sytem in the textile industry. The systems principal components are

1. Air moving devices- fans
2. mixing devices for air and washer- i.e Air washers

Air moving devices are always broken into two halves, 1. Return Air fans and 2.Supply Air fans.
The return air fans return the air to the plant room from where it may circulated or exhausted in the mill
The supply air fans- supply air to the mill from the plant room.
Air washer is a device for intimately mxing water and air. The intimate contact between these two elements is best brought about- for this application- by drawing air through a spray chamber in which atomized water is kept in transit.
The following components are a must in a Humidification system
Return Air and Supply Air fans
Air washer

- Return Air floor grills
- Return Air trenches
- Exhaust damper
- Fresh air damper
- Supply air ducts and grills

- face and bypass dampers on the air washer
- Automation control for damper operation to maintain conditions

FANS:
In any air handling system the fan is a key conponent. It is a device which moves the air. This is achieved by pressurising the air, the resultant pressure difference makes the air to move. Fans can be classifed as follows

1. Classification by air movement-1. centrifugal fan 2. Axial flow fan
2. Classification by housing design -1. Scroll fans 2. Tubular fans
3. Classification by pressure range- 1. high pressure 2. medium pressure and 3. low pressure
4. Classification by Blade configuration - 1.forward curved blades 2.backward curved blades

From the fan laws the following relationship can be arrived

- CFM is directly proportional to fan RPM
- Pressure is directly proportional to sqaure of RPM
- Shaft power is directly proportional to cube of RPM

AIR WASHER:
Basic factors that determine the size of air washer are

- Velocity of air through the washer
- Type of nozzle used
- Water quantity in circulation
- No.of spray banks

The main components in an Air washer are

- Distribution plates
- Distribution Louvers
- Water pipes
- discharge headers
- stand pipes
- nozzles
- Eliminators

REFRIGERATION:
Air conditioning is a process to remove the heat from the place to be conditioned and reject the heat to a place where it is not objectionable. In other words, a heat pump is required to accomplish the same. The heat pump is called the refrigeration machine.
There are three types of refrigeration machines classified according to their type of operation. They are

1. vapour compression system
2. absorption system
3. vacuum

Majority of the airconditioning systems used for commercial purposes work on vapour compression cycle.
The main components used in the mechanical compression machines are

1. compressor
2. condenser
3. metering device
4. evaporator
5. operating controls
6. safety controls
7. accessories

THE COMPRESSOR:

Under atmospheric temperature and pressure the refrigerant is in gaseous form. It is true that the cooling takes place when liquids evaporate to become gas. Therefore the gas refrigerant must be transformed into the liquid form. Most gasses can be made into the liquid form by raising its pressure (and cooling it, which is handled by the condenser). The equipment that increases the pressure of the gas by compressing it, is called the Compressor. Different types of compressors are

1.Reciprocating 2.Centrifugal 3.Rotary and 4.screw

THE CONDENSER:

During compression however the refrigerant becomes hot. This is because of two reasons:

Because of the work done on it (remember how warm the hand pump became when pumping air into your bicycle tires?) and

Because the refrigerant is converted from gas to liquid releasing its latent heat

This heat has to be removed to enable the gas to condense into a liquid easily. The equipment that removes the heat is called the Condenser. Different types are

1.Air cooled 2.water cooled and 3.evaporative condenser

EVAPORATOR:

The Evaporator ('Cooling Coil' to most of us): From the condenser we now have the liquid refrigerant ready to go to work. This refrigerant can remove heat when it starts evaporating. The liquid refrigerant from the condenser is injected through a metering device called the capillary or expansion valve into the cooling coil which is a bundle of tubes.

Inside the cooling coil the pressure is low, because of the metering/throttling device on one side and the compressor suction on the other side. In the low pressure, the liquid refrigerant Starts evaporating rapidly. While evaporating it needs sensible heat to transform itself from the liquid to the gas state. So it soaks up heat from the surrounding tubes, and from the air, with which the tubes are in contact. This is what causes the cooling.