Emerging Eco Friendly HVAC Technologies for Energy Conservation

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Need of Energy Efficient Buildings

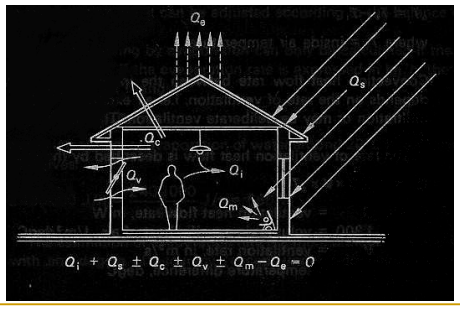
- Demand for energy is increasing fast day by day and is likely to increase in tune with industrialization/ urbanization
- The building sector being one of the largest consumers of energy, has gained prominence over the past few decades.
- 45% of total global energy is used in heating, cooling and lighting of building.
- 5% energy is used in building construction.
- In India energy used for air conditioning of commercial buildings accounts for 32% of the total energy consumption in the commercial sector in 1995.
- Energy consumption patterns can be substantially reduced by energy conserving measures, particularly during the phase of building design.
- Space **heating load** can be **reduced by about 50%,** when **economically-viable insulating** measures are applied to the **building envelopes**, i.e. to ceiling and walls**.**

Energy Use Pattern in Buildings

- Lighting 60%
- Air conditioning 32%
- Other applications 8%
- In conventional Indian buildings, energy consumption is 200 kWh per sq. meter
- This energy consumption can be reduced to 120 kWh per sq. meter by applications of energy efficient building techniques
- Saving up to 60% can be achieved.

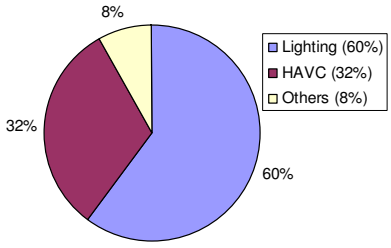
(Source : TERI & BEE, Govt. of India presentations)

Heat transfer in buildings

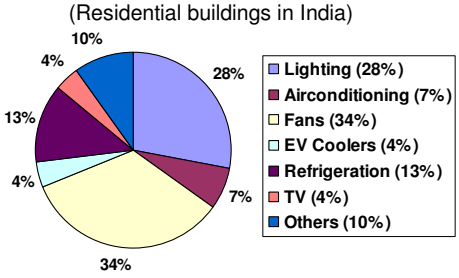


Energy Conservation Studies in Buildings

% of annual electrical consumption (Commercial buildings in India)

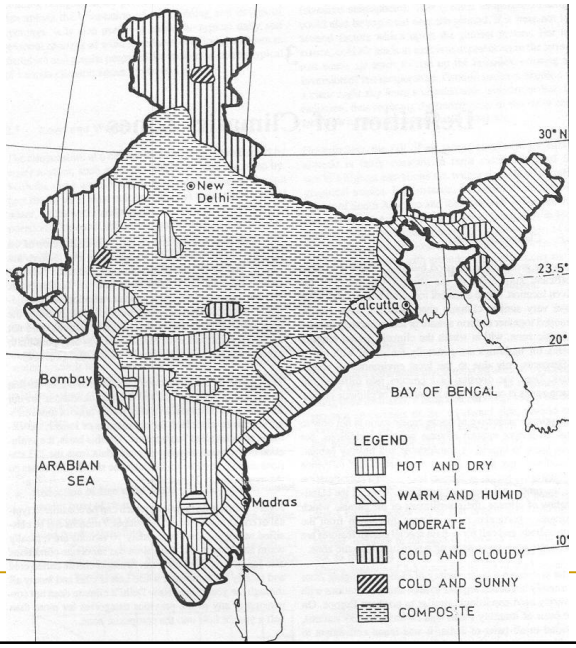


% of annual electrical consumption (Residential buildings in India)



- Energy consumption patterns can be substantially reduced by energy conserving measures
- It is essential to conserve the conventional energy by developing the energy efficient buildings

Climatic Zones of India



Technologies For Building Solar Space conditioning

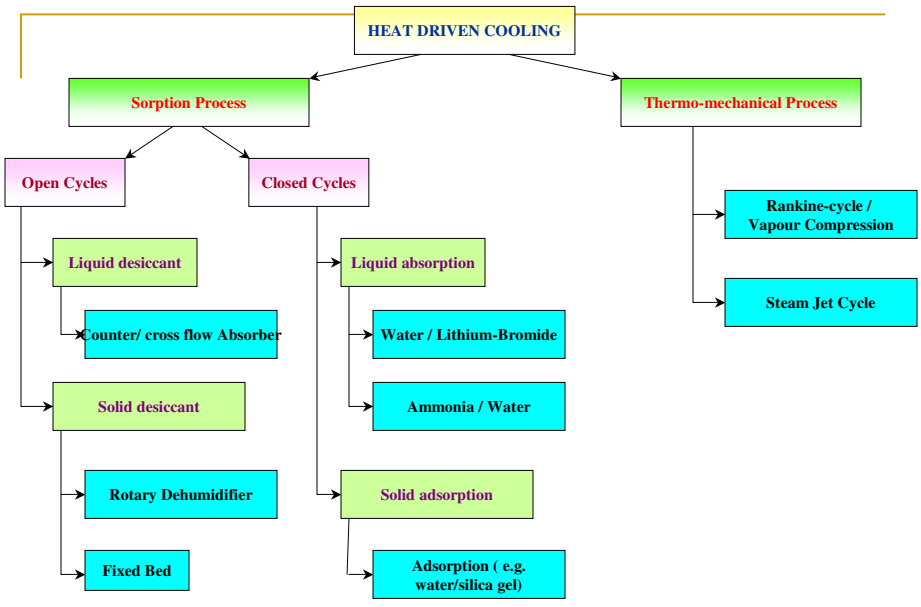
- Conventional Vapor compression based system for air-conditioning
- Solar cooling options
  - Photovoltaic vapor compression cooling
  - Vapor absorption system
  - Adsorption systems (solid and liquid desiccant cooling systems)
- Hybrid cycles for space conditioning
- Heat pipe based space conditioning
- Retrofitting of existing buildings

Draw backs of conventional vapor compression refrigeration and Air Conditioning systems

- Large energy is consumed ; mainly high grade energy
- Compression work is very high again usage of high grade energy
- Although System's Energy efficiency is large
- High grade energy cost is high ; huge electricity bills
- Refrigerants (R11,R12 etc) used are *non eco friendly*
  - * Resulting in ozone layer depletion (ODP)
  - * Large GWP
- Leakage of CFC's causing environmental problem

Thus both energy shortage and environmental degradation

Alternatives must be searched for as Montreal and Kyoto protocols demand phase out of CFCs.



Vapor absorption based cooling options (solar based)

- Instead of high grade energy, low grade energy is used
- Power requirement is low as compared to conventional VCR
- Addresses energy and environ mental problems
  - * Solar energy can be directly utilized (Use solar as heat source)
  - * No CFC's leakage problem

Type of vapor absorption refrigeration systems for A/C

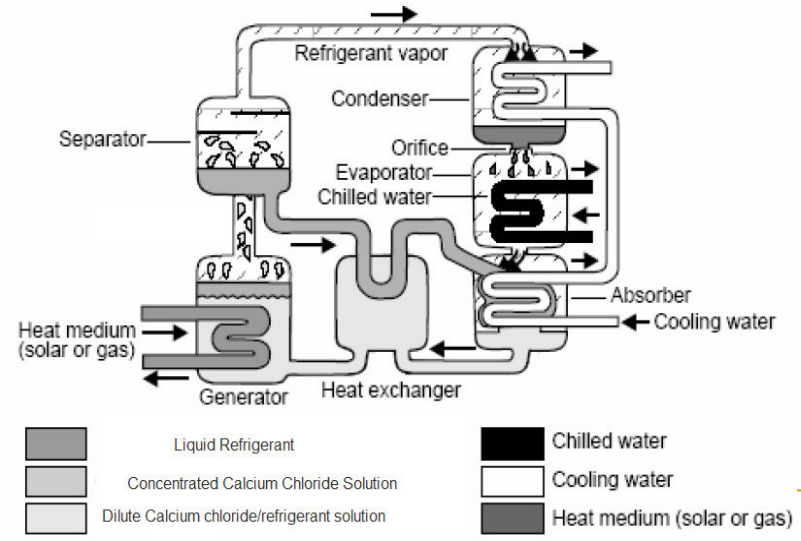
Closed cycle vapor absorption solar cooling system

- Single effect
- Double Effect

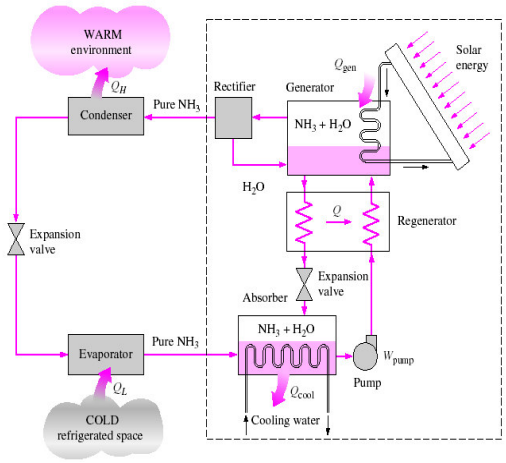
Open cycle vapor absorption solar cooling system

Intermittent and continuous system operation

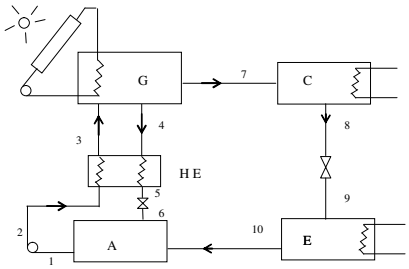
Vapor Absorption System



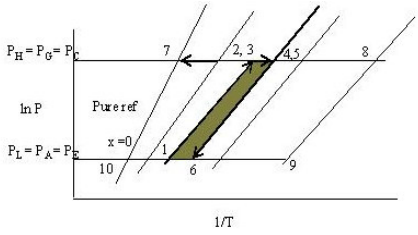
Absorption – Ammonia/ Water



Closed cycle Vapor Absorption Solar Cooling System (single effect)



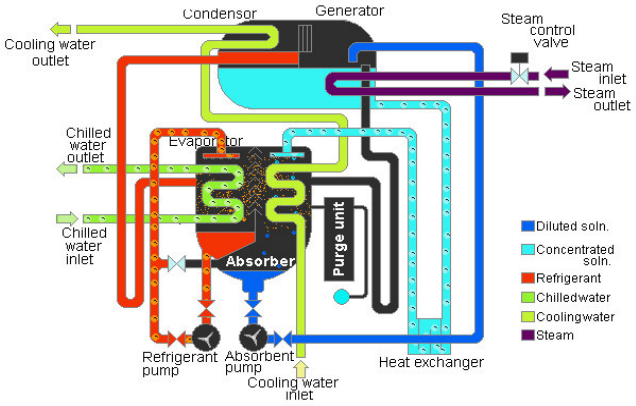
Schematic Diagram



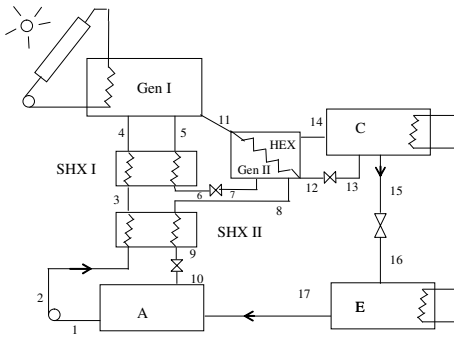
P-T-X Diagram

Commercial Absorption machine

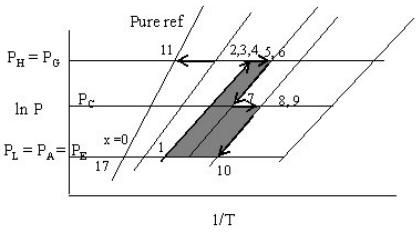
A Single Effect Steam Fired H_2O-LiBr Chiller



Closed cycle Vapor Absorption Solar Cooling System (double effect)



Schematic Diagram

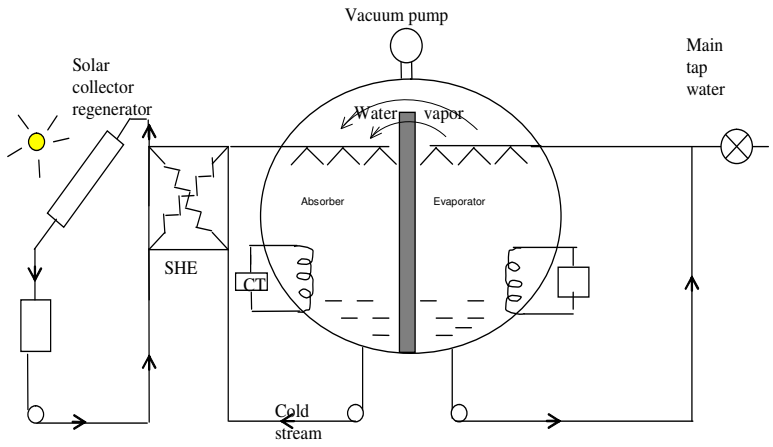


P-T-X Diagram

Conventional Absorption System's working fluids

Ammonia – Water Absorption System	Water-Lithium Bromide Absorption System
* Refrigerant - Ammonia Absorbent - Water * High operating pressures * It is suitable for refrigeration and air-conditioning * High generation temperature * Condenser is both water cooled as well as air cooled * Rectifier is required * COP is low (0.5 to 0.6) * No crystallization problem * Health hazard as it is toxic * Inflammable	* Refrigerant - Water Absorbent - Lithium Bromide * Low operating pressures * It is suitable for air-conditioning or heat pump * It is relatively lower *Only water cooling is necessary * Rectifier is not required * COP is high (0.7 to 0.8) * Crystallization is a major problem * It is not toxic * Not flammable

Open Cycle Vapor Absorption Solar Cooling System



Adsorption Based Cooling Systems
(Solid and liquid desiccant based cooling system)

Desiccant based cooling system offers an environmentally benign alternative to conventional system based on vapor compression refrigeration system

SOLID DESICCANT	LIQUID DESICCANT
*Adsorption is surface absorption –a physical phenomenon *Less degree of dehumidification *Inexpensive materials like Silica gel, molecular sieve, alumina *System is compact *Pressure drop is higher *Poor heat exchange between air streams *Adsorption – desorption is not continuous *Easily coupled with conventional V-C&AC system	*Absorption is volume absorption –a chemical phenomenon *More drying capability *Costly materials like LiBr,LiCl,$Cacl_2$ Glycols with water *It is bulky *Pressure drop is lower *Good heat exchange *Adsorption – desorption is continuous *Modifications are necessary for coupling

SCOPE OF DESICCANT COOLING

Desiccant cooling systems are useful when latent heat load is larger than the sensible heat load. A thermal energy input is used to regenerate the desiccant.

Advantages of desiccant cooing system:

* Since ,only air and water are used as working fluids and no fluorocarbons are required thus there is no danger to ozone layer depletion
* Significant potential for energy savings and reduced consumption of fossil fuels achieved. Electrical energy requirements are 25% less than the conventional V-C refrigeration system. Source of input thermal energy are diverse viz solar, waste heat and natural gas.
* IAQ is improved due to higher ventilation rates and the capability of desiccants to remove air pollutants.
* Since Desiccant systems operate at near atmospheric pressure, their construction and maintenance is simple
* Desiccant systems can be used for summer/ monsoon air conditioner as well as winter heating when regeneration energy can be used for heating

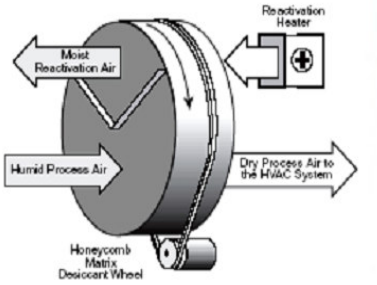
Why Desiccant Cooling?

- Better Indoor Air Quality
  - Allows more fresh air and disinfects air
- Energy savings & Low Maintenance
  - Atmospheric operation
  - Can save upto 25% energy for humid climates (hybrid mode)
- Applications
  - Large latent loads and low humidity requirements e.g. Hotels, supermarkets, auditoriums, ice rinks, pools, Ventilation air etc.

Desiccants

- Chemical absorption or adsorb of water on surface
  - Remove heat of sorption and regenerator heat dumpback
- Liquid Absorbents
  - Glycols e.g. Propylene Glycol and TEG, Lithum Chloride, Lithium Bromide, Calcium Chloride etc. and their mixtures
  - Vapor pressure a function of Temperature and Concentration [Operating ranges : 55-60% LiBr, 45-50% LiCl, 95-97% TEG]
- Solid Adsorbents
  - Silica Gel, Molecular Sieves, Activated Alumina, Activated Charcoal/ Carbon, Natural Zeolites
  - Synthetic polymers (PSSASS), Metal Silicates- Titanium Silicate

Rotary Desiccant Wheel



Desiccant based cycles

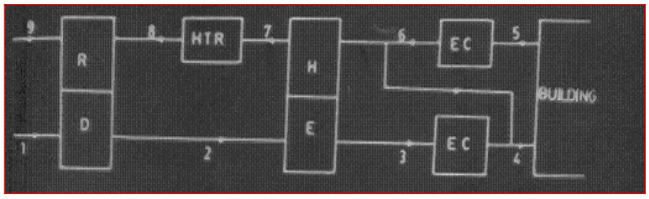
Solid desiccant cycles

- Ventilation cycle (Pennington)
- Ventilation Dunkel cycle (recirculation)
- Modified Ventilation cycle(Dhar)
- Novel solid desiccant cycle (Kaushik)

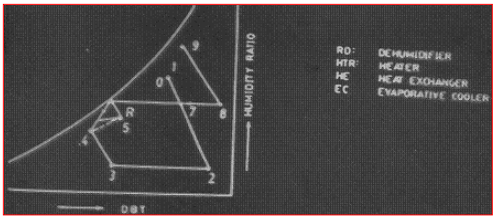
Liquid desiccant Cycles

- LOF
- Gupta & Gandhidasan
- Liquid desiccant system for ERM
- Godara and Jain cycles

Pennington Ventilation cycle

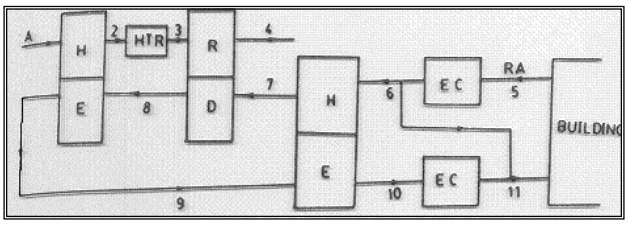


Block diagram



Psychromteric diagram

Dunkle ventilation cycle (recirculation)



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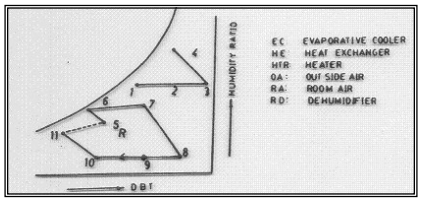
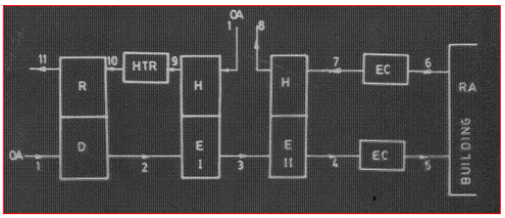


Psychromteric diagram

Modified ventilation Cycle



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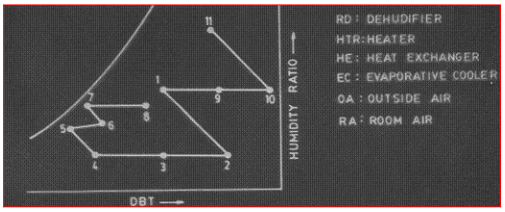
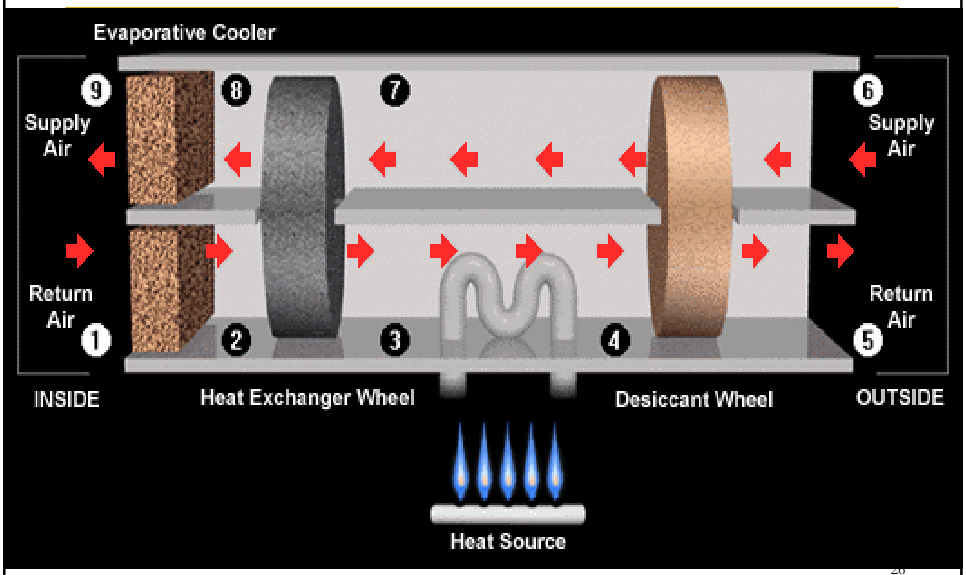
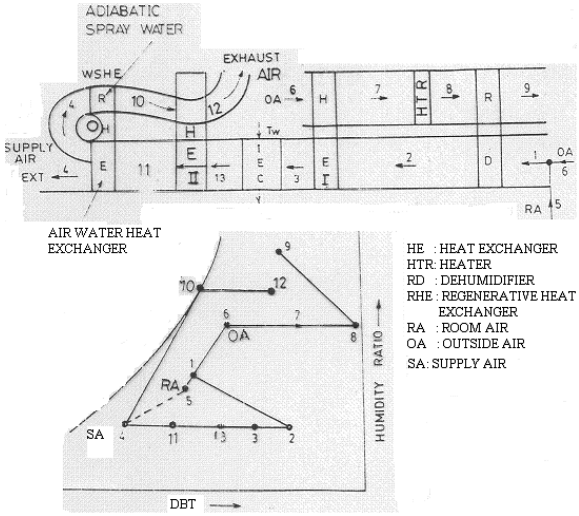


Psychromteric diagram

Solid desiccant Cooling System



Novel Solid Desiccant Cycle (Kaushik et al)



Current Status and Challenges

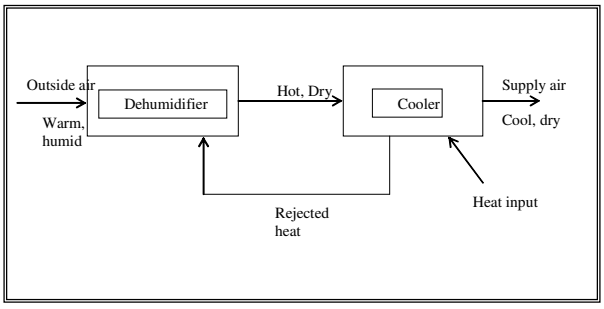
* Absorption Systems
  * Commercial systems based on ammonia-water and water-LiBr
  * Limited installations in the lower capacity range (less than 35kW)
  * Need for bench marking of performance and standardization – parasitic power, climate conditions, air or water cooling
* Desiccant Cooling
  * A nascent technology
  * Membrane type of desiccant systems – promising technology
  * Solar collector cum regenerator – reduce cost and increase COP
  * Open cycle – may need more fan power but not low/high pressures
  * Need for bench marking of performance
* Need for low cost & higher COP systems
* Good System Integration and optimization

Hybrid Desiccant Cooling Systems

- Desiccant dehumidifiers (Solid or Liquid) – Latent Loads
- VCS/ VAS – Sensible Loads
- May be Condenser heat for regeneration
- High Overall COP

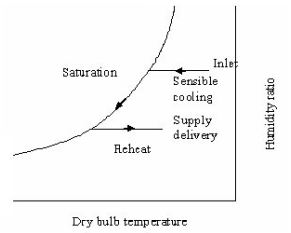
Hybrid Cycles for Air Conditioning

Useful for capacity up gradation and energy conservation (e.g. high latent load conditions as in Supermarkets).

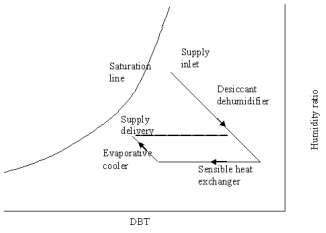


Solid desiccant based hybrid cycle (V-C + Solid Desiccant cycle)

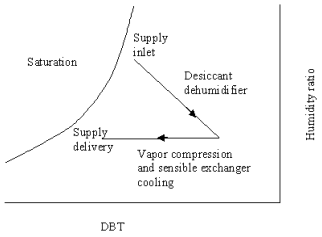
Liquid desiccant based hybrid cycle (V-C + Liquid Desiccant cycle)



Conventional VC Air conditioner

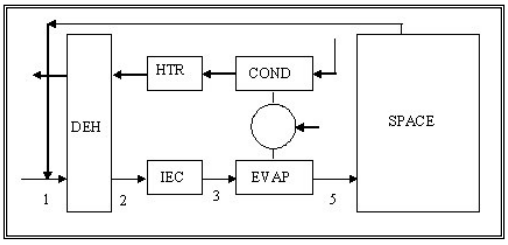


Desiccant Air conditioner

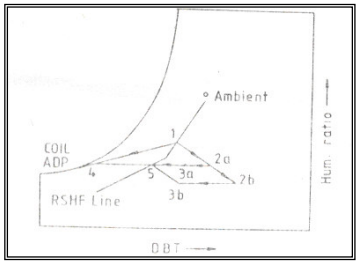


Hybrid Air conditioner

Hybrid desiccant cooling system

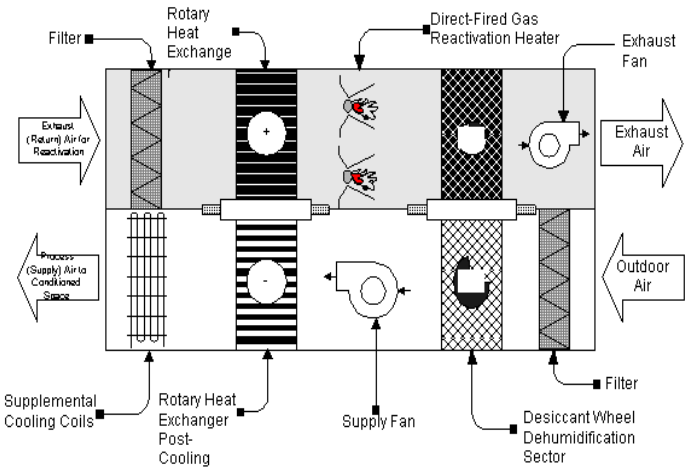


Block diagram

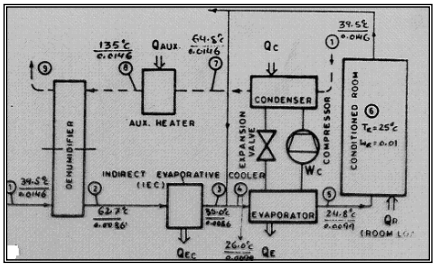


Psychromteric diagram

Hybrid Solid Desiccant System



Solid Desiccant Hybrid space Conditioning (recirculation/condenser cycle)



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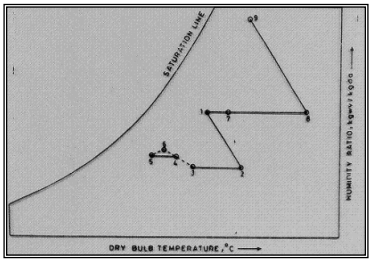
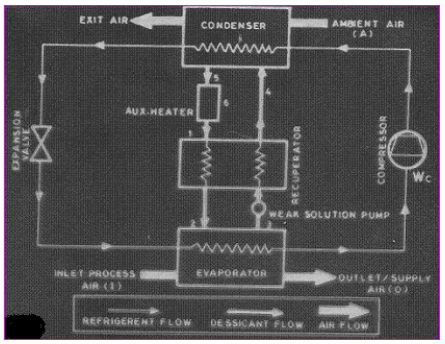


Psychromteric diagram

Liquid Desiccant Hybrid Space Conditioning



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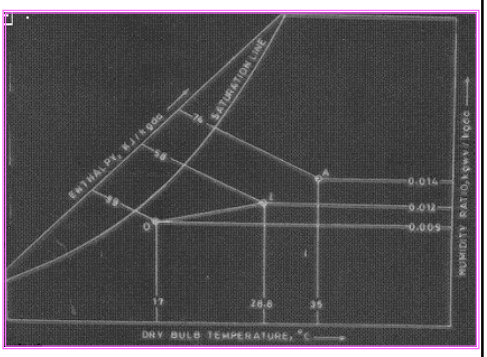

Psychromteric diagram

Conclusions

- For building air conditioning, new technology options are fastly coming up . These are addressing the need of less energy consumption & more comfort with less cost
- Environmental concerns raised by VCRS are properly addressed by solar options using VAR and desiccant based cooling systems
- Hybrid systems are more energy efficient for air conditioning
- Integration of Heat pipes with conventional A/C and solar absorption/desiccant cooling systems is a good proposition for energy conservation.

Thanks for Your Kind Attention

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