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Performance Analysis of Conditioner With and Without Liquid Desiccant

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Abstract **:** This research investigates the performance characteristics of air conditioning systems operating with and without the integration of a liquid desiccant. Liquid desiccants are hygroscopic solutions capable of absorbing moisture from air, offering an alternative method for dehumidification that can enhance overall system efficiency. The study compares energy consumption, cooling capacity, dehumidification effectiveness, and coefficient of performance (COP) under controlled environmental conditions.

INTRODUCTION AIR CONDITIONING SYSTEMS ARE INTEGRAL TO MODERN COMFORT AND AIR QUALITY MANAGEMENT. TRADITIONAL SYSTEMS RELY ON VAPOR COMPRESSION CYCLES TO COOL AND DEHUMIDIFY AIR, WHICH OFTEN LEADS TO HIGH ENERGY USAGE. INTEGRATING LIQUID DESICCANTS INTO THESE SYSTEMS CAN POTENTIALLY IMPROVE ENERGY EFFICIENCY BY HANDLING LATENT HEAT LOADS MORE EFFECTIVELY. THIS PAPER EXAMINES THE COMPARATIVE PERFORMANCE OF AIR CONDITIONING SYSTEMS WITH AND WITHOUT A LIQUID DESICCANT UNIT.

I. Methodology Two experimental setups were used: a conventional vapor-compression air conditioner and a modified version incorporating a liquid desiccant dehumidification unit. Calcium Chloride ($CaCl_2$) was used as the liquid desiccant due to its high moisture absorption capacity. Key parameters such as ambient temperature, relative humidity, cooling load, power input, and air properties at the inlet and outlet were monitored over consistent time intervals.

II. Performance Metrics

- **Cooling Capacity (kW):** Measurement of the total heat removed from the space.
- **Coefficient of Performance (COP):** Ratio of cooling provided to electrical energy consumed.
- **Power Consumption (kWh):** Total energy used by the system.
- **Dehumidification Efficiency (%):** Reduction in humidity level achieved.

III. Theoretical framework

Selection of Pump: Design Conditions / Data

I) 1100 BTU/Pound/hr

= 1100 × 50.75

= 55,781 BTU/Pound/hr

= 16.34 Kw

= 6TR System

II) Specific Heat of Lithium Chloride 1 mol of LiCL = 42.394 grams.

= 42.394 / 1000 = 0.042394 Kg

= 48.03 × 0.042394

= 2.0361 KJ/Kg Kelvin

III) 17°C DBT 50% Relative Humidity (80 to 100°C) CpL = 2.0361 KJ/KgK Cpw

= 4.187 KJ/KgK

IV) Mass of Liquid QH = 16.34 Kw QH

= mL . CpL . ΔT

16.34 = mL . (2.0361) . 20

mL = 0.4012 Kg/Sec

V) Specific Heat of Solution

QH = mw . Cpw . ΔT

16.34 = mw . (4.187) . 20

mw = 0.1951 Kg/Sec

(CpL)w × mw + (CpL)LiCL × mLiCL = (ma + mLiCL) (CpL)Solution (4.187 × 0.70) + (2.0361 × 0.30) = (0.70 +0.30)

(CpL)Solution (CpL)Solution = 3.5417 KJ/KgK

Calculation of Fan

ρa . ma + ρLiCL . mLiCL = (ma + mLiCL) . ρSolution (1000 × 0.7) + (2078 × 0.3) = (0.70 + 0.30) . ρSolution

ρSolution = 1323.4 Kg/m3

Volume Flow rate = mL ρSolution

= 0.4012/1323.4

= 0.00030315

= 18.189 LPM

Selection of Blower For Conditioner

QL = ma . Cpm . (Td1 -Td2) QL = 6TR = 21.10Kw

Cpm = 1.88 Kj/Kgk

Td1 = 40°C , Td2 = 17°C

QL = ma . Cpm . (Td1 - Td2)

21.10 = ma . 1.88 . (40-17)

Mass of Air (ma) = 0.4879 Kg/s ma = $V/V1$

V = ma . V1

V1 = 0.935 m3/kg V = 0.4879 × 0.935

Volume Flow rate (V) = 0.4561 m3/s V = 27.366 CMM

CFM = 970

Liquid Desiccant System (Calculations For Conditioner)

(Water as Refrigerant)

Ma = (L x W x H) ρw

Ma = 0.1665 kg/s

Cooling Capacity (Ql) = Ma (h1-h2)

= 0.1665 x (53 - 52)

= 0.41625 Kw

Water Vapor addition rate

Mv = Ma (W1-W2)

= 0.1665 (0.0125 - 0.0095)

= 4.995 x 10 ^-4

= 1.7982 Kg / Hr

IV. Results and Discussion The system incorporating a liquid desiccant demonstrated enhanced dehumidification capabilities and maintained thermal comfort at lower power consumption levels. The COP improved by approximately 12% in the desiccant-integrated system. While initial system complexity and maintenance requirements increased, the energy efficiency gains offer long-term benefits.

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