Chapter 2

Literature survey

2.1 Research papers related to project

1. Title: - Effect of evaporator numbers on water production of a free convection air-water harvester.

Author: - M. Mirmanto, S. Syahrul, A.T. Wijayanta, A. Mulyanto, L.A. Winata.

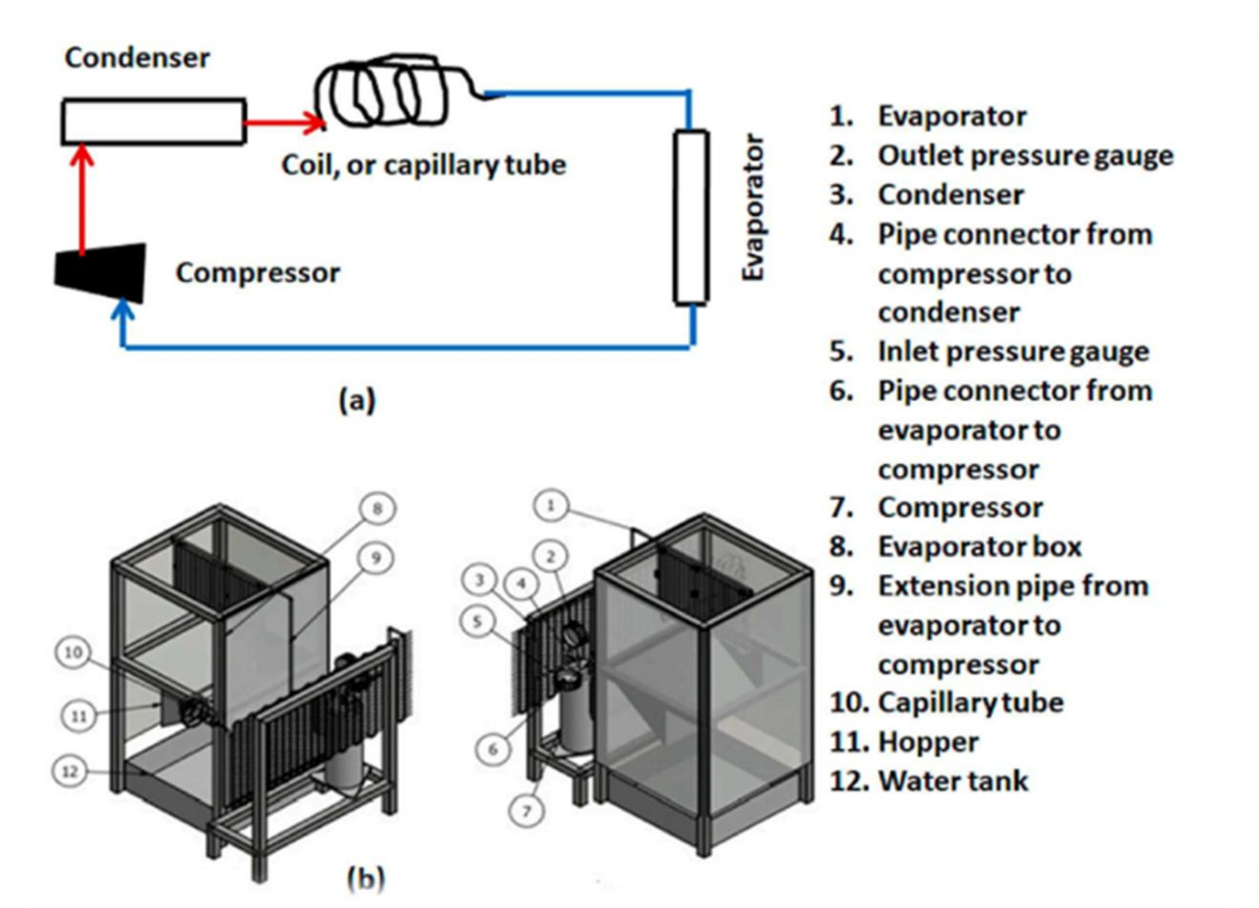

Fig 2.1 Working of fluid flow diagram [1]

This experimental study was aimed at evaluating how the number of evaporators contributes to water production volumes and even the coefficient of performance (COP) in the air-water harvester. The water was evaporated from the walls of the evaporator, which incorporated both free convection and the thermal mass of condensation from water vapor collected from the atmosphere. Each of these evaporators had a dimension of 480 mm by 285 mm by 6.25 mm and were made from copper pipes. The arrangement consisted of several evaporators which were arranged in parallel in an open box measuring up to 500 mm on all the sides. As the working fluid, R134a refrigerant was continuously pumped through the system and operated between low and high pressures of 40 psig and 180 psig respectively. Natural air from the environment moved onto the outer parts of the evaporators bringing along water vapor which they condensed into liquid water.

Three configurations have been examined in the study: one evaporator (Case A), two evaporators (Case B), and three evaporators (Case C). Each of dissipater consisted of 25 copper pipe dolly extends 285 mm. Findings revealed that the number of evaporators was increased, more water could be produced. The maximum water production was 0.51 L/day, together with a maximum of 13% of evaporator efficiency. The machine COP was in the range of 5.2 to 13.3, which certainly improved with the increase in number of evaporators.

2. Title: - A Comprehensive study of an atmospheric water generator using Peltier effect.

Author: - A.H. Shourideh, W.B. Ajram, Jalal Al Lami, S. Haggag, A. Mansouri.

Fig 2.2 Condensed Water from air on the extended surfaces [2]

Malaysia, an experimental layout of a small-type atmospheric water generator was designed and constructed. The AGW design is developed using a systematic and engineering design approach. Specifically, this study built the AWG model using the current performance behaviours of the thermoelectric cooler (TEC) based on driving and load. In the same manner, the rectangular extended surfaces provided a heat sink for the water evaporation rates and was used enhance modeling, where the surrounding fluid temperature and humidity ratio was a driving force. For the above elements, the AWG system was designed as a 3D printed model. The system was completed and then the effect of airflow velocity, humidity and the TEC's current on water generation was tested. The experiments demonstrate that the water generation rate is in some instances lowered with the incorporation of an intake fan. With the addition of relative humidity, the water yield appears to improve. The tests also indicate that elevating the current on the individual TECS will raise the water generation but it will also raise the energy consumption due to lower COP.

3. Title: - Water Generation from atmospheric air by using composite desiccant material through fixed focus concentrating solar thermal power

Author: - S. Srivastava, A. Yadav

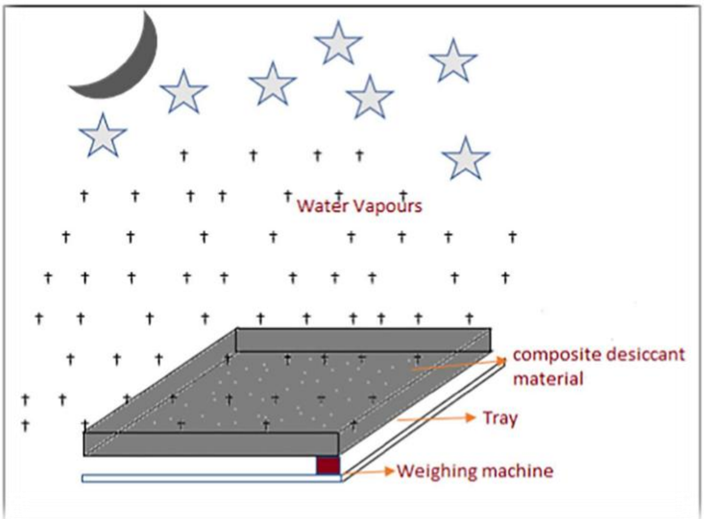

Fig 2.3 water generation by composite material [3]

In this manuscript the authors conducted an experimentation in a bid to harvest water from atmospheric air by utilizing various composite materials in the surroundings of NIT, Kurukshetra, Haryana, India [29°58' (latitude) North and 76°53' (longitude) East]. For this analysis, three composite materials named licl/sand(CM-1), cacl2/sand(CM-2) and libr/sand (CM-3) have used sodium chloride at 37 percent concentration along with sand as host substance. The processes of adsorption and regeneration have been performed in order to extract moisture from air. The adsorption process was provided during the night under open atmosphere while as the regeneration process was carried out during the day with the aid of specially developed 1.54 m2 Scheffler reflector. The amounts of water which have been obtained from CM-1, CM-2 and CM-3 in 330 min, 270 min and 270 min are 90 ml/day, 115 ml/day and 73 ml/day respectively and their annual costs of these water generation amounts are \$0.71, \$0.53 and \$0.86 respectively.

4. Title: - Performance of vapour compression based atmospheric water generation systems in arid conditions in Gulf region.

Author: – E. Ansari, N. L. Ferber, A. Hulleck, L. F. Dumee, N. Calvet.

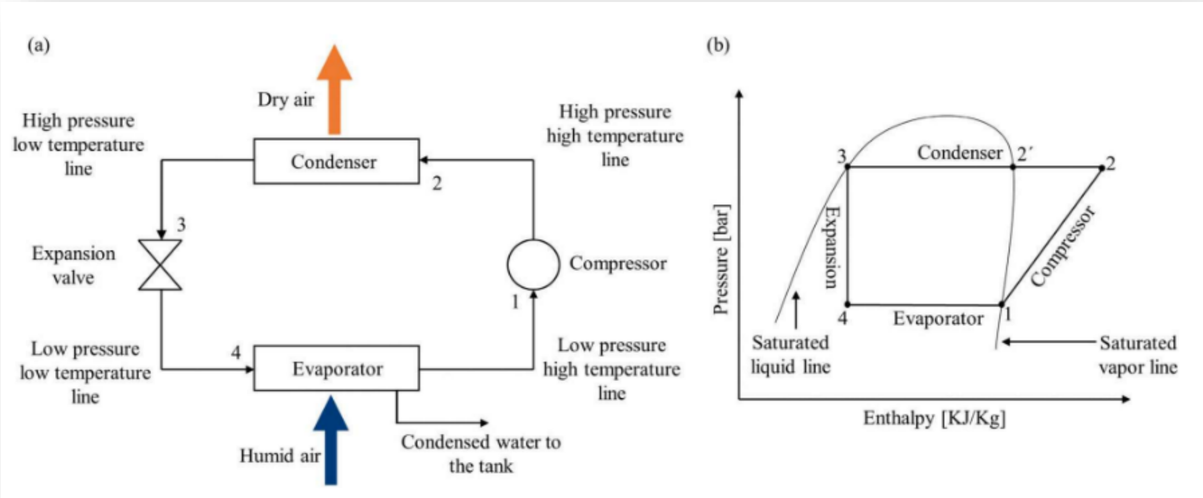

Fig 2.4 Principle of refrigeration using vapour compression [3]

The depletion of readily available freshwater along with the excessive usage of groundwater resources in the Gulf Cooperation Countries (GCC) has led to a growing reliance on seawater desalination to meet domestic water consumption needs. On the other hand, however, extremely humid and hot conditions that dominate this area create a unique opportunity for atmospheric water generation. Presently, most types of AWG systems are used in situations of disaster relief or locations that require water but do not have an option of traditional water synthesis and supply. This paper focuses on each of the key components culminating in the design of an atmospheric water generator that utilizes non-conventional pumping ventilation systems including VCRS and ACCR.

Three commercial VCRS type AWG units were studied concurrently in Abu Dhabi UAE in Masdar City during the field tests of summer 2022 for four months and sought to relate the outcome to the relative humidity and temperature of the inlet air, both indoor and outdoor. In addition, cooling AC coils also yielded condensates that were up to 30.8 L.day-1. TR-1 from 7.87 m3. S-1 FAHU which was mounted at the roof of the University building. This work illustrates the applicability of AWG in addressing water insecurity challenges that are common among arid countries in enhancing self-reliance in water availability.

5. Title: - Optimizing relative humidity based on the hear transfer terms of the thermoelectric atmospheric water generator(AWG): Innovative design

Author: - F. Shahrokhi, A. Esmaeili.

Fig 2.5 Construction of experimental prototype [5]

The main goal of the study is to improve relative humidity by using the heat trans-fer terms of the atmospheric water generator from the air. The atmospheric water generator is maintained with a 0. 04 x 0. 04 m2 thermoelectric cooler. Electricity, air mass rate, relative humidity, and incoming air temperature affect the quality and quantity of water produced from the atmosphere. The results show that the amount of water produced from the atmosphere increases when the atmosphere is moist. It is concluded that a thermoelectric AWG designed with thermos electric cooling as an electric condenser has excellent potential as a kind of power generation through renewable energy sources. The tests show that by decreasing the temperature of the cooling water, the amount of produced water and the efficiency of the device increase. The tempera-ture of inlet air is 37 C, the humidity is 95 %, and the electric current intensity of thermoelectric is 1 A.

2.2 Previous Work

In previous work on atmospheric water generation (AWG) technologies, various approaches have been explored to optimize water extraction from air across different environments. Mirmanto et al. Investigated the effect of increasing evaporator numbers on

AWG performance, finding that additional evaporators improved water production and system efficiency. Shourideh et al. Developed a small-scale AWG system based on the Peltier effect, noting that higher currents increased water yield but raised energy consumption. Srivastava and Yadhav employed composite desiccant materials activated by solar energy for water harvesting, achieving modest yields at low operational costs.

Ansari et al. Evaluated vapor compression-based AWG systems in the arid Gulf region, demonstrating that such systems effectively produced substantial water volumes under extreme conditions, making them suitable for water-scarce areas. Shahrokhi and Esmaeili focused on thermoelectric AWG systems, where optimizing relative humidity and reducing inlet temperature were shown to enhance water production and efficiency. Together, these studies illustrate a range of strategies used to improve AWG systems, addressing specific environmental and resource challenges in water generation from atmospheric sources.

2.3 Mumbai Climate Analysis

The analysis of temperature and humidity data for Mumbai has been identified as essential, as these environmental parameters significantly influence the efficiency of atmospheric water generation systems. Collecting and examining this data is crucial to understanding seasonal variations that impact the moisture content available in the air for condensation. By studying temperature and humidity levels across different seasons, insights are gained into the optimal conditions required for efficient water generation. This analysis thus forms a foundational aspect, ensuring that the design and performance of the system align with the specific climatic conditions of Mumbai.

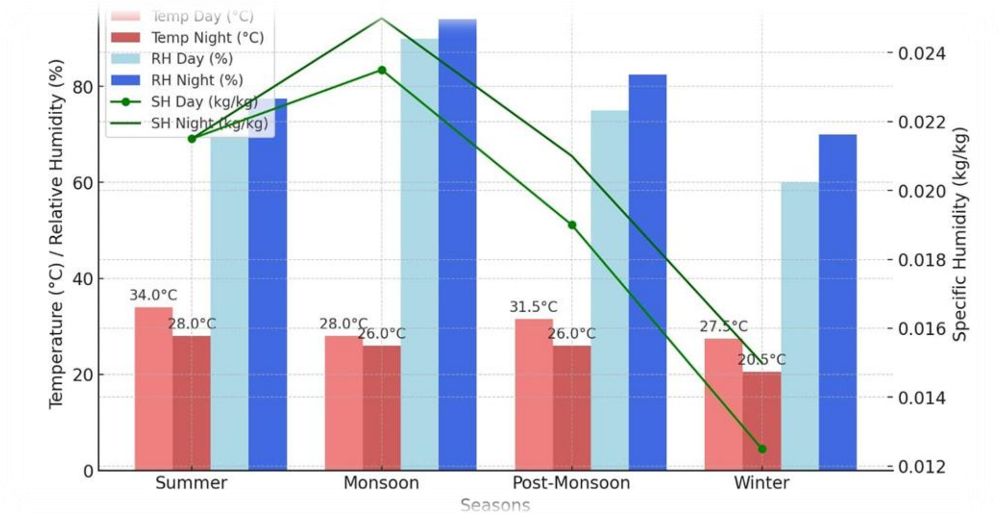

Fig 2.6 Mumbai Climate Analysis

The graph presents seasonal variations in temperature, relative humidity (RH), and specific humidity (SH) for both day and night in Mumbai. Each season—summer, monsoon, post-monsoon, and winter—is represented with bars indicating day and night temperatures and relative humidity, while specific humidity is illustrated as a line.

- **Temperature:**

Daytime temperatures are observed to be highest in summer at 34.0°C, with a gradual decrease through the seasons, reaching a low of 27.5°C in winter. Nighttime temperatures exhibit a similar trend, with a high of 28.0°C in summer and a low of 20.5°C in winter.

- **Relative Humidity (RH):**

The relative humidity, presented as a percentage, is observed to be highest during the monsoon season (above 80%) and decreases slightly in the post-monsoon and winter seasons. RH levels during the night are consistently higher than those during the day across all seasons, indicating greater moisture retention at lower temperatures.

- **Specific Humidity (SH):**

Specific humidity, shown in kg of vp/kg of da, reaches its peak during the monsoon season for both day and night, with values decreasing gradually from monsoon to winter. These peak SH values suggest a higher moisture content in the air during the monsoon, aligning with the elevated RH levels observed during this period.

2.4 Literature Summary

This literature survey examines various methods of atmospheric water generation (AWG), with distinct approaches aimed at improving water extraction from air under varying environmental conditions being highlighted. The innovative strategies and technologies developed to enhance the efficiency and viability of AWG systems across different climates are revealed through the studies examined.

In the study conducted by Mirmanto et al., the impact of the number of evaporators on the performance of AWG systems was evaluated. It was found that a positive correlation existed between the number of evaporators and both water production and efficiency, suggesting that significant benefits could be yielded by increasing the system's capacity.

A small-scale AWG system leveraging the Peltier effect was explored in the research by Shourideh et al. It was discovered that while water yield improved with increased electrical currents, higher energy consumption was also observed, presenting a trade-off between output and energy efficiency that must be considered in system design.

The use of composite desiccant materials activated by solar energy was investigated by Srivastava and Yadhav. Moderate water yields were achieved at relatively low operational costs, highlighting a sustainable method for water generation that could be particularly beneficial in resource-constrained settings.

Vapor compression-based AWG systems operating under extreme climatic conditions in the Gulf region were analysed by Ansari et al., with substantial water production volumes being reported. The potential of AWG technologies in arid environments, which often face severe water scarcity, was underscored by this study.

Thermoelectric AWG systems were focused on by Shahrokhi and Esmaeili, where it was demonstrated that optimization of relative humidity and reduction of inlet temperature significantly enhanced both water yield and overall system efficiency.

In summary, valuable insights into the diverse strategies that can be employed to optimize AWG systems tailored to specific environmental conditions are collectively offered by these studies. Understanding these findings is deemed crucial for the current project, as the design parameters necessary for efficient water extraction in Mumbai's unique climate will be informed by them. The influence of Mumbai's temperature and humidity on AWG performance will be anticipated, guiding the adaptation of this technology to local conditions and ultimately enhancing water generation output throughout seasonal variations.