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The Efficiency of Dehumidifier Closet to Capture Room Moisture in Urban Concept

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Abstract: The disadvantages of using natural methods to capture room moisture and preserve items are not easy to practice in Malaysia conditions especially during the wet season. But, this method was less effective at capturing the room moisture rapidly without any portable device. In this study, a dehumidifier device was used to identify the effectiveness of reducing the room moisture and capture the moisture on the sample test. The dehumidifier device was placed in a closet that contains several samples and the test was monitored hourly. The parameters were measured such as time (s), the volume of water (ml), condensation rate (ml/hour), temperature (°C), relative humidity (%), and mass (g). Sample (five wet clothes) was measured every hour to capture moisture from the sample. The comparison data from 5 samples were analyzed to identify the efficiency of the dehumidifier closet (DC). The results showed that the dehumidifier closet capable to capture moisture samples up to 99.0 % within 11 hours. The distribution of losses from the total volume of room moisture for 5 samples were 42.0 %, 33.9 %, 28.8 %, 26.3 %, and 26.2 % respectively. Thus, it can be concluded that the study more effective to reduce room moisture with wet clothes and able to dry it along the drying process. Therefore, this device has high potential as a dehumidifier closet for reducing and capturing room moisture. It also preserves the quality of stored items for a long-lasting period.

Keywords: Dehumidifier, closet, room moisture, condensation

1. Introduction

Many methods in drying clothes were practiced and applied with differences of materials and types such as leather material, shoes, clothes, books, and other accessories. It had a variety of methods to preserve, saving and drying of materials besides using the heating method. The condensation method was used in this study by using a dehumidifier device/ reactor that has been modified and fits in the closet. Two situations have been tested in this study to measure the changes data needed. Firstly, wet clothes were hung in the closet with closed the door and run the DC. Then, the second situation is the same as the first but change without any clothes as control data. The fan motor in the DC will circulate the humid air inside the closet and the heater will increase the temperature and humidity in the closet [1], [2]. The condenser in the dehumidifier reactor will condense the air in the closet then, transform it into a water droplet [3], [4]. Therefore, the wet clothes will slowly dry.

Malaysia often has a high temperature and relative humidity since its places in the equatorial and tropical climate region [5]. With this high rate of humidity causing fungal problems in the building, material damage such as books, clothing, shoes, leathers, bags, and others. Besides, the humid air also causes anxiety and discomfort in the space. Malaysia also receives a high intensity of rainfall annual. Then, the problems always faced every wet season to dry clothes outdoors [6]. Therefore, those who are drying their clothes off, are always worried to leave the house after the clothes have been dried naturally [7], [8]. For example, during working hours a worker cannot return to collect their

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clothes when it rains. Consequently, they will re-wash and dry their clothes. Same as if they drying clothes in a house without perfect air ventilation or other factors that help to dry the clothes, the effect is the clothes become smelly. Besides, it will decrease the house's aesthetical value besides using a limited house space such as an apartment [9].

A DC is a household appliance that helps humidity in the air in comfort and health level. The machine comes with variable capacity and size to choose for the best surrounding factor effectively. Besides, in commercial buildings, a large dehumidifier is also used such as indoor ice rinks to control the humidity level. By their operation, dehumidifiers extract water from the conditioned air [10]. This collected water is usually called condensate water but does not prefer to use for drinking and it is often discarded. A few designs, such as the ionic membrane dehumidifier, dispose of excess water in a vapor rather than liquid form. The energy efficiency of dehumidifiers could vary widely [11].

Preliminary studies on the characterization of water extracted from humidity [12] showed that raw water successfully can be generated by using a dehumidifier reactor. The result stated that more than 100 ml of raw water was harvested at >80 % relative humidity per day. Thus, the lower temperature and higher humidity will increase the total volume of water collected. Thus, the dehumidifier closet able to preserve any items into closed area. The DC was stored with a sample of wet items, for example, a sample of the wet t-shirt. Then, the dehumidifier has absorbed and condenses the moisture acting as a dryer [13]. The workability of the dehumidifier to absorbed the moisture with time has been taken and the outcome result has been discussed either the dehumidifier closet was capable enough to reduce and extract room moisture content with and without stored item. The objectives of this study are to identify the performance of the dehumidifier closet to absorb room moisture with stored items and measure the captured volume of the closet system. There are other similar studies by others [6], [7], [9], [14], [15] showed that they are using heat source from waste heat air condition to dry the cloth stored in the closet.

2. Experimental Setup

Dehumidifier Closet (DC) model was designed and fabricated based on the standard size in the market as closet and drier (2 in 1). There is not much forming work required in this study only modifications have been made from the closet model at which to be purchased in the current market. This application model has an alternative function as a closet to store the clothes, shoes, bags, and others for a long time saving without any damage in silence. Fig. 1 shows the DC model that has been made to use in this study.

Fig. 1 - DC prototype install with dehumidifier reactor

The closet has been custom fabricated was made by a wood material with a single door. It was a standard closet size with 0.57 m (width), 0.49 m (length), and 1.21 m (height), and the total volume of the closet was 0.34 m3. There was one compartment have been build and a hook was installed on the top of inside DC to hang the samples. The sample was arranged with the maximum sample to ensure that the air ventilation was well circulated. The dehumidifier that was bought was placed at the bottom of the closet by condensation method. A proper wiring compartment was created to ensure the dehumidifier power supply could be plug easily as it was powered by the direct electric power supply. Table 1 shows the specification and the description of the dehumidifier reactor. While Fig. 2 shows the dehumidifier reactor that was used and Fig. 3 shows the tank of the reactor in this study. Semi-conductor refrigeration technology design was used in this dehumidifier reactor hence the condensation effect more than 2 times compared to an ordinary dehumidifier. Therefore, it can effectively enhance the dehumidification process.

Table 1 - Dehumidifier reactor features

Specification	Description
Size	165 mm x 225 mm x 125 mm
Body material	ABS plastic
Input voltage	220 V – 240 V / 50 Hz
Output voltage	DC9V
Power	25W
Application area	10-20 m^2
Dehumidification capacity	200-300 ml / 24 h
Tank capacity	500 ml
Sound produce	30dB

Fig. 2 - Dehumidifier reactor

Fig. 3 - Dehumidifier reactor container

The selected location study at Taman Universiti, Parit Raja, Johor, Malaysia was set up as a house model. This site location has regular monitoring with raw and tested data collection. Other than that, this site in a terrace house was chosen because suitable to simulate in-house model conditions with natural temperature and relative humidity. The DC model was located at the hall corridor in the small house to collect as much as possible data from two data sets such as; (1) Closed model with wet clothes (CMCW) and (2) Closed model without clothes (CMNC).

The samples consist of wet clothes of five different data sets (1 to 5 samples). The samples (1-5 samples) have been washing first until the spinning process from the washer machine. Therefore, the clothes still moist, and then place in the dehumidifier clothes prototype. It has been weighed before, during, and after the test to investigate the drying process in normal humidity in the prototype. For the CMNC prototype, the test was run at the same method but the no clothes sample on it to record as a control DC prototype. All the experiments were tested achieves more to 99 % of the room moisture removal in the prototype. The process was repeated 3 times to find out the average result. These experiments set up as was conducted for less than two months.

The data collection consists of a design of the prototype, the process of drying, and data analysis. The data collection was measured in time taken (hour), relative humidity (%), the volume of moisture removal (ml), condensation rate (ml/hour), temperature (°C), and mass (g) for each sample. All the data were analyzed for the DC test were manually recorded by measuring parameters with specific equipment in an hour. This experiment has been started at 9.00 am until the moisture reduces to 99.0 % for each sample (1 - 5 samples) and the experiment was repeated 3 times.

3. Results and Discussion

3.1 Moisture Reduction Analysis

Fig. 4 shows the value for each sample for mass and volume of moisture reduction. It can be concluded that the quantity increase parallels with the time but, the room moisture reduces at the same time. The higher number of samples contains more room moisture. Therefore, plenty of moisture needs to be removed based on times. The capacity or workability of the dehumidifier closet has a constant variable, therefore, the average of 3 raw data samples was recorded accordingly.

The initial weights of each sample were 208.84 g (1 sample), 359.28 g (2 samples), 490.58g (3 samples), 612.27 g (4 samples), and 790.38 g (5 samples). The wet samples reach 294.85 g, 513.90 g, 726.39g, 888.83 g, and 1163.07 g respectively. The different weights between the initial and wet weight were 86.01 ml (1 sample), 154.62 ml (2 samples), 235.81 ml (3 samples), 276.56 ml (4 samples), and 372.69 ml (5 samples).

Room moisture was monitored in all samples and tested hourly until it reached close to initial weight or tolerate up until +2 gram/ ml. It has been decided to tolerate up until +2 gram/ml because it barely feels the moisture and collects the water (volume). The mass reduction rate for sample 1 to 5 were 17.20 g/ hour (1 sample), 22.09 g/ hour (2 samples), 29.48 g/ hour (3 samples), 30.73 g/ hour (4 samples) and 33.88 g/ hour (5 samples) respectively.

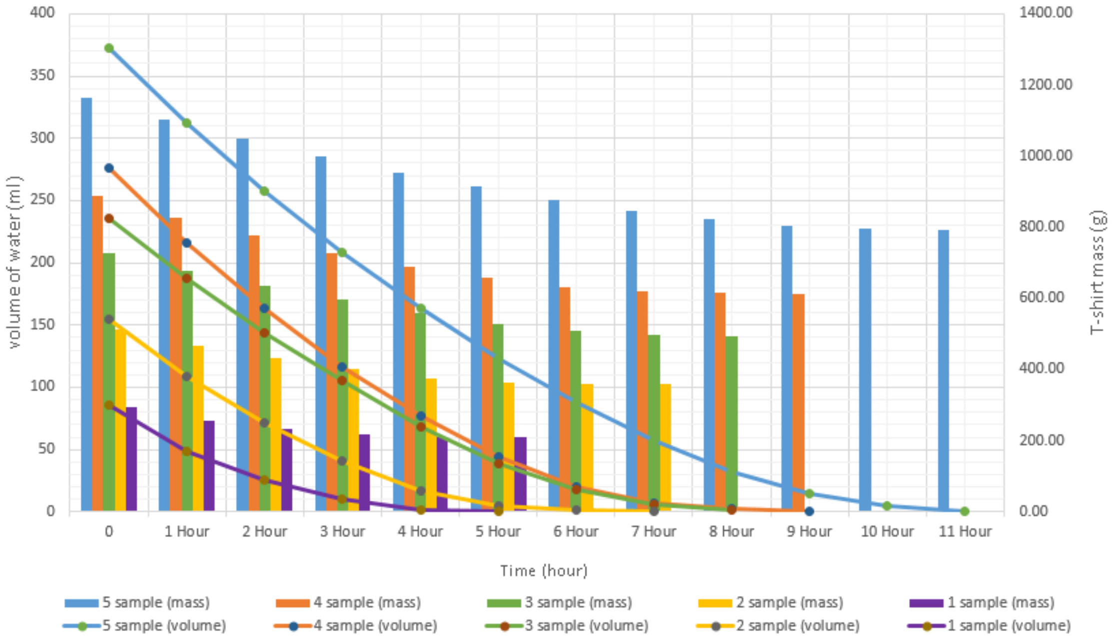

Fig. 4 - Mass and volume of moisture reduction

3.2 Moisture Extraction Analysis

Fig. 5 shows the value for mass and volume of room moisture extraction in average data. The dehumidifier closet was tested by using a condensation process and powered by direct current electricity. Hence, it will keep running extracting the room moisture from time to specific time needed. Therefore, it can be concluded that the volume room moisture can be capture along the time or until to endpoint (dry).

Both tests with and without samples show the capability of the dehumidifier closet to capture the surrounding humidity with the specific time given and there were differences in total volume quantity of room moisture extracted. Therefore, it also has shown the relationship between the higher quantity of room moisture and the volume of water/moisture that could be extracted. The higher quantity of samples contains more water/moisture volume; therefore, there was plenty of room moisture that can be extracted from it. The capacity or workability of the dehumidifier closet that has been used in this study was a constant variable, therefore, the average of results from 3 raw data in this study was dependent on the time taken and moisture content on the sample. The condensation rate was measured for sample 0 to 5 were 5.08 ml/hour (zero samples), 7.23 ml/hour (1 sample), 7.50 ml/hour (2 samples), 8.48 ml/hour (3 samples), 8.09 ml/hour (4 samples) and 8.88 ml/hour (5 samples) respectively.

The initial weight of each sample water extraction container was 131.88g (no sample), 131.75g (1 sample), 131.81g (2 samples), 131.79g (3 samples), and 131.49g (4 samples) 131.77g (5 samples). By the end of the test, the water extraction mass was reached 187.76g, 167.90g, 184.30g, 199.63g, 204.32g, and 229.40g respectively. The different weights between the initial and wet condition that have been extracted from the dehumidifier closet contain which were 55.88 ml (0 samples), 36.15 ml (1 sample), 52.49 ml (2 samples), 67.84 ml (3 samples), 72.83 ml (4 samples) and 97.63 ml (5 samples). Base on the result said that for 0 sample test, it extracts the surrounding moisture content on the dehumidifier closet while for the result that contains samples in the dehumidifier closet, it extracts both moistures from the surrounding and on the sample.

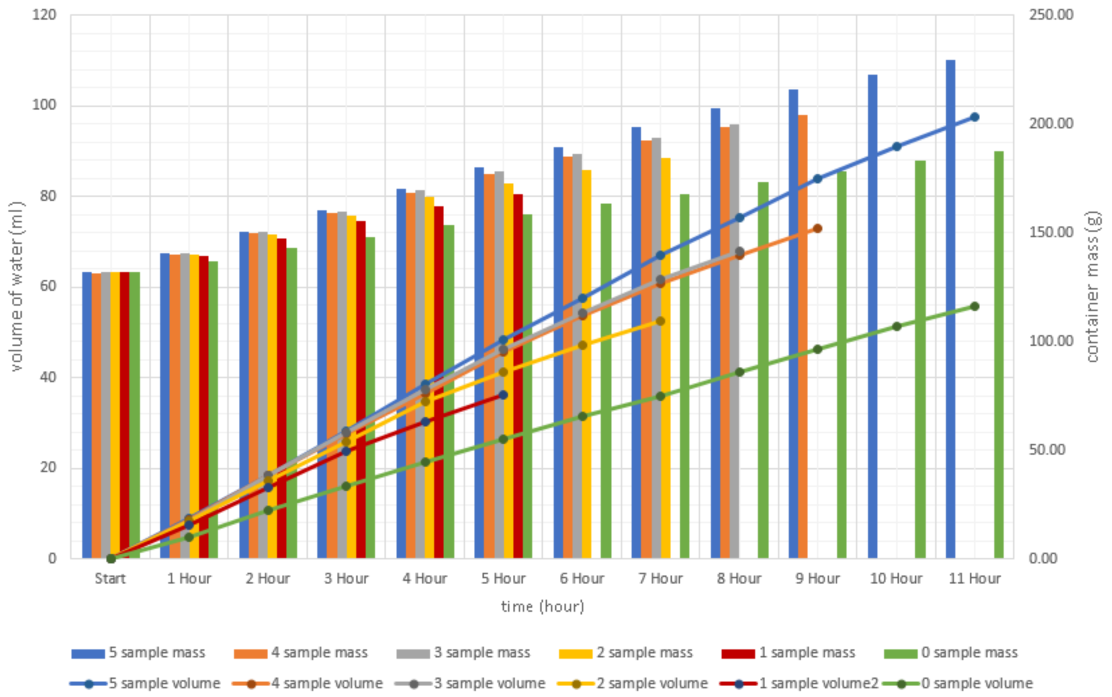

Fig. 5 - Volume of moisture extraction

3.3 Moisture Loss

Fig. 6 shows an example value for the sample for moisture loss from the average result. It showed that the size of the room equal to the total volume of room moisture can be extracted by using the dehumidifier closet. The water content in the sample decreases gradually while the water content in the container increases gradually with time. Proven that the dehumidifier closet workability as extracting room moisture and capture the moisture. The higher quantity of samples contains more room for moisture for testing.

Other than that, it also can be concluded that the higher the number of samples so does longer the time for extraction and reduction of room moisture content in the dehumidifier closet the higher the total volume of room moisture loss. This was due to the evaporation rate of moisture in the closet higher than the condensation rate of the moisture. The condensation process needs more time to condensate the moisture in the dehumidifier closet therefore the time used in the test was not enough for the condensation rate. Otherwise, it can be also predicted that the moisture content in the dehumidifier closet had a loss in the surrounding air while opening the closet when was taking the data or it was absorbed in the closet materials. Base on Fig. 6 showed the value of losses on the total volume of moisture/water content when extracting it from initial time until the end of testing for each sample 1 until 5 which were 58.0%, 66.1%, 71.2%, 73.7%, and 73.8% respectively with the average result. The capacity or workability of the dehumidifier closet that has been used in this study was a constant variable therefore the average responding variable result from 3 raw data in this study were the time, water/moisture extraction, and reduction.

The total initial volume of room moisture in each sample was 372.69 ml (5 samples), 276.56 ml (4 samples), 235.81 ml (3 samples), 154.62 ml (2 samples), and 86.01 ml (1 sample). When the sample was reduced it nearly zero or tolerate up until +2 ml. For water extraction, all samples start from zero until reach maximum value through each samples time limit and the value were 97.63 ml (5 samples), 72.83 ml (4 samples), 67.84 ml (3 samples), 52.49 ml (2 samples) and 36.15 ml (1 sample).

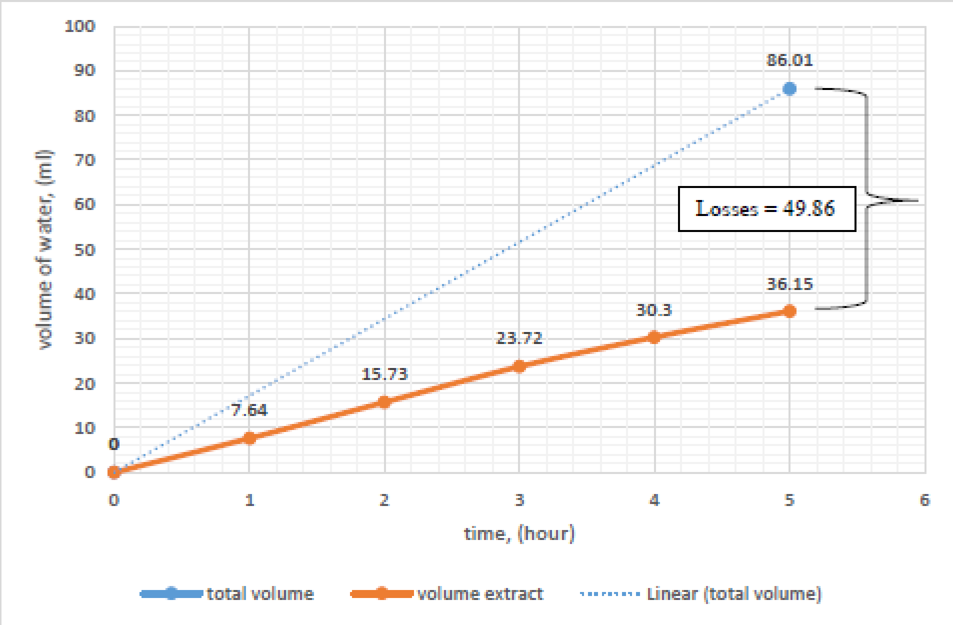

Fig. 6 - Value for 1 sample for moisture loss

3.4 Temperature and Humidity

Fig. 7 shows an example of the relationship between relative humidity and temperature result test for samples 0 until 5 respectively. The temperature both top and bottom inside the dehumidifier closet for all sample were slightly the same along the time. The lowest temperature achieved compared with all samples was 31 °C in sample 5 while the highest temperature was 33.5 °C in samples 2 and 4. All other samples result were recorded between those ranges. For outside temperature reading, it measured that the surrounding area of the dehumidifier closet showed slightly the same along the time. It barely the same with inside temperature result in which the lowest temperature was 31.7 °C in sample 5 while the highest was 33.9 °C for sample 4, all other sample's results was recorded between that ranges. Based on both inside and outside temperatures showed that the samples were dry at room temperature and the dehumidifier reactor does not give a huge effect on temperature and does not affect each other.

For relative humidity average result, both inside and outside of dehumidifier closet have slightly changed through the testing. The moisture in the sample has given some effect in relative humidity reading through the condensation process in the dehumidifier closet. It because the moisture change to humid air increasing its total volume before it changes back to water by using the condensation process. The relative humidity increases at the beginning of the test and makes short-term constant reading before decreasing back to the initial reading and most of the time the reading on the top of the dehumidifier closet was higher than the bottom part. This was because the moisture usually will condense in the air and it light in density therefore it evaporates and lifts in the air. The top part reading can reach up to 89.1 % in sample 5 while the bottom part was 83.8 % also in sample 5 but both initial relative humidity readings for all samples were slightly the same with the surrounding testing area. The reading for the outside dehumidifier closet was no huge difference through the testing time because the test area was contained which less air circulation.

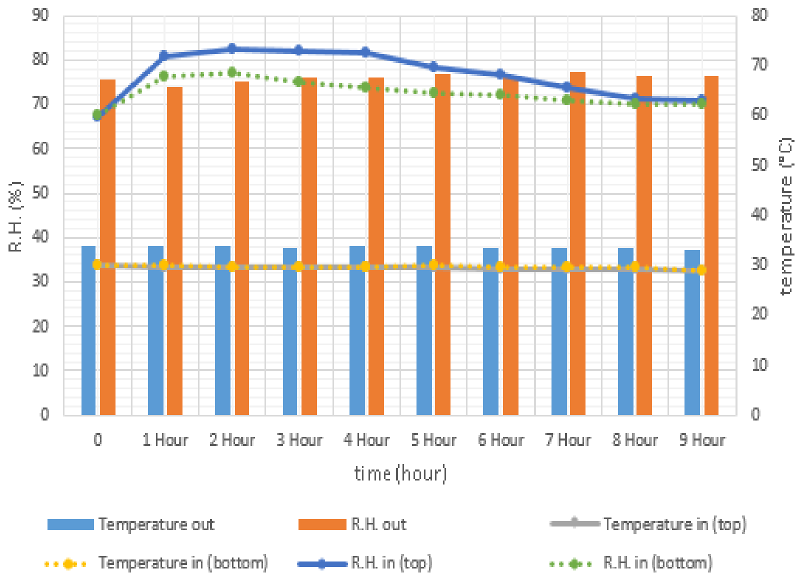

Fig. 7 - Example relationship between R.H and temperature for samples

4. Conclusion

Based on experimental result showed that the DC prototype able to capture room moisture from samples and room for 5 to 11 hours. The volume of losses occurs in the samples where differences volume between samples and extracted in the container. The result showed that the experiment successfully reduces 99 % of the total value of room moisture. Sample 1 to 5 samples were 86.01 g, 154.62 g, 235.81 g, 276.56 g, and 372.69 g respectively. While the volume of moisture that successfully trapped (0-5 samples) was 55.88 ml, 36.15 ml, 52.49 ml, 67.84 ml, 72.83 ml, and 97.63 ml respectively. The total volume of moisture losses in samples 1 to 5 were 49.86 ml, 102.13 ml, 167.97 ml, 203.73 ml, and 275.06 ml respectively. But, the total percentage of water/moisture from samples 1 to 5 only 42.0 %, 33.9 %, 28.8 %, 26.3 %, and 26.2 % respectively successfully trapped in these experiments. It occurs caused by the humid air in the dehumidifier closet escape to surrounding air while opening the closet door during monitoring record. Lastly, the temperature inside and outside of the dehumidifier closet almost the same 31.7 °C to 33.9 °C with no significant difference along with the testing. But, for the relative humidity reading, there were increases during the test that could reach up to 89.1 % and reduce back to its initial reading or room relative humidity which around 70 %. This is the endpoint of the condition. Therefore, the effectiveness of the DC prototype was achieved the objective was to capture room moisture in the air. Our body and environment always expose to active bacteria that can affect any type of material and body. Thus, the dehumidifier is the best method to refresh the higher relative humidity in air or space where are contributes more negative bacteria to our environment and space.

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