Performance Evaluation of Portable Mist Humidifier

M. Mahesh¹, P. Thangavel¹, K. Bhuvaneshwaran¹, V. Boopathi Raja⁴, S. Dinaesh Krishna⁵

¹, Assistant Professor, Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.
²Assistant Professor, Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.
³, ⁴, ⁵ Student, Bachelor of Engineering in the Department of Mechanical Engineering, Kongu Engineering College, Erode, Tamil Nadu, India.

mahesh25391@gmail.com, ptvel@kongu.ac.in, bhuvaneshkrish007@gmail.com, boopathirajavbr3599@gmail.com, dinaesh1998sdk@gmail.com

Abstract. This paper deals with the performance evaluation of portable mist humidifier, for producing a cooling effect in a specified area. A humidifier is an electrical device that increases the humidity of an environment. So the room temperature got reduced with the help of increasing the humidity. This devise provides a cooling effect at low cost without health hazards. The experimental arrangement made with the components of axial fan, copper tubes, hydraulic pump, nozzles, respectively. The misting nozzles are placed into the holes which are made in the copper tube and the copper tube is fitted over the frame on the axial fan. The hydraulic pump is kept in the water tank to circulate the water to the copper tube. When the water flows through the tube it emits water droplets with the help of misting nozzles. Due to the high-speed axial fan, the emitted water droplets are sprayed into the atmosphere as a mist. When there is a increase in the moisture content there will be decrease in room temperature. Due to this effect the room temperature has been decreased by 12% with the help of humidifier.

Key words: Cooling Effect, Copper Tube Humidifier, Humidifier, Humidification

1. Introduction

The process by which the moisture or water vapour or humidity is added to the air without changing its dry bulb temperature is called a humidification process. This process is not possible actually since the humidification is always accompanied by cooling or heating of the air. A humidifier is an electrical appliance device that increases humidity (moisture) in a single room or an entire building. In-home applications, humidifiers are commonly used to humidify a single room. For entire house or industrial applications, the capacity of the humidifier to be increased and provides humidification effect for the entire house. “Portable humidifier” is smaller in size and capacity which could be employed for small rooms. In this humidifier, water is supplied by manually in the tank on a periodic basis. Using appropriate mechanism water diffused into the air and space will be cooled. The various studies indicate that the comfortable value Relative Humidity (RH) for human beings is in the range of 35 to 55%. During the summer season, the atmospheric air is in dry condition and human comfort could not be maintained. Humidification of dry air is essential during the summer season. Based on the financial constrain, the portable mist humidifier unit can be used to create the required environmental condition.
Xiaong Huang et al. studied the performance characteristics like heat and mass transfer of corrugated plate spray humidification air coolers under wet working conditions. So that the humidification process can be done by a corrugated plate. Zhuangbofeng et al. studied that low level of indoor humidity, when human exposes to this will have respiratory symptoms or dryness (for skin, pharyngeal, eye etc.). It is closely related with air quality and indoor thermal comfort. This study showed that humidification improves the breathing quality of human beings.

Mostafasharqway et al. presented the cross-flow packed-bed humidifier. The experimental performance of this humidifier was studied with spraying hot water in a cross-flow arrangement over packing material where air flows through it. So that humidifier was made by simple water flow set up. J. Moureh et al. studied the performance of Refrigerated Display Cabinets (RDCs) and the use of mist flow. To improve the performance, fine water droplets were injected into the air curtain. So that the spraying of water droplets into the atmosphere would increase the humidity level.

Stuart Gaffeny et al. stated that humidification was concerned with the addition of water vapour to a gas. It can be measured as either relative or absolute. This study showed that higher relative humidity could be delivered by active humidification devices (including hot water baths). But were associated with potential hazards and higher cost. Pedro Magalhães Sobrinho et al. discussed about the factors that were directly connects with the energy consumption of a small air conditioning system. This study had been showed that the amount of energy needed for the humidifier.

In most of the literature, the cooling effect was done by refrigerants like HCFC and CFC which are having high ODP and GWP values, which results in Global warming. Low level of indoor humidity exposure may cause respiratory problems, so the usage of humidifier helps to increase the humidity level. A humidifier increases the air-side heat transfer coefficient. In a cross-flow arrangement, water is sprayed on the packing materials where the air flows.

2. Methodology

The problem in the current air coolers was identified by physical observation and experimentation. The literature related to portable mist humidifier were collected from different sources and observed the methodologies used. From the collected literature it has been analysed the gap and drawbacks found, nature of the model and cost involved. Conceptualization of the model to solve the problems found in the currently available methodologies by applying the engineering principles. Feasibility of the model checked by analysing the process parameter in the portable mist humidifier with the proposed mechanism and materials were selected.

Design calculations are carried out to meet up the process required for each component such cooling effect. Materials are purchased for each component according to the requirement and design. Fabrication of each component was done according to design and assembled to achieve the proposed mechanism. The model is operated to perform the cooling effect and results were noted and analysed the obtained results with the other equipment. The performance of the machine is analysed continuously to improve the quality of the work.

3. Materials and Specification

The following table contains the materials chosen for the making of experimental setup and its specification.
Table 1. Components description

| Sl.No. | Parameters       | Pictures                                               | Range                      |
|--------|------------------|--------------------------------------------------------|----------------------------|
| 1.     | Axial fan        | ![Axial fan](image1.png)                               | 900 rpm                    |
| 2.     | Copper tube      | ![Copper tube](image2.png)                             | 7mm-outer diameter, 5mm-inner diameter, 5ft length |
| 3.     | Mist Nozzle      | ![Mist Nozzle](image3.png)                             | 0.2 mm (hole diameter)     |
| 4.     | Hydraulic pump   | ![Hydraulic pump](image4.png)                          | 1100 L/hr.                 |

4. Fabricated Model

Figure 1. Assembly of Portable Mist Humidifier
The assembly unit consists of an axial fan, copper tubes, misting nozzles, hydraulic pump, water tubes and the tank is shown in Figure 1. First, the copper tube is rounded as a coil and then the holes are made around the tubes. Then the misting nozzles are fitted into the holes made in the copper tube. Now the copper tubes are mounted over the frame of the axial fan. The sucking part of the pump is connected to the water tank and the delivery end of the pump is connected to the one end of the copper tube. The water from the copper tube is connected to the tank.

5. Working Process

The power supply was provided to the axial fan and pump for water circulation. Then the water is pumped at high pressure from the water tank to the copper tube. The water is passed through the copper tube and returned to the water tank and this cyclic operation is carried out during the entire process. When water flows through the copper tube, the water molecules are sprayed through the misting nozzles into the atmosphere. When the power supply started supplying the axial fan will provide high velocity of the air and the misting effect of the water particles, the diffusion of water molecules carried out into the atmosphere.

6. Design and Mathematical Calculation

To carry out a design Process, different software are available such as Auto CAD, Solid Works, CATIA V5R20, Creo, etc. The design of the proposed model is shown in Figure. This model is prepared by using CATIA software. This CATIS software was selected as it is most common software for solid modelling and more user-friendly. This setup consists of a table fan, Water tank of 600mmx600mm, the copper tube of diameter 12mm, Water pump, and Misting nozzle, respectively. The designed model is shown in Figure 2.

![Figure 2. Design of Portable Mist Humidifier](image)

6.1 Calculation

For normal room,

\[
\text{Length of the room (L)} = 10 \text{ ft.} = 3.048 \text{ m.}
\]

\[
\text{Width of the room (W)} = 8 \text{ ft.}
\]
= 2.438 m.

Height of the room (H) = 12 ft.

= 3.657 m.

Volume of the room,

\[ V = L \times W \times H \]  

= 3.048 \times 2.438 \times 3.657 

= 27.18 m³.

= 27 m³ (approximately).

By using the dimensions, the volume of the room is calculated.

6.2 Cooling Effect in the room

\[ Q = \frac{(C \times V \times E \times \Delta T)}{3600} \]  

Where,

\[ Q \] = cooling capacity of the room.
\[ C \] = Air changes.
\[ V \] = Volume of the room.
\[ E \] = Energy per cubic meter of the air.
\[ \Delta T \] = Temperature difference.

= (Initial temperature – Final temperature).

For 15 minutes,

\[ Q = \frac{(2 \times 27 \times 9.1 \times 10^3 \times (30-29.5))}{3600} \]

= 0.0682 kWh.

For 30 minutes,

\[ Q = \frac{(2 \times 27 \times 9.1 \times 10^3 \times (30-28.75))}{3600} \]

= 0.1706 kWh.

Cooling effect \[ \frac{33-28.75}{33} \times 100 \]

= 12.87%

7. Result and Discussion

This model had been tested in the room conditions and the results are noted. The test results of the fabricated model are given in the form of the table 2.

| Sl. No | Period of Time (minutes) | Temperature (Before humidifying) (in °C) | Temperature (After humidifying) (in °C) | Cooling Capacity (kWh) |
|--------|--------------------------|-----------------------------------------|----------------------------------------|------------------------|
| 1.     | 0-5                      | 30                                      | 29.9                                   | 0.01365                |
| 2.     | 10                       | 30                                      | 29.7                                   | 0.04095                |
| 3.     | 15                       | 31                                      | 29.5                                   | 0.06825                |
| 4.     | 20                       | 32                                      | 29.25                                  | 0.10237                |
| 5.     | 25                       | 33                                      | 29.0                                   | 0.13650                |
| 6.     | 30                       | 33                                      | 28.75                                  | 0.17062                |

Table 2. Performance analysis of humidifier
Comparison of results with and without humidifier is shown in the figure 3. At the starting time of 5 minutes the room temperature is at 30°C. This study is done at day time in UPS room at Kongu engineering college, so the temperature of the room was varying with the climatic condition and the usage of UPS. When the time increases there is an increase in the atmospheric temperature of the room in the normal condition. While using the fabricated humidifier continuously for 30 minutes the cooling capacity reaches 0.17062kWh.

![Comparison between temperatures with and without humidifier](image)

**Figure 3.** Performance graph for humidifier

8. Conclusion

Thus the developed portable mist humidifier can be used for cooling of a small area. The cooling effect produced in the humidifier is comparatively higher than most of the currently available machines. The hydraulic pump and the axial fan used in the model work flawlessly to produce a good cooling effect. The developed mist humidifier is simple and it can be used by anyone and it is non-toxic. The portable mist humidifier is cost-efficient and it is done at a very affordable price. Comparison of room conditions with and without humidifier is done and results are analyzed and it shows cooling effect. Using this humidifier, the cooling effect is increased by 12.87%.

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References

[1] Xiaoqinghuang, dongliang zhang, xuzhang spray humidification air coolers, volume 205, 2017, pages 1886-1892.
[2] Zhuangbo Feng, Xiaoqing Zhou, ShihanXu, Junwei Ding, Shi-JieCao, portable ultrasonic humidifier, Building and Environment, Volume 133, April 2018, Pages 62-72.
[3] Mostafa H. Sharqawy, Ibrahim Al-Shalawi, Mohamed A. Antar, Syed M. Zubair, cross-flow humidifier, Applied thermal engineering, volume 117, May 2017, pages 584-590.
[4] TingfenKe, Xin Huang, Xiang Ling, Heat and mass transfer in humidifiers, Applied thermal engineering, volume 156, 25 June 2019, pages 310-323.
[5] Stuart Gaffney, Andrew Dalton, Humidification devices, Anaesthesia and intensive care medicine,
[6] Moureh J, Letang G, Palvadeau B, Boisson H, Mist flow process, International journal of refrigeration, Volume 32, issue 2, March 2009, pages 203-219.
[7] Pedro Magalhães Sobrinho, Celso Eduardo Tuna, Humidity in air conditioning system, Experimental thermal and fluid sciences, Volume 49, September 2013, pages 152-159.
[8] Peng Xu, Xiaoli Ma, Xudong Zhao, Kevin Fancey, Applied energy, Volume 203, October 2017, pages 761-777.
[9] Samira Pourhedayat, instant running water cooler, Applied energy, volume 229, November 2018, pages 364-374.
[10] M. Ghazikhani, I. Khazaee, S. Vahidifar, Energy analysis of humidifier, Energy and buildings, volume 124, July 2016, pages 129-140.
[11] W. Chen, S. Shang, B. Wang, X. Li, Y. Cao, and W. Shi, “Experimental study on effects of supply-air humidification on energy and emission performance of domestic gas boilers,” Energy Build., vol. 209, p. 109726, 2020, doi: 10.1016/j.enbuild.2019.109726.
[12] E. Eder and M. Preißinger, “Experimental analysis of the humidification of air in bubble columns for thermal water treatment systems,” Exp. Therm. Fluid Sci., vol. 115, no. November 2019, p. 110063, 2020, doi: 10.1016/j.expthermflusci.2020.110063.
[13] W. F. He and D. Han, “Performance Simulation of an Air-Heated Humidification Dehumidification Desalination System,” IOP Conf. Ser. Earth Environ. Sci., vol. 73, no. 1, 2017, doi: 10.1088/1755-1315/73/1/012004.
[14] S. Rabczak, D. Proszak-Miąśik, and K. Nowak, “Energy consumption in humidification process,” IOP Conf. Ser. Earth Environ. Sci., vol. 214, no. 1, 2019, doi: 10.1088/1755-1315/214/1/012129.
[15] R. Tu, J. Li, and Y. Hwang, “Fresh air humidification in winter using desiccant wheels for cold and dry climate regions: Optimization study of humidification processes,” Int. J. Refrig., vol. 118, pp. 121–130, 2020, doi: 10.1016/j.ijrefrig.2020.04.009.