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Research Article

Window AC System Coupled with Ducting for Ameliorating Air Flow and Cooling Effect

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A B S T R A C T

In this work, a window air-conditioner has been integrated with ducting for improving air circulation and making the cooling of a room more uniform. Temperature distribution at different points in the room in room equipped with window airconditioner was recorded and found to be non uniform. Thus, due to the temperature variation at the points where such decentralized featured systems exist, the problems of high energy consumption and low energy efficiency occur to meets the cooling load. A solution for such quandary has been made in this pilot project, by developing a ducting network for such a system to distribute cool air engendered by ac system in the entire room so that the uniform temperature is achieved at different locations in the room. It was found that the cooling was affected significantly by integrating ducting with window air conditioner.

Keywords: Centralized and Decentralized Air Conditioning Systems, Window Air-Conditioner, Ducting

Introduction

Air-conditioning can be broadly categorized into two sections- centralized air-conditioning and decentralized air-conditioning. It has been found that air distribution and cooling uniformity was better in Centralized air-conditioning systems, but at the expense of high investment and running costs. Most of the houses and small scale dwellings use the decentralized air conditioning system. The decentralized systems are less expensive but lack the uniformity of cooling and the different corners of the room can be at different temperature. The windows air conditioners are used for a long time in a number of buildings in India as a typical representation of a decentralized Air Conditioning (AC) system.

Decentralized AC systems are in some respects more beneficial than centralized ones. The user can control the AC terminals according to his needs with a decentralized AC system.

However, no distribution system exists in decentralized AC systems, which means that the air is supplied to room via single outlet which is the reason for non uniform air flow. The centralized air-conditioning systems are always installed with ducting after making all the heat load calculations, while the decentralized systems are without ducting.

Figure 1.Window air conditioner

Figure 2.Central air conditioning

Literature Review

A background study was conducted of the available literature and following was the work available in the context.

S. No.	Researchers & year	Findings
1.	G.S. Sharma et al. (2012)	They studied various duct shapes, and came to the conclusion that circular ducts have low friction loss and easy to design, but rectangular ducts are used because of the space availability.
2.	Virendra G et al. (2013)	They employed softwares to study the flow of air in ducts; developed the Computational Fluid dynamic (CFD) technique. This can be used to calculate frictional pressure drop, static pressure, velocity pressure and other functional units to improve the cooling efficiency of the system.
3.	Gadd H et al. (2012)	In different seasons, they investigated the shift in heat load. The conclusion was that the heat load variations in different seasons were approximately 2.3 per cent.
4.	Liang C et al. (2018)	They studied the non-uniform air flow in indoor environment. Their research developed a better air-conditioning system design that increases air supply and temperature uniformity.
5.	Subei C et al (2019)	They investigated the pressure drop in refrigerant pipes. Using CFD this was corrected 42.4% while upto 55.8% in one-dimensional models.
6.	Jebin A et al. (2012)	They examined the lack of air supply in window air conditioners and proposed a duct design to improve air throw and thereby the efficiency of the system.

From the above literature we can conclude that window air-conditioners have the potential to be ducted which can provide uniform cooling in the room.

Experimentation

A room to the size of 10x15 feet was selected for the experimental work. The room was equipped with a window air conditioner. The heat load was calculated taking into consideration the number of occupants in the room, the other heat generating units like workstation, printer, light, etc.

Thermal analyzer was used to find the temperature at the various corners in the room to have a clear understanding of the disparity in the temperature of the room.

Survey and measurement

Step 1:- Area to be cooled

Area BTU = Length (ft.) X Width (ft.) X 31.25

= 20 X 10 X 31.25 = 6250 BTU

Step 2:- Heat Gain through Windows

South Window BTU = Area of South facing Window (m sq.) X 868

= 1.524 X 0.9144 X 868 = 1209.5975 BTU

As there is no shading, so

South Window BTU = South Window BTU X 1.4

= 1209.5975 X 1.4 = 1693.4366 BTU

Step 3:- Heat Generated by Occupants

Occupants BTU = No. of People X 600

= 5 x 600 = 3000 BTU

Step 4:- Heat Generated by Machinery

Equipment BTU = Total Equipment watts X 3.4

= 300 x 3.4 = 1020 BTU

Step 5:- Heat Generated by Lighting

Lighting BTU = Total Lighting Watts X 4.25

= 50 x 4.25 = 212.5 BTU

Step 6:- Total Heat Load

Total Heat Load = Area BTU + Total Window BTU + Occupant BTU + Equipment BTU + Lighting BTU

= 6250 + 1693.4366 + 3000 + 1020 + 212.5

= 12175.9366 BTU

Ton required:- = (12175.9366)/12000 = 1 ton (approx.)

Therefore, the air-conditioning tonnage requirement is 1 Ton.

Duct Design

The ducts were prepared as per measurements. Rectangular ducts were used.The circular ducts though provide very low friction loss, but involve a lot of installation problems. For this reason the rectangular ducts were chosen because of the limited space availability. Plastic fans were also installed inside the ducts so as to create a vacuum, such that the air from the window air-conditioner flows through the ducts easily and gets distributed in the room properly.

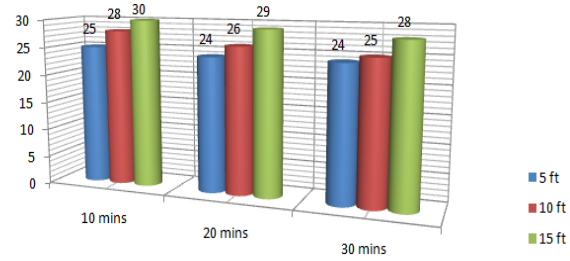
Figure 3.Duct assembly for window ac

Figure 4.Duct integration

Result

To have a good idea of how well the duct addition to the window ac have changed the temperature disparity, a thermal analyser and digital thermometer were used to get the different temperatures in the room. Graphs were plotted to have a better understanding.

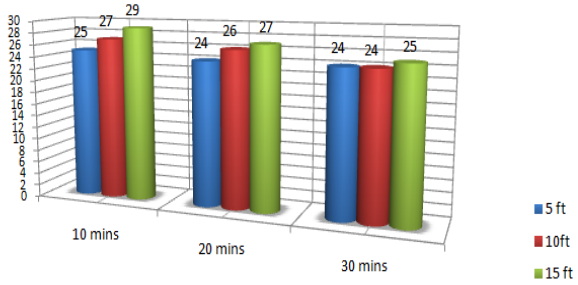
Figure 5 shows the temperature disparity clearly as at a distance of 30 feet from the Window ac unit the temperature had come down to 28^{0}C from the 30^{0}C initial room temperature, even after 30 minutes of the working of the air-conditioning system.



	10 mins	20 mins	30 mins
5 ft	25	24	24
10 ft	28	26	25
15 ft	30	29	28

Figure 5.Temperature disparity with respect to time and distance from the unit before the installation of ducts

Figure 6, shows the temperature disparity clearly as at a distance of 30 feet from the Window ac unit the temperature had come down to 25^{0}C from the 30^{0}C initial room temperature, after 30 minutes of the working of the air-conditioning system. This very well proves the effectiveness of the ducts in increasing the air flow in the system.

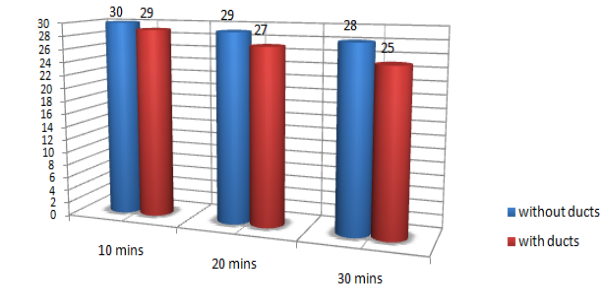


	10 mins	20 mins	30 mins
5 ft	25	24	24
10ft	27	26	24
15 ft	29	27	25

Distance of duct from window ac

Figure 6.Temperature disparity with respect to time and distance from the unit after the installation of ducts

From the above two graphs a third co-related graph can be made which clearly shows the temperature disparity. In Figure 7, the blue columns show the temperature recorded without ducts, and the red column shows the temperature with ducts. The temperatures have been recorded at a fixed distance of 30 feet from the window ac and at intervals of 10, 20 and 30 minutes.



	10 mins	20 mins	30 mins
without ducts	30	29	28
with ducts	29	27	25

Temperature at a distance of 30 feet from window ac

Figure 7.Temperature variation at a distance of 30 feet before and after installation of ducts

Conclusion & Future Scope

The analysis of the measurements and survey results indicates that the main reason for the

A window air conditioner with a cooling capacity of 1 ton was installed. Ducts equipped with air throw were also installed. The temperature of the room at different corners was measured now using the thermal which were found to be more uniformly distributed.

From the above practical work it can be concluded that:

- Adding ducts to window air conditioner increases the air distribution and the uniformity in temperature.
- The ducting also improves the efficiency of the air-conditioning system, and the human comfort conditions.

As this was a pilot study which was found to be successful, this can be implemented by HVAC professionals and consultants.

Uniform thermal stability was achieved in the room leading to more comfort to the occupants.

It has been found that there has been an improvement of 9.82% in the air flow and temperature distribution by the installation of ducts. This can further be improved by studies and CFD implementations by HVAC professionals and consultants.

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