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Study the Effect of Sunlight on the Coefficient of Performance of Condenser of an Air Conditioning Unit

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Abstract - *The problems of global warming and climate change are on a rise, increase in the use of air-conditioning systems is one of the causes. The performance of the condenser of an Air-Conditioning unit decreases when it is subjected to irradiation from the sun. The technique that is used to reduce the cooling demand in buildings and subsequently save energy is called as Shading, in which the condenser of the Air-Conditioning system is covered either partially or completely. This study investigates the reduction in consumption of electricity and the reduction in the cost of electricity by shading the condensers of air-conditioning (A/C) equipment. Hence, this study aims at increasing the coefficient of performance of an AC in hotter conditions and also reducing the electrical consumption.*

Key Words: **Air-Conditioning, Shading, Condenser, Heat Transfer, Energy**

1. INTRODUCTION

An analysis compares the performance of several A/C units the results show that the theoretical increase in the coefficient of performance (COP) due to shading is within 2.5 % [1]. There are two mechanisms by which the performance of an A/C condenser can be improved, which are:

Direct shading and Temperature depression. Direct shading involves covering the condenser with trees or bushes, whereas temperature depression involves a shading object which covers the condenser. This study focuses on the indirect shading part of condenser shading. Implementation was completed in two phases, viz. COMSOL Analysis Phase, which includes finding the heat transfer coefficient and the subsequent heat transfer which takes place. The next phase includes calculating the energy consumed by the compressor of the Air-Conditioning Unit.

2. Modelling and COMSOL Analysis

The first step for analyzing the compressor model is to design the compressor, which was done in CATIA. Next step is importing the geometry in COMSOL Multiphysics.

2.1 Geometrical Modelling

A simplified model of the compressor (outdoor unit) of the Air-Conditioning Unit was designed using CATIA V5. The dimensions of the model were taken from the catalogue obtained from the company (the CATIA model was of the same dimensions as of the model on the experiments were performed) Since, the company used copper tubes for the condenser tubes, our model employs copper tubes. The outer structure of the Compressor is made up of Galvanized Steel.

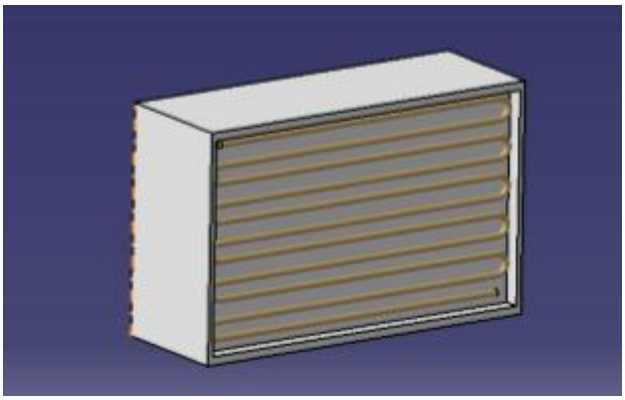

Fig -1: Using copper tubes and galvanized Steel as the materials for the CATIA model

The shading object needs to reflect sunlight incident on it. A survey was done on materials which provide the highest reflectivity. The results can be seen in the table below:

Table -1: Survey of the reflectivity of materials

Materials	Reflection Factor(%)
Aluminum, pure, highly polished	80 - 87
Aluminum, anodized, matt	80 - 85
Aluminum coatings, matt	55 - 56
Chrome, polished	60 - 70

Hence, aluminum was used as the material for the design of the shading object.

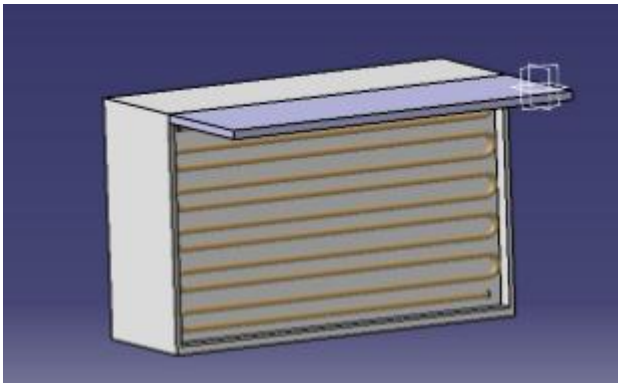

Fig -2: Horizontal shading object having aluminum as material

2.2 COMSOL Analysis

The object modelled in CATIA V5 was imported into COMSOL Multiphysics and a stationary study was performed on the imported geometry. A study comprising of the Heat Transfer was implemented, which uses the Surface-to-Surface Radiation phenomenon. From the catalogue provided by the manufacturers, the temperature of the condensing coils can be roughly approximated to 340.15 K. Hence, the temperature of the coils was provided as 340.15 K (the initial values given to the system). A conventional heat flux was provided, which utilizes the Nusselt number co relations to determine the heat transfer coefficient. The working fluid was chosen as air, with a vertical wall height which is equal to the height on the compressor. The external temperature was set according to the time of the day; the simulation was done for.

The mesh was done using the physics induced sequence, with the tetrahedron element, with the meshing size being normal.

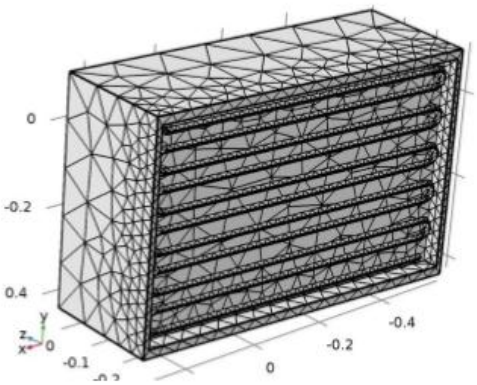

Fig -3: Meshing of AC outdoor unit

The study when computed for both the cases i.e. With Shading and Without Shading yielded the following results. The average surface temperature of the coils at 09:30AM without shading was found to be 304.57 K, where as in the case of the outdoor unit with horizontal shading(HS) was found to be 303.23K. Hence, from this we can conclude that the shading object makes the coils a bit cooler when compared to the outdoor unit without shading. The incident radiation on the condenser coils also decreases due to the shading object.

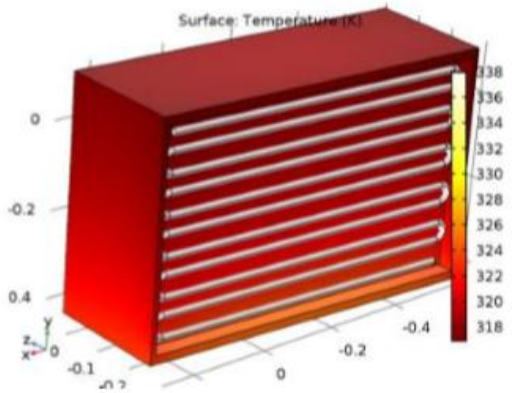

Fig -4: Temperature of condenser at 09:30AM

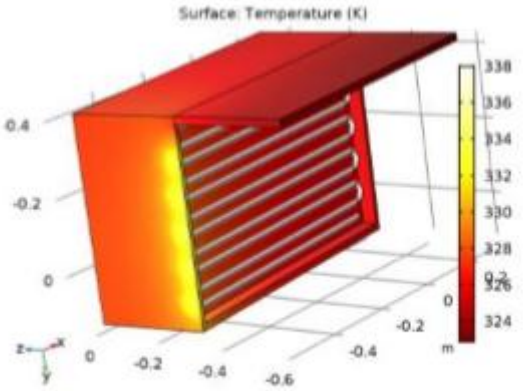

Fig -5: Temperature(HS) at 09:30AM

Where when computed for the same cases at 12:00 PM the values of average surface temperature of coils were found out to be 315.25K and 311.29K for condenser without and with shading respectively.

Hence, it can be concluded that the temperature of the coils is lowered when a shading object is used. Subsequently, there will an increase in the heat transfer from the condenser coils and hence more efficiency.

3. Experiment

Before setting up the experiment a schematic diagram of the experimental setup was drawn as follows:

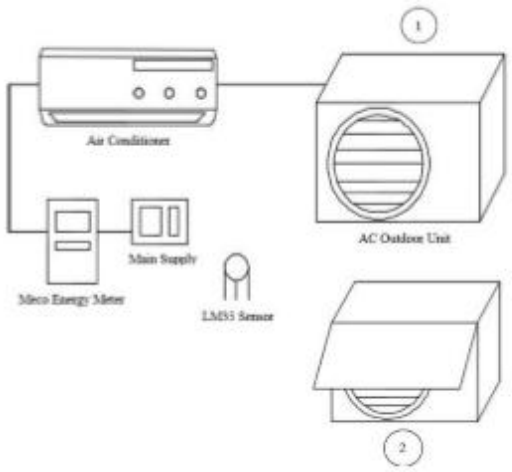

Fig -6: Schematic Diagram

The energy meter was connected across the AC to measure the energy consumption. Later, the LM 35 temperature sensor was connected and kept in a central area so that the sensor could record the temperature. The energy meter readings were recorded in an interval of 60 seconds.

From the readings taken the it was observed that the compressor consumed less power when the outdoor unit was subjected to a shading object. The observations from the experiments are compiled below:

Table 2: Mean Power Consumption

Time	Without Shade	With Shade
09:30AM	1.3481 KW	1.3402 KW
12:30PM	1.4370 KW	1.4265 KW
03:00PM	1.4573 KW	1.4470 KW

The graphs of the energy consumed by the compressor at different times of the day are compiled below: The graph of the comparison between the power consumed by the compressor at 09:30AM is given in the chart 1. The graph of the comparison between the power consumed by the compressor at 12:30 is given in the chart 2.

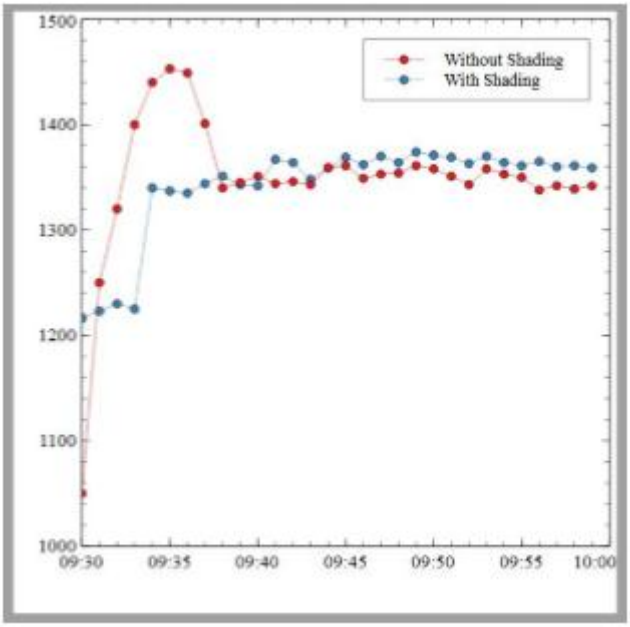

Chart -1: Comparison between the power consumed by the compressor at 09:30AM

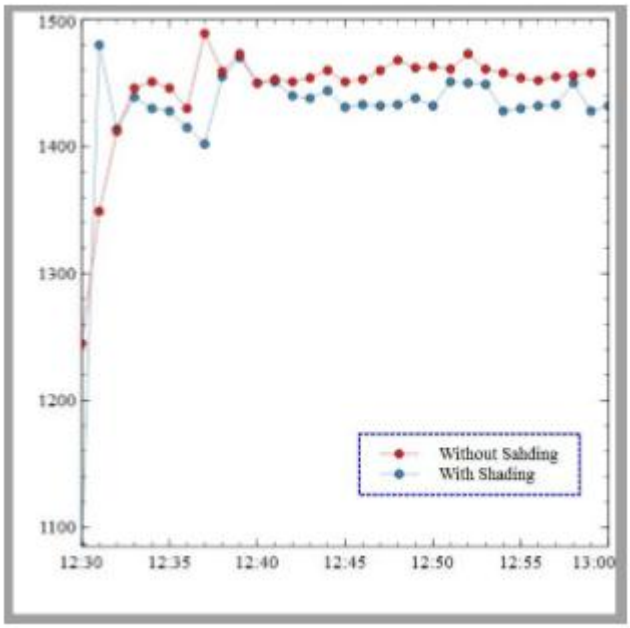

Chart -2: Comparison between the power consumed by the compressor at 12:30

4. CONCLUSIONS

From the COMSOL Analysis it was found that the temperature of the condenser coils was lowered. Hence, with the help of COMSOL we found that a shading object can help increasing the Heat Transfer, which can be used in many commercial applications, where the outdoor unit of the Air-Conditioning is exposed to sunlight.

The practical experiments yielded positive results with the shading object employed on the outdoor unit. The difference in the at 09:30AM with and without the shading object are almost the same, which goes on to prove that fact that the compressor is capable of operating at its maximum capacity when it isn't exposed to sunlight. Whereas when we consider the operation of the AC at 12:30PM we can find that there is a difference in the electricity

The analysis in COMSOL Multiphysics yielded promising results, i.e. the doubling of the heat transfer coefficient and increase in the heat transfer occurring when the shading object is brought in the picture. On the other hand, due to the various factor that effect the operating of a compressor the savings in the bill obtained weren't as large as expected, but the results show that the shading object helps in increasing the heat transfer.

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