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Effect of Dust and Particulate Matter on Evaporator Coil Performance

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Abstract: Air conditioning is responsible for substantial electricity consumption and peak demand in conditioned spaces. Evaporator coils are most common in air conditioners and absorb heat when air is passed through them. One area which has been neglected by researchers is fouling of evaporator and condenser coils. This paper investigates experimentally the effect of dust and particulate matter on the performance of an evaporator coil before and after cleaning of it. The experimental results indicated that the stability of temperature distribution, humidity and reduction in power consumption occurred when the coil surface is cleaned regularly and kept free of fouling particles.

Keywords: *Air conditioning; Dust and particulate matter; Evaporator Coils; Fouling.*

1. INTRODUCTION

Fouling of evaporator coils affects the heat transfer coefficient, increases pressure drop, reduces system air flow rate, and leads to a loss in cooling capacity and increased energy consumption and service costs. Filters are often employed upstream of evaporators to reduce these effects and improve indoor air quality in the building [1]. As time goes on, the air conditioners evaporator coils inside the conditioned spaces may become contaminated and clogged with particles of debris, dust and pollen. In addition, the potential for microbiological growth is increased when moisture is present.

The problem of air-side fouling of heat exchangers has been studied by many researchers[2]-[4]. Fouling was found to have a large impact on coil pressure drop and result in reducing the cooling capacity[2] because of the reduction of air flow through the evaporator coil. A reduction in the energy efficiency ratio(EER) was also reported[2] due to increased fan power as a result of fouling.

2. INDOOR AIR QUALITY

Many people think that air pollution is usually associated with the contamination of automobile exhausts and industrial effluents. But the crux of the matter is that indoor air quality creates serious problems if not diagnosed properly. A poorly ventilated room or a building, especially a crowded one, sometimes lacks enough proper fresh air supply to keep carbon dioxide concentrations at low levels. This sometimes results in drowsiness or discomfort among the inhabitants.

The US Environmental Protection Agency (EPA) concedes that about 30% of new or renovated buildings have serious indoor air quality problems, and ranks IAQ as the most prominent environmental problem [5].

Air conditioning, as is known to be, the simultaneous control of temperature, humidity and quality of air. IAQ is defined as the process of providing air which is comfortable in every way and does not cause negative health effects(disease or sickness in humans) and is devoid of dust, smells, draughts and noise [5]. A home or building's air conditioning system greatly affects Indoor Air Quality (IAQ), while the system's evaporator or indoor coil has the most impact. It provides cooling by absorbing heat and dehumidifying the air as it passes over it. But, because the air moving across the coil usually contains dust, dirt, pollen, moisture, etc., the coil will soon get dirty. In addition, the coil, as well as the condensate pan, can become fouled with pollen, bacteria, mold spores and other particulate matter. This will reduce the quality of the air within the home or building [6].To improve indoor air quality and protect air conditioning equipment, outdoor air and re-circulated indoor air must be filtered to remove dust, bacteria, pollens, insects, soot and dirt particles before they enter the air conditioning system.

3. MODEL SPACE CONDITION

The experiments were conducted on a conditioned experimental office which uses an old room air conditioner (Window type). The building has dimensions of 4 m x 4 m with height of 2.75 m.

4. AIR COOLING COILS

Evaporator coils are generally found in heating and cooling systems in many houses and buildings. They are most common in air conditioners and absorb heat when air passes through the cooling system. They are covered with cooling fins with very narrow spaces between them. After a period of time especially during humid weather conditions they can accumulate dirt and debris. Ice can also accumulate and cause blocking of air flow, which can affect the performance of the evaporator coils. Figs 1 and 2 show the appearance of coil before and after cleaning is done while Figs 3 and 4 depict the compressor and condenser coil before and after cleaning.

It is worth mentioning here that significant factors should be considered when air cooling coils are designed [7]:

i. The resistance to airflow through a cooler battery shall not exceed 125 Pa taking into account wet air condition. The face velocity of airflow shall not exceed 2.5 m/s.

ii. Air cooling coils shall be supported so that their weight is not transmitted to ductwork and they can be removed without disturbing adjacent ductwork. Access doors with air seals shall be provided on both the upstream and downstream of the cooling coils and shall be sized for the full height of the connecting ductwork but need not exceed 1800 mm.

iii. Before leaving the manufacturer's works cooling coils shall be proof tested at 26 bar and leak tested at 17 bar.

Fig. 1. Evaporator coil before cleaning

Fig.2. Evaporator coil after cleaning

Fig.3. Compressor and condenser coil before cleaning

Fig.4. Compressor and condenser coil after cleaning

5. EXPERIMENTAL METHOD

The purpose of the experiment is to determine how dust and particulate matter affect the performance of the air conditioner evaporator coil. In this investigation, temperature and humidity sensors are placed at different locations inside the conditioned space and evaporator coil in order to sense dry bulb temperatures and relative humidity to compare it with the results before and after cleaning of evaporator coil and also to determine how and where coils foul. The duration of the experimental work took four days (two days before cleaning the evaporator coil and two days after the evaporator coil was cleaned). Six time intervals were selected for data recording (9 am, 10am, 11 am, 12pm, 13pm and 14pm) to ensure the validity of the evaluations.

6. RESULTS AND DISCUSSION

The following Figures show the results obtained after testing the system for four days (from 9 am to 14 pm each day).From Figure 5 it is clear that the inside air temperatures of the conditioned space for the first and second day (before cleaning of evaporator coil) range between 28^{o}Cto 24^{o}Cwhile the temperatures for the third and fourth day (aftercleaning of evaporator coil) vary from 23.5^{o}C to 26^{o}C. This is attributed to the accumulation of dust and particulates on the surface of the evaporator coil.

Fig.6 shows that the supply air temperature (measured at exit of evaporator coil) of the office building. It is clear that stability of temperature distributions occur from 11am to 14am for the third and fourth day (after cleaning of evaporator coil). On the other hand the temperatures for the first and second day (before cleaning of evaporator coil) swing from point to another, which suggests that the fouling of evaporator coil does not create stable temperature inside the conditioned space.

Fig.7 shows that the relative humidity of inside air decreases between 9am to 10am and seems to be constant during the rest of the day. Fig. 8 shows the variation of outside air temperature during the experimental period. The horizontal axis indicates hours of experimental work during the four days while the vertical axis illustrates outside air temperature at different hours of the day. It is clear that the outside air temperature is high ranging between 30^{o}C to 41^{o}C.

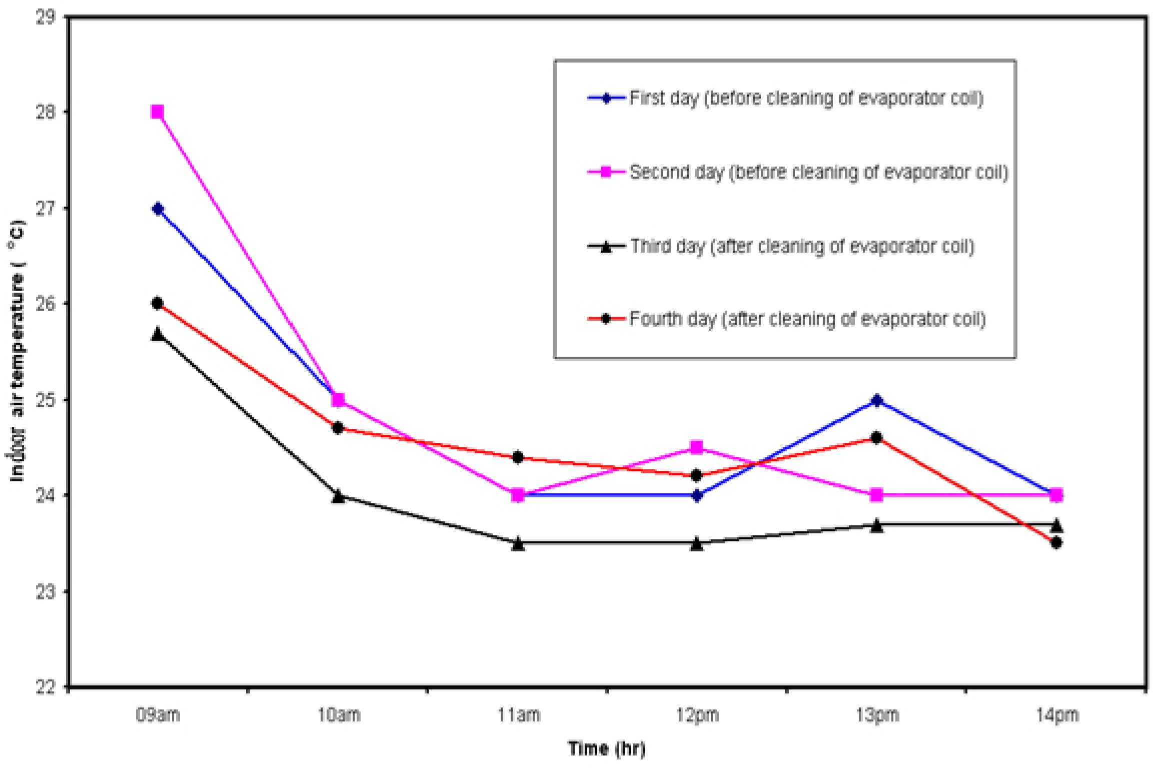

Fig.5. Indoor air temperature of the office building during the day

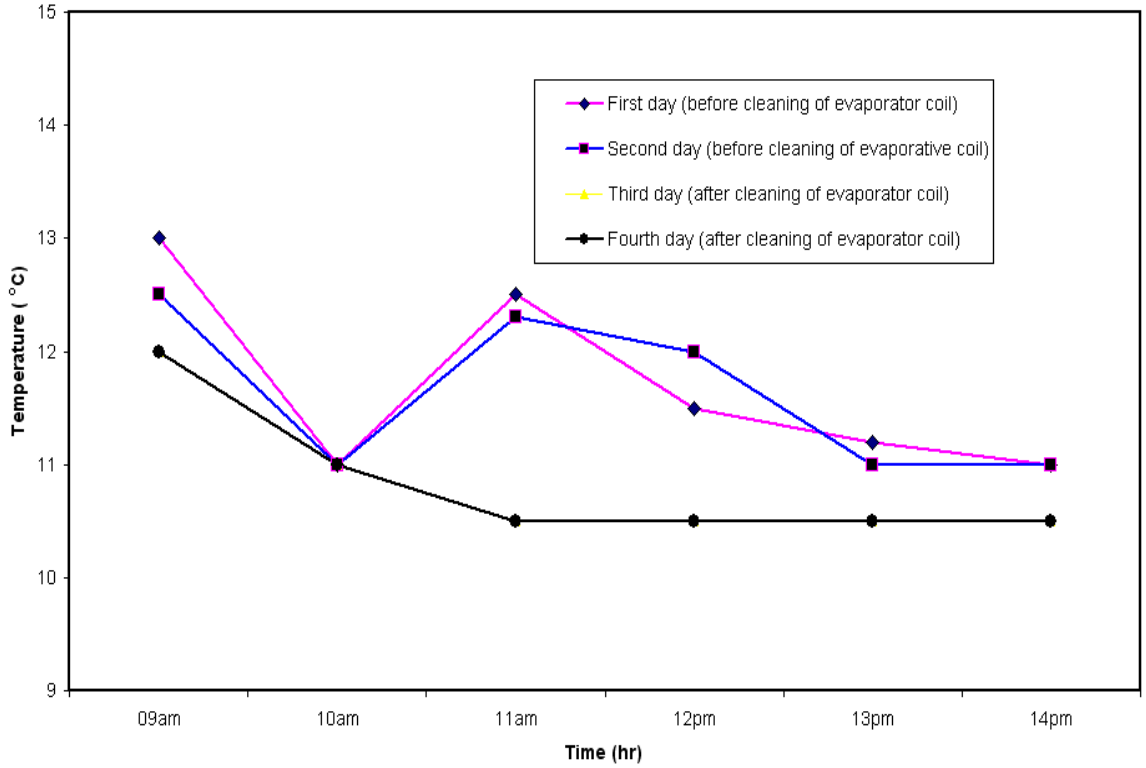

Fig.6. Supply air temperature at exit of evaporator

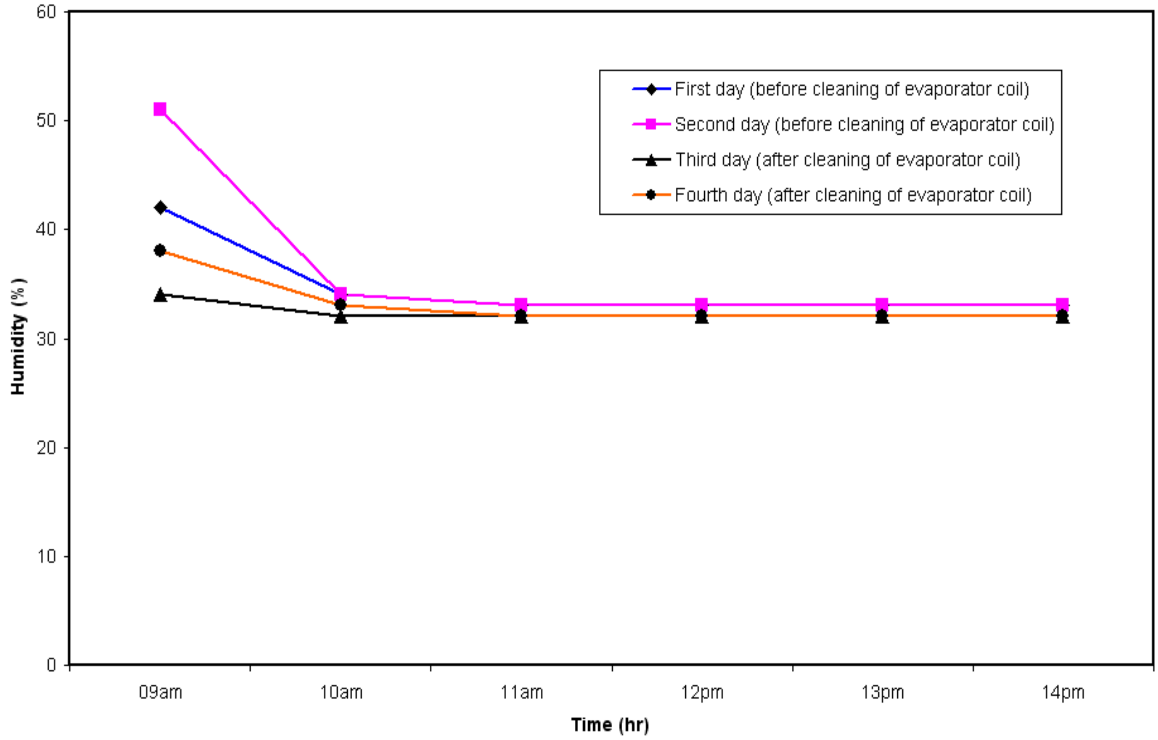

Fig. 7. Humidity of indoor air

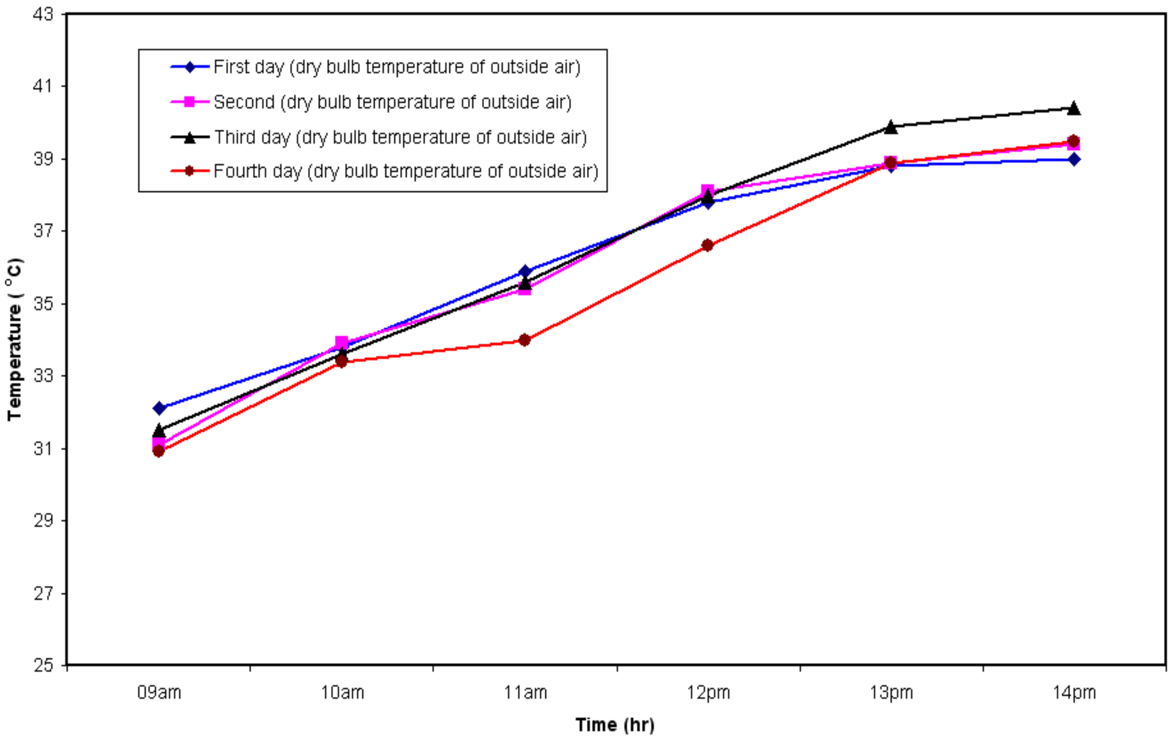

Fig.8. Outside air temperature during the day

7. CONCLUSIONS

It can be seen from this study that accumulation of dust and particulate matter on indoor evaporator coil affects its performance significantly and that the following conclusions may be drawn:

- Controlling bacteria growth, particles of debris, dust and pollen will assure optimum air quality.
- Cleaning of evaporator coils has great advantages in improving thermal comfort and reducing power consumption as less resistance to air movement through the cooling surface is experienced.
- Cleaning of evaporator coils improve indoor air quality (inside air temperature remains within the comfort range).
- Cleaning of evaporator coils creates uniform temperature distribution (inside air temperature and supply air temperature) as shown in this paper.

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