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Effect of Heat Pipe on Performance of Window Air-Conditioner

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Abstract: *This Paper contents about experimental investigation of the effect of fitting a heat pipe in an air window air conditioner. A conventional air conditioner consumes 30-35% of energy in reheating the overcooled air. A heat pipe can be used to reheat the overcooled air gaining heat from the hot air leaving the condenser. The current investigation studies the effect of fitting a heat pipe in a 1.5 Ton window air conditioner. The heat pipe is fabricated using copper pipe as the container, R-11 as the working fluid and cotton as wick material. It has been observed that use of heat pipe in air conditioner has substantial effect if used at proper location.*
Keywords: *Heat pipe, heat addition & removal, performance analysis*

Nomenclature
DBT – Dry Bulb Temperature
WBT - Wet Bulb Temperature
RH - Relative Humidity
KWH - Kilo-Watt Hour
Tr - Room Temperature
Te - Evaporator Temperature
Tc - Condenser temperature
Ta - Ambient Temperature
Wc – Compressor work.
Qa - Heat Absorbed.
Qr - Heat Rejected.
Qe - Heat absorbed in Evaporator.
Qc - Heat rejected in Condenser.
COP - Coefficient of Performance.

I. Location Of Heat Pipe

The location of heat pipe in the system is such that maximum heat can be extracted and supplied without any heat loss. One end of heat pipe (evaporator) is placed behind the condenser; at bottom left corner and the other end i.e. condenser end is placed in the cold air stream supplied to the room. The inclination angle of heat pipe with the horizontal is 45 ^{0}.

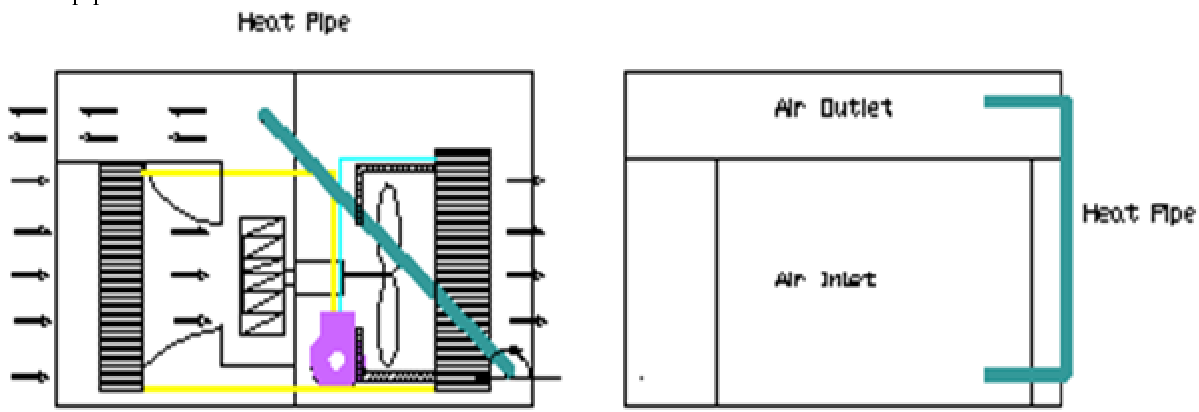

Fig 1.1 Experimental setup (Location of Heat Pipe in air conditioner)

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II. Methodology

The first step was to measure the data by taking trial on air conditioner. The initial room temperatures dry bulb and wet bulb were measures with the help of mercury thermometers. The temperatures of cold air coming out from air conditioner were also measured using mercury thermometers. The condenser temperature was measured using a portable digital temperature indicator. The energy meter reading was recorded in KW. The velocities of air at evaporator outlet and condenser exit were measured using a digital anemometer in m/s. The heat pipe was designed and fabricated as per the requirement.
The data is collected for both the cases, without heat pipe and with heat pipe.

III. Calculations Performed

For given ambient and room conditions, it is possible to obtain the instantaneous room cooling load using the thermodynamic model of the room. Using the condenser temperature T (cond), ambient temperature T(ambient), it is possible to determine the heat rejection at the condenser. Once the heat rejection at the condenser and the heat removed in the evaporator are known, the compressor work may be determined using the energy balance condition.

The difference between the instantaneous cooling capacity and the instantaneous cooling load can be considered to be the capacity available to lower the room temperature. To obtain an accurate estimate of the heat flows involved, it is necessary to know not only the dry bulb temperature of the room at any time, but also the corresponding wet bulb temperature (or relative humidity). The psychometric model of the room, which relates the sensible heat ratio of the room loading line and the supply condition enables determination of the wet bulb temperature of the room corresponding to any given dry bulb temperature (assume that the rise in room temperature always occurs along the sensible heat ratio line).
Coefficient of performance (COP) = Te/ (Tc-Te)
Heat Absorbed (Qa) = ma.Cpa. (Tr-Te)
Heat Rejected (Qr) = ma.Cpa. (Tc-Ta)
Compressor Work =Heat Absorbed-Heat Rejected = (Qr-Qa)

IV. Results and Discussions

This chapter discusses the result obtained in the form of graphs.

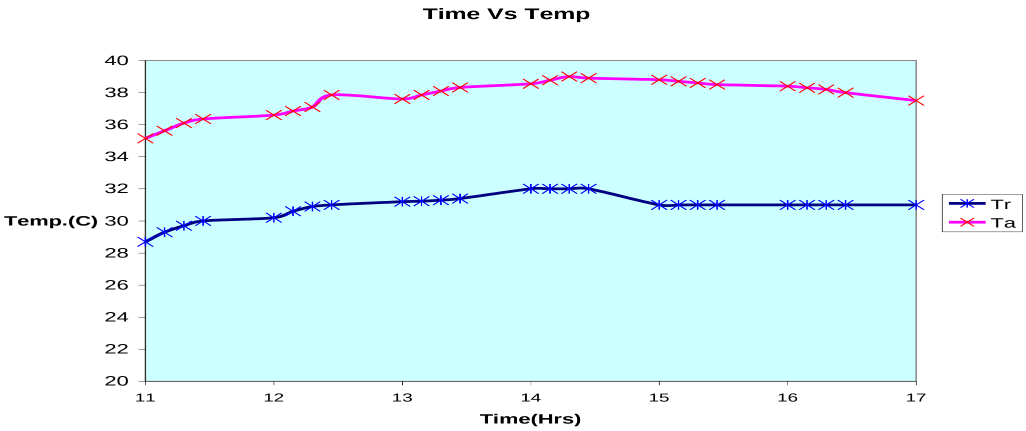

Fig. 1.1 Comparison of temperature with time without heat pipe
Figure 1.1 shows the variation of room temperature and ambient temperature with time without heat pipe. As the ambient temperature increases with time the room temperature stabilizes after initial rise.

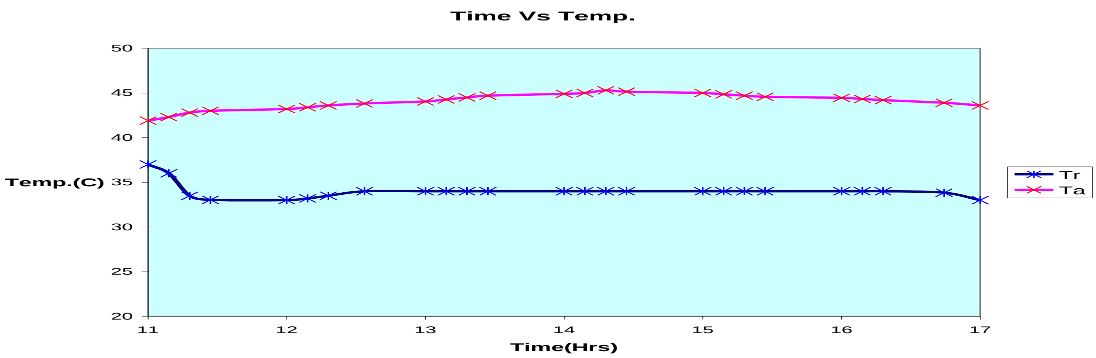

Fig. 1.2 Comparison of temperature with time with heat pipe

Figure 1.2 shows the variation in room temperature and ambient temperature with time after the fitment of heat pipe. The graph shows that the room temperature shows a decreasing trend initially but it again stabilizes due to addition of heat by heat pipe at the latter stage.

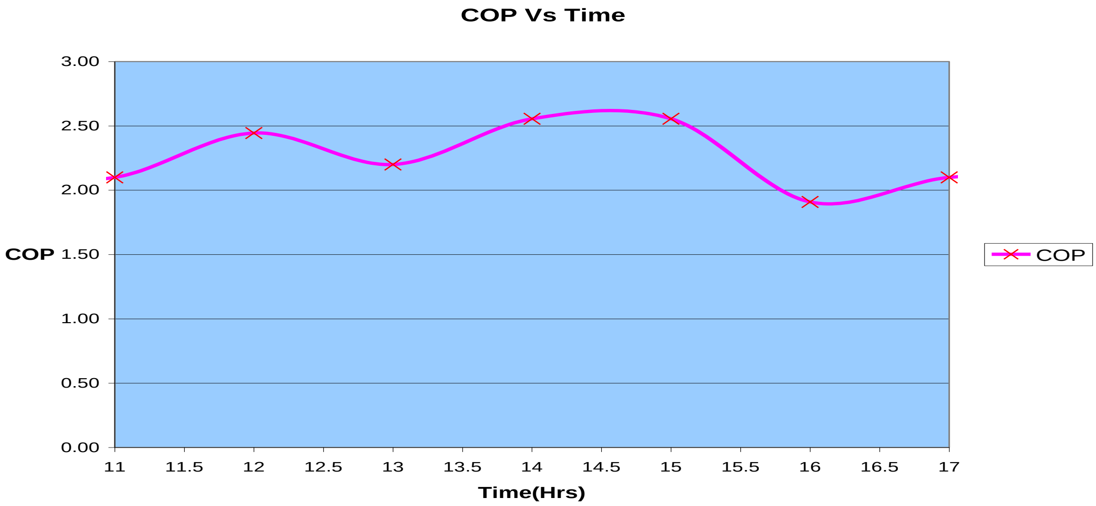

Fig. 1.3 Variation of COP with time without heat pipe

Figure 1.3 does not present a fair view about the trend of COP possibly due to intermittent opening of door of the room and the power break downs. However the trend is stable one.

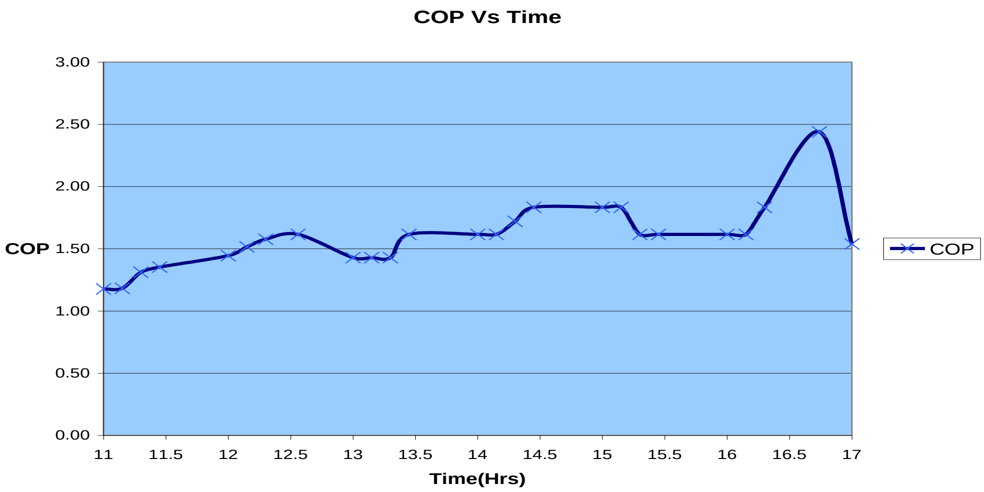

Fig. 1.4 Variation of COP with time with heat pipe

Fig. 1.4 shows the variation of COP with time after the installation of heat pipe. Though the graph is quite fluctuating in nature, it is showing an increasing trend in COP of system.

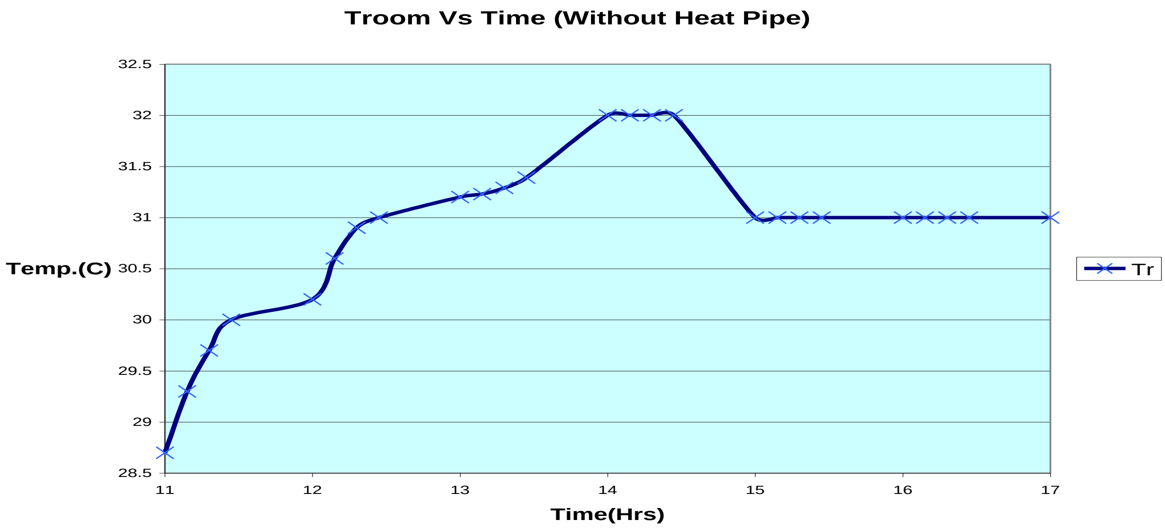

Fig. 1.5 Variation of room temperature with time without heat pipe

Figure 1.5 shows the variation of room temperature with time. It goes against the general trend of decreasing room temperature. But in the latter part of graph it shows the decreasing trend. The graph shows that the ac was unable to meet the load in the earlier stage but managed to overcome in the latter part of the graph.

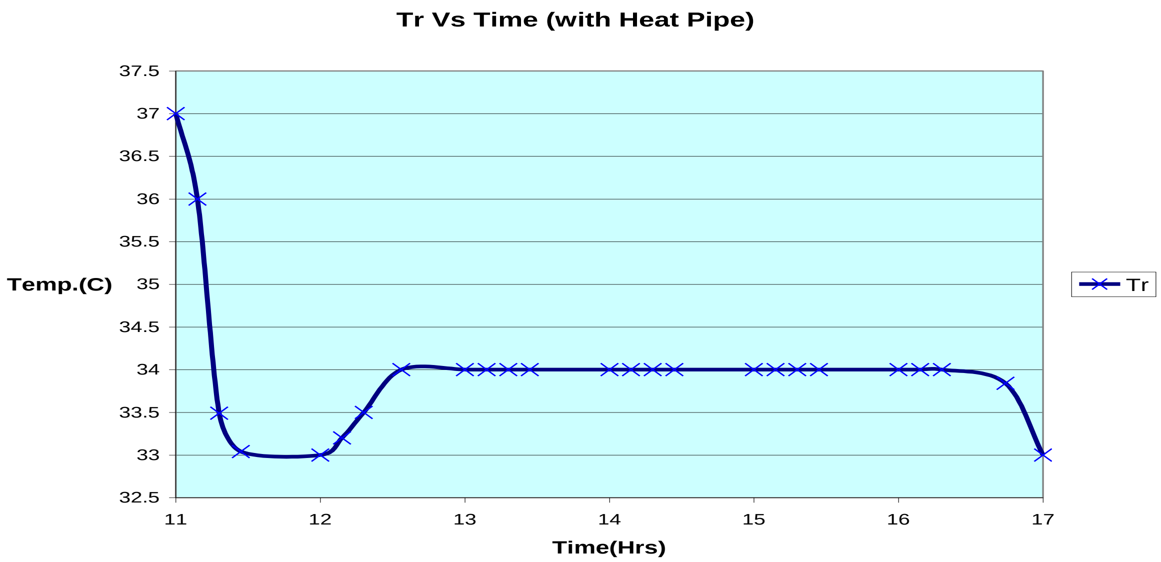

Fig. 1.6 Variation of room temperature with time with heat pipe

Figure 1.6 shows the variation of room temperature with time after fitting heat pipe. Differing from the earlier graph, this graph shows reducing trend in the room temperature. There is steep decrease in the room temperature, and then there is slight increase in room temperature due to heat addition by heat pipe. The temperature stabilizes and shows again a reducing trend at the end.

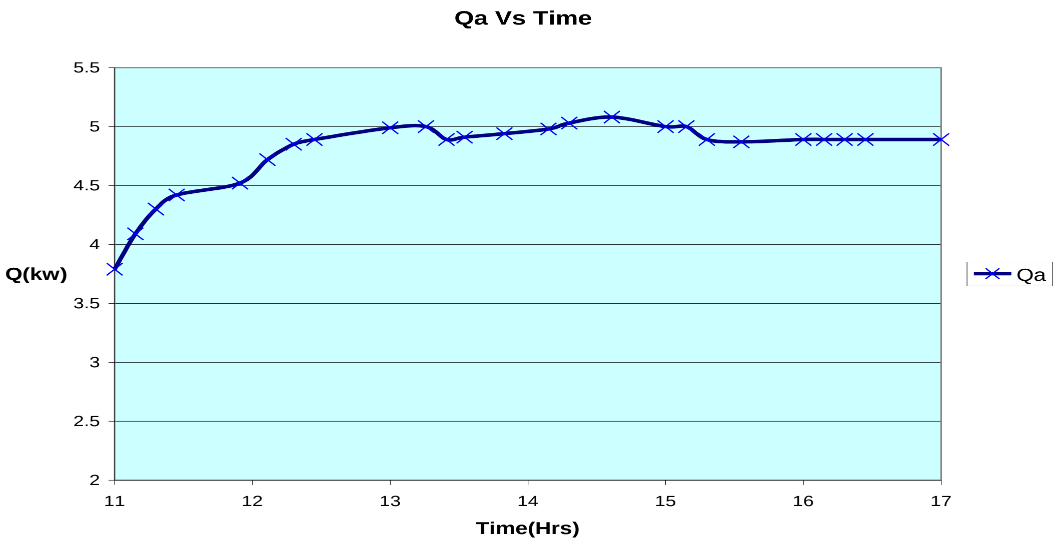

Fig. 1.7 Heat absorbed with time without heat pipe

Figure 1.7 shows the variation in heat absorbed with time. The graph shows a increasing trend in the earlier stage with some fluctuations it stabilizes in the end. This shows that the heat extraction was more at the initial stage due to higher temperature difference in the room and ambient temperature.

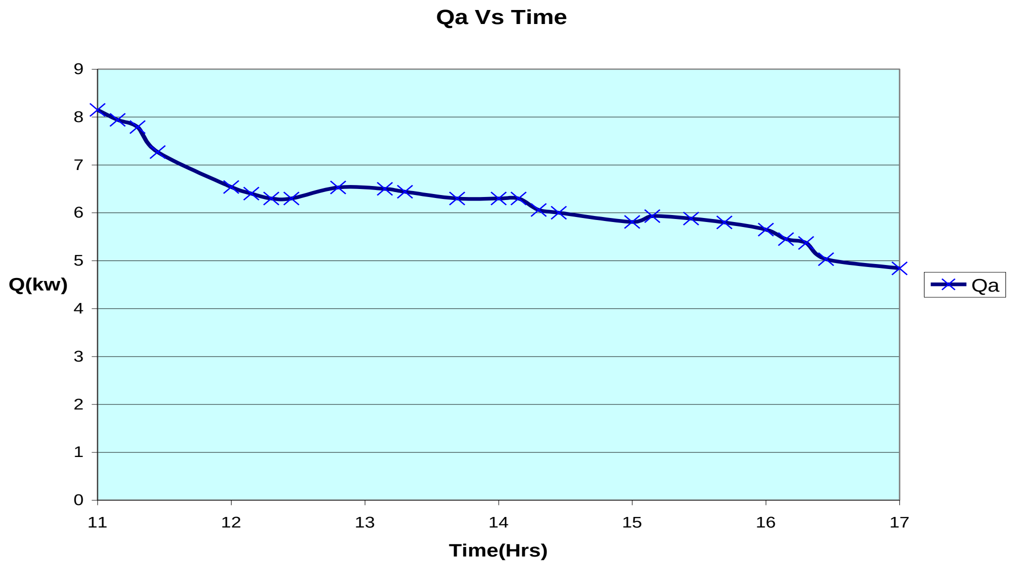

Fig. 1.8 Heat absorbed with time with heat pipe

Figure 1.8 shows the variation in heat absorbed after fitting the heat pipe in the system. the graph shows a negative trend in heat absorption possibly due to constant heat addition by heatpipe.

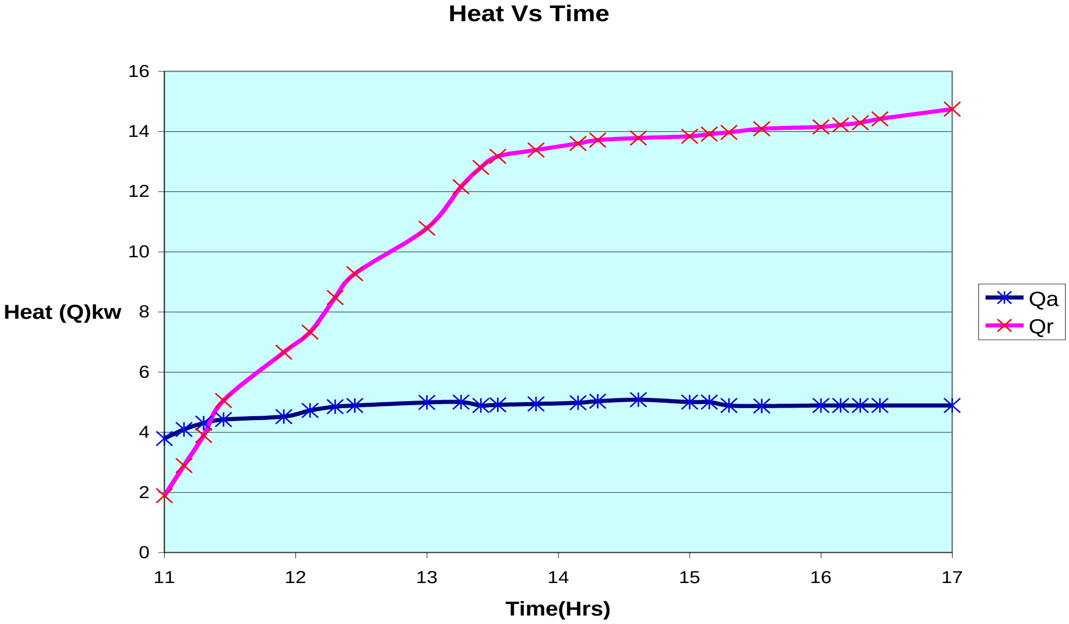

Fig. 1.9 Variation of heat with time without heat pipe

Figure 1.9 shows the difference in heat absorbed and heat rejected by the system without heat pipe. The graph shows that the heat absorption was higher as compared to heat rejected in the initial stage. Latter on heat rejection rose significantly as the condenser temperature increases.

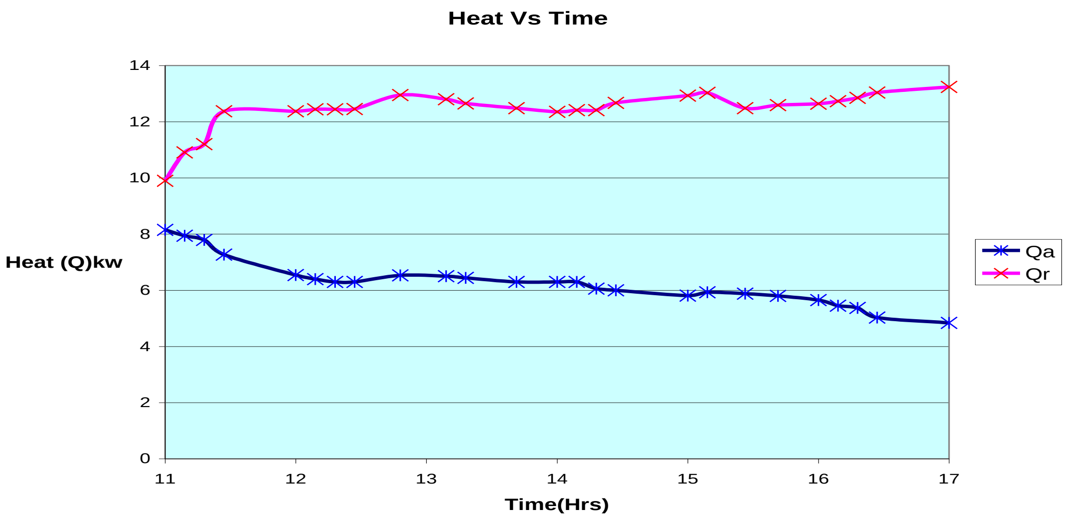

Fig. 1.10 Variation of heat with time with heat pipe

Figure 1.10 shows variation of heat with heat pipe. Heat absorbed shows a decreasing trend and heat rejected shows a increasing trend with the fitment of heat pipe.

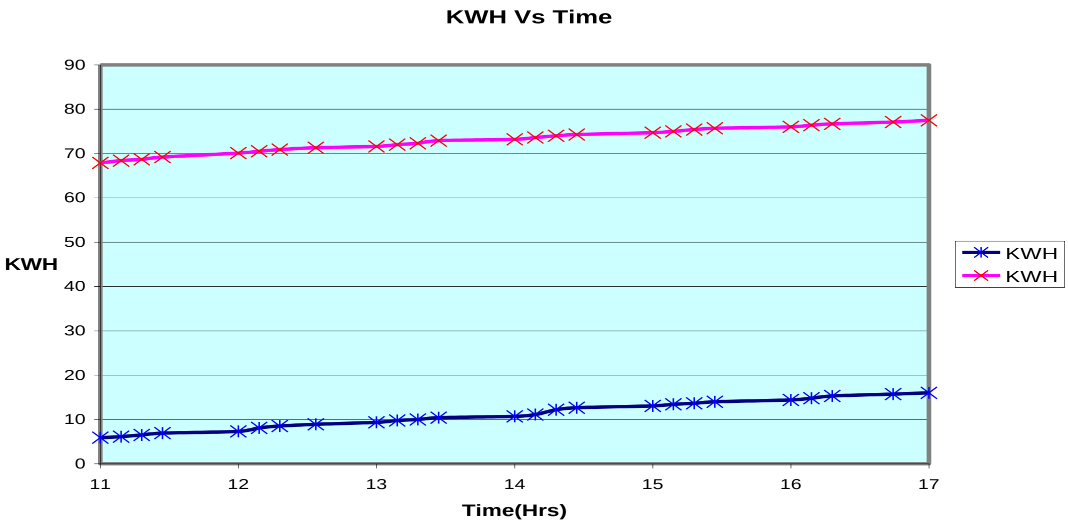

Fig. 1.11 Variation of power consumption with time

Figure 1.11 shows the variation of power consumed with time. Blue line shows power consumption pattern of unit without heat pipe. Magenta line shows power consumption with heat pipe.

V. Conclusion

An air conditioner of capacity 1.5 Tons was selected and purchased from the market. The maintenance was done to make the unit ready for experimentation. Trial of the unit was conducted and data was gathered from the preliminary trial of the unit. As per requirement the detail design of heat pipe was done. After the design of heat pipe, the fabrication of heat pipe was done.

The heat pipe was installed in the air conditioner at the most suitable place. The trial was again conducted and new set of reading was collected. After performing the calculations mentioned in appendix II-A and II-B, the graphs were plotted and conclusions were drawn. Referring to the graphs it was seen that there is slight rise in air temperature delivered by the air conditioner due to heat added by heat pipe. Heat pipes can be effectively used to reheat the cold air to bring it back to comfort temperature. A conventional air conditioner consumes 30-35% of energy in reheating the overcooled air.

A heat pipe can be used to reheat the overcooled air gaining heat from the hot air leaving the condenser. The current investigation studies the effect of fitting a heat pipe in a 1.5 Ton window air conditioner. The heat pipe is fabricated using copper pipe as the container, R-11 as the working fluid and cotton as wick material. It has been observed that use of heat pipe in air conditioner has substantial effect if used at proper location.

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