International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 11 | Nov -2016 www.irjet.net p-ISSN: 2395-0072

"AUTOMATION IN AIRCRAFT"

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ABSTRACT: *The cooling coils have wide range of applications in the field of refrigeration and air conditioning. The cooling coils performance depends mainly on its maintenance. The optimum performance result depends on various factors such as velocity of the flow primary surface area, number of tubes, fins spacing etc. The application also depends upon the number of rows of cooling coils. The cooling coils used in condensers are normally used for heat rejection. A fresh air application requires maximum 8 rows of the coils. Variations in any of the design factor may also affect the performance of the coil.*

Keywords: *Compressor, Direct expansion Evaporator, Feeder Pipes, Flooded Evaporators, Flow of Refrigerant, Thermostatic Expansion Valves.*

I INTRODUCTION

The air cooling coil with direct expansion uses a thermostatic expansion valve and these coils are used in the majority of comfort air conditioning applications, mostly below 100 tons capacity. If we look at the basic refrigeration cycle and the part played by the evaporator, the function of an evaporator is to take the heat into the system from the surrounding atmosphere. The refrigeration entering in the coil is a low pressure low temperature mixture of a saturated liquid and vapour. As refrigerant mixture gradually travels towards the outlet of the coil, the liquid while absorbing the heat gases converted in to vapour and at outlet the entire refrigerant is in the form of superheated gases.

II CONDITION FOR OPTIMUM PERFORMANCE

2.1 Factors to Be Ensured For Optimum Performance

In order to get maximum performance from the cooling coil we try to ensure that maximum proportion of liquid enters the evaporator inlet with minimum proportion of vapour. This is essential because it is latent heat while converting the liquid refrigerant into vapour, absorbs a large amount heat from the surrounding. Heat absorbed the vapour is insignificant. The proportion of liquid to vapour increase can be ensured by sub cooling the liquid before it enters the expansion valve so that at the evaporator less flash gas is formed.

2.2 Factors under Designers Control

The general equation of coil capacity is

$$Q = U \times A \times \Delta T$$

U = Over all heat transfer coefficient.

A = Coil surface area

Some of the factors that influences coil design are as follows

- Tube diameter – 5/8", ½", 3/8", or 7 mm
- Tube spacing and the arrangement
- Coil circulation

- Fin thickness, fin material, configuration either plain/ corrugated or slotted etc.

2.3 Measures to Reduce Heat Transfer Resistance

The main objective of the designer is to reduce the resistance to heat transfer and can be achieved by

- Increasing heat transfer coefficient on air side by increasing the ratio of external to internal area or by increasing air side heat transfer coefficient.
- Increasing the air velocity over the coil.

III Factors controlling the performance

3.1 Effect of Air Velocity Increase on Capacity

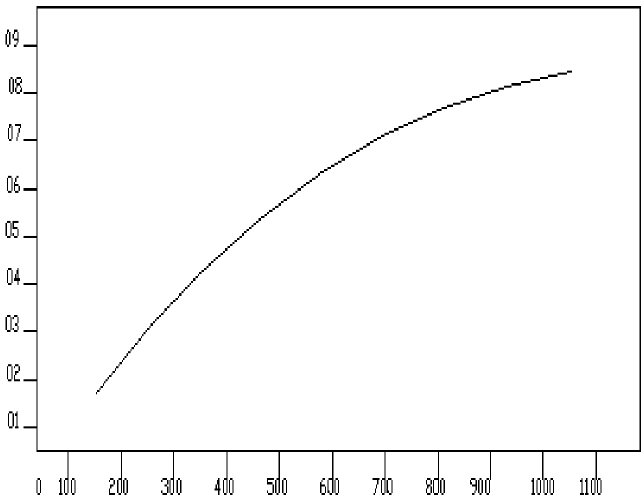

Fig 1 Effect of Air Velocity Increase

The above figure indicates that as the velocity of air increase the coil capacity increases. However the rate of increase is less at higher face velocities as can be seen from the reduced slope of coil performance coil. We know that increasing velocity means more air quantity (Cfm). So we take both the results into account i.e. coil performance and fan performance to assess the net result.

3.2 Overall Performance of Fan and Coil Combination

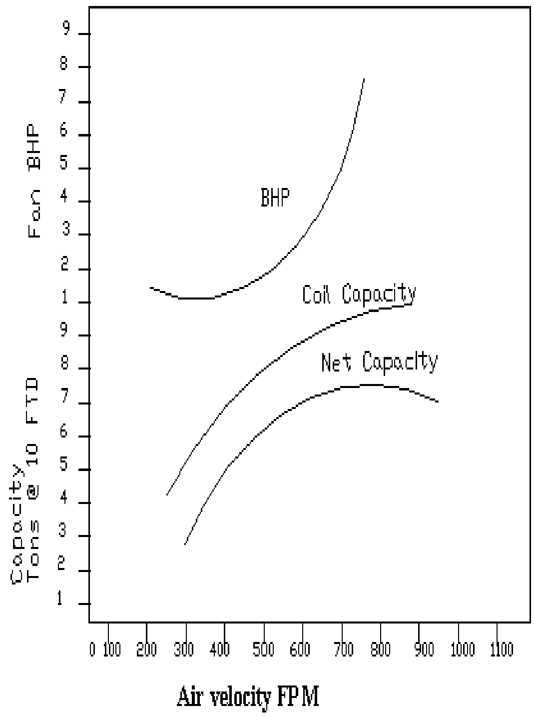

Fig 2 Overall Performances of Fan and Coil Combination

The fan laws indicate that the fan horse power increases as the cube of velocity increases. As shown in the above figure after a particular velocity the net heat effect in fact is a capacity loss, since the motor heat input more than offset the gain in coil capacity.

3.3 Effect of Increasing Heat Transfer area

Increasing the external surface area is the most common approach to improving coil performance. Once the tube is selected the internal area gets fixed where as external area can be increased by adding fins of various designs and increasing the number of fins per unit length. This also need careful consideration since as the ratio of secondary to primary surface area increase the effectiveness per square foot area decreases conversely lower the ratio for the required performance the more effective the surface per square foot of area. While comparing coils of difference manufacturers one should check the primary area provided and not the total surface area because more primary area of coil will provide more efficient coil.

3.4 Effect of using Small Diameter Tube

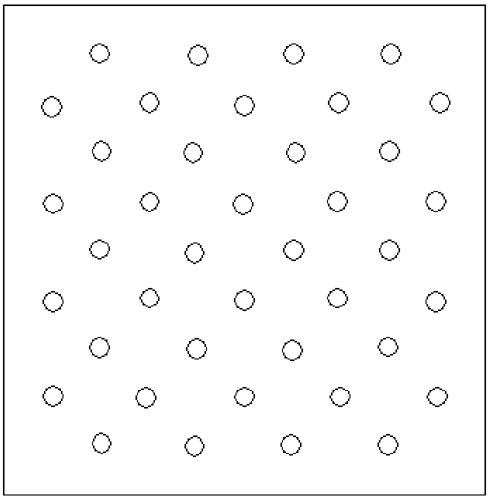

Fig 3 Effect of using Small Diameter Tube

- More compact tube arrangement.
- Higher pressure drop
- Smaller tube diameter
- More fan power
- Lower secondary to primary area

As shown in above figure more primary area available face area is possible by reducing the tube diameter and packing the tubes more compactly. (Lower secondary to primary area ratio). The drawback is only that more the compact coil higher is the air side pressure drop, resulting in more fan power to deliver the same air quantity.

3.5 Effect of Increasing Number of Rows

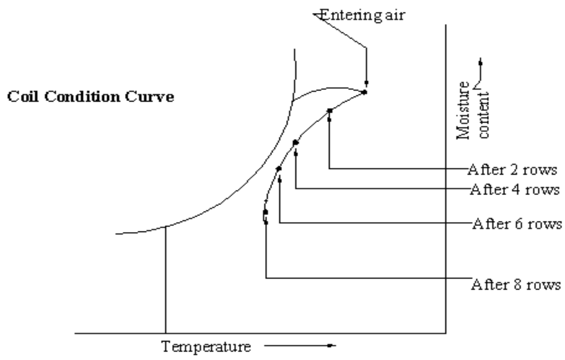

Fig 4 Effect of Increasing Number of Rows

As the number of rows of coil increases for a same area or the coil is deeper lower will be the air leaving the temperature and moisture content. The refrigeration capacity also increases. It can be seen from the above figure that each successive row of tubes is less efficient and less effective. This means less moisture removal or temperature drop is expected from 5th or 6th row compared to 1st or 2nd row. The greatest rate of heat transfer is where the air is entering the coil since at entry condition, the moisture content and temperature is highest as the air temperature curve approaches the saturation line the curve becomes steeper indicating that the ratio of moisture removal to temperature drop is greatest at the last row or at the exit of the coil. Such coil designs with more rows are used in cold rooms, blast freezers, or in low temperature application. Coils with a large face area and lower number of rows with very high air quantities are preferred for the application where we do not need moisture to be separated from air like in grape storage room where humidity needs to be maintained to prevent weight loss.

3.6 Effect of Fin Spacing

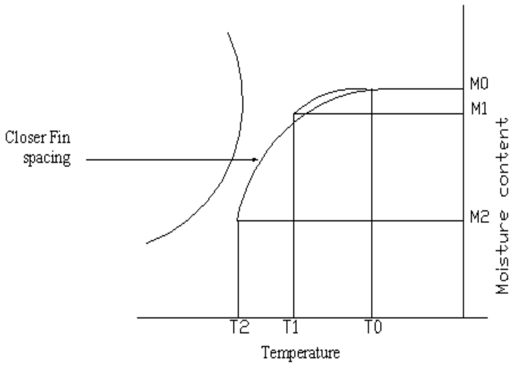

Fig 5 Effect of Fin Spacing

Closer fin spacing also lowers the coil condition curve as shown in the above fig. similar to one with face area increases. However closer fins means a higher pressure drop across a coil, resulting in decrease in air quantity or increase in fan horse power for the same air quantity. In case of coils used for low temperature application the defrosting becomes difficult if the coils have closer fin spacing.

3.7 Effect of Increase in Air Flow

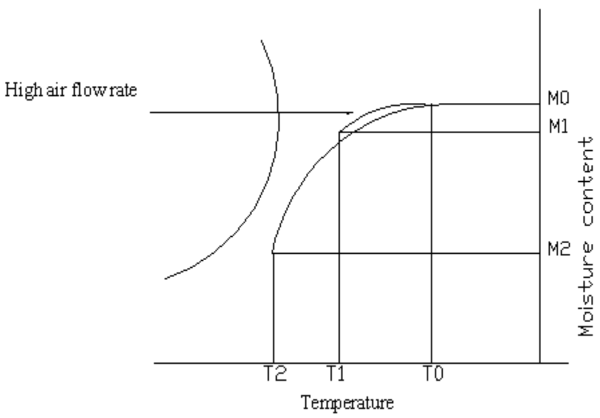

Fig 6 Effect of Increase in Air Flow

Higher air flow will raises the coil condition curve which means the air outlet temperature will be higher to compare to the coil subjected to a lower air flow. The refrigeration capacity however increases because of air flow rate increases in greater proportion than decrease in enthalpy.

$$Q \alpha \ Cfm \times \Delta H.$$

Where ΔH = the enthalpy difference.

By increasing air flow the heat removal will be faster and the temperature will be more uniform in the conditioned space. Increasing air quantity will however mean a higher fan power as well as higher noise level.

3.8 Effect on By Pass Factor

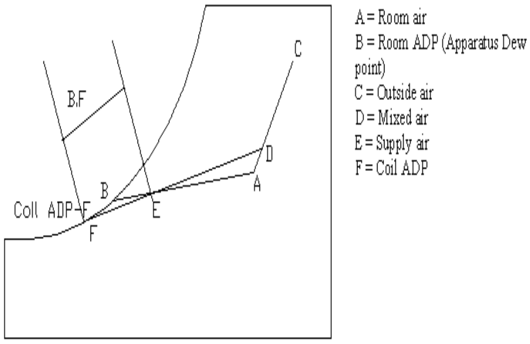

Fig 7 Effect on By Pass Factor

The design of coil also affects B.P Factor. As the air travels over the coil, if it remains in contact with the coil for longer duration, the bypass factor reduces, which mean the supply air condition never to the saturation line. As the air leaving the coil is nearer to be saturated line the required air quantity reduces. It also means that the supply air temperature it lower and air leaves in drier condition as more moisture is removed from it. While estimating cooling loads and air quantity we have to assume certain by pass factor which depends upon the coil configuration.

IV BY PASS FACTOR

4.1 By Pass Factor for Varying Load Depth

Depth of coil (rows)	8 fins per inch velocity 300-700 fpm	14 fins per inch velocity 300-700 fpm
2	0.42-0.55	0.22-0.38
3	0.27-0.40	0.10-0.23
4	0.15-0.28	0.05-0.14
5	0.10-0.22	0.03-.09
6	0.06-0.15	0.01-0.05
8	0.02-0.08	0.00-0.00

Table 1 By Pass Factor for Varying Coil Depth

From the analysis of the above table following conclusion can be drawn.

- As the fin density increases, there is more resistance for air to travel and by pass factor reduces.
- As the number of row increases the air remains in contact for a longer duration leading to a lower bypass factor.
- As the velocity increases, since the air passes through the coil faster, the bypass factor. If we reduce the velocity below a particular point, the chance of coil freezing increases
- If the velocity increased beyond a point, the increased fan horse power neutralizes the gains in capacity, which has been demonstrated.

V MAINTENANCE OF COOLING COILS

5.1 Necessity for Keeping the Coils Clean

The coils do get dirty. In fact, in humid climates particularly coils not only gets dirty, but they become home to fungi, slime and all types of microorganism. Justin Salmon said that 'Dirty coils are like termites'. It is not a matter of if you will get them but it's more a matter of when and how severe.

5.2 Way to Keep the Coil Clean

It is of course, best to start with a clean coil. As the part of commissioning process clean the coil to remove the construction dirt. Then begin a regular schedule of cleaning at least twice year. The most important thing is the maintenance staff can do to ensures years of trouble free coil operation is to use ASHRAE 60 percent efficient filters and change them frequently. Filters are cheap and will intercept most of the dirt and fungal spore before they get to the coil. Proper filtration may even decrease the need to clean a coil. To ensure the cleanliness inspect the coil on regular basis.

- **How does Dirty Coil Increases the Cost of Coil**

We should know that the dirty coil is an inefficient coil. It increases the cost by decreasing the efficiency of the two factors. The first is fan power lost due to increased static pressure loss through the coil. Reduction in capacity caused by the layer of dirt bio logical growth coating heat transfer surfaces.

- **Frequency of Cleaning the Coils**

The state of Minnesota recommends the cleaning of the coil twice in a year whether the coil looks dirty or not in fact, if a coil looks dirty then it may be too late to clean effectively.

VI COIL CONSTRUCTION

6.1 Chilled Water Coil Construction

In the above coil shown the tubes used are of copper and are arranged parallel to one another either in staggered or non staggered pattern, along the length 'L' of coil a staggered pattern is commonly used. Plate or ripple fins are used to enhance the heat transfer area. Thus primary surface area is enhanced greatly by adding a secondary area of fins the total area including fin is called as 'Outside surface area' for use in the calculations. The cross section (L x H) across which air flow is called the face surface area or the finned area. Thus L is finned length and H is finned height. Fins are arranged perpendicular to the tubes. Fin spacing varies between 8 and 14 fins per inch of tube. Average air velocity across the face area is called coil face velocity or simply faces velocity. Thus,

$$\text{Face velocity (fpm)} = \frac{\text{Dehumidification air flows (cfm)}}{\text{Face area (sq. ft)}}$$

The number of rows of copper tubes in the direction of air flow is termed as depth of coil. Coils with 3, 4, 6 or 8 rows are commonly used. Refrigerant or chilled water enters the first row and leaves the coil from the last row. A coil in which chilled water or refrigerant is supplied to all the tubes in the first row (also referred to as tubes high or tubes in face.) is called a maximum or full circuit coil. If the supply is given to alternate tubes in face we get a half circuit coil.

6.2 Final Coil Selection Procedure

For sizing the coil the following data is required from the heat load calculations.

- Room DB temperature (f)
- Fresh air DB temperature (f)
- Dehumidification air quantity (cfm)
- Fresh air quantity (cfm)
- Grand sensible heat factor(GSHF)
- A.C load (ton)
- Apparatus dew point (ADP) (f). This denotes average outside surface temperature of the coil.

VII COILS AND THEIR APPLICATION

7.1 Direct Expansion Coil

- The two direct expansion coils is generally used for light loaded jobs. Minimum latent load and a high air volume.
- 3 and 4 coils are frequently used for air conditioning applications
- 5 row coils for large latent load.
- 6 row coils are used for applications with stringent controls on relative humidity.
- 8 row coils are used for 100% fresh air circulation.

7.2 Chilled Water Coils

- For normal air conditioning application 3,4, or 5 row coils are used
- 6 row coil for application involving high outside air.
- 8 row coil for 100 % fresh air application.

7.3 Condenser Coil

In normal air conditioning these are used for heat rejection.

VIII CONDENSATE TRAPS FOR COOLING COILS

The condensate trap perhaps is a most overlooked item in the design and the installation of fan coils and air handlers with cooling coils often condensate traps are inadequately described in contract do comments and sometimes are not described at all which levels important details to be determined by the installing contractor. There are wide misconceptions about how condensate traps work and how to properly size them. Little or no though is devoted to simple, inexpensive details that can make them such easier to inspect and maintain.

8.1 Review

The purpose of one of these traps is to allow accumulating condensate to drain off while preventing air from entering draw thru unit or escaping a blow thru unit. A cooling coils drain pan opening is located at the point in an air flow system where the air pressure either positive or negative is the greatest. It makes sense to prevent an air “leak” at this location, especially in view of the effort we typically expend to seal and pressure test system duct work. In short the fundamental purpose of one of these traps is to use a column of condensate in such a way as to prevent air movement in to or out of the equipment casing, while still allowing condensate to drain away.

8.2 Potential Problems

An improperly constructed or missing trap can cause the following problems

No Trap or Trap Outlet is too Low For draw thru units in either of these situations; condensate accumulating in the pan will be subjected to a "jet" of incoming air, which often results in spray being carried over into the fan inlet area. This sometimes is referred to as "geysering" for blow thru units, escaping air may be the most serious consequence, but in the presence of copies consideration, a turbulent air/ water mix in pan also may cause some spillage as spraying of water downstream of the coil.

Trap Outlet too High In draw thru units with this problem an air seal will be maintained, however if the condensate net "Column" height in the trap is less than the equipments negative air pressure in inches of water column, the condensate will be unable to drain away. This will cause the accumulating condensate to overflow the pan into the surrounding part of the equipment casing. In a blow thru unit, an outlet as high as the inlet will work during fan operation as high as the inlet will work during fan operation as long as the rest of the trap is properly dimensioned.

One Trap Shared by Two or More Fan Coil Units If one of the fan coil units sharing a trap is shut down, the other will blow air into or draw air from the inactive system, depending on whether the units are of the draw thru or blow thru variety. For this reason each fan coil unit should have its own trap.

Dry Trap A common problem in very arid climates and during periods when cooling coils are inactive such as winter, in evaporation of the water in traps. A liquid seal can be maintained by either continues drip or intermittent trap "Priming". Designers are uncertain whether or not evaporation occurs or who anticipate that it does should specify either a means of priming or trap features that will allow priming to be easily added later. A dry trap on a draw thru unit can be the sources of the object ional odors and noxious fumes in a building (At a military air base in the desert a draw thru air handless was located near a flight line. While the unit fresh air intake was located near a flight line. While the unit fresh air intake was located well away from any sources of contaminated air, the flow drain for the trap was not and building occupants were sickened by the fumes or burn jet fuel inducted through the dry trap. Priming the trap solved the problem). Priming water should be applied to the downstream side of the trapped care should be taken to assure adherence to plumbing codes regarding air gaps for protecting portable water sources.

Draw Thru Traps The necessary dimension of a trap on a draw thru unit and the maximum level of condensate that can exist in such a trap with the fan off. The recommended safety factor of 1 in. added to the casing pressure in a reasonable balance between the need to account for unanticipated increase in that (negative pressure and the practical need to keep the total trap depth (L) to a minimum especially on pad mounted equipment. Many traps are improperly installed because dimension "L" was not taken into account in mounting the air handler high enough to accommodate the trap.

Blow Thru Traps The fig. shows the required dimensions of traps on blow thru units and maximum level of condensate that can exit in such a trap with the fan off. Here again 1 in. safety factor is a practical recommendation for accounting for an increase in casing pressure caused beyond the situation by the designers control. In most system 1 in. of water gauge is a significant percentage of the casing air pressure. Of course the designer can increased the calculated equipment pressure as necessary.

8.3 Recommendation

A trap with two tees and plugs allows easy access for inspection cleaning and if necessary, priming. Although the plugs can be wrench tight, a hand tight condition usually prevents air leakage on the inlet side, and one does not have to have a wrench to inspect the trap. The purpose of the plug on the outlet side is to keep dirt small animals, and insect out of the trap. Traps commonly are constructed of either copper or plastic pipe. Under the pressure of design deadlines, it often is difficult to pay attention to detail that all project deserve. In the matter of condensate traps, however, a couple of simple standard drawings in a designers CADD repertoire, with fill in the blank dimensions, will go a long way towards demonstrating completeness of design and preventing problem.

IX CONCLUSION

The increase in air flow will increase the refrigeration capacity of the cooling coils. Closer fins leads to higher pressure drop which result in decrease in air quantity and increase in fan H.P for same quantity of air. Increase in number of rows of coil increases the refrigeration capacity. More is the compact coil higher is the air side pressure drop, resulting in more fan power to deliver the same air quantity. Proper maintenance of the coil within the regular interval of time also reduces the cost of the coil. Increase in heat transfer area improves the coil performance.

REFERENCES

[1] www.Msifla.com

[2]Service clinic coil cleaning By Dillard W. M. and Salmon J.S.

[3]Voltas Engineers (Handbook)

[4]Blue stars engineers (Handbook)

[5]Air- conditioning and refrigeration journal (July Sept 2003) Page 78-82

[6]Air- conditioning and refrigeration Journal (Oct-Dec 2002) Page 75-79, Page 90-92

BIOGRAPHIES

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