International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-6, August 2013

Optimization of Energy Saving Techniques in Air Conditioning Systems

Ch.Bhnau Prakash, A.V.Ramana Rao, M.Praveen, M.N.V.S.A Sivaram. K

***Abstract*— In a conventional air conditioning system, chilled water flow and air quantity supplied to air conditioned area is constant irrespective of the building load. The building load will generally vary from 60% to 100% for 10 hours operation per day during the year. Maintaining the continuous chilled water flow of air quantity in an air conditioning system will consume more power during part load conditions. Thus by supplying variable chilled water flow by using constant primary pumps, variable flow secondary pumps, VAVs(variable air volumes) and variable frequency drives in air handling units in the air circuit, we can decrease the energy consumption during part load conditions.**

In the present project attempt has been made to calculate the energy savings and payback period of existing system. This is done by introducing primary and secondary pumping with VFDs .The VFDs are in turn provided AHUs and VAVs in the duct. In many conventional air conditioned buildings, the air conditioning system generally consumes the maximum power. This can be minimized by taking proper care during the selection, design and erection of air conditioning equipment ultimately leading to substantial savings in long run.

By introducing secondary pumping with VFDs, VAVs in the duct and VFDs in AHUs, the power consumption has been reduced to 12.25% over existing constant flow pumping, constant airflow systems. Payback period is 2.69 years for introducing VAVs in the duct and VFDs in the AHUs and payback period is 3.73 years for primary and secondary pumping system.

***Index Terms*—Air conditioning systems, Energy saving techniques, VFDs, VAVs.**

I. INTRODUCTION

Several methods are presented for lowering the energy consumed during air conditioning of buildings. Some of these strategies can be implemented during the design stage; others can be used to retrofit existing AC systems; and still others can be applied with hardly any changes on existing equipment. The methods that are discussed include heat recovery and utilization, absorption refrigeration systems, thermal cool storage, liquid (refrigerant) pressure amplification, reprogramming of the AC control systems, economical methods of removal of moisture from the air and initiation of awareness programs for the conservation of A/C energy. The percentage of energy consumed by air conditioning (A/C) systems in buildings in a city like Hyderabad, Secunderabad during the summer is over 50% of the total electric energy consumed.

It is, hence, clear that energy is utilized in sizeable quantities to provide comfort air conditioning in offices, commercial buildings, educational institutions and homes. There seems to exist, therefore, a pressing need to study alternative means of air conditioning and to identify and implement methods to save energy while maintaining a comfort environment in buildings. One immediate and obvious way, which does not require additional investment, to conserve air conditioning energy is to properly maintain the buildings such that the cooled air is not vented into the atmosphere. Another equally effective method is to develop, frequently update and enforce daily, weekly and monthly occupation schedules for each air conditioned space so that cooling is provided only when it is required. In order to implement the foregoing measures, a necessary preliminary step would be to initiate an awareness campaign, starting with the top management and involving everyone using the cooled facilities, with special emphasis on maintenance, janitorial and security staff, to stress the importance of keeping the doors and windows closed. People need to be educated about and made conscious of saving A/C related energy and not to leave open windows, doors, cracks, holes, vents and other openings when the A/C is running. Inspection and security teams must be tasked to go around air conditioned locations regularly and ensure that appropriate measures are taken to prevent the wastage of cooled air. Because the nature of maintenance contracts in large installations, especially in the public sector, it is considered that the operation of A/C systems according to occupation charts can be readily realized. Furthermore, maintenance contracts must call for prompt repairing of broken windows and doors and other openings in buildings. The administration, on its part, must strictly enforce such ideas and call for swift action when necessary. There are still other methods for conserving energy while cooling buildings. Some of these may require additional investments.

II. OBJECTIVES

To calculate the energy savings and payback period of existing system by introducing primary, secondary pumping with VFDs and by providing VFDs in AHUs, VAVs in the duct. To understand that maximum power is consumed in an air-conditioning system. To minimize energy consumption by proper selection, design and erection of air conditioning equipment. To recognize the fact that substantial savings ultimately is the final outcome of minimum energy consumption.

Manuscript published on 30 August 2013.
* Correspondence Author (s)
Ch.Bhanuprakash*, Asst.Prof, Mechanical Engineering, JNTU Kakinada/Vishnu Institute of technology, Bhimavaram, A.P, INDIA.
A.V.Ramana Rao, Asst.Prof, Mechanical Engineering, JNTU Kakinada/Vishnu Institute of technology, Bhimavaram, A.P, INDIA.
M.Praveen, Asst.Prof, Mechanical Engineering, JNTU Kakinada/Vishnu Institute of technology, Bhimavaram, A.P, INDIA.
M.N.V.S.A Sivaram Kotha, pursuing M.Tech (CAD/CAM) SRKR Engineering College affiliated to Andhra University Vishakapatnam, Andhra Pradesh, INDIA.

III. METHODOLOGY OF AIR CONDITIONED LOAD

Consideration of ambient conditions. Estimation of plinth area of the building. Height of the ceiling and false ceiling. Consideration of all AHUs bypass factor for chilled water coils with six rows deep. Enumeration of details of occupancy in each floor. Consideration of lighting load. Consideration of equipment load in each floor (from 1st to 5th floor).Calculation of ventilation load. Calculation of air-conditioned load based on addition of all the above loads and some of the parameters like duct leak loss, fan horse power gain, additional gain for the piping and pump, safety factor and additional safety factor.

IV. ABOUT THE BUILDING IN THE PROJECT

The office is a five- storied air-conditioning building. The total built –up area is approximately 37,375 sqft. With almost 85% area is air-conditioned. The outer wall is made of 8" brick wall with ½" thick sand cement plaster and the inner wall or the partition walls are one brick wall with both sides plastered. Few areas are with work stations with half height partitions, few areas are with full height rooms. Exposed roof is made of 5" RCC slab with 0.5" thick and cement plaster. Single plane ordinary glass with internal shading is used in all windows. The average floor height is 10'.

Each floor is air- conditioned by using one air handling unit with constant air flow arrangement. The three sides of the building has two third as wall area and one third as glass area and an other side of the building is only with wall. The air conditioning plant will be operated around 10 hours per a day for 26 days in a month throughout the year. In this building there are lot of computers and heat and heat dissipation of each computer is considered as 200watts.The lighting loads considered is 1.5 watts per square feet. The number of air changes considered is one.

V. DETAILS OF BULDING TO BE AIR-CONDITIONED

The main purpose of heating, ventilation and Air conditioning (HVAC) system is to provide thermal comfort and maintain good indoor air quality. The choice and design of the (HVAC) system also can affect few other high performance goals such as energy consumption and acoustics. Air-conditioning system in an office improves the efficiency of people. Communication and process system generate heat if heat generated is not removed it would lead to destruction or quality related problems, similarly conference rooms, guestrooms, etc, also demand air-conditioning for better comfort. All these activities require conversion of energy from one from to the, mostly electrical energy to mechanical. Conversion of energy from one from to other involves loss of energy. The losses depend upon conversion system and method. Details of air conditioning load in all floors.

AHU	Location description	Floor areas (Sqft)	Total Air CFM	Fresh Air CFM	Load (TR)
01	First floor	7475	17,816	997	36.18
02	Second floor	4600	5,737	613	13.82
03	Third floor	7475	14502	997	30.92
04	Fourth floor	7475	12024	997	27.07
05	Fifth floor	7475	13576	997	30.01
Calculated totals		34,500	63,655	4,601	138.0

Chiller packages three numbers of 60TR water cooled open type reciprocating chiller packages. Two chiller packages will be working with approximately 0.8 diversity factor and chiller package is standby. The chiller packages are provided with reciprocating open type compressor, shell and tube water cooled condenser, DX type shell and tube cooler with thermostatic expansion valve. Chilled water circulation pumps (single circuit) three numbers Chilled water circulation pumps. Two pumps will be working and pump for standby. Condensed water circulation pumps three numbers condensed water circulation pumps. Two pumps will be working and pump for standby. Cooling towers two numbers forced draft cooling towers of 120 TR capacities each are installed. One cooling tower will be working and another cooling tower will be standby. Air handling units Conventional type single skin air handling units of following capacities are installed in each floor. The cooling tower, condenser pumps and condensers are connected with GI B class pipeline. The chiller packages, chiller pumps and AHUs are connected with MS class C piping With 50m.m thick.TF quality EPS insulation, finished with polythene sheet, chicken wire mesh and two layers of sand cement plastering. Main MCC is provided in the chiller plant room for chiller packages, chilled water circulation pumps and condenser water circulation pumps. Starter panels are provided for AHUs in the AHU rooms and near the cooling tower for cooling tower.

VI. AIR HANDLING UNITS CAPACITIES

S.NO	Location of AHU	Capacity of AHU
1	First floor	40 TR
2	Second floor	15 TR
3	Third floor	30 TR
4	Fourth floor	30 TR
5	Fifth floor	30 TR

VII. FACTORS CONSIDERED FOR CALCULATIONS

Considered ambient conditions: 106^{0}F DB78^{0}F WB.
Plinth area of the building:115^{1*}65^1.
The height of the ceiling :10^1
Height of false ceiling: 8^1

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-6, August 2013

Considered bypass factor for all AHUs, for chilled water coils with six rows deep: 0.1

Details of occupancy in each floor:

First floor	:	30
Second floor	:	30
Third floor	:	40
Fourth floor	:	50
Fifth floor	:	60

Considered lighting load per square feet: 1.5 watts.

Equipment to be used in heat loads:

First floor: 10 computers

Second floor: 30 computers

4KW miscellaneous equipment like Photocopiers, Water cooler, Fax machines, Printers and servers.

Third floor: 40 computers.

Fourth floor: 45 computers

8 KW miscellaneous equipment like Photocopiers Water cooler, Fax machines, Printers and servers.

Fifth floor: 40 computers2 KW miscellaneous equipment like, Photocopiers, Water cooler, Fax machines, Printers and servers. The load for each computer considered is 200 watts.

The ventilation load is calculated as follows:

Room sensible load : CFM X 1.08 X BFXΔT

Room latent load : CFM X 0.68 X BFXΔT

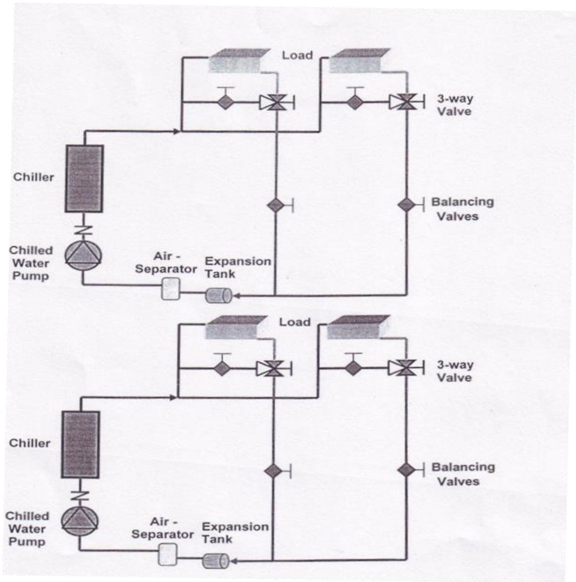
Outside air sensible heat gain: CFM X 1.08(1-BF) XΔT

Outside air latent heat gain : CFM X 1.08(1-BF) XΔT

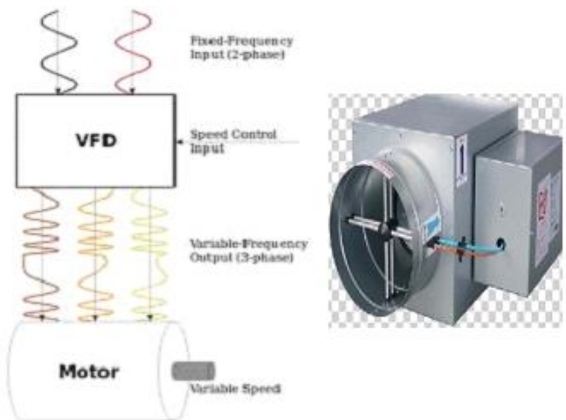
Duct leak loss and fan horse power gain is together taken as 10% of the total Room Sensible load (expect equipment load as it is added)2% additional gain for piping and pump is considered over total heat gain.10% safety factor is considered in the latent heat gain.5% additional safety factor is considered in the overall total heat gain.ADP has been interpolated using the excel formula for the ESHF between the standard values available in the carrier design guide book. Air conditioned load has been calculated based on the above parameters.

VIII .VARIABLE FREQUENCY DRIVE PUMPS IN CHILLED WATER CIRCULATION PUMPS

Cooling loads are often highly variable. In order to track changes in cooling load, chilled water systems must respond by varying chilled water flow rate, chilled water temperature differential, or both. Typical chilled water system design practice is based on either a constant flow/variable temperature difference or variable flow/constant temperature difference concept. These are called constant volume and variable volume systems respectively. Systems can also be classified according to the levels of pumping. System with a single level of chilled water circulation pumps are called primary-only systems and those with both circulating pumps for chillers and distribution pumps are called primary-secondary systems.

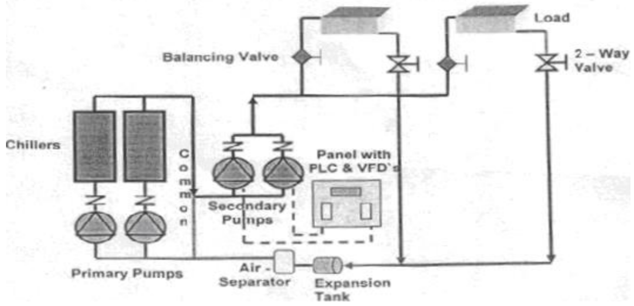


Some systems may have load circulators as well which are sometimes called tertiary pumps. In this section, a description of common chilled water system types from the most basic comprehensive constant flow to all variable flow systems is provided. For purposes of discussion, chilled water pumping systems are divided into three categories. Constant volume chilled water systems, Variable volume chilled water systems with constant evaporator flow and Variable primary flow chilled water systems (VPF).Chilled water pumps run at a constant speed.3-way monitored valve is provided at each AHU.Room thermostat detects the room temperature and gives signal to 3-way valve whether to increase/decrease the chilled water flow through coil. This depends on the load in the air-conditioned area. The excess flow will be by-passed in the coil and goes to the return flow.



In case of variable chilled water flow system, the primary pump will run at constant speed to deliver designed flow rate through the chillers. Secondary pumps will maintain the required flow rate through the AHUs based on the load. All AHUs are provided with two way valves. Room temperature is measured by room thermostat and signal is given to two-way valve to close or open depending on the load. The back pressure in the supply header will increase/decrease based on the two-way valve position.

The differential pressure between the supply header and return header is sensed by DPT (differential pressure transmitter) and gives signal to VFD to increase/decrease the frequency of output power supply. Power supply at increased /decreased frequency will be supplied to pump motor to reduce/increase the speed to maintain the required flow.



IX. CALCULATIONS

Primary pump head calculations. These readings are taken for the fallowing components in air conditioning system like pipe, Y Strainer, Check valve, Butter fly valve, Balancing valve, cooler, Flexible joints, T connection, Expansion in diameter near pump, Expansion in diameter near pump from morning 8 A.M to evening 6P.M.

Primary pump total head, ft WC 24.17
Primary pump total head, Mt WC 7.37
Secondary pump head calculations
Total head = 21Mts
Secondary pump head=Total head-primary head
=29-7.37
=21.63
Considered secondary pump head as 22Mts
Secondary pump flow rate in USGPM 288
Pump motor rated capacity in kW (p1) 5.6
Pump motor rated RPM (4 pole) (N1) 1450
Total power saving in KWH per day per pump due to reduction in RPM of pump due to variable frequency drive =24.42
Total power saving in KWH per day for two pumps due to reduction in RPM of pump due to variable frequency drive =48.83
Total power saving in KWH per year considering 300 working days= 14650.02
Total power saving in rupees considering Rs.5 per KWH=73250.10

X.TOTAL ENERGY SAVINGS IN AIR CIRCUIT DUE TO ALL VAVS AND VFDS

S.No	Description of AHU	Power saved in Kwhr due to VFDs,VAVs
1	First floor AHU	40.55
2	Second floor AHU	16.13
3	Third floor AHU	32.70
4	Fourth floor AHU	32.70
5	Fifth floor AHU	32.70
Total power savings per day		154.78
Total power savings considering 300 working days		46435.33
Savings in rupees per year considering R.s.5.00 per Kwhr		232176.66
Payback period in years by using VFDs, VAVs		2.69

Energy savings calculations of total Air conditioning plant
Total power consumption per day 1454.44 KW
Total power consumed per year considering 300 working days 436332 KW
Reduction in percentage of power consumption due to VAVs, VFDs 12.28

XI .RESULTS &DISCUSSION

From the calculations we have observed that the internal air conditioning load varies according to the season. But the system is designed for peak load conditions for the month of MAY. In other seasons, the internal air conditioning load would be less. Since the equipment is running on constant parameters there would be loss of energy. For reducing these losses, we have introduced secondary pumping with VFDs, VAVs in the duct and VFDs in AHUs. By introducing secondary pumping with VFDs, VAVs in the duct and VFDs in AHUs, the power consumption has been reduced to 12.25% over existing constant flow pumping and constant air flow systems. The payback period is 2.69 years for introducing VAVs in the duct and VFDs in the AHUs and the payback period is 3.73 years for primary and secondary pumping systems.

XII. CONCLUSION

In the present project an attempt has been made to calculate energy savings and payback period of existing air conditioning system by introducing primary, secondary pumping with VFDs and by providing VFDs in AHUs and VAVs in the duct. To conclude there is a good business potential in this line for air conditioning companies, since this system saves lot of energy to consumers and to our nation at large.

REFERENCES

[1] P.N. Ananthanarayana, *Basic Refrigeration & Air conditioning*, New Delhi, Tata Mc Graw-Hill Publishing Company Ltd., 1996, 1982
[2] Carrier Air conditioning Company Hand Book of Air conditioning system Design, Tata Mc Graw-Hill Book company,© 1965
[3] Indian Society of Heating Refrigeration & Air conditioning Engineers, HVAC Hand book 1997.
[4] CP Arora, *Refrigeration & Air conditioning Engineers*, New Delhi, Tata Mc Graw-Hill P Publishing Company Ltd., 1981, 2001
[5] Dr.S.S.Thipse, *Refrigeration & Air conditioning Engineers*, Jaico Publishing House, 2005
[6] M. Adithan, Practical Refrigeration and Air conditioning1st Edition, 1991
[7] Manohar Prasad, Refrigeration and Air conditioning Data Book1989, reprint 2012
[8] P.L.Ballaney, *Refrigeration and Air conditioning (in S.I. Units)*15th edition, reprint 2012
[9] Prof.P.S.Desai, *Modern Refrigeration and Air conditioning for Engineers* (Principles, Practices and Applications) Reprint, 2010
[10] Glossary of terms used in refrigeration and air conditioning (IS 3615)Bureau of Indian Standards (BIS), Govt. of India2007
[11] Khandwawala,Thermodynamic Approach for Refrigeration and Air conditioning1st Ed. 2011
[12] R.K.Rajput, Refrigeration and Air-Conditioning2nd edition 2013
[13] 2009 ASHRAE Handbook - Fundamentals (SI Edition)American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE)2009
[14] S.K.Kulshrestha,*Refrigeration and Airconditioning*,4th edition, 2001
[15] Ahmadul Ameen, Refrigeration and Air Conditioning 2007.

Mr.Bhanuprakash.CH completed M.Tech(Energy Systems) in the year 2011 with Distinction from JNT University Hyderabad, has 7 years of experience and is serving as an Asst. Prof. at Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, INDIA.He has guided many B.E Projects & published one international journal in the year 2013.

Mr. A.V.Ramana Rao completed M.Tech (Machine Design) in the year 2011 from JNT University Kakinada, has 4 years of experience and is serving as an Asst. Prof. at Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, INDIA. He has guided many B.E Projects & published one international journal in the year 2013.

Mr. M.Praveen completed M.Tech (CAD/CAM) in the year 2012 from Swarnandhra college of Engineering and techmnology affiliated to JNT University Kakinada, has 4 years of experience and is serving as an Asst. Prof. at Vishnu Institute of Technology, Bhimavaram, Andhra Pradesh, INDIA. He has guided many B.E Projects & published one international journal in the year 2013.

Mr. M.N.V.S.A Siva Ram Kotha pursuing M.Tech (CAD/CAM) SRKR Engineering college affiliated to Andhra University Vishakapatnam, Andhra Pradesh, INDIA. He has published one international journal in the year 2013

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)