RESEARCH ARTICLE OPEN ACCESS

Design And Prototype Testing Of Economizer In HVAC Systems

Kongara Ajay[1], G Sudhakar[2], B Keerthi Priyanka Reddy[3], G Hazarat Kumar[4]
[1, 2, 3](Department of Electrical & Electronics, K L University, Vaddeswaram)
[4] (Department of Mechanical Engineering, K L University, Vaddeswaram)

ABSTRACT
Power, the word itself says to what extent the world is dependent on it. It may be fortunate or unfortunate, we are totally dependent on the power which is making the usage higher and higher which left us with energy crises and increasing costs of the energy usage. It's time for Energy saving. These days, number of people in favour of the Energy saving has been increasing not to lessen the cost of usage but to let our future generations live with light and luxury.
In this project, I have worked on the Energy conservation measures for HVAC that will save the energy to a little higher extent by designing an economizer. The theme of the project is to design a energy efficient economizer for HVAC Systems. A single unit of energy saving will yield in generation of two units of energy. My concern is to conserve energy and reduce usage by using ECMs where ever required.
Keywords – Conservation, Energy, Ecm's, Economizer, HVAC

I. INTRODUCTION

In spite of a total installed power generation capacity of about 223 GW (as of April 2013), India is still struggling to meet increasing power demand. Government of India came up with the Electricity Act in the year 2003 to reform the unorganized power sector in India. EA-2003 has helped to improve efficiency and has brought some much needed order in the overall power sector. However, we are still facing severe power cuts and many regions in India are still lacking something as basic as an electricity connection. Recent structural reforms in the power sector will take some time for complete implementation. In the short to medium term, supply-demand mismatch and limited ability of the financial systems to support subsidies are expected to push consumer tariffs upward.

II. OUTLOOK ON ENERGY EFFICIENCY AND CONSERVATION

Energy crisis is one of the major problems in the existing world. An energy crisis is a great bottleneck in the supply of energy resources to an economy. There has been an enormous increase in the global demand for energy in recent years as a result of industrial development and population growth. Since the early 2000s the demand for energy, especially from liquid fuels, and limits on the rate of fuel production has created such a bottleneck leading to the current energy crisis. This problem will solved through Energy conservation and use of energy efficient equipment.

With the use of energy efficient measures in different sectors of consumption like Lighting, Refrigeration and HVAC helps energy conservation.
An energy efficient lighting design with controls reduces the power consumption and will be a major energy saving component along with commercial and residential sectors. A proper light Design will be able to percept the surroundings and can reduce energy consumption.

III. HVAC SYSTEMS

HVAC (heating, ventilation, and air conditioning) is the technology of indoor and vehicular environmental comfort. HVAC system design is a sub discipline of mechanical engineering, based on the principles of thermodynamics, fluid mechanics, and heat transfer. Refrigeration is sometimes added to the field's abbreviation as HVAC&R or HVACR, or ventilating is dropped as in HACR (such as the designation of HACR-rated circuit breakers).
HVAC is important in the design of medium to large industrial and office buildings such as skyscrapers and in marine environments such as aquariums, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors.

Heating:

A heater is an object that emits heat or causes another body to achieve a higher temperature. In a household or domestic setting, heaters are usually appliances whose purpose is to generate heating (i.e. warmth). Other types of heaters are Ovens and Furnaces.
Heaters exist for all states of matter, including solids, liquids and gases. There are 3 types of heat transfer: convection, conduction and radiation.

The opposite of a heater (for warmth) is an air cooler (for cold) (see air conditioning) used to keep the user cooler than the temperature originally surrounding them.

Ventilation:

Ventilation is the process of changing or replacing air in any space to control temperature or remove any combination of moisture, odors, smoke, heat, dust, airborne bacteria, or carbon dioxide, and to replenish oxygen. Ventilation includes both the exchange of air with the outside as well as circulation of air within the building. It is one of the most important factors for maintaining acceptable indoor air quality in buildings. Methods for ventilating a building may be divided into mechanical/forced and natural types.

Air Conditioning:

Air conditioning and refrigeration are provided through the removal of heat. Heat can be removed through radiation, convection, or conduction. Refrigeration conduction media such as water, air, ice, and chemicals are referred to as refrigerants. A refrigerant is employed either in a heat pump system in which a compressor is used to drive thermodynamic refrigeration cycle, or in a free cooling system which uses pumps to circulate a cool refrigerant (typically water or a glycol mix)

IV. Functions of HVAC

The main purposes of a Heating, Ventilation, and Air-Conditioning (HVAC) system are to help maintain good indoor air quality through adequate ventilation with filtration and provide thermal comfort. HVAC systems are among the largest energy consumers in schools, offices, industries, and commercial buildings. HVAC systems control the ambient environment (temperature, humidity, air flow, and air filtering)

A Heating, Ventilating, and Air-Conditioning (HVAC) Control system operates the mechanical equipment (boilers, chillers, pumps, fans, etc.) to maintain the proper environment in a cost-effective manner. A proper environment is described with four variables: temperature, humidity, pressure and ventilation.

Temperature: The comfort zone for temperature is between 68°F (20°C) and 75°F (25°C). Temperatures less than 68°F (20°C) may cause some people to feel too cool. Temperatures greater than 78°F (25°C) may cause some people to feel too warm. Of course, these values vary between people, regions and countries.

Humidity: The comfort zone for humidity is between 20% relative humidity (RH) and 60% RH. Humidity less than 20% RH causes the room to be too dry, which has an adverse effect on health, computers, printers, and many other areas. Humidity greater than 60% RH causes the room to be muggy and increases the likelihood of mildew problems.

Pressure: The rooms and buildings typically have a slightly positive pressure to reduce outside air infiltration. This helps in keeping the building clean.

Ventilation: Rooms typically have several complete air changes per hour. Indoor Air Quality (IAQ) is an important issue. The distribution pattern of the air entering room must keep people comfortable without feeling any drafts, and this is important as well.

V. HVAC: ECONOMIZER

The function of the economizer is, as its name implies, to "economize" or save on cooling costs. Obviously, it costs money to operate the compressor. If the compressor can be shut down and the system still provide adequate cooling, energy savings can be realized.

An economizer consists of dampers, sensors, actuators, controls and links that work together to determine how much outside air to bring into a building.

Heat internal to the building, such as people, lights, computers, copy machines, motors, and other machines, causes the temperature inside a structure to increase. Heat soaked up by the building structure may also continue to heat the building long after the temperature outside the building has dropped. There are times when the temperature outside a building is lower than the temperature inside.

Whenever the HVAC system is calling for cooling and the temperature outside is cool enough, it is economical to shut off the compressor and bring in cool outside air to satisfy the cooling needs of the building. Such is the function of an air economizer system.

If the indoor thermostat calls for cooling and the outside air enthalpy (total heat) is low enough, then the economizer brings in this cooler and less humid air and uses it for cooling instead of operating the compressor. Using the outside air for cooling is less expensive than operating the compressor to provide cooling.

So an enthalpy control is a control which checks to see if both the temperature (sensible heat) and the humidity (latent heat) are low enough to be used for cooling. This combination provides for the greatest comfort at the least cost.

Not all economizers use enthalpy controls. Some just check the outside air temperature and do not check the outside air humidity. Those controls do not provide the same levels of comfort as enthalpy controlled economizers.

Economizers can save a great deal of energy. They can also waste energy if they are not operating properly or are improperly adjusted. For example, if the outside air dampers are not closing properly when the outside air temperature is high, then hot air is unnecessarily entering the building and causing the air conditioning compressor to operate longer and under higher loads, thus consuming a great deal more energy than necessary.

If the dampers are open too far during the heating season, the heating system must heat the extra outside air entering the structure. Such extra heating and cooling costs can be quite high. The cost of a service call to repair such a problem is often less than the cost of one or two months of energy wasted. Many economizers are not functioning at all or are out of service because they are not well understood by some service technicians. In fact, some service technicians simply disable them. It is essential that economizers are working properly and saving energy rather than increasing costs.

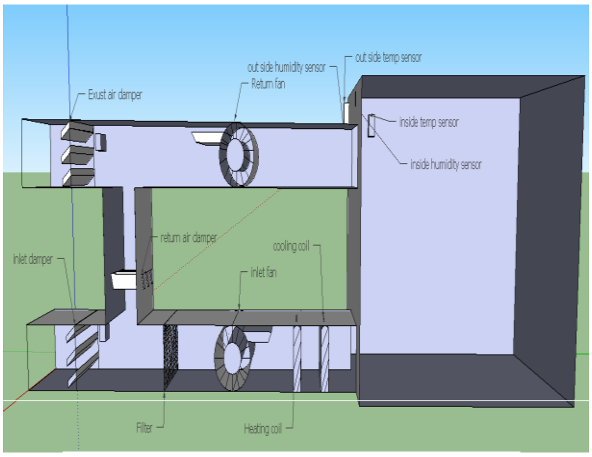
Since air economizers control and vary the amount of outside (fresh) air brought into a structure, they play an integral role in maintaining the quality of indoor air. A properly operating economizer can greatly improve indoor air quality (IAQ) and reduce air quality-related illnesses. Therefore, it is important for the service technician to have at least some knowledge of indoor air quality and its relationship to heating and cooling system operation.

Air economizers are available for residential and commercial systems and can be retrofitted to most systems as energy conserving devices. Most packaged light commercial systems (rooftop systems) have an economizer add-on package as an option which can be installed when the system is new or added to the system later.

Components in Economizer:

The economizer (minimally) consists of the following components:

i) Induino Board.
ii) Sensors.
iii) 9g Mini Servomotors.
iv) 12v BLDC Fans.
v) 4 Channel Relay Board.
vi) Voltage Regulators.
vii) Dampers.
viii) Resistors.
ix) Capacitors.
x) Bread Board.
xi) Jumper Wires.
xii) Single Lead Wires.

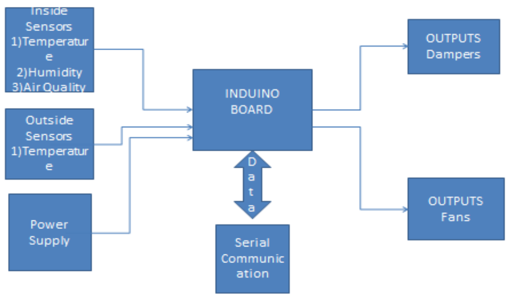


MODEL DIAGRAM USING SKETCH SOFTWARE

Procedure for Operation of Economizer:

- Ask User for Input Temperature.
- Read Inside Temperature and Outside Temperature.
- Compare w.r.t Set Point.
- Generate Respective Variable value(=,>,<)
- Read Inside Humidity
- Generate Respective Variable
- Read Inside Air Quality.
- Generate respective variable.
- Using Switch Conditions the output is declared

By output signal form Induino the dampers and fans are operated.



Block Diagram

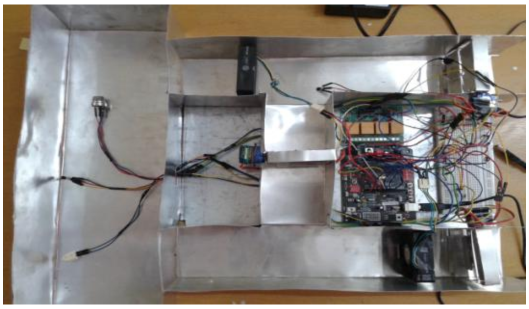
VI. Savings Calculations:

1 Ton =4.714 HP; 1 Ton=3504Watts=3.504 kW
1 HP =0.21 Ton; 1 HP=745.6Watts=0.746 kW
1 unit =1000 Watts=1 kWh
Let us assume for KLU Central Library the area is 27000 Sq Ft
For 27000 Sq Ft it requires 225 tons of Air conditioning Equipment
Refrigeration Tonnage Required =225 Tons=1060.65 HP.
Working Hours=8784hours /Year
Cost of Electricity Per Unit=6Rs/- per kWh.
kW =1060.65*0.746*0.8=632.99

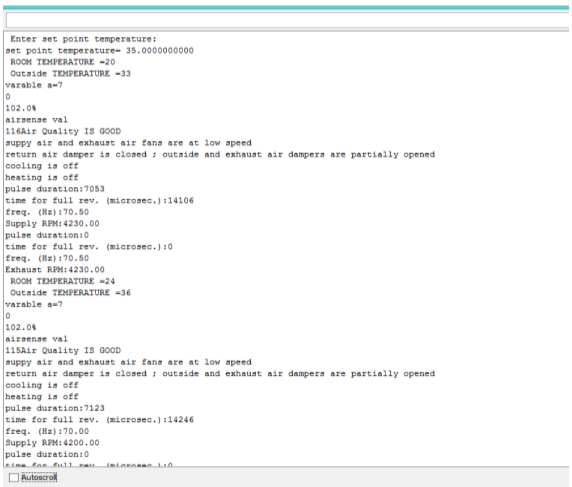
Total kWh Consumption=kW*Working Hours
=632.99*8784
=5560236.161
Energy Cost =5560236.161*6
=33361416.97
By installing VFD in the Place of Fans
From Bin data by observation,
•30.57% Time the VFD running at 40% Speed.
•24.52% Time the VFD running at 50% Speed.
•28.57 % Time the VFD running at 60% Speed.
•8.23 % Time the VFD running at 70% Speed.
•4.22 % Time the VFD running at 80% Speed.
•2 % Time the VFD running at 90% Speed.
•1.72 % Time the VFD running at 100% Speed.
By Affinity Laws Power Required by motor is Proportional to cube of speed.
1) At 40% of Speed For 30.57% of Time:-
Power@40% speed= Power@100% speed*{Speed@40%/ Speed@100%}3
= 40.512 kW
Cost@40% Speed= Power@40% speed*[30.57 % of 8784]*Cost per kWh
= 40.512*2685.26*6
=652708.287 Rs/-
2) At 50% of Speed For 24.52% of Time:-
Power@50% speed= Power@100% speed*{Speed@50%/ Speed@100%}3
= 79.12
Cost@50% Speed= Power@50% speed*[37% of 8784]*Cost per kWh
=1021635.418 Rs/-
3) At 60% of Speed For 28.57 % of Time:-
Power@60% speed= Power@100% speed*{Speed@60%/ Speed@100%}3
= 136.728
Cost@60% Speed= Power@60% speed*[18.5% of 8784]*Cost per kWh
=2053742.06 Rs/-
4) At 70% of Speed For 8.23 % of Time:-
Power@70% speed= Power@100% speed*{Speed@70%/ Speed@100%}3
= 217.19
Cost@70% Speed= Power@70% speed*[4.68% of 8784]*Cost per kWh
=941762.17 Rs/-
5) At 80% of Speed For 4.22 % of Time:-
Power@80% speed= Power@100% speed*{Speed@80%/ Speed@100%}3
= 324.09
Cost@80% Speed= Power@80% speed*[1.59% of 8784]*Cost per kWh
=720811.421 Rs/-
6) At 90% of Speed For 2 % of Time:-
Power@90% speed= Power@100% speed*{Speed@90%/ Speed@100%}3
= 461.45
Cost@90% Speed= Power@90% speed*[2% of 8784]*Cost per kWh
=486405.21 Rs/-
7) At 100% of Speed For 1.77 % of Time:-
Power@100% speed= Power@100% speed*{Speed@100%/ Speed@100%}3
= 633
Cost@100% Speed= Power@100% speed*[1.77% of 8784]*Cost per kWh
=587811.90 Rs/-
By installing VFD's
Total=6464876.472
Net Savings=33361416.97-6464876.472
=26896540.5
By Installing Economizer,
By Weather Bin Data
Coil Tonnage=1kW for 1 Ton
225 Tons=225 kW
Total kWh=45kW*4000 hours
=180000 kWh
Now cost=1080000 Rs/- saved
Total Annual Savings by installing VFD & Economizer=26897541.5 Rs/- saved per year
In Ideal conditions 80% Savings
But Practically only 60% savings

VII. Results

By the output signals from Induino board
1) Dampers are operated by servos with PWM technique.
2) Supply Fan speed and Return Fan speed is Controlled.



HVAC Economizer Design Induino Results



```
 Enter set point temperature:
set point temperature= 35.0000000000
 ROOM TEMPERATURE =20
 Outside TEMPERATURE =33
varable a=7
0
102.0%
airsense val
116Air Quality IS GOOD
suppy air and exhaust air fans are at low speed
return air damper is closed ; outside and exhaust air dampers are partially opened
cooling is off
heating is off
pulse duration:7053
time for full rev. (microsec.):14106
freq. (Hz):70.50
Supply RPM:4230.00
pulse duration:0
time for full rev. (microsec.):0
freq. (Hz):70.50
Exhaust RPM:4230.00
 ROOM TEMPERATURE =24
 Outside TEMPERATURE =36
varable a=7
0
102.0%
airsense val
115Air Quality IS GOOD
suppy air and exhaust air fans are at low speed
return air damper is closed ; outside and exhaust air dampers are partially opened
cooling is off
heating is off
pulse duration:7123
time for full rev. (microsec.):14246
freq. (Hz):70.00
Supply RPM:4200.00
pulse duration:0
Autoscroll
```

REFERENCES

[1] http://www.bijlibachao.com/
[2] http://www.energy.gov
[3] http://www.beeindia.in/
[4] http://en.wikipedia.org/wiki/HVAC
[5] http://www.epa.gov/iaq/schooldesign/hvac.html
[6] http://www.johnsoncontrols.com/content/us/en/products/building_efficiency/products-and-systems/integrated_hvac_systems/hvac.html
[7] http://en.wikipedia.org/wiki/Economizer
[8] http://www.energy.wsu.edu/documents/AHT_Economizers[1].pdf