REDUCING AHU POWER CONSUMPTION BY EQUIPMENT ADJUSTMENT

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ABSTRACT

Operating air conditioning and refrigeration systems consume great amount of electrical power in buildings and industrial plants . According to energy ministry in the state of Kuwait , equipment power consumption spends more than 45% on HVAC operation “Ref [1] “ . This energy spend is going to rise as industrial developments and population growth over coming years . This study discuss the different ways to reduce energy demand by AHU used as an essential part of the cooling system . The main study points on steps which can save significant amount of power and reduces consumption are to minimize air leakage from unit casing and a proper sizing and selection of AHU components such as fans, motors , coils filters and dampers .Results showed that energy reduction of air leakage decreased up to (6 %) , and fans, motors, coil and filters decreases up to (9%) .It is concluded the result of resizing the internal components and improvement of AHU performance cannot be ignored .

Index Terms - Chillers, Cooling System, Energy Saving , Face velocity , Power, AHU, Efficiency.

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1. INTRODUCTION

Air handling units (AHU) is a machine used as part of the cooling /heating plant in air conditioning (HVAC) system to circulate air in the proposed treated area to provide a comfortable condition for the user space “Ref [2]” .The AHU device consist typically of cooling coil , heating coil , fan , motor , filter , dampers and control panel as shown in Figure (1) . The air handling units are suitable for outdoor and indoor installations, it is used in a wide range of applications such as schools, residential buildings, hospitals , industrial plants, cinemas , hotels, and Supermarkets.

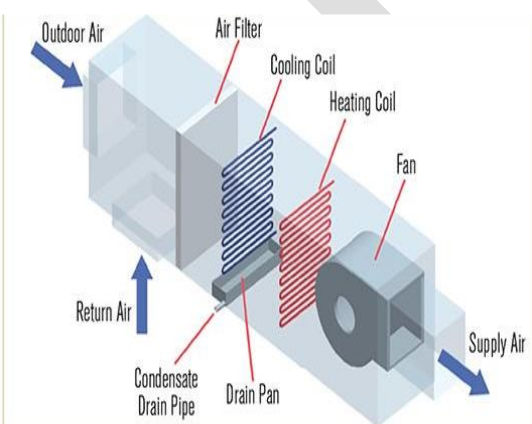

Figure (1) Schematic of atypical draw through AHU

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The AHU is normally a large metal box which connects to the ductwork that distributes the conditioned air throughout a building and has return back route for the air to be reconditioned. The AHU is normally provided with a cooling/heat exchanger which connected to cold or hot

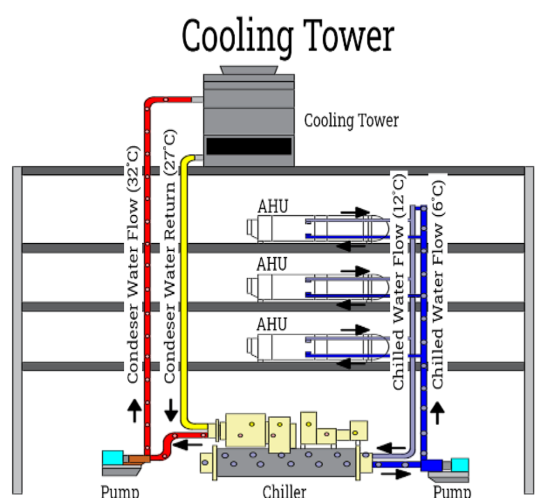


Figure (2) typical connection duct and piping to AHU

water supplied by the chillers / boiler for increasing capacity and energy saving. AHU’s supply fresh air to the space “Ref [5]”. The units take air from the outside, filter it and recondition it (cooled by a cooling coil or heated by a heating coil. Figure(2) shows the connection cycle of air and water to the AHU.

As shown earlier, the basic items of an AHU system are its casing ,supply fan, electrical motor, the heating / cooling coil, and filters, The AHU's housing is constructed of aluminum or galvanized steel profile Figure (3). Inside it the AHU's fan, filters, coils and motor are fixed.

Figure (3) AHU housing

AHU is fitted with centrifugal fan, which is used for forcing air to the building. There are many types of fans to use from, each with its own unique characteristics. The famous AHU fan types are airfoil , backward (curved or inclined) and forward curved. Selection of the fan depends on the building design "Ref [7]" .The latest technology introduced the variable air volume (VAV) , which makes us able to adjust the fan speed based on the required building load. Fan selection depends on the requirements of duct route and air quantity supplied to building, which is selected by aid of software simulation before construction.

Heating/Cooling Coils are typically constructed from seamless copper pipes and are expanded to aluminum fins. Coils provide heat or cool air needed through heat transfer process between the water circulating inside the coil and air passing among the coil fins " Ref[2]" .The AHU's filters are there to stop dust and harmful particulate matter from passing through to cooled and cleaned area.

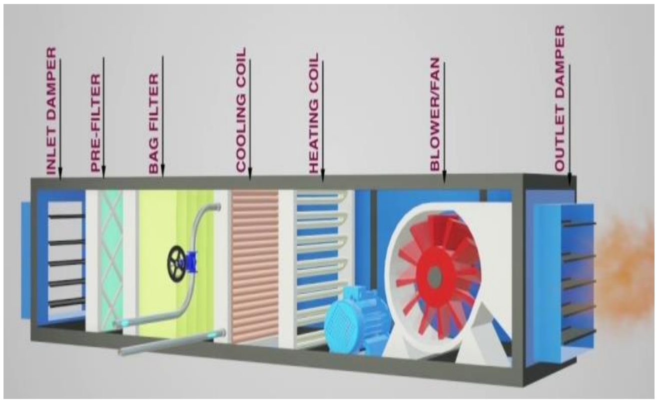
2 –Test system Description

We tested intelligent water cooled chillers system with main equipments of chiller, cooling tower ,chilled water pumps , air handling units , controllers with the capacities as shown in table 1 and measuring probe of temperature , humidity , and data logger which installed on the subject HVAC equipment to collect different needed measurements . The test conducted for 7 consecutive day period.

Table (1) chiller system equipments capacities

s	Equipment	Quantity	Capacity	System Average Energy Use KW/Ton
1	Air cooled chiller	2	300 ton / each	0.54
2	Pumps	2	720 gpm each	0.11
3	Cooling towers	2	--	0.06
4	Air Handling Units	8	15000 CFM @ 4.0 IWG - TSP	0.17
5	Total system Average Energy Use			0.88

Figure (4) shows atypical AHU layout college of technology at Shuwaik near the capital of state of Kuwait. Performance and test study on AHU was carried on July .Air quantity (CFM) , temperature , voltage and velocity reader logger used with needed probes . The following tests we carried out and result collected and analyzed.



Figure(4) AHU takes return air and pushes to buildings

3- Measurement of Air Handling Unit Leakage

HVAC equipments have exfiltration and infiltration rates from 5% to 8% of total air supply depending on AHU structural rigidity . The more loss the casing , the more the equipment leaks depending on the applied operational pressure on unit panels" Ref { 6]" .Many improvement made to the initial installation steps of the AHU , and its air distribution and their controls panel. AHU performance was recorded by using air CFM, temperature and humidity logger to read supply air , return air and fresh air . The test team also checked the duct work throughout the building supplied by the specified AHU and determined the duct durability and leakage characteristics .It is noticed through data collection and analysis that for 1% of air leaks into unit or 1% of air leaks out of unit mean more air to be cooled or heated and pushed to the system throw the fan . In other words for every 1% of air leaks the unit will consume 1% more power . Annual power saving connected with 1% AHU leakage compared to 5% is shown in table (2).

A/C Energy use = 0.88 kw/ton x 600 ton x 3600 hours
= 1900800 kw.hrs

Annual A/C Energy Cost = $ 0.15 kw.hrs x 1900800 kw.hrs
= $ 285120

Table 2 . Leakage Energy cost saving

s	At 1% leakage	At 5% leakage
1	101% x $190080 = $ 191980	105% x $ 190080 = $ 199584
2	Energy saving of 1% in comparison to 5% air leakage in AHU = $ 7604 per operational season	

4- Study Proper Sizing and Selection of Fan

The selection of the AHU fan will depend on the quantity of air and the total external static pressure required in duct design . The types of fan commonly used in HVAC units are axial fan Figure (5) , forward curved centrifugal fan and backward inclined "Ref [7]". Axial blades arranged in a propeller shape around a rotating shaft. This type designed for low airflow and low static pressure application .

Figure (5) axial fan

A centrifugal fan will produce a higher pressure than an axial fan, but with higher power consumption . This type of fan is belt- driven by motor or directly connected to motor, it also can be driven with a variable frequency drive

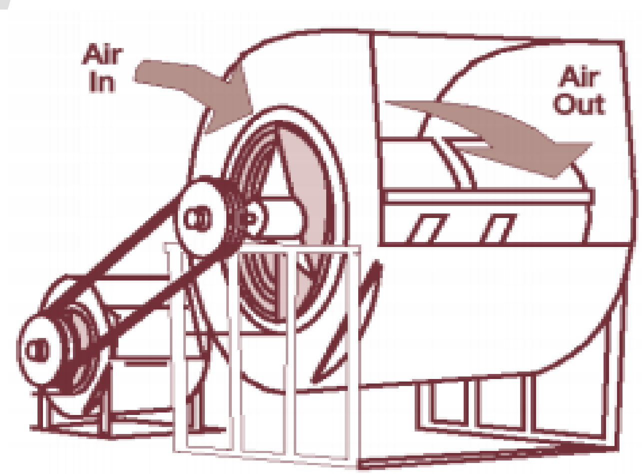


Figure (6) centrifugal fans

In air conditioning systems, centrifugal fans are one of the main application in air-handling units, which are required to push air into duct system route . This type of fans can overtop the static pressure of the air duct net layout. Backward inclined fans are calcified by their unusual blade shape. These fans are mainly used in different industrial applications with a high airflow and variable resistance. Selecting the proper fan for the required job is very important for power conservation in air handling units. Therefore in our study we made many fan selections by using a computer analysis program and compared several centrifugal fan types for our AHU and the study as shown in table 3 explains the power saving by choosing the most efficient fan.

Table (3) Energy Saving by Selecting The proper Fan

S	Item	AHU Existing Fan	New Selected Fan By Computer Program
1	Fan Description	Size (Forward Curved) = 22" dia Mech. Efficiency = 67% Brake Horsepower = 19	Size (Backward Curved) = 28" dia Mech. Efficiency = 80 % Brake Horsepower = 14.5
2	Fan Energy Difference – KW	(19 – 14.5) hp X 0.746 KW/hp = 3.357 KW	
3	Annual Fan Use KW-hours	3.357 KW X 3600 hours = 12085 KW.hrs	
4	Annual Fan Energy Cost	$ 0.15 / KW.hrs x 12085 KW.hrs = $ 1812.75	

It is clearly shown from calculation in table (3) , selecting the proper and most efficient fan is a very important procedure for power consumption and energy conservation .

5- Study Affect Of AHU Coil Face Area & Face Velocity On Energy Saving

In HVAC unit selection air-handling units performance are selected air face velocity at 500 fpm (2.5 m/s)) for sizing cooling coils with a maximum of 10 fins per inch(fpi). This is considered as higher number of fins per inch can have moisture carryover at 500 fpm (2.5 m/s), and increases air-side pressure drop and not provide enough space between fins for coil cleaning. Also confirms that lower velocity is better for high-performance operation.

Two different air handler applications selected to study the energy savings table (4) . First AHU selected with 500 fpm and the second AHU with 600 fpm face velocity .Operating parameters recorded using energy simulation software based on operating schedules. Air handing unit costs were determined by manufacturers on the site. Final filter pressure drops considered two-times initial filter pressure drop as calculated in filter supplier catalogue . Total Static pressure calculated from drawings and used in the energy simulations. The average electrical rate was $0.15/kWh for these two applications.

Table (4) Energy Saving by Selecting The proper Fan

S	Item	AHU-1	AHU-2
1	Fan Speed (fpm)	500 @ 4.5 (IWG) Total Air Pressure Drop	600 @ 5.2 (IWG) Total Air Pressure Drop
2	Brake Horsepower	15.5	23
3	Fan Energy Difference – KW	(23 – 15.5) hp X 0.746 KW/hp = 5.595 KW	
4	Annual Fan Use KW-hours	5.595 KW X 3600 hours = 20142 KW.hrs	
5	Annual Fan Energy Cost	$ 0.15 / KW.hrs x 20142 KW.hrs = $ 3021.3	

It is clearly noticed a reduction in face area of the coil decreases the heat transfer surface and also increases the face velocity and air pressure drop across the coil .This practice minimize the unit size and reduces AHU costs, but in the other hand increases energy costs.

6 – CONCLUSION

This paper show the study points on ways in which can save power and reduces energy consumption. The study concentrated on ways to minimize air leakage from air handling units casing and a proper sizing and selection of AHU fan , electrical motor and face velocity across the cooling coil .Results showed that energy reduction in improvement of air leakage, fans, motors, coil sizes result in improvement of AHU performance and energy saving which cannot be ignored.

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