Central Heating Ventilation Air Conditioning System Energy Cost Optimization

Sandesh Hegde[1] Dr. Ramachandra C G[2]
[1,2]Department of Mechanical Engineering
[1,2]Srinivas Institute of Technology, Mangaluru, India

Abstract— The world's population is growing in fast rate and, at the same time consumption of energy and resources also increasing rapidly. After the raw materials, energy got the second highest cost factor in the industry. This cost can be considered as increasing costs. Therefore energy efficiency improvement has two benefits: it benefits not only our environment, but also the profitability of the companies. Heating, ventilation and air conditioning (HVAC) systems will consume major portion of the money spent by a company on the energy. The optimization of the HVAC systems will improve the environment in the organization building and can reduce energy consumed by the particular HVAC system; Hence we can save some amount of energy which consumed by the chiller, so we can reduce the cost which is spent on the energy[1].

Key words: HVAC; Optimization; HHR Fan; FRP Blade; Air handling unit

I. INTRODUCTION

The world's population is growing in fast rate and, at the same time consumption of energy and resources also increasing rapidly. After the raw materials, energy got the second highest cost factor in the industry. This cost can be considered as increasing costs. Therefore energy efficiency improvement has two benefits: it benefits not only our environment, but also the profitability of the companies. The HVAC System in any organization account 40% to 50% of total energy used by the organization in the building [2]. So it is no wonder building owners, engineers are looking to improvement in the energy efficiency that can save energy so that we can reduce the costs. By implementing an optimization process, the cooling cost can be reduced by 2 to 15 percent.

II. ENERGY SAVING RECOMMENDATION

Once the original chillers system design and the facility are understood, then the condition of the equipment is evaluated, how it's is all connected together for the operation and how well it has been maintained. The measurement is taken for power consumption and process variables including temperatures, chiller loading is noted. Then the following energy savings techniques are recommendation are made.

A. FRP Blades for Cooling Tower Fan:

It is observed that the HVAC plant have 6 cooling tower in primary side of HVAC loop. The HVAC cooling tower fan blades are made up of aluminium. The all Fan is driven by 55KW motor each. Then it is recommended to use FRP Blade in cooling tower fan instead of aluminium blade for emerging saving purpose [6].

Currently the aluminium blades are used in the cooling tower fan. The Metallic blades are heavy; they need a high starting torque requiring a high HP motor.

1) Recommendation:

It is better to use Fiber reinforced plastic (FRP) blades in cooling tower Fan. Because

- FRP Blades are light weight.
- FRP Blade fan need a low starting torque and requiring a lower HP motor to drive it.
- The life of the gear box, motor and bearing is increased because of light weight.
- Non corrosive characteristic.
- Low noise levels.
- Less power consumption.

The cases reported where metallic or glass fiber reinforced plastic fan blades have been replaced by efficient hollow FRP blades. As a result, the usual payback period for replacing aluminium fans is only 6-7 months.The resulting fan energy savings were in the order of 20-30% and with simple payback period of 6 to 7 months.

Return on Investment for FRP Fan in cooling Tower:

Sl. No	Particular	Details of existing Aluminium fan	Details of FRP Fan
1	Type	Axial Flow	Aerodynamically Designed Energy efficient Axial Flow
2	Model	-	PARAG-MAP-5791-8HV-P19
3	Fan Diameter	552CM	552CM
4	No. Of Blades	12	08
5	Fan speed	193RPM	193RPM
6	Blade Material	Aluminium Alloy	Fiber Glass Reinforce Polymers
7	Airflow	570236ACFM	570236ACFM
8	Motor Capacity	55KW	55KW
9	Power consumption	50.6KW	42.8KW

Table 1: Comparison of Aluminium blade and FRP Blade

Aluminium Blade	
Fan Diameter	552cm
Air flow	570236ACFM
Power Consumed by existing fan	50.6KW/H
Running Hours of each fan per day	Average 18 Hours
Power consumption of existing fan/Day	910KW/Day
Power Consumption of existing fan/Month	27300KW/Month
Total Energy Cost Per Month(Considering power cost as Rs.11.28)	Rs.3,07,944

Table 2: Aluminium Blade Fan Energy cost

FRP Blade	
Fan Diameter	552cm
Airflow	570236ACFM
Power Consumption	41.4KW/H
Running Hours of each fan per day	Average18 hours
Power Consumption per day	745.2KW/Day
Power Consumption per month	22356KW/Month
Total Energy cost per Month (Energy cost Rs.9.8)	Rs.2, 19, 088

Table 3: FRP balde Fan Energy cost

Total Savings from each fan per Month = Energy cost per month while using existing aluminium fan – Energy cost per month considering Light weight FRP fan

Energy Savings per each fan each fan per Month

= 2, 67, 540– 2, 19, 088

Energy Savings from each per Month

= Rs.48, 452

Sl. No	Specification	No. of Fan	Cost/Unit	Installation charge per fan	Total Cost
1	Energy Efficient FRP Axial flow fan blade Assembly	6	Rs. 2, 70, 000	Rs. 30,000	Rs.18,00,000

Table 4: Cost of FRP Blade

Total energy saving by all 6 Fan = 6 * Energy savings per month/Fan

= 6 * 48, 452

Total Energy Savings = Rs. 2, 90, 712

Return on Investment =Total Cost of fan/ Total Savings per month

= 18, 00, 000/2, 90, 712

=6.19

Payback Period = 6 to 7 months

B. Small Capacity Chiller:

At present there are six chillers of 2500TR capacity of each. During the low load period the plant will operate two or more chillers in part load condition. In part load condition the efficiency of the chiller is less [4]. It is suggested that to install a small capacity chiller of 1250TR can be installed as standby unit to operate in low load condition such as 3500TR/Hour, 6000TR/Hour etc…

Below sample data shows TR demand in different days.

Time\Date	01-12-14	07-12-14	20-12-14	25-12-15
0	3609.31	3656.34	2578.53	2921.26
1	1970.33	3453.27	2514.36	2773.68
2	2106.34	1740.03	2574.36	2823.045
3	2360.69	1877.925	2381.0625	2787.27
4	2448.28	2346.75	2361.15	2667.6
5	2482.34	2438.1	2345.625	2369.25
6	2484.41	2514.375	2346.6375	2416.875
7	2444.06	2471.925	2154.3	2298.71
8	2514.68	2227.665	2446.35	2280.33
9	2484.35	4518	2375.325	2329.95
10	3771.99	4051.6575	2333.8125	2471.43
11	2990.22	3073.77	2392.875	2411.1
12	3013.13	3153.7125	2428.3125	2559.63
13	3163.71	3199.995	2418.9	2612.92
14	3176.80	3351.72	2022.3	2622.6
15	3286.31	3387.825	2573.4375	2728.12
16	3382.65	3373.65	2741.04	2726.62
17	3321.99	3610.2375	2759.04	2816.34
18	3289.67	3493.875	2672.28	2853.63
19	3438.58	3525.9	2701.86	2868.75
20	3529.50	3435.6	2884.05	2930.58
21	3483.76	3599.7375	28242.0075	2795.22
22	3387.57	3652.8375	2868.75	2845.12
23	3893.92	3590.445	2754.045	2687.45

Table 5: Chiller loading in TR/Hour

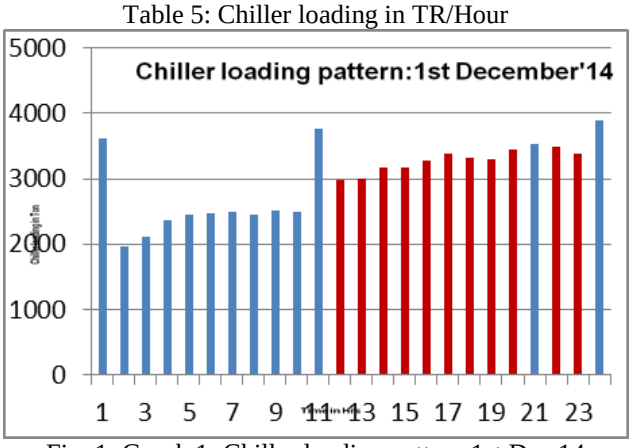

Fig. 1: Graph 1: Chiller loading pattern 1st Dec 14

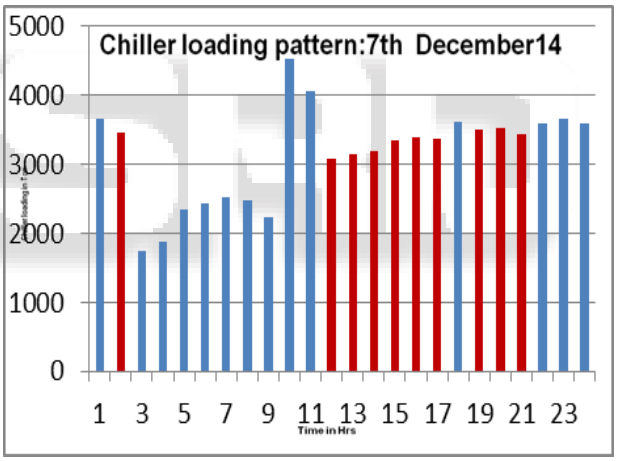

Fig. 2: Graph 2: Chiller loading pattern 7th Dec14

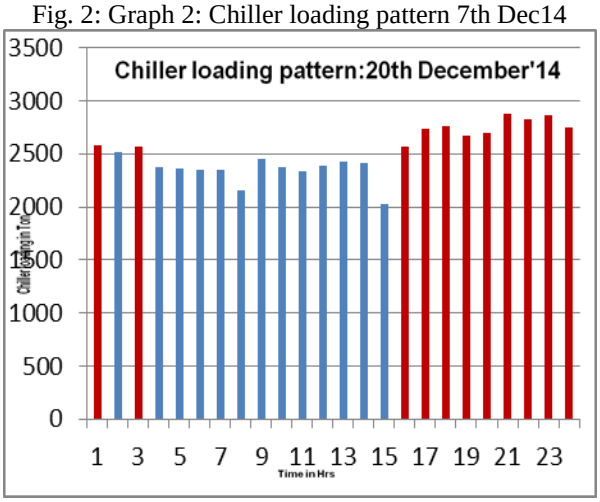

Fig. 3: Graph3: Chiller loading pattern 20th Dec14

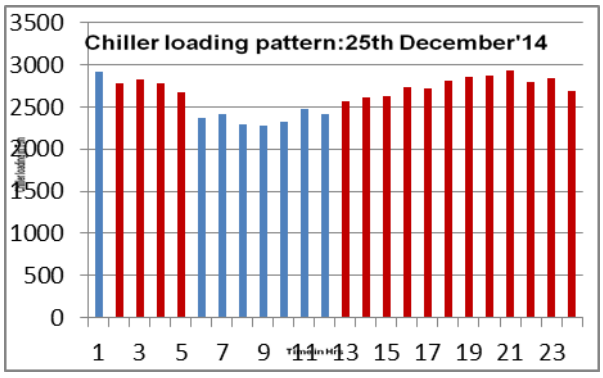

Fig. 4: Graph 4: Chiller loading pattern 25th De14

1) Return on Investment Calculation (ROI):

Existing Chiller capacity 2500TR

There numbers of chillers are installed in the utility.

= 6

It is observed that most of a period in a day chiller is operated at 60 to 70% load. Hence instead of running two big chillers in part load, it is recommended to install a small capacity chiller to match the demand. So energy can be saved.

Now average 11 to 12 Hours/Day chiller are operated at 60 t0 70% of full load

Then the power consumption

= 0.628 /Ton at 90%FLA

For 2500TR the total KWH would be

= 0.63 * 2500

=1, 575KWH

Total power consumption at 70%FLA

= 1, 103KWH

Now consider a small chiller of 1250TR capacity is installed.

For centrifugal chiller KW/TR

= 0.63KW/TR @ 90%FLA

Total KWH for small chiller of 1250TR capacity would be = 788KWH

Then total energy Savings

= 1, 103KWH-788KWH

= 315KWH

Savings in Energy Cost per Hour =315*9.8=Rs.3, 087/Hour (Energy cost Rs.9.8/KWH)

Now Consider Small chiller is operating Average 11 hours/Day

Then, Savings in Energy cost per month = 3, 087 * 11 * 30 =Rs. 10, 18, 710/Month

The Cost of new small 2500TR capacity Chiller 1.95Cr (approximate)

Pump, Motor Cabling Cost +Accessories = 15 Lak (approximate)

Total Cost for new 1250TR chiller = 2.1Cr

Pay Back Period = Cost of new chiller / Total Savings per month

= 2, 10, 00, 000 / 10, 18, 710

= 20.61

Pay Back period will be 20 to 21 Months.

C. Closed Loop Control for Air Handling Unit:

In the site Variable Frequency Drives are installed for all the AHU's. It is observed that the all AHU's Variable Frequency Drives are operated manually. Though they are having temperature sensors the feedback is not taken to vary the speed. Hence supply frequency has to be varied manually according to the demand.

The reason for manual control of VFD is that, Summation of output of the Temperature sensors are not made those which are there in a particular area for which a particular AHU is serving.

1) Advantages of Closed Loop Control:

- Accurate flow Control.
- Improved Energy Efficiency.
- Improved Comfort level.

D. VFD For High Head Roof Fan:

In site there eight HHR fan is there on Level 4 roof. The HHR fan is used for smoke exhausting purpose. The HHR fan is in auto mode and is controlled and monitored by Building Management System[6].

During the day time the radiation from sunrays will falls on the level 4 roof, due to that the temperature inside the level 4 will increases. As we know according to the conduction principle heat will be conducted to the lover level of the building. If we exhaust hot air from level 4 then we can reduce the conduction of heat from top flower to bottom. It is observed that HHR fan can be used to exhaust the hot air from Level 4.

A temperature sensor should be installed in the level 4 which is dedicated for HHR fan to form closed loop. Cooling tower fans might have been cycled ON at full power, when temperature reaches to its set point. When the when temperature is reduced then the fans were turned OFF coming back ON when the temperature rose again. This arrangement uses a great deal of energy and the frequent cycling causes a great deal of wear on equipment.

Hence it is recommended to install VFD for HHR fan.VFD will slows down the HHR fan speed to perhaps 30Hz to constantly maintain the required temperature. The fans speed up or slow down according to the demands. On the chart above, if the fan is running at 30Hz, half of the full speed, assuming no friction losses, the energy level is 1/8th the HP at full speed[7].

III. CONCLUSIONS

Based on the observation and the surveys of the HVAC literature, this study originally identified 4 technological options that could potentially reduce the energy consumption of HVAC systems in CSIA Mumbai. Optimization is great way to decrease the monthly energy bills. If we install one more small capacity chiller then it can be used to match the load demand and hence we can save chiller energy consumption. The replacement of aluminum blades of cooling tower by FRP blade will also reduces the energy consumption. The ATC Technology will clears the deposition killers inside the chiller coil Tube. The Thermal storage system will reduce the electricity cost of chiller by changing the operation sequence of the chiller. Hence we can some amount of energy which consumed by the chiller, so we can reduce the cost which is spent on the energy. Implementation of these techniques can result in reduction in the reduction of energy cost which benefits in profitability of the company.

A. Abbreviations and Acronyms:

- HVAC- Heating ventilation Air conditioning system
- FRP- Fiber reinforced plastic
- AHU- Air Handling unit
- HHR –High Head roof
- VFD- Variable frequency drive

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