HVAC Retrofit
Saves Energy for Infosys

Global Education Centre-1, Infosys Mysore

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Introduction

The HVAC system is one of the largest consumers of energy in a building. In most buildings, these systems are based on rule of thumb parameters, conservative estimates or calculations and large safety factors. This increases not only the cost of the system but also energy consumption.

Infosys, a premier IT company in India with over 28 million square feet of built up area and 130,000 employees embarked upon an aggressive energy efficiency drive in 2008 in an effort to reduce its carbon footprint. The annual energy consumption for 2010-11 was about 265 million units, approximately 40% (106 million units) of it from HVAC. The company has an installed capacity of about 50,000 TR of cooling with 50 chiller plants across different locations in India. HVAC, being the major head of energy consumption, was the primary focus area for energy savings through optimization of operational pattern, replacement of inefficient equipment, re-engineering chiller plants and adding smart controls for demand based operation.

Overview

This article details the approach to re-engineer and retrofit existing chiller plants to upgrade them to the highest efficiency standards. This includes redesigning of pumps to match the actual operating heads, changing the pumping system from constant speed or primary-secondary system to variable primary flow system, and integrating variable speed drives and smart controls to the plant room for accurate demand based operation. The article provides a detailed comparison of the *before* and *after retrofit* scenarios for connected load, energy consumption and space utilization in the plant room. The retrofit project was completed in September 2011 and a saving of about 200,000 units was recorded in just four months of operation, exceeding all expectations. With a payback period of less than 2 years, the case study would serve as an example for the industry, and proves that major retrofits not only increase energy efficiency but are commercially viable too.

About the Authors

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System Description

The retrofit project was taken up in one of the buildings – Global Education Centre (GEC)-1 in the Mysore campus. With a built-up area of about 440,000 sq. ft., the building is divided into south and north wings and comprises 52 training rooms, 183 faculty rooms and a state-of-the-art library that can accommodate 60,000 books.

The HVAC system consisted of 4 x 250TR water-cooled screw chillers and 4 cooling towers with a total capacity of 1,000 tonnes. The pumping system comprised five constant flow primary chilled water pumps, four variable flow secondary chilled water pumps and five condenser water pumps. There were 14 Air Handling Units (AHUs) with a total installed capacity of 1690TR and 570,000 cfm. The diversity is due to the large number of training rooms and faculty rooms, which are not occupied simultaneously. The system included 74 valves – motorized, non-return, isolation and balancing, for controlling flow through the different circuits.

The Case for Retrofit

The analysis began with a comprehensive energy audit of all the equipment in the chiller plant. The following equipment efficiencies were measured during the audit:

- Primary pump : 48-50%
- Secondary chilled water pump : 16-20%
- Condenser pump : 58%
- Cooling tower effectiveness : 27%-37%
- Chiller efficiency : 0.75-0.81 kW/TR
- Plant efficiency : 0.95-1.10 kW/TR

In addition, a typical phenomenon was observed, which indicated an imbalance in the flow between the primary and secondary systems. The pump design details and the actual measured flow readings in the chilled water circuit are shown in *Table 1, 2* and *3*.

Table 1: Pump design details (before retrofit)

Pump type	Head (m)	Flow (gpm)	Motor (kW)
Primary	22	717	15
Secondary	30	1324	37
Condenser	22	717	15

S. No.	Location	Flow, gpm
1	Across Chillers	1525
2	Decoupler line	2094
3	Across AHU's	3619

Table 3: Measured temperature details

S. No.	Location	Temperature, °F
1	North wing chilled water return header	55.4
2	South wing chilled water return header	57.0
3	Decoupler line	55.4
4	Primary pump suction/ discharge	55.0
5	Secondary pump discharge	51.0
6	Chiller outlet	47.0

Observations from the measurements with three chillers in operation were:

1. Primary flow measured across the chiller circuit was 1525 usgpm.
2. There was a bypass flow of 2094 usgpm back into the secondary system through the decoupler line. This indicated demand being higher than supply. This caused the AHU inlet temperature to rise up to 51°F due to which the AHUs were never able to meet the set point.
3. Due to the high chilled water inlet temperature to AHU coils, the space conditions were not comfortable because of high RH.

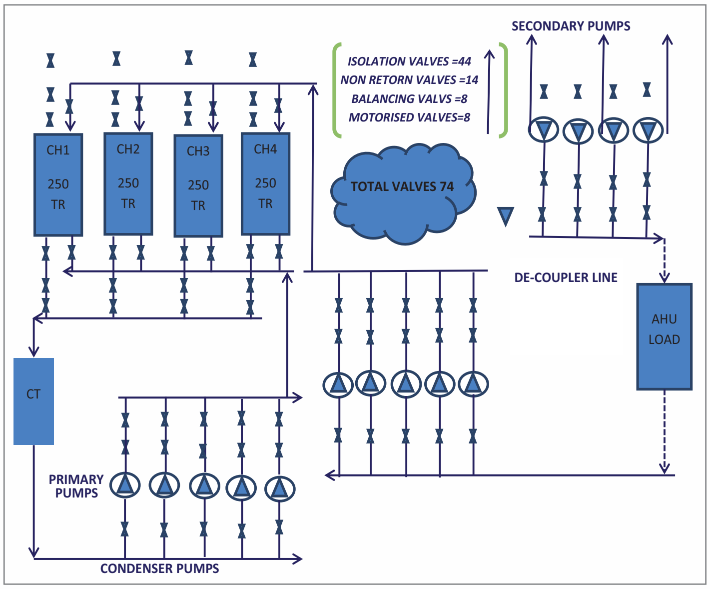

Figure 1: Chiller plant schematic before retrofit

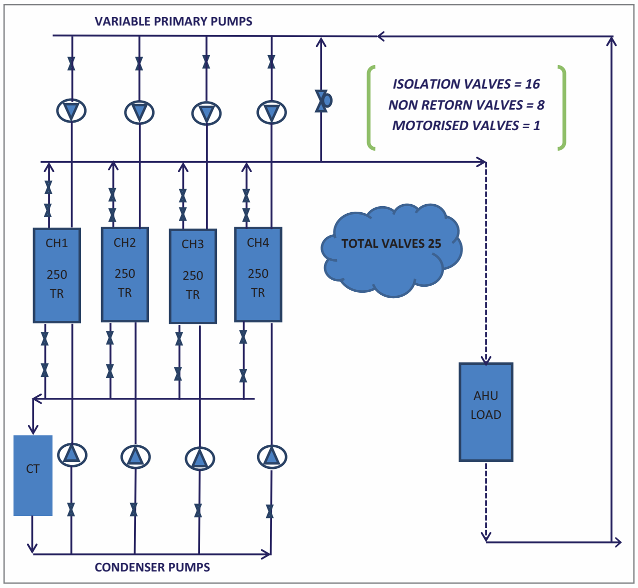

Figure 2: Chiller plant schematic after retrofit

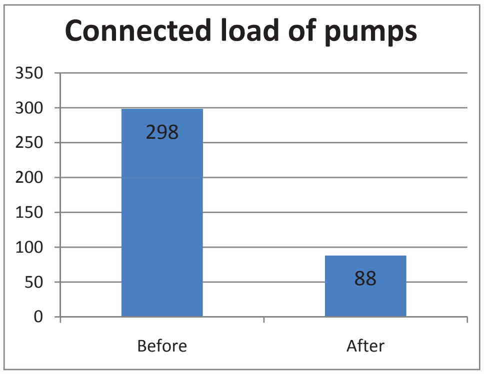

Figure 3: Reduction in connected load of pumps

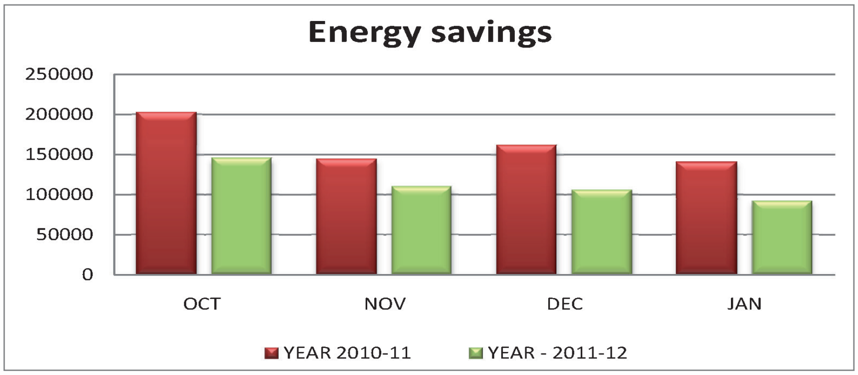

Figure 4: Energy savings

4. The third chiller was required to be operated throughout the day.

Approach to New Design

The new design approach included several parameters for the most efficient contemporary chiller plant designs. These were:

1. *Converting constant primary – variable secondary to variable primary flow pumping system for chilled water.*
   A variable primary flow system ensures that chiller outlet temperature is close to its design temperature and AHU coil inlet is close to the chilled water outlet temperature. With this concept, the two sets of chilled water pumps were replaced by one set.
2. *Redesign and right sizing of chilled water and condenser pumps.*
   Measuring operational parameters gives the advantage of selecting new equipment to match the exact requirements in retrofit projects. In this retrofit, a total of 14 pumps were replaced by 8 pumps of much lower capacity, thereby reducing the connected load substantially.
3. *Connecting vertical in-line pumps directly to each chiller to eliminate water balancing issues.*
   This concept results in eliminating balancing valves and at the same time helps in controlling water flow to individual chillers. Traditionally, balancing valves are usually adjusted to get the desired flow across each chiller, which results in a large pressure drop. The pressure drop measured across chilled water balancing valve was 0.5 kg/cm^2, and across condenser line 0.4 kg/cm^2. By removing the balancing valves, the head of chilled water pump was reduced by 5m and condenser pumps by 4m. Additionally, with in-line pumps, motorised valves were eliminated as the pumps are coupled to the chillers and whenever a chiller needs to operate, the respective chiller pump has to operate. Due to this optimization, the number of valves in the chiller plant was reduced from 74 to 25.

Valve description	Before	After
Motorized valves	8	1
Non retrun valves	14	8
Isolation valves	48	16
Balancing vlaves	4	0
Total valves	**74**	**25**

With all the above improvements in the pumping system, the chilled water pump head reduced from 52m to 20m, and the condenser water pump head reduced from 22m to 18m.

4. *Demand based control for cooling tower fans to improve overall plant efficiency.*
   Variable frequency drives were installed on the chilled water

Figure 5: End-suction pumps – before retrofit

Figure 6: In-line pumps – after retrofit

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pumps, condenser pumps and cooling tower fans to vary the speed as per requirements and to operate the plant always at the highest efficiency point.

The combined effect of piping and pumping system optimization resulted in space savings in the plant room to the tune of 23%.

Results

1. ***Reduction in connected load of pumps by 70%*** (see *Figure 3*)
2. ***Reduction in energy consumption by 30%*** (see *Figure 4*)

The retrofit project was completed in September 2011, and energy data for the next 4 months showed a reduction of about 30% compared to the same months of the previous year.

3. ***Reduction in plant room space by 23%***

Due to the in-line pumping system design, the space occupied previously by the 14 end-suction pumps was freed up in the plant room. This resulted in release of about 750 sq. ft. This serves as a valuable input for optimization of areas in new plant room designs. *Figure 5* and *6* show photographs of the plant room before and after the retrofit.

Conclusion

The case study shows that major retrofits such as changing the pumps and pumping system are very useful in old chiller plants, since they result in significant energy savings and have short pay back periods. This project in Mysore had a payback period of less than 2 years for the investment made towards the entire retrofit including a central plant manager. ❖