HVAC for Ashwini Hospital Solapur

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Solapur is the 7th largest city in Maharashtra with a population of close to a million, near the border with Karnataka and Andhra Pradesh. An ancient city, at one time it was also a large textile centre and even today Solapur 'chaddars' and towels are well known.

Ashwini Sahakari Rugnalaya and Research Centre or Ashwini, for short, was established in 1983 by a team of fourteen devoted doctors and social workers, as an OPD facility in a slum area. But with a broad vision and immense determination, the founders saw this small beginning blossom into a 30 bedded hospital within a span of five years, in 1988, in the heart of Solapur city, with functioning radiology and pathology departments. Now, almost 22 years later, Ashwini Hospital, with all its expansions and newer buildings, has a bed capacity of 300 and has become a premier co-operative hospital, one of the largest co-operative ventures in Solapur. It is ranked as one of the best in providing modern medical services, under one roof, on a no-profit, no-loss basis to the 'common' man in a variety of social classes and at subsidised charges to low income groups, not only from south Maharashtra, but also from neighboring states of Karnataka and Andhra Pradesh.

Design Philosophy

Solapur, as well as most parts of the state are facing a tremendous power shortage, leading to frequent power cuts and dependence on captive power generating sets, which proves to be very expensive. This factor alone called for an energy-saving design of the air conditioning system and "appropriate" technology, which can be understood and followed by the local plant operators and technicians.

The other important considerations that were kept in mind during the design phase were:

- Solapur, essentially, has a dry climate.
- Since rainfall is scanty, water availability is a problem and water quality is poor.
- A co-operative hospital called for low first costs.

Fresh Air

The design was based on ASHRAE fresh air standards for OTs, ICUs and other areas.

About the Authors

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Most patient rooms are not air-conditioned. 100% fresh air was not considered, since it was neither an ASHRAE requirement nor was it a necessary stipulation laid down by the doctors, as the kind of operations envisaged to be done in the OTs were possibly not super-critical and/or were not expected to generate critical cross-contamination issues. 100% fresh air would not only increase the cooling load in a large proportion, thereby increasing initial as well as operating costs, but would also end up necessitating energy recovery wheels which would further increase initial costs.

Fresh air considerations were taken as 5 fresh air changes per hour for the OTs and 2 fresh air changes for the ICUs / CCUs. ASHRAE ventilation standard (ASHRAE 62-1999 which was referred then) specifies 25 cfm per person for OTs, and 15 cfm per person for ICUs. Looking at the expected occupancy figures, these were much beyond that.

Filtration

Filtration ends up being a very critical element especially for OTs & ICUs. The OTs were given class 10,000 level filtration and laminar flow and ICUs were given 5 micron level filtration. This is done by use of pre-filters, fine filters and terminal HEPA filters in series for the OTs and pre-filters and fine filters for the ICUs and CCUs.

Majority of the AHUs installed here are for specific areas like cath-labs, ICUs, CCUs and the like with two AHUs having only pre-filtration, i.e. without fine-filtration. It may be noted that even though the filtration levels given here are in 'EU' classification, during tendering stage it was defined as HEPA, fine and pre-filters with micron level specified to specific percentages.

The overall HVAC system was designed to cater to multiple areas located on various floors. Detailed, computer-based simulation of the individual, floor-wise and overall heat loads was done across all seasons to arrive at the applicable TR/CFM/ADP/SHR etc. The results obtained were analysed for minimum air quantity for clean air application, SHR & ADP figures to decide on the CHW temperatures, CFMs, blower selections, coil designs etc.

AHU-Id	Temp - DB	RH	Fresh ACH/hr	Filtration level	Tonnage TR	Air flow CFM
G2	22	50	5	EU 13	5.0	2400
G1	24	55	2	EU 7	9.0	4300
G3	24	55	2	EU 7	5.0	2000
G4	24	55	2	EU 7	10.0	4000
G5	24	55	2	EU 4	15.0	7000
F2	24	55	1	EU 7	8.5	2400
F1	24	55	2	EU 13	8.0	3400
F3	22	50	5	EU 7	10.0	4000
F4	24	55	2	EU 7	5.0	2000
F5	24	55	1	EU 4	15.0	7000
S1	24	55	2	EU 7	4.0	2000
S2	24	55	2	EU 7	10.0	5500
S3	24	55	2	EU 4	8.0	3400
S4	24	55	1	EU 7	8.0	3400
					120.5	**52800**

Table 1: Heat Load summary sheet

These calculations were then tabulated for various areas and the overall TR was derived. The eventual summation gave the results and selections as per *Table 1*.

System Selection

Two other issues mentioned earlier i.e. power cuts and water quality and quantity had to be factored into the design. Since water availability, both in terms of quantity and quality was a problem, the choice of system was air-cooled chillers. Based on the seasonal and hourly analysis and the operational timings of the OTs and other areas, it was decided to use multiple chillers configured as 1 x 50% plus 2 x 25%. During execution, the actual capacities of the chillers came out as 55TR + 35TR x 2 nos.

For the above configuration, reciprocating chillers were a fitting solution. However, during tendering, scroll / screw chillers were also allowed to be quoted. Eventually, for the capacities required, reciprocating chillers were the best option. *See Photo 1.*

The weather data analysis for Solapur indicated a summer DBT as high as 43°C, but with a low WBT. The monsoon and winter DB were also quite low - thereby clearly showing that air-cooled chillers could operate with good efficiency during monsoon and winter seasons, but not during summer conditions, especially during the afternoon.

Hence the "sensible air-precooling system (SAPS)" system was used to lower the condenser-air-entry temperature only when the ambient DBT exceeded 32/33°C, thereby effectively bringing the condensing temperature for the chiller to 42/44°C range which was almost equal to the typical water-cooled range of 42°C. This also eliminated the hassle and maintenance issues of cooling towers, de-scaling etc. Moreover, the SAPS would operate at DBs exceeding 32°C i.e. for not more than 6 hrs/day during summer, based on the daily DBT variation at Solapur.

The end result of this exercise was simple : conserving precious water and power in the most judicious way. *Photo 2* shows the sensible air pre-cooling system.

Requirement of Hot Water

Any hospital will necessarily require hot water and this is a regular need. The client had an intention of going in for a solar water heater based system. However, when they heard that hot water can actually be generated out of the air conditioning system, they were a happy lot and were willing to try out the design.

It must be noted that even with a condensing temperature of 43°C, the discharge temperature of the chillers was more than adequate to heat water to 60°C. Since hot water was very much needed for the hospital use and also for re-heat, a Heat Recovery system was proposed, to generate around 12000 LPD of hot water with a storage capacity of 6000 L in insulated tanks.

The Heat Recovery system provided useful hot water for the HVAC and for the hospital use, at zero energy cost and in the process also lowered the heat transfer needed at the air-cooled condenser by about 5%, thereby generating further energy savings in terms of chiller power.

Additionally, to save blower power, for areas using HEPA filters, suitable VFDs (Variable Frequency Drives) were proposed for the OTs

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Photo 1 : Air-cooled chillers with sensible air pre-cooling system and shades

Photo 2 : Sensible air pre-cooling system in operation

which needed high static for the HEPA filters. VFDs for motors with high static applications always prove beneficial for overall power consumption, owing to the variable nature of the static pressure drop across the HEPA filter in clean and choked conditions.

Exposed roofs were insulated and all windows were film coated to minimise load and air quantity needed. Special laminar flow plenum designs were installed in OTs.

Execution

As consultants, once the design was frozen and detailed specifications laid out, on placement of order it was now the turn for execution monitoring. This is a very critical area of the project, which essentially ensures that the project actually comes out the way it has been designed. There are times, when certain site decisions have to be taken, which may not be exactly as planned on the drawings. The correctness of such decisions goes a long way in getting the required end-result.

Energy Saving Payback Analysis

Since an extra effort in terms of designing and cost had been incurred for the energy saving equipment, it was important that the payback analysis and other energy saving calculations were put in place to confirm the effectiveness of the system.

Sensible Air Pre-cooling System Energy Savings

Due to a reduction in condensing temperature from 54°C to 44°C the compressor power consumption reduces by approx 0.2 kW / TR. Therefore, for an operating TR of 120, the power savings are :

120 TR x 0.2 kW / TR = 24 kW of net power savings.

Considering that the hospital operates for 365 days and considering the annual load pattern for the design loads [approx 67% of maximum load as the annual average], the energy savings per annum with energy rate at Rs.5.5/kWh are :

24 kW x 67% x Rs.5.5 / kWh x 24 h/day x 365 days/year = Rs.7,74,734 of net Rupee savings.

Considering the first cost, the payback period was less than six months.

Heat Recovery Energy Savings

The Heat Recovery system installed is to provide 12000 LPD (Litres per day) of hot water at 60°C. Considering that the average water "In" temperature to be 20°C, the net heat recovered is :

12000 LPD x (60°C - 20°C) = 4,80,000 Kcal / 24 Hrs = 23.27 kW.

Since these savings represent less than 5% of the total condenser heat rejection, these savings are always in use for 365 days of year. Therefore the net annual Rupee savings using the same energy rate is:

24 kW x Rs.5.5 / kWh x 24 h/day x 365 days/year = Rs.11,56,320 of net Rupee savings.

Considering the first cost, the payback period was less than six months.

It must be noted that the energy consumption figures were taken as commitments at the time of order placement and these were checked based on the above workings. They were subsequently verified to be as per the commitments made.

Conclusion

India's population of over 1.1 billion lives mainly in its villages, neighbouring towns and cities. Such cities, like Solapur, which need more and better healthcare facilities to match the rapid urbanisation which is taking place all over the country. Planning and building more hospitals and expanding existing hospitals is the only way to satisfy the large demand for better healthcare in the rural areas.

Building costs must be kept under control and so also the cost of HVAC and MEP systems, so that the common man can afford the price of healthcare services. Green building designs can help cut heat loads and reduce cooling plant capacities. HVAC systems must be kept simple, sturdy, dependable and easy to maintain, considering the shortage of educated and trained technicians to operate and maintain such plants in these small towns.

With the shortage of water and its poor quality in most parts of the country, the use of air-cooled DX systems or air-cooled chillers is essential. Free supply of hot water from heat recovery units installed in the refrigeration plants is highly recommended. Minimising the use of power not only reduces operating costs but also reduces the crippling, additional cost of using genset power, when grid-power cuts take place. ❖