Design and Analysis of HVAC System for Service Room of a Shopping Mall Using Rivet-MEP Software

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Abstract

A distinctive Heating, Ventilating and Air Conditioning Systems (HVAC) are established for the most part of cooling purpose in addition to retain the air quality. In view of the fact that, nearly everyone of the HVAC group has not have of exact inputs for the manipulate reason leads to uncomforting. In a general heating, ventilation, and air conditioning (HVAC) system, huge amount of energy is wasted all the way through an incompetent operation due to the lack of consistent building tenancy measurement and forecast. The present work is concerned with the design and analysis of a most effective HVAC system which provides the complete calculations for different components and spaces in a service room of the shopping mall. Entire building and various rooms layout was designed by using the Rivet-MEP software from the previous measured inputs. The different HAVC system output parameters like, peak cooling load, peak latent load, peak heating load, peak sensible cooling load, peak cooling air flow and peak heating air flow were obtained for the selected service room of a shopping mall from the rivet-MEP Software. It was shown that the exact heating, cooling rates and loads were observed by the components of the service room are measured by the software significantly.

Keywords: Shopping mall, service room, HVAC system, design, analysis, rivet-MEP Software.

1. Introduction

A Heating, ventilation, and air conditioning (HVAC) system is designed to achieve the environmental requirements of the comfort of occupants and a process. HVAC systems not only regulate the temperature inside the building, they also improve the quality of air. The quality of air pertains to humidity, and a typical HVAC system will reduce the amount of humidity in the air so your workers and employees can continue enjoying a cozy and pleasant atmosphere at work. A typical HAVC system is shown in figure.1
Since last three decades, the energy crisis has been certainly one of the strong motivations in the changes of the HVAC industry towards more energy-efficient buildings without compromising the comfort. As energy requirement and fuel consumption of heating, ventilation and air-conditioning (HVAC) systems have a direct impact on the operational cost [1]. HVAC- Heating, Ventilating and Air Conditioning, is a branch of mechanical engineering that is concerned with achieving both indoor and vehicular human comfort by providing adequate and acceptable heat and fresh air. Apart from residential applications, the HVAC system is also very important and essential in many industries and laboratories in cold storage and preservation purposes, pre-cooling and Pasteurization of milk, in various manufacturing processes in rubber industries, textile industries, etc. It involves the process of exchanging or replacing air in any place to provide high quality indoor air, which involves temperature control, oxygen replenishment, and removal of moisture, odours, smoke, heat, dust, etc. from the air [2]. With rise in temperature because of global warming [3], the increase in the unavailable energy (increase in entropy) and unusual climatic changes seen in recent years [4] has caused an increased demand for heating and cooling technologies, which is what HVAC systems do and so these systems have a wide applicability ahead. HVAC design is a critical component and if performed carefully, energy efficient system at affordable cost can be developed. Although, designing an HVAC system is a complex task since there are various parameters which need to be taken care. There parameters include the selection of proper tonnage and specifications because, if not selected properly, then the required comfort cannot be achieved and the design efforts are wasted. Heating, Ventilating and Air Conditioning systems (HVAC) vary in their needs from one place to another, they are of extreme necessity in Middle East. Such systems involve many mechanical and electrical components that require a considerable and continuous supply of energy [5]. In this study a typical HVAC system was designed for a service room in shopping mall to estimates the different heating and cooling loads due to the various components which are available inside the room.

2. HVAC system requirements

Heating, ventilation, and air conditioning (HVAC) system is designed to achieve the environmental requirements of the comfort of occupants and a process. HVAC systems not only regulate the temperature inside the building, they also improve the quality of air. The quality of air pertains to humidity, and a typical HVAC system will reduce the amount of humidity in the air. So workers and employees can continue enjoying a cozy and pleasant atmosphere at work. HVAC systems condition the air temperature, humidity, and air quality for the comfort of the
people inside a building. HVAC is classified into three main categories: All-Water, Water-Air and All-Air systems [6]. All-water systems are those with fan-coil, unit ventilator, or valance-type room terminals, with unconditioned ventilation air supplied by an opening through the wall or infiltration. Cooling and dehumidification are provided by circulating chilled water or brine through a finned coil in the unit. Heating is provided by supplying hot water through the same or a separate coil using water distribution from central equipment. Water-Air systems are systems where the spaces within a building are cooled by air and water. Generally the cooling water is furnished to carry away most of the sensible energy from the conditioned space. The air provides the ventilation required for air quality and carries away the moisture resulting from the space latent load. The air may also provide some additional sensible cooling.

Figure 2 Requirements for HVAC system implementation

3. HVAC System design

Design process of HVAC system for a service room in a shopping mall is initially started with the building layout configuration with the existing layout data’s like area of the entire mall, roof area, wall area, power, number of people, sensible heat gain/person and latent heat gain/person etc. The next stage of this system design is moved to the selection of various HVAC components based on the heating and cooling load calculations. The various components which are used in a typical HVAC system is shown in figure.3 (A) - 3 (H) respectively. The very next stage is to placing the various components of the HVAC system in the building layout, according to the space availability and type of rooms in the shopping mall. Placing of diffuser is the next step of the design process to deliver the conditioned air to the corresponding rooms. Supply air diffusers are arranged in the building layout as per the requirements of individual rooms. In order to collect the exhausted air by the living things (people) and non living components inside the rooms, an appropriate return air diffuser has been chosen and placed on the building layout. Placing air handling unit (or) fan coil unit on the layout is the very next step of the HVAC system design. In this stage, fan coil unit has chosen for cooling purpose of the exhausted air from the selected room of the shopping mall. After the successful installation of the various
components of the HVAC system on the building layout, a comprehensive three dimensional visualization model has created by the software. After this model creation, the required input data’s are provide for the calculated results for the comfortable air to the all rooms and spaces of the shopping mall. Shopping mall layout without HVAC system is shown in figure.4. The complete ceiling layout of the shopping mall, after the HAVC system implementation is shown in figure.5. A 3D visualization model of the complete shopping mall obtained from the rivet-MEP software with HVAC ceiling layout is shown in figure.6.

![Diagram of HVAC system components](image)

Figure 3 Components of a typical HVAC system (A) Fan coil unit (B) Flexible ducts (C) Damper (D) Supply air diffuser (E) Return air diffuser (F) Supply air register (G) Linear slot diffuser (H) Return air register
Figure 4 Layout of shopping mall

Figure 5 Ceiling layout of the shopping mall after HVAC system implementation
4. Results and Discussions

The following results are obtained from the rivet-MEP software for the successful design, analysis and implementation of a typical HVAC system in a service room for a shopping mall. Peak cooling load and peak sensible cooling loads for various places inside the shopping mall is shown in figure. 7. It was observed that the minimum peak cooling load of 565 W was found in janitor room and the maximum peak cooling load of 13229 W was found in MV room respectively. It was noted that the minimum peak sensible cooling load of 539 W is gained from the janitor room and the minimum peak sensible cooling load of 20556 W is found at store room-2 respectively. The amount of peak latent load and peak heating load required for various spaces, equipments, components inside the shopping mall is shown in figure. 8. From that figure, it was noticed that the minimum peak latent load of 07 W is observed from the gents wash room and the maximum peak latent load of 336 W was obtained from the MV room respectively. On the other hand, the peak heat load of the shopping mall service room was found maximum at MV room (851 W) and the minimum peak heat load was obtained from janitor room (44) respectively. Peak cooling air flow to the different rooms of a service room for a shopping mall is illustrated in figure.9. It was denoted that the maximum flow of cooling air (9007 CFM) was utilized at ladies prayer room and also the minimum of cooling air flow was observed from janitor room (95.1) respectively. In figure.10 maximum and minimum flow rate of the heating air
which is exhausted from the various rooms of a shopping mall is represented. It was noticed that the maximum peak heating air flow into the various rooms was observed maximum of 140 CFM at MV room and minimum of 7.3 CFM at janitor room respectively. Amount of cooling load observed by the individual components in a shopping mall of service room is shown in figure.10-13 respectively. Amount of cooling load utilized by the wall and roof was represented in figure.11. It was noted that the maximum amount of room cooling load was observed by the store room wall of 788 W and the minimum cooling load was observed by stair-01 wall of 09 W respectively. Observed cooling load by the different shopping mall roofs was found maximum at LV room roof of 10973 W and the minimum cooling load of 352 W was observed by gent’s prayer room. Cooling load distribution and utilization by infiltration and lighting of the shopping mall service room was illustrated in figure.12. It was noticed that the store room inside the shopping mall was utilized the maximum cooling load of 466 W and the minimum cooling load of 08 W was utilized by stair-01 respectively. Cooling load observation due to the lighting inside the shopping mall is found maximum in MV room (497 W) and the minimum cooling load of 17 W is noticed in janitor room respectively. Cooling load for power and people is shown in figure.13. It was noticed that the maximum cooling load of 647 W for electricity power consumption is found at MV room. Minimum cooling load of 22 W for power consumption due to electricity was found in janitor room respectively. Cooling load for shopping mall peoples was found maximum in transfer room (303 W) and also the minimum cooling load of 08 W is observed in janitor room respectively. Percentage of cooling load observed by wall and roof of the different rooms in a service room is shown in figure.14. It was noticed that the maximum cooling load of 26.82% is found at gent’s prayer room. Minimum percentage (0.30%) of cooling load was found in stair-01 walls. Minimum percentage of cooling load was observed by the gent’s prayer room roof (24.25%). On the other hand maximum percentage of cooling load (89.52%) was found at gent’s wash room respectively. Percentage of cooling load distribution and utilization by infiltration and lighting of the shopping mall service room was illustrated in figure.15. It was noticed that the gent’s prayer room inside the shopping mall was utilized the maximum percentage of cooling load (18.57%) due to infiltration and the minimum percentage of cooling load due to the infiltration (0.25%) was utilized by stair-01 respectively. Percentage of cooling load observation due to the lighting inside the shopping mall is found maximum in gent’s prayer room walls. Minimum and maximum heat load exhausted by the shopping mall’s different walls and roofs were shown in figure.17. It was noticed that the minimum heat of 178 W was obtained in store room wall and the minimum heat load of 03 W is found at strai-01 wall respectively. Heat load of 647 W for roof of the shopping mall’s different portions were found maximum at MV room and the minimum heat load (21 W) for roof was found in gent’s prayer room respectively. Infiltration heat load of 48 W was found at rest room and minimum heat load (01 W) for infiltration was observed at stair-01 respectively. Percentage of heating load observed by wall, roof and infiltration of the different rooms in a service room is shown in figure.18. It was found that the maximum heating load of 67.86% is found at gent’s prayer room walls. Minimum
percentage (1.76%) of heating load was found in stair-01 walls. Maximum percentage of heating load (100%) was observed by the gent’s wash room roof. The minimum percentage of heating load (7.11%) was found at ladies prayer room respectively. Maximum percentage of infiltration heating load (47%) was found at stair-01 and minimum infiltration heating load percentage (0.84%) was observed at water heater room correspondingly.

Figure 7 Peak cooling and peak sensible cooling loads for various places of shopping mall

Figure 8 Peak latent and peak heating loads for various places of shopping mall
Figure 9 Peak cooling air flow in different locations of shopping mall

Figure 10 Peak heating air flow in different locations of shopping mall

Figure 11 Amount of cooling load for wall and roof
Figure 12 Cooling load for infiltration and lighting

Figure 13 Cooling load for power and people

Figure 14 Percentage of cooling load required for wall and roof in a shopping mall
Figure 15 Percentage of cooling load required for infiltration and lighting in a shopping mall

Figure 16 Percentage of cooling load required for power and people in service room

Figure 17 Amount of heating load required for wall, roof and infiltration in a shopping mall
Conclusion

A typical shopping mall’s building layout was created and the design, analysis of HVAC system of a service room for a shopping mall is accomplished successfully with the help of rivet-MEP software. Different inputs for the shopping mall HVAC system design were analyzed and the corresponding outputs from the HVAC system to the different spaces, rooms and components of a service room were noticed. Various HVAC system parameters for the entire shopping mall also executed and the corresponding heating and cooling effects inside the mall was observed and compared with each other. Minimum, maximum cooling and heating loads distribution to the all portions inside the shopping mall were calculated by rivet-MEP software correspondingly. It was found from the software output results, maximum cooling and heating load was observed by the particular rooms compared with all other rooms of the shopping mall.

References


