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ScienceDirect

Energy Procedia 134 (2017) 386–393

Procedia Engineering

www.elsevier.com/locate/procedia

9th International Conference on Sustainability in Energy and Buildings, SEB-17, 5-7 July 2017, Chania, GREECE

Operational performance of an Air Handling Unit: insights from a data analysis

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Abstract

Space heating and cooling is one of the most relevant causes of energy consumption in both residential and tertiary sector buildings. In particular, service buildings and offices are mostly served by all-air HVAC systems in which control logics are fundamental to guarantee reliability and performance. Building automation systems are therefore becoming more and more relevant as a support tool for reducing the energy consumption in these contexts. For this reason, the detailed analysis of operational data from real units can help in understanding the main variables that affect the performance and functioning of all-air systems. This paper presents some results from operation data analysis of an Air Handling Unit (AHU) serving a large university classroom. The main drivers of the energy consumption are highlighted, and the classroom occupancy is found to have a significant importance in the energy balance of the system. The availability of historical operation data allows performing a comparison between the actual operation of the AHU and the expected performance from nominal parameters. An example of fault detection is proposed, considering the operation analysis of the heat recovery unit over different years.

Peer-review under responsibility of KES International.

Keywords: Air Handling Unit, Heating, Energy Performance, Operation Analysis

1. Introduction

This paper presents the operational analysis of the performance of an AHU heating and cooling a large classroom in a university. Another point to be considered is the variable internal heat gain generated by the students, which can provide in some cases the heat required by the classroom in winter and become a significant challenge in the cooling season. The variable occupancy of the space can be an issue in a number of other applications, such as theaters, restaurants, cinemas, etc.

In addition, the paper considers some possible improvements to the current operation of the AHU, in order to perform a preliminary evaluation of the potential energy savings.

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Peer-review under responsibility of KES International.
10.1016/j.egypro.2017.09.579

2. Energy monitoring of HVAC systems

Data analysis techniques can provide a significant support in the operational optimization of HVAC systems, both for fault detection and diagnosis and for reduction of energy consumption. In particular, Air Handling Units (AHU) represent a significant share of the HVAC systems of the service sector (offices, schools, commercial buildings). The operation of AHUs shows common problems and solutions, and therefore any methodology could be extended to similar applications.

The combination of knowledge and information from monitoring data is the base for an effective operational optimization [1]. Data driven methodologies described in the literature are mainly used for fault detection and diagnosis [2,3] and for optimization of the operation parameters, aiming at reducing energy consumption [4,5]. Along with the evolvement of energy-efficient HVAC in commercial buildings, the use of fault detection and diagnosis in HVAC fields has been increased continuously thanks to various computer-aided techniques with low-cost installation [6]. Some applications have considered machine learning techniques [7] and neural networks [8], with the aim of developing a reliable, scalable, and affordable diagnostic solution for such systems.

3. Methodology

3.1. Description of the HVAC system

The Air Handling Unit considered in this study provides the air conditioning of a large classroom (volume of about 1,500 m^3) with maximum occupancy of 400 students. The HVAC system has been working since 1991 and is used around 2,000 hours per year (8-19 Mon-Fri and 8-14 on Sat). The controlling system is based on the commercial building management system developed by Siemens for HVAC (Desigo^{TM}). A general refurbishment of the classroom was carried out in the summer of 2015. The windows were replaced with new ones with higher insulation and an automated opening and closing system.

The HVAC system is an all air system supplying 10,000 m^3/h and returning 8,000 m^3/h, and 2,000 m^3/h get lost for overpressure. The supply air fan has a nominal power of 5.5 kW and the return air fan has 2.2 kW of installed power. The fans are currently at fixed speed, with no inverter, and as a result the clogging of the air filters causes lower electricity consumption and air flow rate. The system can operate with 100% outdoor air, partial recirculation or total recirculation.

Some of the data available include:

- Power draw for ventilation;
- Fans pressure increase;
- Supply,return, outdoor and exhaust airflow rate;
- Indoor air quality (supply and return air): CO_2, temperature, RH%;
- Pressure drop across filters;
- Thermal power, separate for heating and cooling mode;
- Particle concentration upstream and downstream of the fine filter bank.

The particle concentration and pressure drops across filters have not been analyzed in this study.

A scheme of the HVAC system is shown in Figure 1, with its main components and the instrumentation available.

3.2. Data acquisition and processing

The data acquisition has been performed with a time interval of 15 minutes since the beginning of the monitoring project, mainly to provide data that is consistent with the measurement of power. The software for data acquisition in the first part of the project was a custom SCADA application written in Movicon (similar to VBasic) and the data was sent via MODBUS/TCP. In October 2015 this application has been substituted by a more simple and effective Perl script with a free command line tool to query Modbus devices (MODPOLL.EXE). Moreover, this script runs on a virtual machine in order to increase its reliability.