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Influence of air-conditioning outdoor unit arrangement strategy on energy consumption

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Abstract

How to prevent the hot air entering the outdoor unit is thus critical for Split-type air conditioner (AC) operation temperature control. This investigation studied the influence of louver installation (angle and spacing) and outdoor AC unit arrangement (style and location) on the system ventilation using computational fluid dynamics (CFD) technique. With the louver spacing increasing and the distance between neighbouring outdoor AC units decreasing, the working temperature increases. Considering heat dissipation and protecting machines from rainwater, the optimum louver angle is 100 degrees. The vertical arrangement for outdoor units is more beneficial to exhaust hot air than the horizontal arrangement. In conclusion, in order to reduce operation temperature while saving energy, the following design points are recommended:

a. Vertical arrangement for outdoor units;
b. Larger distance between neighbouring outdoor units;
c. Smaller louver spacing;
d. 100 degrees for the louver angle.

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Keywords: Angle and spacing of louver, Arrangement and location of air-conditioning outside unit, High-rise building;

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1. Introduction

Nowadays, split-type air conditioners are widely used. The operation temperature of air-conditioning outdoor units has a significant effect on the coefficient of performance (COP) of air conditioners (Chow et al 2002 and Barreira et al 2013). High working temperature could decrease the efficiency of split-type air conditioners and increase the energy consumption. Sometimes it results in that outdoor units stop working. However, large demand and limited installation space for split-type air condition outdoor units in high-rise residential buildings would enhance the thermal buoyancy and raise the working temperature of air-conditioner outdoor units. Therefore, how to prevent the hot air entering the outdoor unit is critical for ACs operation.

Nomenclature

b	the source term or boundary conditions
ϕ	the flow variables (velocity, enthalpy, and turbulence parameters)
ϕ_p	the variable of the present cell
ϕ_{nb}	the variable of the neighbouring cell
α_p	the coefficient of the variable at the present cell
α_{nb}	the correlation coefficients of the variable of the neighbouring cells
$\Gamma\phi,eff$	the effective diffusion coefficient
$S\phi$	the source term

Significant effort has been made in recent years to optimize the operation temperature of outdoor AC units by CFD. For example, Xue et al (2007) found that it could attenuate the temperature rise if the blowing angle of condenser fans titled upward. Avara and Daneshgar (2008) recommended various optimum distances between outdoor AC unit and supporting wall in different conditions. Bojic et al (2002) showed that deeper recessed space placing condensing units was good for inner condenser units but do harm to some outer condenser units. Chow et al (2001) investigated that using a light well for the discharge of cooling air from the condensing units of the split-type air conditioners had better energy performance than the case when condensing units are being placed inside a building re-entrant. Chow et al (2000) found that T-shaped re-entrant had best energy performance compared with I-shaped and L-shaped re-entrant which outdoor condenser placed on. Choi et al (2004) investigated that operation temperature rose with outdoor wind speed increasing. However, few research were focused on the influence of louver parameters and outdoor AC unit arrangements on the heat dissipation of outdoor AC units. Due to the research gap, this study used CFD to investigate the effect of louver setting and outdoor AC unit arrangement on the working temperature of outdoor AC units, and proposed some design recommendations. It can be further developed as a strategy for building energy saving.

2. Methods

2.1. The test cases

Fig. 1 showed air-conditionings installed on the outdoor wall of a 30-storey high-rise apartment building in Chongqing, China. Considering the effect of outside wind, the computational domain is extended 50 m from the building front wall and 24 m from the left and right walls of building. To analyse the rising flow, the computational domain is extended 115 m above the top of the building, as shown in Fig. 1(a). The outside temperature of the summer design specification was assumed to be 36.3℃ in Chongqing. Considering that outdoor wind could influence outdoor AC units arrangement style, this research assumed breeze from right with 0.2m/s instead of no wind.

The ACs installation locations were showed in Fig. 1(b). All ACs operated simultaneously at full loads, which was the worst operating condition. The outdoor AC unit exhausted hot air from its front with a heat dissipation rate of 3.5 kW. There are two arrangement styles, as shown in Fig. 1(c) and (d). Louvers are used to enhance the building appearance, and its spacing d and angle α is showed in Fig. 1 (e). This investigation studied the influence of louver