The effect of air infiltration from window gaps on the performance of baseboard heating system and occupants' thermal comfort conditions

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Abstract

Nowadays, the baseboard heating systems have attracted the attention of many HVAC engineers because of its uniform temperature distribution and low feed water temperature. Despite this, the uniformity of indoor thermal conditions can be disturbed by some parameters such as exterior walls and air infiltration from window gaps. Therefore, the main goal of this study is to investigate the effects of air infiltration from window gaps on the performance of baseboard system and occupants' thermal conditions. For this reason, a room has been considered under the terms of "ASHRAE 140 standard/Case 600" and climatic conditions of Tehran with winter outdoor design temperature of -10°C. Also, the heat power on the baseboard panel has been set as much as the average of occupants' thermal dissatisfaction index stays within the allowable range (lower than 10%). The results show that the heating baseboard system can provide the appropriate thermal conditions for sitting occupants with average panel temperature of 43°C. In spite of this, the distribution of occupants' dissatisfaction index near the floor is not uniform. The results indicate that the air infiltration can cause to increase the thermal dissatisfaction index up to 40% in the floor region.

Keywords:
Baseboard heating system
Air infiltration
Thermal comfort
Energy Consumption

References

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### Table 1: Sample Data Table

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value 1</td>
<td>Value 2</td>
<td>Value 3</td>
</tr>
<tr>
<td>Value 4</td>
<td>Value 5</td>
<td>Value 6</td>
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<td>Value 7</td>
<td>Value 8</td>
<td>Value 9</td>
</tr>
<tr>
<td>Value 10</td>
<td>Value 11</td>
<td>Value 12</td>
</tr>
</tbody>
</table>

### Figure 1: Diagram Description

- **Figure Description**
- **Legend and Axes**
- **Data Points**
- **Interpretation**

### Equation 1

\[ S + \rho + \phi + \beta + \alpha = \text{Eq} (\Delta) \]

### Equation 2

\[ \rho \neq 0 \]

### Data Points

- **Point A**: Coordinates (x, y)
- **Point B**: Coordinates (x, y)
- **Point C**: Coordinates (x, y)
- **Point D**: Coordinates (x, y)

### Notes

- **Research Methodology**
- **Findings and Analysis**
- **Conclusion**
116

4-Predicted Percentage of Dissatisfied

\[
\begin{align*}
\theta &= \alpha v^2 T + S_f \\
\psi &= \frac{u + v f + w k}{\alpha} + \frac{\partial f}{\partial x} + \frac{\partial k}{\partial y}
\end{align*}
\]

\[
S = \beta (T - T_0)
\]

\[
M = H + \mu
\]

\[
\mu = 0.387\rho F
\]

\[
P = \frac{0.028 + 0.303 \sin(0.363)}{(M - W) - 0.00305(5733 - 6.99)(M - W) - P_s} - 0.124(M - W) - 58.15
\]

\[
T_{a_1} = T_f - f_{\text{a_1}}(P_0(T_0 - T_f))
\]

\[
T_{a_2} = T_f - f_{\text{a_2}}(P_0(T_0 - T_f))
\]

\[
T_a = 35.7 - 0.0275(M - W)
\]

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سیرت جریان کترم از 0.01 متر تا نهایی است. مقایسه میان نتایج در دو حالت مذکور، به عضوی نشان می‌دهد که اگرچه نفوذ هوا باعث افزایش سرعت در نزدیکی جدار انبساطی می‌شود ولی در هر دو حالت در به پایین توجهی از فضای افقی، سرعت هوا در حجم حداکثر کترم از 0.01 متر به شیب قرار گرفته و به خطر افتاد. غیر از اینکه به افتخاده نگرانی این محاسبه جایی از می‌گیرد، اینجا نگرانی اینکه حادثه چنین پدیده‌ای به همراه صرعی یک نمایش جدایی بررسی می‌شود.

شکل 6 نوریت سرمایه از 4 روی سطح تقسیم در اتاق دارای سیستم قرارگیری با نظر گرفتن اثرات نفوذ هوا از در یک شب.

شکل 7 نوریت سرمایه از 4 روی سطح تقسیم در اتاق دارای سیستم قرارگیری با نظر گرفتن اثرات نفوذ هوا از در یک شب.

شکل 8 نوریت سرمایه از 4 روی سطح تقسیم در اتاق دارای سیستم قرارگیری بدون در نظر گرفتن اثرات نفوذ هوا از در یک شب.

شکل 9 نوریت سرمایه از 4 روی سطح تقسیم در اتاق دارای سیستم قرارگیری بدون در نظر گرفتن اثرات نفوذ هوا از در یک شب.

لازم به ذکر است که به دلیل امکان مقایسه میان نتایج دو حالت مذکور، توی سیستم قرارگیری در دو حالت یک روی تفریش می‌شود در شکل 8 نوریت دیاها در سیستم قرارگیری، به دلیل نفوذ هوا از در نظر گرفتن اثرات نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل نفوذ هوا از در یک شب اولیه یک روی تفریش می‌شود در سیستم قرارگیری، به دلیل N
7- فهرست علائم

فاکتور بایس (بیع)

\( f_b \)

شتاب تریپت (سیم)

\( g \)

ضرب انتقال حرارت جایگی

\( h_c \)

مقاومت حرارتی ایست

\( I_i \)

نرخ حرارتی در سطوح

\( M \)

فشار

\( P \)

شادی احساس حرارتی افراد

\( P_{PMV} \)

شادی احساس حرارتی افراد

\( P_{PPD} \)

جلقه چشمه

\( S \)

دما

\( T \)

ضرب انتقال حرارت کل

\( U \)

سرعت

\( V \)

علاوه بوناتی

\( \alpha \)

ضرب انتقال حرارتی

\( \beta \)

مقدار

\( \rho \)

لزج دیمانسیکی

\( \mu \)

زیربوس

\( a \)

مربوط به هوا

\( c_l \)

مربوط به دیگر

\( e_{ff} \)

پوست

\( s_k \)

اهویشی

\( t \)

ناپیش

\( r_d \)

8- مراجع


