THERMAL COMFORT NEAR THE OUTSIDE WINDOWS UNDER COLD CLIMATE CONDITIONS

TERMĀLAIS KOMFORTS PIE ĀRSIENU LOGIEM AUKSTA KLIMATA APSTĀKĻOS

Raivis Jēčis
Riga Technical University, Department of Heat and Gas Technology
Āzenes iela 16, LV-1048, Latvia
raivis@uponor.lv

Arturs Lešinskis
Riga Technical University, Department of Heat and Gas Technology
Dr.sc.ing., asoc.professor

Keywords: thermal comfort; indoor climate; downdraught

1. Introduction

Considering that nowadays it's quite typical to make large glazed facades both in residential and municipal buildings it's important to make sure that thermal comfort near the outside windows is within the limitations of standards. The developments in window constuction have resulted in a surface temperature on the inner pane that is closer to the room air temperature. From this follows that the strenght of the downdraught from the window and the cold radiation to the surrounding surfaces are considerably reduced, thus allowing to use larger panes of windows without thermal discomfort near the windows. Large reseach work have been made at University of California, Berkley [1] mostly foccusing on window perfomance in summer season. Various studies have been made mainly to investigate convective air flow created by window and heat sources (radiators, floor heating, air heating), for example, Peng Shia-hui and Peterson [2] analyzed convection from cold window with simulated floor heating, Muhren and Holmberg [3] investigated the impact of heating systems on cold down-flow from ventilation supply units installed in outside wall and compare the results to measurements made by Olesen [4] made in real life test room.

2. Requirements for thermal comfort

Human thermal comfort is affected by a number of parameters, namely according to respective standard EN ISO 7730 [5]. Criteria for an acceptable thermal climate are specified as requirements for general thermal comfort, for example as a predicted mean vote (PMV), predicted percentage of dissatisfied (PPD) or operative temperature (air and mean radiant temperature), air velocity, humidity and local thermal discomfort (surface temperature, vertical air temperature differences, radiant temperature asymmetry, draft) must be taken into account. Thermal comfort is expressed by that condition of mind, which expresses satisfaction with the thermal environment [6]. The PMV and PPD indices express warm and cold discomfort for the body as a whole. But thermal dissatisfaction may also be caused by unwanted cooling (or heating) of one particular part of the body (local discomfort). Local thermal discomfort may be caused by draught, high vertical temperature difference between head and ankles, too warm or too cool floor, or by too high radiant temperature asymmetry. Sitting persons with little activity are most sensitive to local discomfort.

3. Radiant asymmetry

People are most sensitive to radiant asymmetry caused by warm ceiling or cool walls – windows (Figure 1.). Temperature asymmetry limit for cool walls – windows according to EN ISO 7730 depends on buildings category and is 10-13K . Table 1 applies to this group of people with a thermal sensation for a whole body close to neutral.

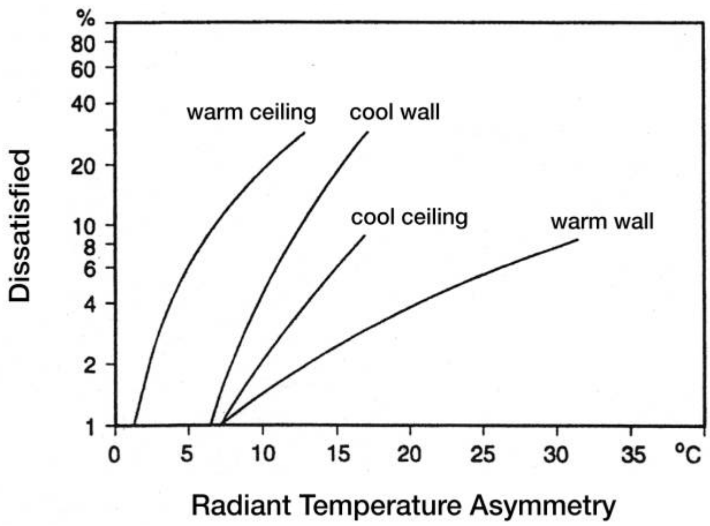

Fig. 1. Relation between number of dissatisfied sedentary person and the radiant asymmetry CEN CR1752.

Table 1. Categories for local thermal discomfort parameters (EN ISO 7730)

Category	Vertical air temp. diff. K	Floor surface temperature C	Radiant temperature asymmetry, K			
			Warm ceiling	Cool ceiling	Cool wall	Warm wall
A	2	19 - 29	5	14	10	23
B	3	19 - 29	5	14	10	23
C	4	17 - 31	7	18	13	35

The internal surface temperature (t_w) of a window shall be determined from

$$t_w = t_o - Um_i\ (t_o - t_u) \tag{1}$$

where

U thermal transmittance of window (w/m^{2}K)

m_i internal surface resistance of window (0,12 m^{2}C/W)

t_o desired operative temperature at the coldest point in the occupied zone (near window or other cold surface) (^{0}C)

t_u design outdoor temperature (^{0}C)

Figure 2 show that using glazed fasades - windows with *U*-value below 1.5 W/m^{2}deg is enough to assure that temperature difference between internal surface of window and room is within the limitations.

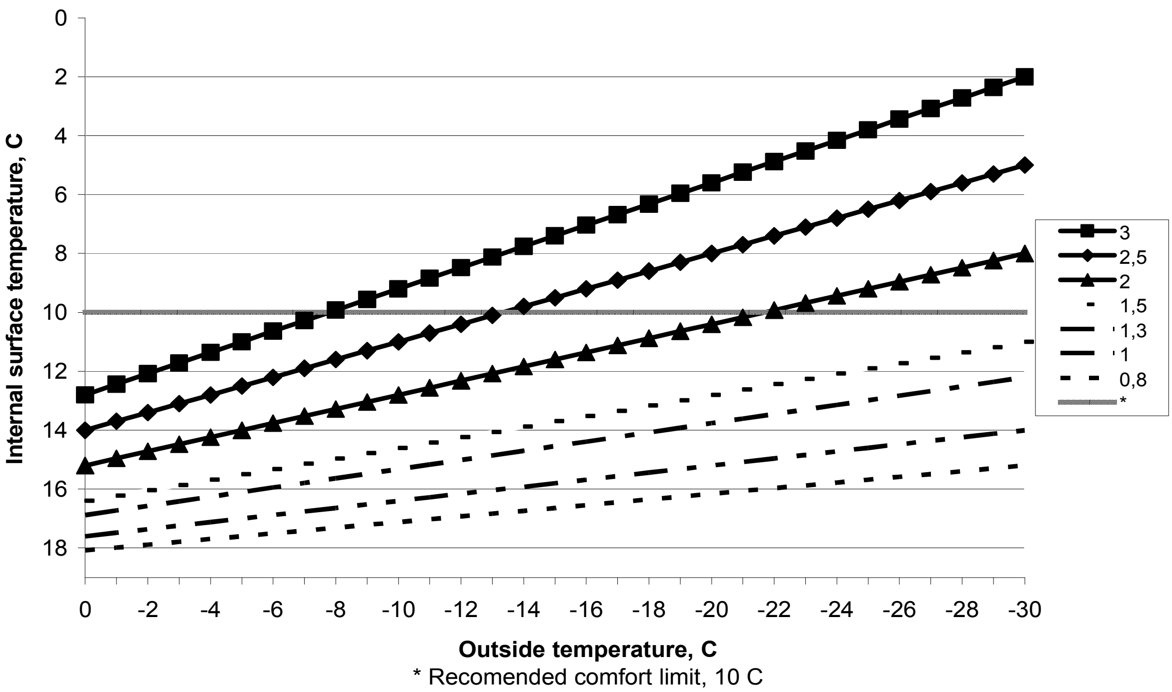

Fig. 2. Window internal surface temperature using different U values at +20^{0}C room temperature.

4. Draught, air velocity

Downdraught from cold surfaces (windows) is another factor that may cause discomfort. It is worth mentioning that the downdraught is the cold stream of air created by the temperature difference between the room air ant the surface of the window. This phenomenon can couse an uncomfortable indoor climate in the occupied zone. On the basis of a calculation method, the relation between the window heights, *U*-value for the wall/window, outside temperature and the maximum air velocity can be determined.

Table 2. Calculation of maximum air velocity, v_{max} and minimum air temperature t_{min} along the floor due to cold air draught from a cooled wall as a function of the temperature difference between room t_{room}, and cooled surface, $t_{surface}$. It is assumed that the cooled wall has the same width as the room (EN 15377-1) [9]

Parameter	Distance from cold surface	Formular	Unit
Min. Air temperature at the floor	x	$t_{min} = t_{Raum} - (0,30 - 0,034*X)(t_{Raum} - t_{Fläche})$	°C
Max. air velocity at the floor	x<0.4 m	$v_{max} = 0,055 \cdot (\lvert t_{Raum} - t_{Fläche} \rvert \cdot h)^{0,5}$	m/s
	0,4<x< 2,0	$v_{max} = \frac{0,095}{X + 1,32} (\lvert t_{Raum} - t_{Fläche} \rvert \cdot h)^{0.5}$	m/s
	2,0<x	$v_{max} = 0,028 (\lvert t_{Raum} - t_{Fläche} \rvert \cdot h)^{0.5}$	m/s

Assuming airflow with a low turbulence intensity (10% to 20%) and an air temperature of 21^0C, the recommended maximum acceptable air velocity in existing standards is 0,18 m/s [7]. Figure 3 shows the relationship between window *U*-value, window height and resulting maximum air velocity in the occupied zone by -20^0C outside temperature.

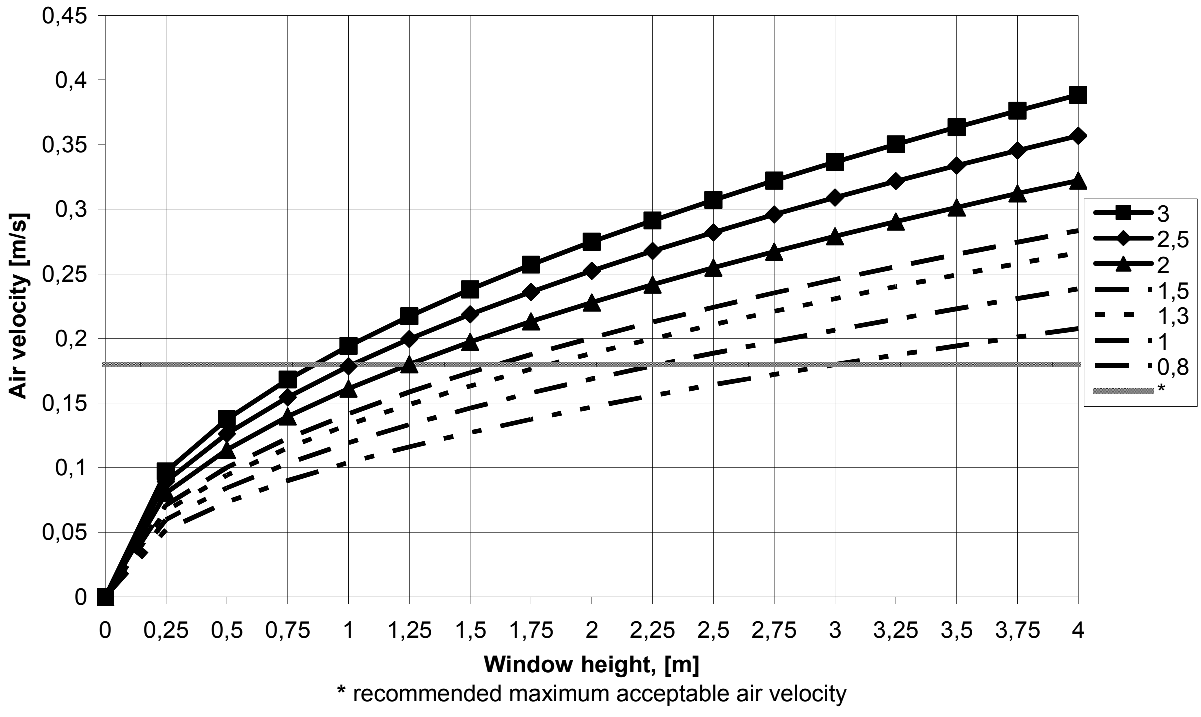

Fig. 3. Draft air velocity from window at 0,6m distance from a window in the room up to 4m high as a function of the window U-value at -20^0C outside temperature.

If the air velocity is lower than the 0,18 m/s at design conditions, it is unnecessary to compensate with heating below the window.

5. Conclusions

In the present study, indoor thermal climate near the windows where analyzed, main attention was made on radiant asymmetry and cold air downdraught. Results show that using windows with *U*-value below 1.5 W/m^{2}deg in most cases is enough to assure thermal comfort within the limitations even in cold climate zones where outside temperature drops below -20^{0}C . In modern buldings using hight perfomance glass for outside glazed surfaces radiant asymmetry can be kept in limits as one can see from Fig.2. at rather low outside temperature. It is more complex situation with downdraft, with increasing hight of a cold surface the risk of too high air velocity (more than acceptable 0,18m/s) is obvious. Improving the thermal perfomance of the windows indirectly creates an opportunity to eliminate traditional heating systems such as radiators and convectors below the window. Other heating systems such as underfloor heating system can be used.

6. List of References

1. C. Huizenga, H. Zhang, P. Mattelaer, T. Yu, E. Arens, Window Perfomance for Human Thermal Comfort // Final report to the national fenestration rating council, University of California, Berkley, 2006.
2. Peng Shia-hui, F. Peterson, Convection from a cold window with simulated floor heating by means of a transiently heated flat unit // Energy and Buildings 23 (1995), p. 95-103.
3. J. Are Myhren, S. Holmberg, Flow patterns and thermal comfort in a room with panel, floor and wall heating // Energy and Buildings (2007).
4. B.W. Olesen, E. Mortensen, J. Thorshauge, Thermal comfort in a room heated by different methods // Technical Paper no. 2256, Los Angeles Meeting, ASHRAE Transactions 86, 1980.
5. ISO EN 7730:1994, Moderate Thermal Environments—Determination of the PMVand PPD Indices and Specification of the Conditions for Thermal Comfort, revised version, International Organization for Standardization // Geneva, 1994.
6. Jan Babiak, Bjaren W. Olesen, Dušan Petraš, Low temperature heating and hight temperature cooling // Rehva guidebook No 7, 2007

Jēčis R., Lešinskis A. Termālais komforts pie ārsienu logiem auksta klimata apstākļos
Pēdējos gados daudzas jaunbūves kā arī projektēšanas fāzē esošās ēkas tiek veidotas ar lielu stiklojumu – logiem. Ierasta lieta ir projektēt logus no grīdas līmeņa līdz pat griestiem. Iemesls ir acīmredzams – lieli logi nodrošina saikni ar apkārtējo vidi kā arī ir modernas arhitektūras simbols, taču bieži vien šis koncepts tiek sabojāts novietojot loga priekšā apsildes radiatorus, šāda realitāte var tikt novērota lielākajā daļā jaunuzcelto ēku. Raksta mērķis ir analizēt cilvēka termālo komfortu pie ārējām stiklotām virsmām pie salīdzinoši zemām ārgaisa temperatūrām. Galvenā uzmanība tika veltīta temperatūru asimetrijām un aukstā gaisa plūsmām. Aprēķini tika balstīti uz spēkā esošajām Eiropas normām (EN). Tika analizētas stikla paketes ar septiņām dažādām U vērtībām pie iekštelpu temperatūras 20^{0}C un ārējās temperatūras -20^{0}C, aprēķinot temperatūru asimetriju starp stiklotās virsmas temperatūru un iekštelpu gaisa temperatūru, kā arī aukstā gaisa plūsmas intensitāti. Rezultāti rāda, ka stiklotās virsmas ar U vērtību zem 1.5 W/m^{2}deg vairākumā gadījumu nodrošina pieņemamu termālo komfortu saskaņā ar Eiropas standartiem.

Jēčis R., Lešinskis A. Thermal comfort near the outside windows under cold climate conditions
In recent years lot of new built and renovated buildings as well as buildings that are in a design phase are made with large glazing - windows. It's quite common to design windows in some premises from the floor level to almost ceiling level. The reason of doing it is obvious – large windows allow one to get better view at outside environment (garden, lake, etc.), but all this beautiful concept could be ruined by placing radiator in front of the window, such situation could be seen on lots of new built houses. The aim of the paper is to analyse thermal comfort of people near the outside glazed surfaces taking into account comparatively low outside calculation

temperatures. The main attention was made on radiant asymmetry and cold air downdraught. Calculations where made based on the applicable European norms (EN). Seven different U-values for window pane where analysed at room temperature 20^{0}C and outside temperature -20^{0}C, analysis include radiant asymmetry and downdraught calculations. Results show that using windows with U-value below 1.5 W/m^{2}deg in most cases is acceptable to ensure thermal comfort according to European standarts.

Ечис Р., Лешинскис А. Термический комфорт вблизи от наружных окон в холодных климатических условиях

В последнее время в проектировании и строительстве новых зданий все чаще используется обширное фасадное остекление – панорамные окна. Распространенный вариант – проектировать окна от пола до самого потолка. Причины очевидны - большие окна создают видимость единения с окружающей средой, являются символом современной архитектуры. Однако, эта концепция часто не выдерживается из-за установки перед окном объемных радиаторов отопления. Такую ситуацию можно наблюдать в большинстве новых зданий.

Целью данной статьи является анализ термального комфорта человека в помещениях с большой площадью фасадного (внешнего) остекления при сравнительно низкой внешней температуре. Основное внимание уделено температурным ассиметриям и потокам холодного воздуха. Все рассчеты проведены на основании существующих европейских норм (EN).

Произведен анализ стеклопакетов с семью различными U величинами при температуре внутри помещения +20^{0}C и вне помещения -20^{0}C методом определения температурной ассиметрии между температурой поверхности стекла и температурой воздуха внутри помещения, а также интенсивности потока холодного воздуха. Результаты показывают, что стеклянные поверхности с величиной U ниже 1.5 W/m^{2}deg в большистве случаев обеспечивают приемлемый термальный комфорт в соответствии с европейскими стандартами.