Fraunhofer IBP

IBP-Mitteilung 496

36 (2009) New research results in brief

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Temporary Thermal Insulation by Shutters with Infrared Reflecting Surface Coating

Introduction

Shutters can be used as a protection against burglary, as weather protection as well as protection against overheating in summer. In addition, closed shutters reduce heat losses during the night. Current commercial systems can reduce heat losses through the windows at night by up to 25 per cent. Infrared reflecting (IR) surface coatings reduce heat exchange by radiation. In how far it is possible to improve the thermal performance of closed shutters by means of IR reflecting coating of shutter blinds is to be analyzed by investigations in a test building of the Fraunhofer Institute for Building Physics (IBP) in Holzkirchen.

Test Set-up and Investigations

Measurements are carried out in the modular test facility for energy and indoor climate investigations (»VERU«). This building is designed to allow investigations of façade systems and the interaction with building technology systems used as well as the effects on the spaces behind. In this context, priority is given to the integral effect of energy input and output through façades, energy use for heating, cooling and lighting as well as to thermal and visual comfort.
On the eastern façade of the building – see Fig. 1 – the effect on heat transmission of closed shutters with IR reflecting surfaces is measured under winter conditions. Investigations are carried out in a test room in the ground floor. The room has two windows with thermal insulation glazing. The thermal transmittance of the glazing (Ug) indicated by the manufacturer is 1.2 W/m²K. The wooden windows are equipped with external shutter systems. Since these systems are installed on the external side of the window frame, effects of thermal bridges do not occur here, compared to shutter systems that are integrated in the window lintel. Figure 2 shows the external view of a window with shutters half closed.
To investigate the influence of IR reflecting surface coatings, aluminium foil is glued to the internal shutter blinds of one of the two shutters, the reflectance of which is at approx. 95 % within the thermal range. The other shutters remain unchanged. The influence of the IR coating can be represented by means of direct comparison of the thermal performance of the two shutter systems. To measure the heat losses through the windows, heat flow meters are installed on the internal sides of the glazing. Inside and outside surface temperatures of the glazing and the frame are measured, as well as the indoor air temperature and the outdoor air temperature in front of the façade. To avoid the influence of solar radiation, measurements are evaluated exclusively at night.

Fig. 1: Façade on the eastern side of the test facility VERU

Fig. 2: External view of a window with half-closed shutters

Investigation Results

During a first pilot test the temperature and heat flow gradients on both windows with open shutters are compared. The result is that both windows show an almost identical thermal performance. This test is repeated with closed shutters on both sides. In this test, too, the thermal performance of both systems is almost identical. The closed shutters reduce the U-value of the glazing (Ug) determined by the measured values from approx. 1.05 W/m²K (without shutters) to 0.85 W/m²K (glazing and shutters). These preliminary investigations show that the windows or the combination of shutters and windows have an identical energy performance in both cases.
For the following investigations aluminium foil is glued to the internal surface of one of the two shutters, which is highly reflecting in the long-wave thermal range. The following Fig. 3 and Fig. 4 show the temperature and heat flow gradients on the glazing as well as on the internal surface of the closed shutters during a cold winter night. At this time, the mean outdoor air temperature is around -2.9 °C, the mean air temperature in the heated test room amounts to 20.9 °C. Considerable differences occur with the measured heat losses through the glazing. The mean heat flow density is -20.3W/m² (black curve) for the shutters without IR coating (Fig. 3). The negative sign describes the direction of the heat flow from the inside to the outside. The variation with IR coating reduces heat losses to -14.9 W/m². Differences also occur in the field of surface temperatures on the glazing. The mean surface temperature on the outside of the glazing is 3.2 °C for the standard system with conventional shutters. Due to the IR coating on the inside of the shutters with thermal improvement the surface temperature on the outside of the glazing is elevated to 7.2 °C. The internal surfaces of the glazing also differ in temperature performance. Thus, the internal temperature of the pane surfaces for a shutter system with IR coating is 0.8 K higher than that of the standard system. The U-value calculated by measured data is reduced in case of internal shutter surfaces with IR reflecting coating from 0.85 W/m²K (conventional system) to 0.63 W/m²K (Table 1).
This is equal to a reduction of the U-value by 26 %. Compared to a window without shutters, heat losses during the night can be actually reduced by approx. 40 %, which corresponds to a 16 % reduction in the annual heating energy requirement according to [1] due to the above-described system with IR reflecting coating of the shutters.

Table 1: List of measurement results

Period of investigations November 22./23, 2008; 6 pm until 6 am		Shutters without IR	Shutters with IR
Heat losses	[W/m²]	-20.3	-14.9
Eexternal surface glazing	[°C]	3.2	7.2
Internal surface glazing	[°C]	17.9	18.7
U-value total system	[W/m²K]	0.85	0.63

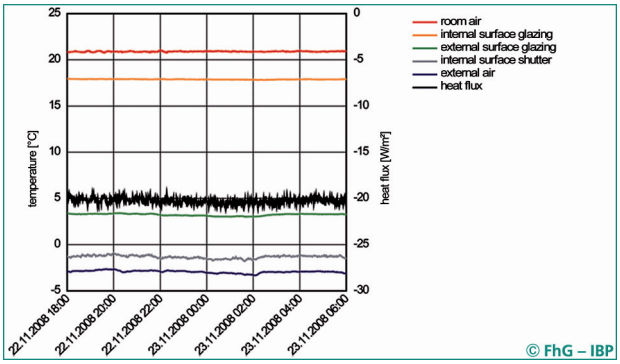

Fig. 3: Temperature and heat flow curves with closed shutters and without IR coating

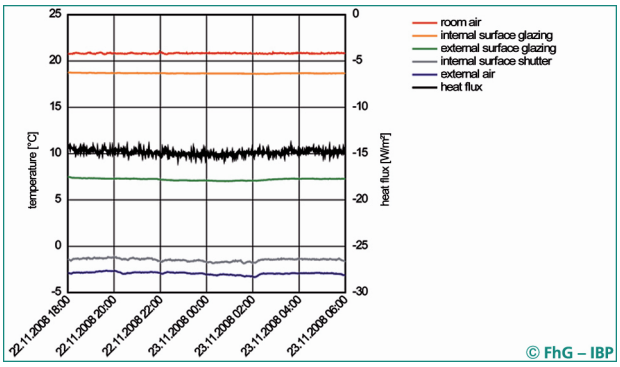

Fig. 4: Temperature and heat flow curves with closed shutters and with IR coating

Summary

The investigations of the two shutter systems show to what extent it is possible to improve thermal performance by IR reflecting coating on the inner surface of the shutter blinds. Compared to a conventional system, shutters with IR coating that are kept closed during the night may reduce current heat losses by approx. 26 %. In addition, airtight shutters can reduce temporary heat losses caused by air infiltration due to leaky windows. Consistent use of shutters during the night can reduce the heat loss through windows considerably. Investigations will be continued to demonstrate in how far it is possible to further optimize thermal performance by additional IR coating on the outside of the shutters. Moreover, shutter blinds with low thermal conductivity can contribute to further improve the whole system.

References

[1] Hauser, G.: Passive Sonnenenergienutzung durch Fenster, Außenwände und temporäre Wärmeschutzmaßnahmen -Eine einfache Methode zur Quantifizierung durch keq-Werte. HLH 34 (1983), H. 3, S. 111-112, H. 4, S. 144-153, H. 5, S. 200-204, H. 6, S. 259-265.

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Herstellung und Druck: IRB Mediendienstleistungen des Fraunhofer-Informationszentrums Raum und Bau IRB, Stuttgart
Nachdruck nur mit schriftlicher Genehmigung des Fraunhofer-Instituts für Bauphysik