INDICATOR FOR ESTIMATION VACUUM LEVEL IN TRANSPARENT INSULATION OF SOLAR COLLECTORS

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The major part of heat loss in solar collectors (up to 90 %) occur through transparent cover, thus the main problem in solar collector design is to chose transparent cover with high thermal resistance. As a rule a single glazing is used for transparent insulation of solar collectors. A glazing can be covered with a selective coating that reduces heat loss: selective coatings have low-emissivity properties in infrared wave range.

Thermal resistance of a single glazing with selective coating is equal to 0,24 $m^2 \cdot K/W$ and without selective coating is equal to 0,13 $m^2 \cdot K/W$ at the following operating conditions: thermal receiver temperature is 100°C, environment temperature is –20°C, heat transfer coefficient from glazing to the environment is 20 $W/(m^2 \cdot K)$.

It is possible to reduce heat loss of solar collector using vacuum (evacuated) glazing as transparent insulation (fig. 1). Vacuum glazing consists of two glass sheets of 2,5…4 mm thick with a gap of 0,2 mm between them. Glass sheets are sealed along the perimeter; the gap is evacuated and fixed by glass-ceramic support pillars (fig. 2).

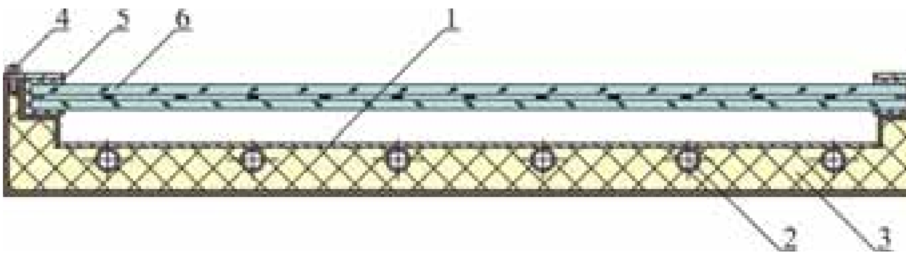

Fig. 1: Solar collector with vacuum glazing: 1 – absorber plate, 2 – fluid/air channel, 3 – thermal insulation, 4 – bonding, 5 – rubber, 6 – vacuum glazing

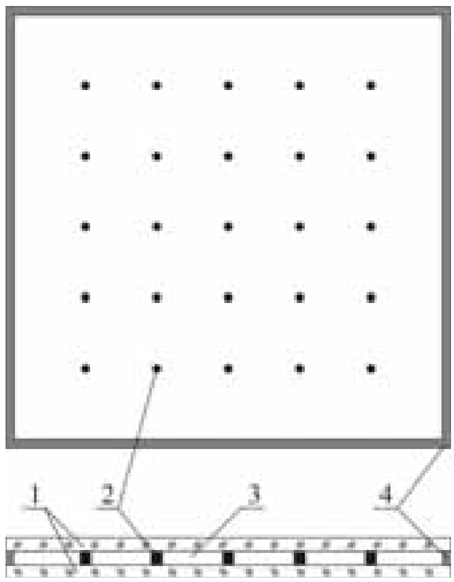

Fig. 2: Vacuum glazing construction: 1 – glass sheet, 2 – support pillars, 3 – vacuum gap, 4 – edge seal

Vacuum glazing can be used as transparent insulation also in greenhouses or windows of low-energy houses.

According to information provided by vacuum glazing producers the pressure in a vacuum gap is equal on the average to 10^{-3} torr (Ivlyushkin et al., 2001; Ivlyushkin and Samorodov, 2001). Thermal resistance of vacuum glazing at this pressure is 0,77 $m^2 \cdot K/W$ (Mitina et al., 2008). But according to experimental data (Mitina et al., 2008; Mitina, 2009) vacuum level in a vacuum gap is lower and is equal to

$10^{-2}...5\cdot10^{-3}$ torr. Thermal resistance of vacuum glazing at this pressure is also lower and is equal to 0,43…0,5 $m^2\cdot K/W$ (operating conditions are the same of above indicated).

It is very difficult to estimate vacuum level in evacuated glazing with a special device or visually, i.e. to monitor and control gas (air) pressure. It is suggested to insert an indicator inside the vacuum glazing. This indicator is supposed to change color with changing the vacuum level. Moreover, an indicator must meet the following conditions (that are correspond to producing requirements of vacuum glazing): to change color with changing gas pressure from 10^{-3} to 10^{-1} torr; to stand heating up to 450°C with heating rate of 5°C/min. and exposing at this temperature during 30 min. at atmospheric pressure; do not deteriorate from the air evacuation down to $5\cdot10^{-5}$ torr at the temperature of 370°C down to indoor temperature with cooling rate of 5°C/min.; do not react with the glazing.

It is suggested to use a synthetic zeolite AgA (the formula is $Ag_2O\cdot Al_2O_3\cdot SiO_2$) that is modified by ion exchange that permits inserting in structure an element that forms colored hydrates when reacting with water molecules, for example silver (Ag). AgA meets above-mentioned conditions and can indicate little amounts of water vapor, which is part of air, about 40…70 ppm. Zeolite AgA changes color while gas pressure rising (vacuum degradation) at pressure range of $3\cdot10^{-2}...5\cdot10^{-2}$ torr from bright orange to light yellow, and at pressure range of $0,8\cdot10^{-1}...10^{-1}$ torr from yellow to light pink and then to grayish white (Ralek et al., 1962). The described abilities are demonstrated in fig. 3.

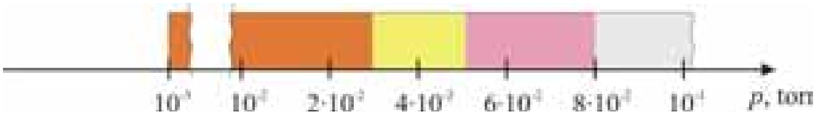

Fig. 3: Color scale – zeolite AgA at different pressure

This indicator may be attached to an inner side of a glazing, and its size must have the diameter of about 10 mm in order to be visible to a human eye and do not shield the view.

This method of vacuum level estimation allows monitoring the gas pressure in a vacuum gap during the production process or during the use of vacuum glazing as transparent insulation for solar collectors, greenhouses and fenestration.

References

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