Elżbieta Greiner-Wrona
AGH – University of Science and Technology, 30-059 Kraków ave. Mickiewicza 30 POLAND
Jarosław Wrona
Vesuvius Poland

Exposed historical glass corrosion changes due to temperature and relatively humidity gradients created in museum circumstances

Le verre est généralement considéré comme un matériau stable, mais il peut se détériorer dans certaines situations. Cet article traite des problèmes très spécifiques des objets historiques en verre et de l'influence des paramètres de conservation internes non uniformes dans les vitrines. La situation est déterminée par l'interaction complexe de plusieurs facteurs. Nous avons dans un premier temps pris en considération les paramètres thermo-hygrométriques mesurés dans les vitrines du musée. Les modifications visibles des objets exposés ont été créées par la différence de température et le gradient d'humidité relative dans un laps de temps très court et répété sur 24 heures Ce papier présente les tests en température et en humidité relative. Leur influence sur la surface du verre a été comparée avec les résultats de la corrosion induite sur des échantillons de verre témoins. Ces données obtenues ont souligné que la situation réelle dans les vitrines des musées peut être une raison de la détérioration progressive d'objets historiques en verre.

Glass is generally treated as a stable material but becomes in some circumstances very much deteriorated. This paper is focused on very specific changes of glass historical object caused by not uniform internal parameters of showcases. Their circumstances is determined by the complex interaction of several factors. First of all we took into consideration thermo-humidity parameters measured in the internal part of museum cabinets. Visible changes of exposed objects were created by differentiated temperature and relative humidity gradients in a very short period of time and repeated for 24h. Testing temperature and relative humidity by the datalogers and thermovision method was presented in this paper. Their influence on glass surface was compared with the results of induced corrosion on chosen glass sensors. These obtained data emphasized that a real situation in museum cabinets can be a reason for the gradually deterioration of historical glass objects.

INTRODUCTION

Glass, which is undergoing some interactions with other media, or due to bad physical local parameters becomes deteriorated. Due to these, created changes are called: "glass illnesses", and they are following [1]:

– weathering (Fig.1),
– covered by new corrosion layer (Fig.2)
– crizzling – incipient (Fig.3)
– crizzling – average (Fig.4)
– crizzling – heavy (Fig.5)

Chemical reactions involved in glass dissolution are divided in the following categories:

– Hydration
– Interdiffusion on protons, and alkali, and earth alkali ions.
– Hydrolysis

To begin the glass reactions with some media, activation energy must be delivered to the object. It could be done by temperature. The temperature is the parameter which determines the direction of the net flow of heat between two bodies, i.e. from the warmer to the colder one. The temperature is a consequence of the present and past energy balance.

That is why the temperature is a very important factor in conser-

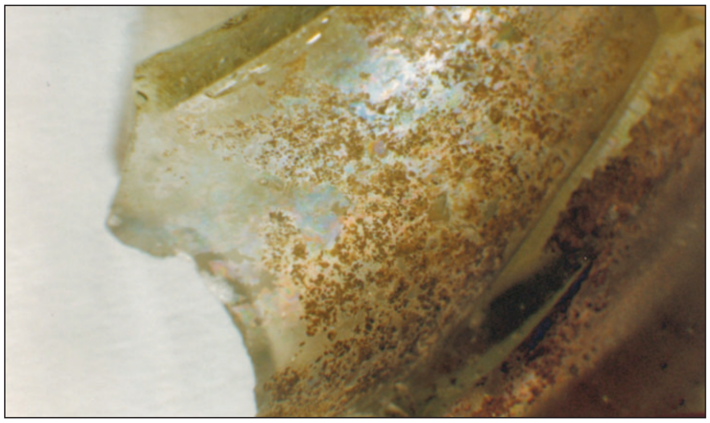


Fig.1. Weathering of the XII-th c. excavated glass

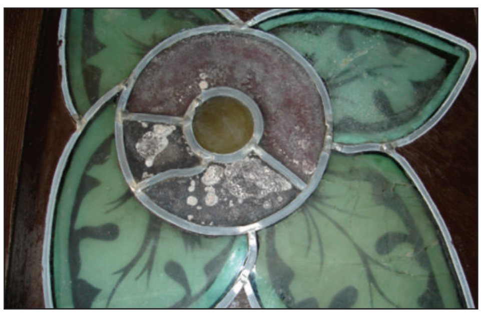


Fig.2. The XIV-th c. stained glass window with white organic deposit

Fig.3. Incipient crizzling on the XVIII-th c.beaker

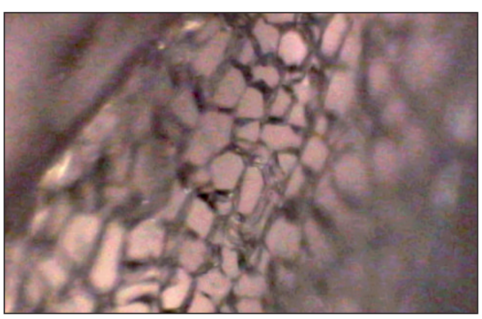


Fig.4. Average crizzling on the XVIII-th c. beaker

Fig.5. Heavy crizzling of the XVIII-th c. museum object

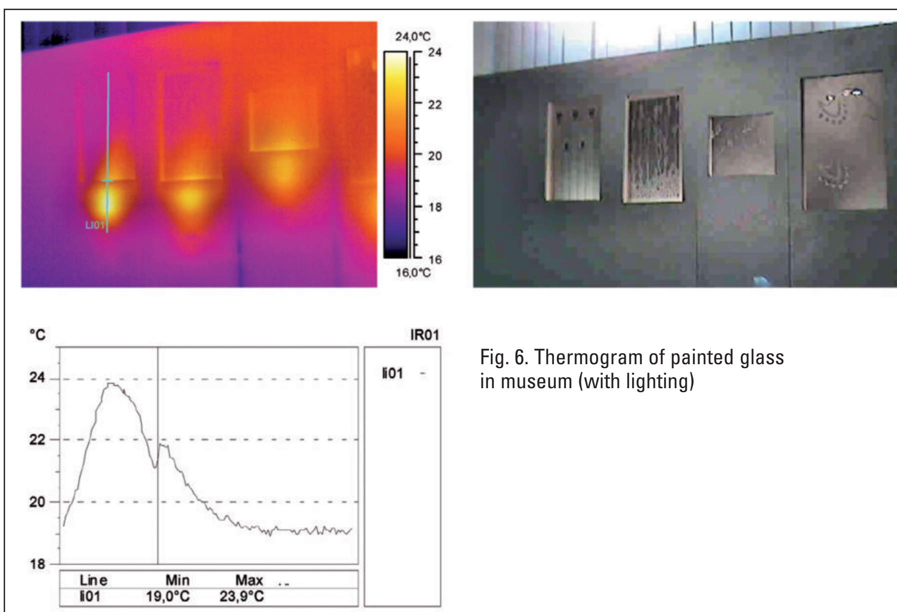


Fig. 6. Thermogram of painted glass in museum (with lighting)

vator works of art. Its changes caused differential expansion in the materials and tensile strengths between the surface and the subsurface structure. These changes induce a number of mechanical weathering mechanism, and accelerate fatigue failure in susceptible materials. Taking into consideration the nature of glass character, repeated very often during each 24 h, caused ageing glass material.

Energy, called activation energy is necessary to start any reaction. Energy can be supplied to the object by heat. Heat is defined by the temperature value. Changes of this parameter induce different expansions in the material and tensile strengths between the surface and the subsurface structure. Temperature is the requisite that determines the direction of the net flow movement of heat between two bodies. Temperature can induce a number of mechanical weathering mechanisms and accelerate fatigue failure in susceptible materials.

Because of temperature changes the conditions inside showcase can be differentiated. In sunny days glass objects inside showcase can become overheated by the sun's radiation and affected by changes in the surrounding temperatures. We can talk about: the temperature gradient or so called overheating point. The situation drastically changes after sun-sat and cooling. In a closed room hot air rises, but its ascent is stopped by the ceiling. The air, distributes, according to its density: 1 the relativity hot and less dense to the top of the ceiling and 2 the relatively cold and more dense to the bottom. Moreover, it must be said, that even a small change in temperature can result in several effects. Temperature change is not as important as humidity change. For example: internal sources of moisture in historic buildings can cause trouble during the whole year.

Humidity can even increase the deterioration rates in several ways. First of all, the presence of water can favour some chemical reactions [2].

EXPERIMENTAL

As is suggested above, the reason for temperature changes has been proved by regularly temperature measurement by the dataloger system and thermovision method. Some of them are: not stable temperature due to central heating or the occasionally gathered of a large number of visitors in small museum rooms during the summer. Due to this, temperature gradients are created. Sometimes they take place in very short time intervals. Glass is effected by such situation and in many cases glass undergoes visible deterioration [1, 3]. To recognize the real temperature in a museum, thermovision method was applied. The temperature in chosen places in the hall and inside of showcases was measured.

The following obtained thermograms (fig 6) pointed to created temperature changes in chosen place. For example Fig.6 pointed how the lamp behind the pointed glass caused its heating. It happens in a regular way but depends on creating temperature gradients.

Because the time of lighting is limited that is why after turning off the light, the whole object became cooler. Created temperature gradients on glass are differentiated. The lower part of the presented picture is much warmer than the upper one.

Moreover, the place where showcases are located has a very important meaning. One of observed cabinet's exposed to the sun's rays (as presented on Fig.7) was tested by thermovision method too. (Picture before and after sun's rays consists of two photos of close and open showcase).

As it is presented on the Fig.7 left at 11.30 a.m.(when outside temperature 25°C was measured) in the showcase without the inside lighting, on the upper shelf was 24°C, but on the lowest shelf only 21°C. But after few hours, at 3.00 p.m. (when outside temperature was equal to 29°C) inside on the upper shelf was 26°C and only 21,5°C on the lowest one. The next one changeable situation was created by artificial light. It was proved by thermovision measurements in another cabinet (Fig.8. A,B,C).

Measurement in the showcase, where light lamps were mounted in the ceiling, after ca 3h of lighting, the temperature was higher, reaching a maximum temperature equals to 22,8°C and minimum was: 20,5°C (Fig.8. A).

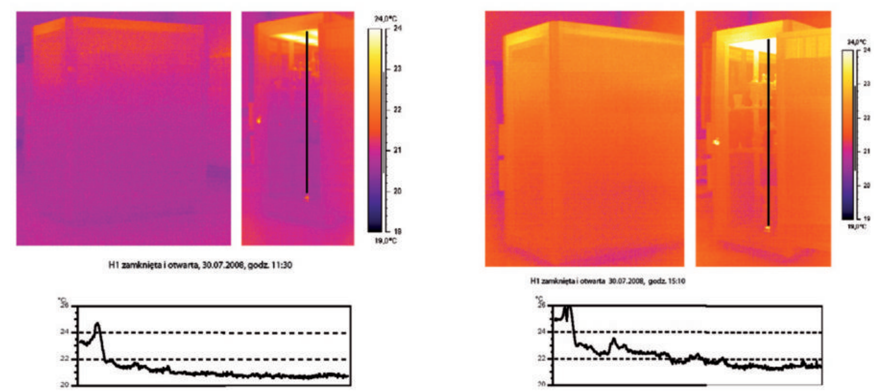
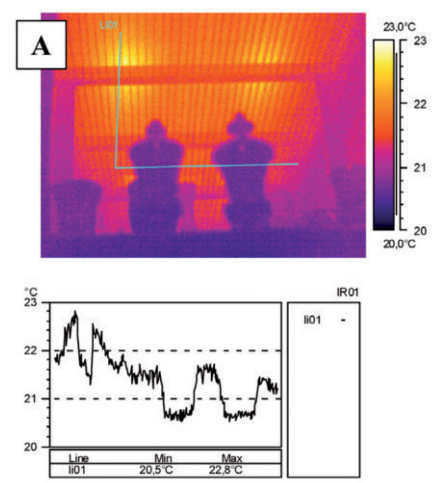
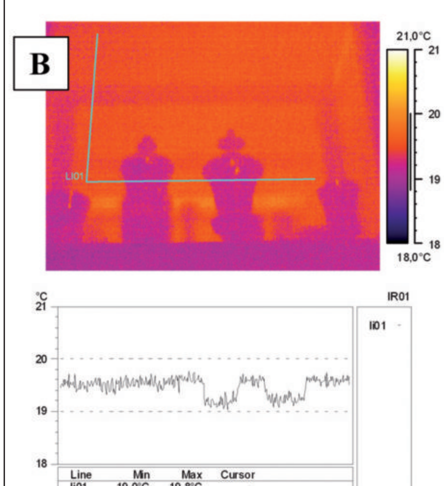


Fig.7. Showcase temperature changes due to sun's rays
(left :before, right: after sun's rays)

Fig.8. Thermogram of museum cabinet
A. with internal lighting, measuring outside.





◄ Fig.8. Thermogram of museum cabinet
B. without internal lighting , measuring inside

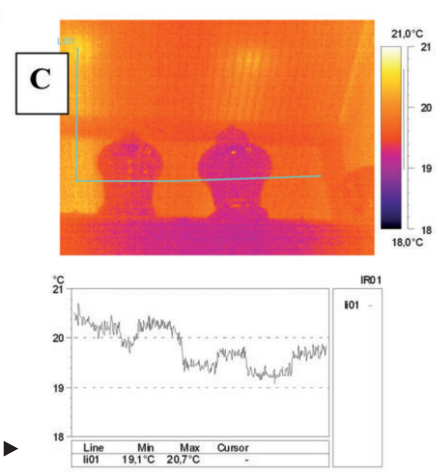


Fig.8. Thermogram of museum cabinet
C. with internal lighting, measuring inside ►

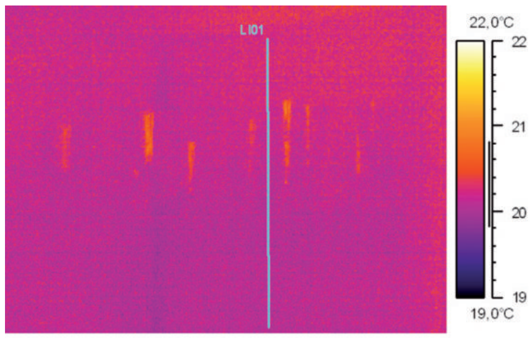
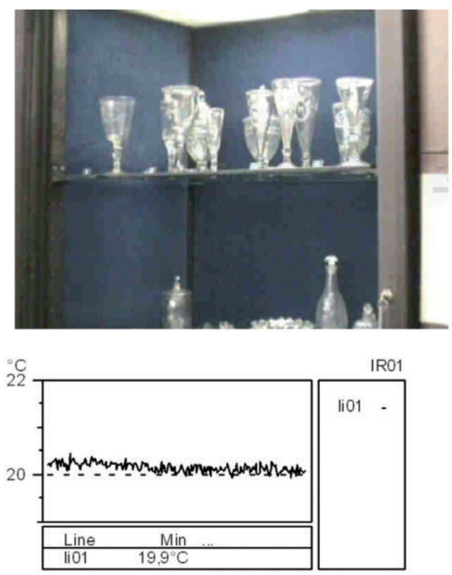


Fig.9. Showcase mounted in the wall



The temperature of the glass beaker in the showcase without inside lighting at 10.30 was maximum: 19,8°C and minimum 19,00°C (Fig.8. B).
Fiveteen minutes after turned on the light (Fig.8. C), was maximum temperature equals to 20,7°C and minimum: 19,1°C. After few hours, at the end of visiting time lamps were turned off. Temperature was gradually lowering. This procedure has been regularly repeated every day.
It should be emphasized that such parameters create frequent changes in temperature gradients. This situation has not been observed in the cabinet which was mounted on the wall, and not exposed to the sun's rays (Fig.9) [4].
The another thermogram is connected to the heated showcase by a fixed power supply at the bottom of cabinet (Fig.10). Obtained data allowed us to realize that it is the next unexpected source of heat. This caused increasing internal temperature of cabinet, in irregular way, too.
Another object, the XVIII-th c. chandelier was analysed. It was hanging in the corner of one museum exposition hall. Thermovision measurements were done during lighting time of the lamp. Obtained temperature data are presented on (Fig.11). It was noticed that the highest value was on the level of lighting lamp bulks, and was equals to 23,5°C. In the area without lighting, below the lamps was 17,9°C. Taking into consideration the fact that all kind of the XVIII-th c. chandeliers have a tendency for crizzling, they are unstable [5, 6]. Observed changeable temperature parameters in museum, glass of this lamp became deteriorated with advancing crizzling [1, 7]. It was confirmed by analyzing of chosen pieces of broken glass from the original XVIII-XIX –th c. chandeliers.
Most of the pieces have visible corrosion, like crizzling. Testing pieces of original glasses from chandeliers proved that most part of them undergoing the same kind of corrosion, like average crizzling. It is presented on Fig.12. The analysed parts of the glass belong to the same category, from a composition point of view. Actually, many parts of these objects are corroded because of the shock reactions and

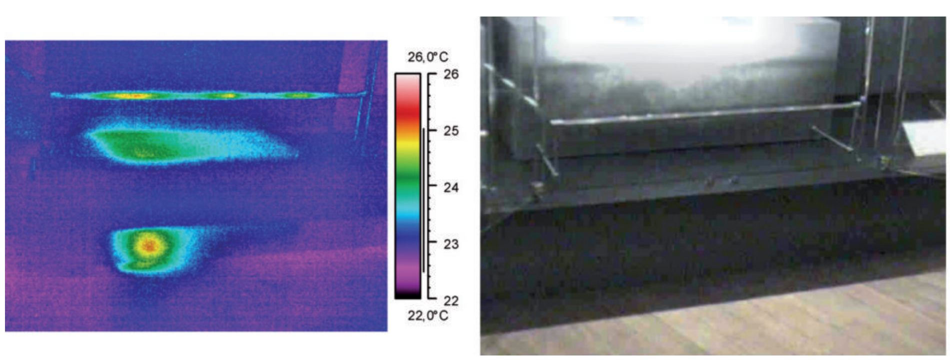


Fig.10. Thermogram of bottom of showcase with power supply

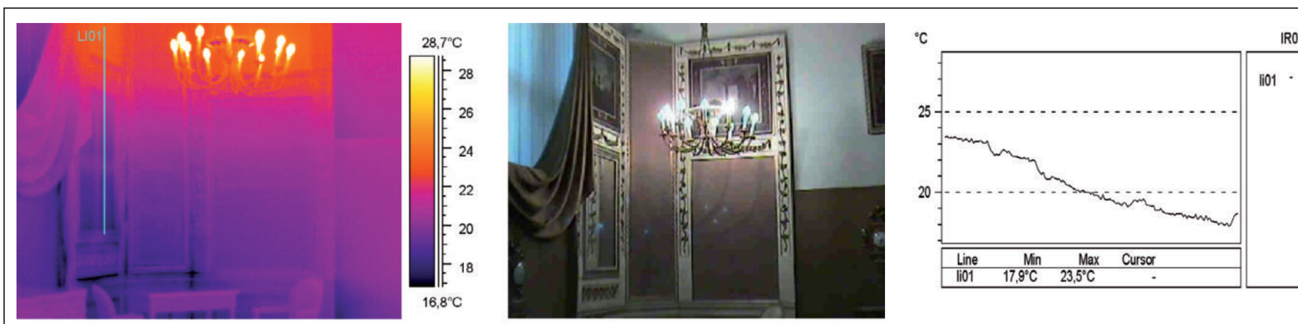
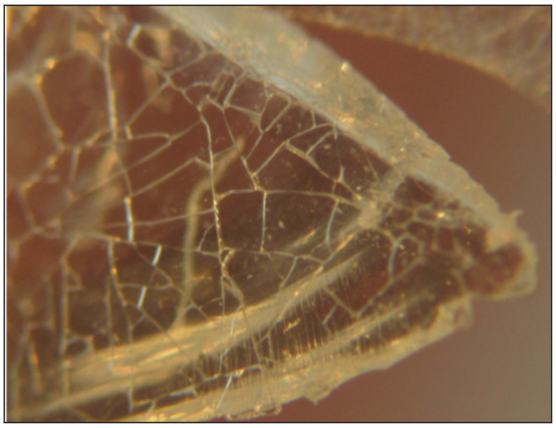
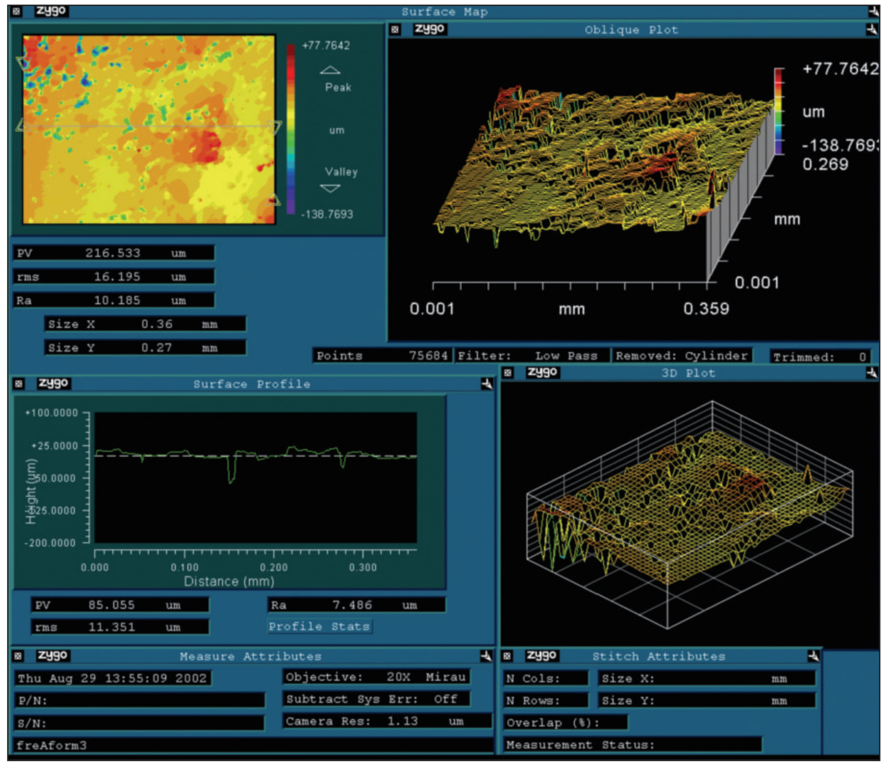


Fig.11. Thermogram of lighting chalandier



▲ Fig.12. Optical microscope (NEOFOT) observation of original glass from the XVIII-th . chalandier

Fig.13. Optical Interferometer of corroded glass in formaldehyde ▶



the long term heating and quick cooling, after turning off light [5]. Observed some other chandeliers in museum, was found that crizzling phenomena has been found mainly around the area of holders for candles or bulks. To prove this harmful situation, due to temperature and relative humidity gradients, induced corrosion process was carried out by glass sensor method.

The test was connected with the XVIII-th c. objects. Prepared for them glass sensors of the XVIII – th c. beaker was kept in 20% formaldehyde at RT and occasionally boiling for few hours. Those parameters caused temperature gradients. Actually, the surface did not deteriorated in visibly. But an observation on the optical interferometer, presented on Fig.13 pointed to pitting corrosion. That leads to a process, which induces later very serious glass deterioration. [4, 6].

CONCLUSIONS

The internal temperature in cabinets is created by many sources: central heating (radiators) during winter, by the air conditioning throughout the year, solar radiation and lighting. The lighting is in the hall where the cabinets are, and all types of internal cabinet lighting delivers some portion of heat too.

The distance between the glass object and the light source influences on the surface object temperature. That is why object placing in showcase should be very carefully planned, to avoid overheating.

As well as internal and external lighting is on for only for some definite period of time. After turned off, temperature and relative humidity gradients are created. The cooling process in unventilated showcases caused deposits of humidity on the bottom of the cabinets. Taking into consideration the fact that water plays a fundamental role in glass corrosion, the higher humidity level will induce the corrosion of glass. Moreover this kind of interaction is stimulated by the condition of the historical objects.

In order to arrive at a better interpretation of the described phenomenon, some experiments involving induced corrosion of glass sensors should be carried out in changeable physical-chemical parameters. They will emphasize, for example the dependence of higher temperature on the influence of glass object deterioration. ■

Acknowledgements

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