Thin-Layer Materials as a Heat Transfer Blocking Agent

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***Abstract*—This is the 2nd phase of a research within the multi-annual plan focusing on the function of the coating layer with reflective properties, whereby the main measured values are especially the heat transmissions. A thin coating "functional" layer from the mixture of "Glass Bubbles" 3M ™ and the fixation medium is applied to a matrix, that is to be improved in terms of its thermo-technical behavior. [2] As part of the mid-term research, a coating layer was selected on which a series of thermal and technical parameters were measured. For the research, a measuring base was set up at Nova Ves (CZ), where 3 identical cargo container units A, B and C are all differing with in application of the functional layer – heat blocker. A - without application, presenting a reference container, B - with application on inner walls and C - with application on outside walls. In these units, indoor temperature and ambient humidity is being measured, along with the surface temperature of the shell outside and inside the unit. Data of outdoor temperatures, humidity, precipitation and solar intensity are measured with a meteorological station nearby.**

***Index Terms*— Hollow glass microspheres, Heat blocking agent, Reflective layer, Thermal-technical behavior**

I. Introduction

A. Thesis

At the monitored objects - containers A, B and C with different application of the functional layer - the blocker, we assume inadequate thermal properties for the container shell, which change after the application of the blocker. [1]

Each unit represents the sample with a different application of the functional thermal reflecting. Container B is prepared by spraying the layer of the blocker from the inside and we expect a generally smoother thermal-technical behavior in terms of a slower increase and a slower drop off in the indoor ambient temperature. [2, 3, 4] Container C is modified by spraying the blocker from the outside and we expect a total reduction in heat gains from the exterior.

For the functional layer, we assume linear behavior in the monitored thermal range, i.e. from -20 °C to + 50 °C. [4]

For the second phase of the research plan, a measuring area was built with a focus on the data acquisition from the measurements. The base is located in Nová Ves, near Mělník, CZ. It is on AZ Tech, Ltd. premises, a participant in this research project, that assists as a technical consultant, know-how provider and material assurance provider.

B. Parameters

The monitored parameters / quantities are: indoor temperature and humidity - ambient, contact temperature of the shell inside and outside the container and external parameters - air temperature, air flow, solar radiation and total solar radiation over the monitored time period.

When installing container units and at a period of monthly intervals, the sky light component was measured outside and in each of the containers, and a 360 ° reference capture was taken for other measuring purposes. [5]

C. Measuring Base and Subjects

The measuring base consist of three same container units located in a row, spaced about 20 m, in order to minimize their thermo-technical interference. The cargo containers are made of galvanized trapezoidal sheet with dimensions ca 6m / 2,2m / 2,6m (l / w / h) with an internal volume of about 34 m^3. The containers are equipped with doors on the shorter wall and a luminaire/window made of cellular polycarbonate in dimensions about 6m / 1 m located in the axis of the roof shell. [1]

II. Previous Research

In the previous phase of the research, a series of measurements was carried out on a gradually evolving measuring area, where individual containers were by installments placed. In the first phase of the research, the influence of the layer of the studied material on the thermal and technical properties of the structure was examined empirically, where the status of the functional layer and the temperature of the two containers A and B were monitored. [1]

Unit A was left without modifications, without a blocker layer, and was used as a reference / native unit. Container B was modified by spraying the blocker layer from the inside. On these two units, the application technology and the suitability of the composition of the functional layer and fixation medium have been tested. During the 1 measurement period (approximately 1 year),

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the technical parameters - strength and coherence of the surface, behavior during cyclic thermal expansion of the base surface of the structure (galvanized sheet) were monitored. The fixation medium were gradually developed to fit the needed parameter of non-influencing the heat blocker. The starting medium was derived from FBMI CTU research [6]. For the container, the parameters were measured - temperature and humidity in the interior - ambient, and the contact temperatures of the shell on the inside and outside.

During the measurement, the temperature and behavior data of the investigated subject were collected. It partially confirmed the hypothesis of a change in the thermal behavior of the container B. The temperature fluctuations caused by the solar gains incident to the outer side of the container were slower in comparison with the container without internal functional layer.

The previous phase of the research is dealt in an article Innovative coating materials for glass structures, presented on 2017, Hanoi. [1]

In the first phase of the research, repeated measurements exposed instability of the inner environment of the containers caused by the infiltration of external air. The data provided from the nearest meteorological station of Nové Ouholice (CZ) confirmed, there is an indisputable relation to the weather situation. On windy days, the collected data were rather confusing, thus noted as unsuitable for further processing.

This particular situation shifted the starting measuring methods in near ideal conditions with almost no external involvement [7] to more empiric testing in field experiment.

For measurements in the next phase of the research, the measuring system was supplemented by an automatic meteorological station, which will collect wind direction and wind speed data as well as data of solar radiation. On the basis of the data obtained from the meteorological station, the data measured on the containers will be sorted out and the data from the windy days will be removed from the measurement evaluation.

III. Current Research

Fig. 1, for the next measurement season, running from March 2017 until the end of 2017, container C is introduced. Data on ambient and container behavior A, B and C will be collected, it will be compared with the data from the meteorological station in the district and will be evaluated and processed into comparative linear graphs showing the different behavior of units A, B and C.

IV. Research Question

A. Main Research Question

Is it possible to use innovatively the 3M ™ "Glass Bubbles" material to improve the thermal and optical parameters of building structures and to verify this improvement empirically? [1]

B. Research Question for the 2nd Research Phase

Is the improvement of thermal-technical parameters of the specific structure of the functional layer and metal carrier matrix empirically verifiable?

V. Problem

Figure 1. Measuring base with the containers, from right A, C and B.

Fig. 1, within the current research phase, a set of 3 containers is prepared in the measuring area. On containers A, B and C - with a different application of the functional thermal reflecting layer - the blocker is expected to have different thermal-technical behavior. [2,3,4]

Each unit represents the examined sample with a different application of the functional thermal reflecting layer - the blocker. Container unit A is left without modifications, without a blocker layer, and is used as a reference / native unit for which unsuitable thermal-technical parameters are assumed. Container B is modified by spraying the layer of the blocker from the inside and we expect a generally smoother thermal-technical behavior resulting in a slower increase and a slower drop of the ambient temperature. Container C is alternated by spraying the blocker coating from the outside in this case a total reduction of heat gains from the exterior is to be expected. [2,3,4]

VI. Methodic

A. Data Aquisition

Each container unit is equipped with an identical independent measuring system that collects ambient temperature and humidity data at 10 minutes interval. The unit is located in the geometric center of the container. Another independent measurement unit collects the contact temperature data of the container sheet on both the inner and outer side simultaneously. The measuring probes are located on the southern façade of the container both from the outside and inside. These units collect data also at 10 minute intervals. For environmental data collection, such as: air temperature, wind strength and its velocity, solar radiation intensity and time course are simultaneously collected for all 3 containers by a meteorological station located at a distance of approximately 20 m from the measuring area of the containers.

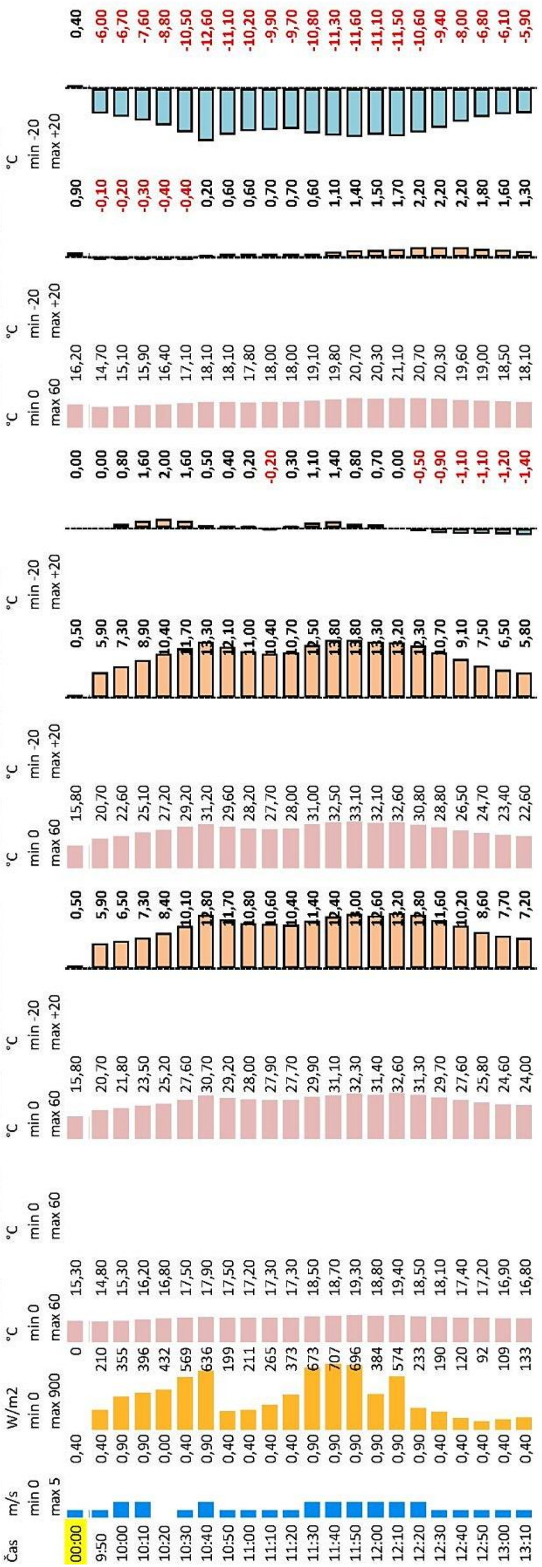

Figure 2. Reference day September 2nd 2017, Partly sunny day, from the bottom: Time index, Wind speed, Solar radiation, Exterior temperature (ET), Container A interior temperature (CAIT), Comparison with ET; Container B interior temperature., Comparison with ET, Comparison with CAIT; Container C Interior temperature, Comparison with ET, Comparison with CAIT

The data collected from independent devices are progressively evaluated in a four-step sequence, where filtering by relevance, sorting according to circumstances, and data comparison is gradually performed.

The expected outcome of the second phase of the research is a dataset containing the values measured during the relevant measurement days and suitable for the following statistical processing.

B. Data Evaluation

Data collected from independent devices are thereupon progressively evaluated in a multi-step sequence. The first step is to identify windy days where measured parameters are potentially affected. Such data are unsuitable for further processing because the container's interior environment is affected by the infiltration of air from the outside and the variance of the measured data is so great that the data cannot be processed into a relevant comparison.

Fig. 2. The second step is the processing of sorted data into comparative graphs, which show the differences between individual containers, i.e. A, B and C - with a different application of the functional thermal reflecting layer. These charts are divided into measuring sequences from 00:00 to 23:50 hours, which we consider to be the reference day.

Fig. 2. The third step is to compare such comparison graph from the reference day with the solar radiation data and the duration of sunshine. Charts of comparatively sunny days are categorized into several groups.

The fourth step is the comparison of comparative graphs in groups according to sunny days. We focus on two groups of sunny days - more or less full sun days, when we want to read the temperature differences between individual containers and alternating cloudy days where we want to read from the comparison charts the delays between the temperatures of the individual containers

VII. Conclusion

A. Evaluation of the Ongoing Phase of Research

As the previous research proved our hypothesis us with the expected results and, the research continues in profoundly improved conditions, with correct datasets provided by all 3 containers and a recently introduced meteorological setup. After the evaluation of this data, according to the methodology mentioned above, the material properties can be then certainly declared. Including the stability of the layer, that is exposed to elements, on the matrix within a longer time period. On this basis, the differences in ambient temperatures of the environment that is contained within the structure of the alternated matrix can be acknowledged. The following results are then to be published.

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