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CHOOSING THE OPTIMAL COATING FOR THERMOGRAPHIC INSPECTION

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Lately, the method of thermography is becoming an unavoidable method in non-destructive testing of different metal materials and constructions. The application of this method is found in testing the energy efficiency, deterioration of structural components, as well as testing the energy efficiency of housing units. Using the thermographic method it is possible to reduce the negative environmental impact and prevent a environmental incidents. Lately it finds its increasing application in testing of substructure changes in the material caused by deformation. A major impact on the measurement has a condition of samples surface, because of that the samples are prepared by applying a coating. In this paper testing were carried out on the effect of coating type on two important factors: stability in testing and factor of emissivity.
Key words: thermography, emissivity factor, plastic deformation, tensile testing.

Odabir optimalnog premaza za termografska ispitivanja. Metoda termografije u posljednje vrijeme postaje nezaobilazna metoda bez razaranja pri ispitivanju različitih metalnih materijala i konstrukcija. Svoju primjenu je pronašla od ispitivanja energetske učinkovitosti, dotrajalosti dijelova konstrukcija, pa sve do ispitivanja energetske učinkovitost stambenih objekata. Korištenjem termografske metode moguće je smanjuje negativnog utjecaj na okoliš te spriječiti ekološke incidente. U posljednje vrijeme sve češću primjenu pronalazi kod ispitivanja substrukturnih promjena u materijalu uvjetovanih deformacijom. Na rezultate mjerenja velik utjecaj ima stanje površine ispitivanih uzoraka, zbog toga se uzorci pripremaju nanošenjem premaza. U ovom radu provedena su ispitivanja utjecaja vrste premaza na dva važna faktora: postojanost kod ispitivanja i faktor emisivnosti.
Ključne riječi: termografija, faktor emisivnosti, plastična deformacija, statički vlačni pokus.

INTRODUCTION

The method of thermography today has an increasingly important role in a variety of studies in the chemical industry, oil industry, and increasingly in the laboratory tests of material deformation. With this method it is possible to determine the various sources of thermal radiation, by which it can be located e.g. the place of overheating of the reactor, the loss of thermal energy due to poor insulation, or a predicted the place for crack initiation in metal structures [1,2].

The basic device for the implementation of thermographic testing is so called infrared camera. The infrared camera detects the total amount of energy that comes to its detector [3,4]. This total energy consists of emitted energy, transmitted energy and the reflected energy. Thermographic method aims to measure only the emitted energy from the body that carries information about the state of the structure. Most of the materials used in construction are bodies that have no possibility of transmission of heat energy. If we eliminate the reflection of surface of samples, it is measured only the emitted energy of the body.

For the accuracy of the thermographic method is necessary to know the exact emissivity factor of the body. He is dependent on the type of material and it changes with polishing the surface and temperature of the body. For this reason, it is often necessary to determine the factor of emissivity, since it has a significant impact on the value of the measured changes in temperature. There are some methods of thermography that eliminate the influence of emissivity factor [5]. Newertheless, in laboratory research the preparation of sample surface is still carried out, in order to ensure the accuracy of the measurements. For that purpose the different types of coatings are used which are applied to the surface of the material being tested. In doing so, it seeks to ensure a high and constant amount of emissivity factor throughout the whole tested body [6-8]. Using a matte coating also reduces the reflection, ensuring the high-quality implementation of thermographic testing.

Preparation of samples for thermographic testing is not defined in detail and various researchers are using different coatings for the preparation of samples. In doing so, there are used coatings from black matte to even the white matte coatings in some cases. Some research suggests that the best way of preparing of samples is by vapour deposition of graphite on the samples, which has a good thermal conductivity and emissivity factor very close to ideal black bodies [6-7]. But conducted testing do not indicate how these coatings act when deforming the observed samples.

As in a variety of laboratory testing of behaviour of metallic material while deforming, are observed samples that greatly alter their dimensions, it is important to predict the behaviour of the coating in this conditions.

The aim of this study is to determine the most appropriate coating for thermography testing method during deformation of samples in laboratory conditions. The coating should withstand a certain amount of deformation and in doing so that does not come to the separating of coating from the surface of samples. Further on, the coating must have a uniform, and stable emissivity factor on the whole observed surface of samples.

EXPERIMENTAL WORK

Studies were conducted on flat samples for tensile testing, on which it was previously applied three different coatings. Tests were conducted at room temperature of 25 °C. Tested coatings were black matte coating Chromos DS MASK, black matte Motip basic RAL 9005, and white matte Motip basic RAL 9010.

Samples for tensile testing were made from low-carbon hot-rolled steel sheet from the ST52-3N steel. On the pre-cleaned surface of samples coatings were applied by spraying a thin layer of coating. Tests were conducted on 6 groups of samples, depending on the method of applying the coatings, Figure 1.

On the first group of samples it is deposited a classic black matte coating over the entire surface of the sample, on the second group Chromos DS MASK and the third white matte coating, Figure 1 a). Other three groups of samples were coated with two different coatings, each on one half of the sample has one coating, so that one group has a white mat and black matte coating, the second black matte and Chromos DS and third white matte and Chromos DS coating, Figure 1 b). In this way it was meant to demonstrate the difference in the measured values of temperature changes on the same sample, depending on the type of used coating.

a)

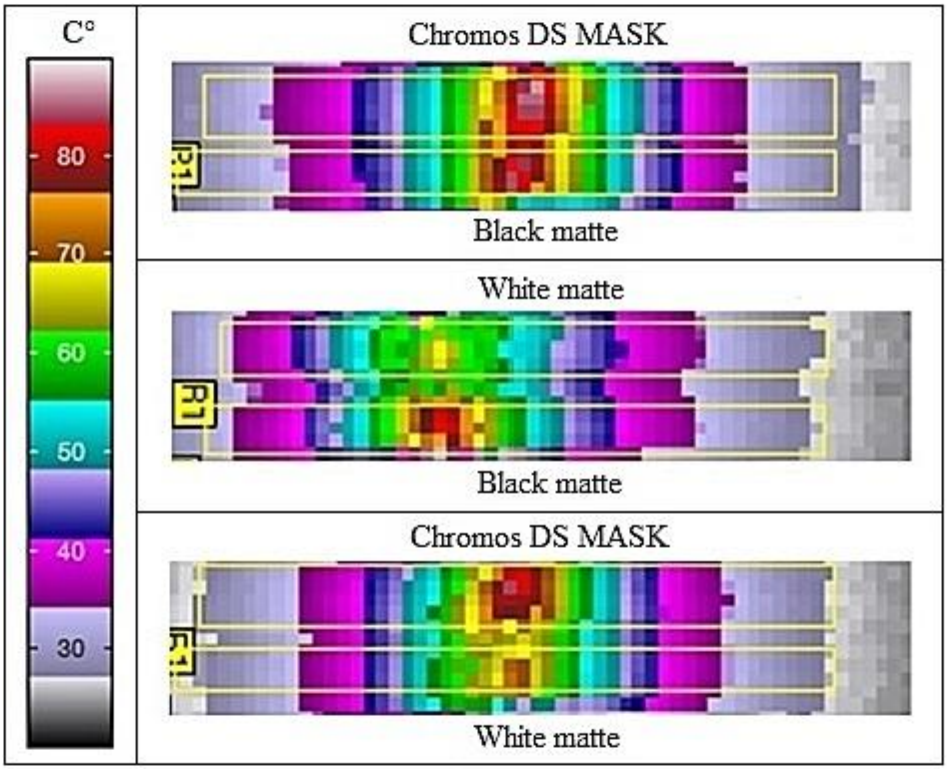
b)

Figure 1. Samples with coatings
Slika 1. Uzorci sa premazima

Measurements of temperature changes during the static tensile experiments were performed using infrared camera JENOPTIK VarioCAM M82910, which has a sensitivity of 80 mK. During the test was used to record the frequency of 50 Hz. Before the test, the camera is calibrated to room temperature. To determine the emissivity factor of the examined coating, the current temperature of samples was measured by the contact thermometer DOSTMANN electronic GmbH, model P410, with the probe type K. In the settings of thermographic camera the factor of emissivity was adjusted until the temperature of the sample on thermo-graphic camera was equal to the temperature measured by a contact thermometer. After the calibration samples were subjected to tensile testing and temperature changes were recorded with thermographic camera. The same surface of samples was recorded simultaneously with optical camera, in order to record the changes on the surface of samples during testing, i.e. stability of the coating. Subsequent analysis of thermographic measurements was carried out through a software package IRBIS 3 professional.

EXPERIMENTAL RESULTS AND DISCUSSION

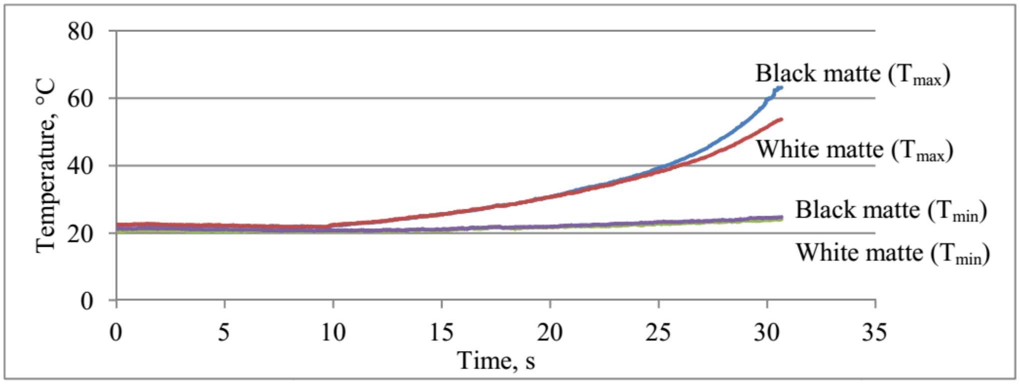
By adjustment of emissivity factor within the parameters of thermal camera it was determined that white matte coating has emissivity factor below 0.9, black matte coating around 0.92 and Chromos DS MASK a maximum of 0.95. Using these emissivity factors, on recorded thermograms a significant differences between the readings of temperature changes were observed. This difference is particularly evident in samples where it was used two parallel coatings, Figure 2.



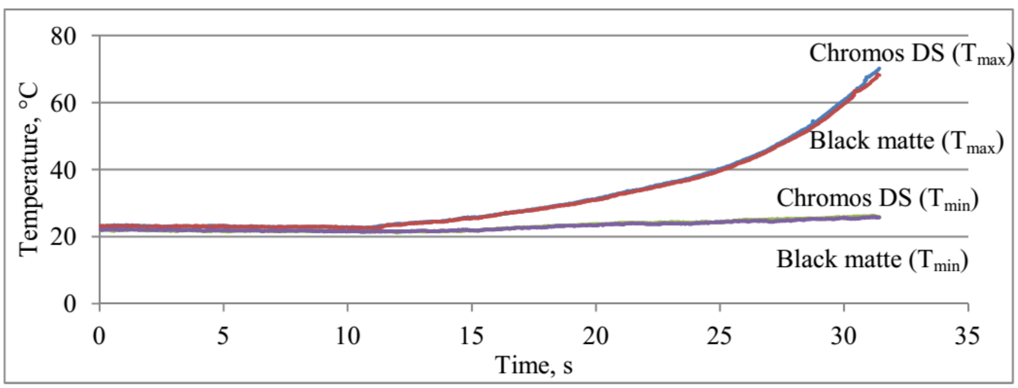
Slika 2. Razlika u očitanju temperatura kod korištenja različitih premaza
Figure 2. Difference in temperature readings when using different coatings

From the temperature distribution at the surface of the of samples, shown in Figure 2, it can be seen that in the case of using a white matt coating, parallel with Chromos DS MASK coating, the temperature differences are the most obvious.

It can be noticed that in the case of white matte coating the measured tempera-ture changes are the smallest. On the surface that had a common black matte coating temperature change are somewhat smaller amount, but approximately close as in the case Chromos DS coatings. In order to determine the temperature difference, depending on the used coating, the software package IRBIS 3 professional was used to analyze temperature changes throughout the entire process of deformation, for each coating separately. The place of measuring of temperature changes is shown with yellow rectangles in Figure 2. The results of measured temperature changes are shown in Figure 3 and Figure 4.



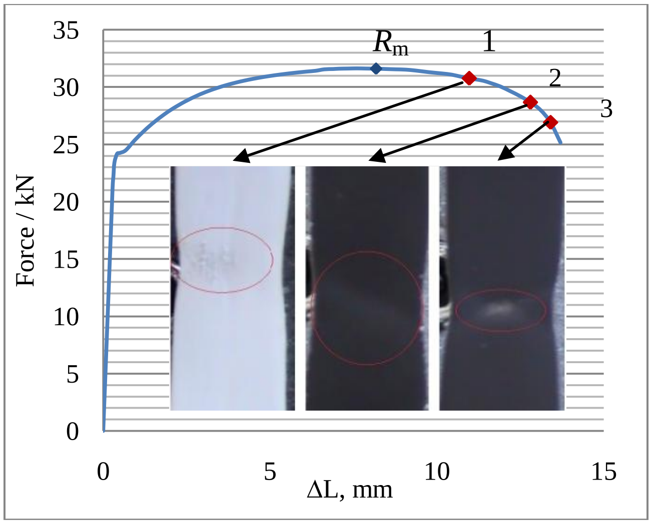
Slika 3. Izmjerene promjene temperature kod crnog mat i bijelog mat premaza
Figure 3. The measured temperature changes with a black matte and white matte coating



Slika 4. Izmjerene promjene temperature kod crnog mat premaza i Chromos DS MASK premaza
Figure 4. The measured temperature changes with a black matte coating and Chromos DS MASK coatings

Results of thermographic analysis shown in Figure 3 and Figure 4 indicate that on the part of the samples that had Chromos DS MASK, the measured temperature change is the largest, which corresponds to the highest amount of emissivity factor. The change in temperature was uniform across the width of the samples and it is caused by plastic deformation during static tensile testing. Measured temperature diffe-rences were due to different emissivity factors of used coatings.

Another important criterion that the coating must meet is when testing with a large amount of stretching of the samples the coating must be steady the entire time. During tension testing of samples, the surface was recorded with digital camera to determine the moment of cracking and chipping of the coating from the samples, Figure 5.



Slika 5. Mjesto odvajanja premaza i diskoloracije
Figure 5. Location of chipping of coating and discolorations

It was found that the Chromos DS MASK is the best coating of three tested coatings. White matte coating, Figure 5 1), has endured the lowest deformation and very quickly comes to the chipping of the surface. The black matte coating, Figure 5 2), also very early began chipping from the surface of samples. When using Chromos DS MASK coating, Figure 5 3), chipping occurred just before the rupture of the samples.

This is very important because during the test thermographic method if for any reason there is a separation of the coating from the surface of the observed body, thermographic camera measures the surface of this coating, which does not give the exact condition that occurs in the material with which then is not in contact. Another problem if the paint chips off is that part of samples the emissivity factor is changed, which gives error of measurements. By analyzing the photos that were taken with a digital optical camera during the stretching of samples, it is also found that during stretching of samples, ie coatings on the samples, there is a discoloration of used black coatings.

This is in the case of Chromos coating also before the fracture which hosted a very large amount of local deformation in the zone of necking. In an ordinary black matte coating is followed earlier and subsequently peeled from the surface of samples. All this proved that the Chromos DS MASK, black matte coating, is the most suitable for the measurement by method of thermography in cases when there are very large deformation of the samples.

It was observed that during deformation of samples on which the coatings were deposited for a longer period, the separation and chipping of the coating occurred earlier. For this reason it is necessary to put coating on samples shortly before testing. In the case of Chromos DS MASK, it takes some time to coating to dry out, and it was determined that is optimum that samples are coated with Chromos DS MASK about 12 hours before the tensile testing.

For this reason, when using thermal imaging to observe the process of deformation of samples, or in other cases when observed bodies have a big change in dimensions during the test, the coatings must be applied within a reasonable time prior to the test. But it must be kept in mind that the coating must dry completely before testing, otherwise it possible to come to measurement error due to spending part of dissipated heat to the evaporation of solvents from the paint that has not yet dried.

CONCLUSION

It can be concluded that the tested Chromos DS MASK coating has the best properties for use in thermographic studies. With the largest amount of emissivity factor, it stays on the surface of samples at even a larger amount of deformation, and at the same time there is no significant discoloration. When testing objects that are not subjected to deformation, one can use classic black matte coating, but you have to take into account the slightly lower emissivity factor. Applied coating must be in a thin even layer, and must be given a sufficient time to completely dry out.

If coating is on the surface for a longer period, it can lead to earlier separation and chipping from the surface of samples.

By thermographic method it cannot be detect the place or time when chipping and discoloration occurs, and consequently it can lead to the measurement error.

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