Dariusz ULBRICH, Marian JÓSKO, Ryszard MAŃCZAK
Instytut Maszyn Roboczych i Pojazdów Samochodowych Politechniki Poznańskiej
ul. Piotrowo 3, 60-965 Poznań
e-mail: dariusz.m.ulbrich@doctorate.put.poznan.pl

MONITORING OF THE KINETICS OF ADHESIVE BOND TYPE CAR PUTTY COATING-STEEL SUBSTRATE WITH ULTRASONIC METHOD

Summary

A method used for monitoring the formation process of adhesive bond type car putty coating and steel substrate is presented in this article. In the experiment some samples made of steel and universal car putty are used. The main goal of the experiment is to designate changes of two parameters: the variation of the ultrasonic gain and reflection coefficienvt during the cure time. These parameters are calculated based on the echo height changes of the ultrasonic signal. The test's results: average, minimum and maximum values of determined parameters are shown in the figures. Time of the test is equal to 60 minutes and every three seconds the variation of echo height is recorded. The obtained results will be compared to the results for other car putties as the next step of the research.
***Key words**: ultrasound, adhesion, car putty coatings*

MONITOROWANIE KINETYKI TWORZENIA POŁĄCZENIA ADHEZYJNEGO TYPU POWŁOKA SZPACHLÓWKOWA-PODŁOŻE STALOWE METODĄ ULTRADŹWIĘKOWĄ

Streszczenie

W artykule przedstawiono metodę monitorowania konstytuowania połączenia adhezyjnego typu powłoka szpachlówkowa-podłoże stalowe. Badania wykonano na próbkach stalowych. Celem badań było wyznaczenie, na podstawie zmiany wysokości impulsu ultradźwiękowego, trendu zmiany wzmocnienia sygnału i modułu ciśnieniowego współczynnika odbicia. Wyniki zobrazowano na wykresach; przedstawiono wartości maksymalne, minimalne i średnią wyżej wymienionych parametrów w czasie utwardzania połączenia, który wynosił 60 minut, a zmiany wysokości pierwszego echa sygnału ultradźwiękowego zapisywano co 3 sekundy. W kolejnym etapie badań zostanie zastosowana inna powłoka szpachlówkowa, a otrzymane wyniki będą porównane z zaprezentowanymi w niniejszym artykule.
***Słowa kluczowe:** ultradźwięki, adhezja, powłoki szpachlówkowe*

1. Introduction

Glued joints and bonds type car putty coating-steel substrate are widely used in motor vehicle industry. Car putty is a material applied on the car body while repairing. It is used to smooth the surface in a purpose to restore the original shape of car body sheet. To evaluate the adhesion and durability of the adhesive bond of type car putty coating-steel substrate are used destructive [1] and nondestructive methods [2-4]. In group of nondestructive methods, the ultrasonic method is widely used in automotive industry.

In the ultrasonic method some ultrasonic waves (longitudinal, surface, transverse waves) are used. This waves propagate in the tested material. Changes of the ultrasonic parameters evidence about the weakening or strengthening of adhesion between car putty coating and car body sheet. The ultrasonic method is mainly used to control the degradation process of adhesive bond, type car putty coating to car body sheet [2, 4]. Also ultrasonic method can be used to detection of flaws in the materials and to measurement of the thickness of some objects.

Maintenance the right condition of car putty application on the steel substrate is very important in point of view of quality and durability of the adhesive bonds. Any deviation from the recommended by the car putties manufacturers application technology can cause problems such as falling of car putty. This problems rise during the operation of vehicles. Therefore is very important a nondestructive control of the curing process, between car putty coating and car body sheet.

The goal of described in the article experiment is designation of changes of the course of ultrasonic gain and reflection coefficient in a cure time. As the next step of the experiment will be comparison of the given results with the results for other car putties.

2. Description of research

During the study are used some samples made of steel. These samples are in the shape of the disc with a diameter of 60 mm and the thickness of 30 mm (Figure 1).

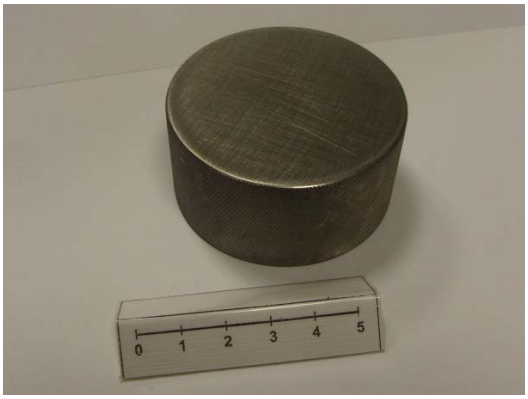

Figure 1. View of a sample

The surface of each sample is degreased and then it is sanded with sandpaper of grain size No 80. Grinding is carried out manually in two perpendicular directions. Next, the surface is degreased again with the KD CHECK PR1 remover made by Karl Deutsch Company. After preparation of the surface and before car putty coating was applied, each sample was measured by profile measurement gauge. This process of measuring allowed to control profile parameters (R_a, R_z) for all of the samples. The measurements of roughness profile are carried out on Carl Zeiss Jena profile measurement gauge.

The example of roughness profile for selected sample is shown in Figure 2. The comparison of two main parameters for all of the samples: the arithmetic average of absolute value (R_a) and profile height by 10 points profile (R_z) is shown in Figure 3 and Figure 4.

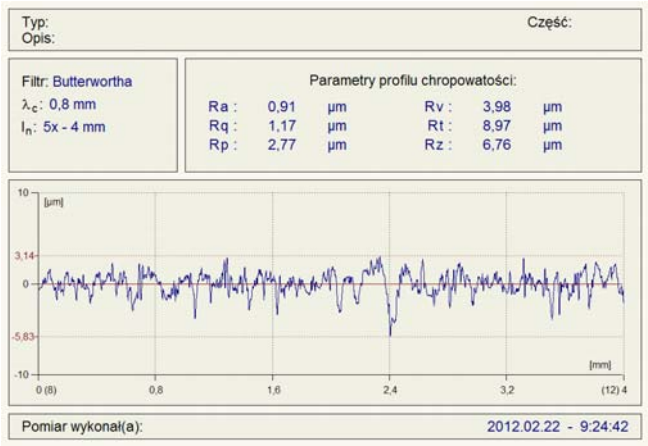

Figure 2. Selected surface profilogram, received by Carl Zeis Jena profile measurement gauge before car putty is applied

For most of the samples the parameter R_a is in the range from 0.81 to 0.99 microns. Worth of the arithmetic average of absolute value for the second sample is equal 0.57 microns. This value is smaller than values for other samples but this difference has not influence on the results of ultrasonic parameters. The value of second checked parameter of roughness profile (R_z) is in the ranged from 4.45 to 8.34 microns.

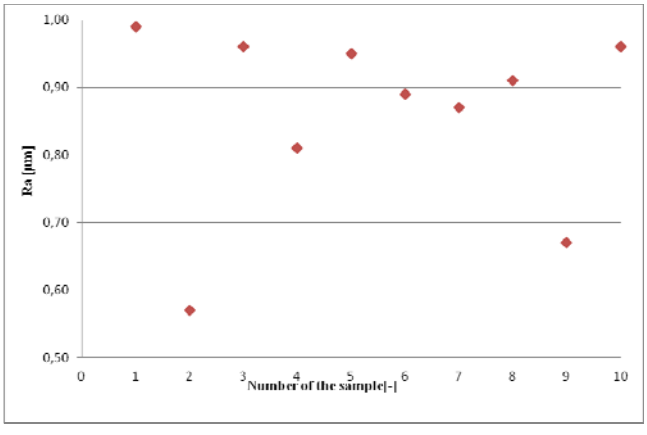

Figure 3. Values of the parameter R_a for all samples

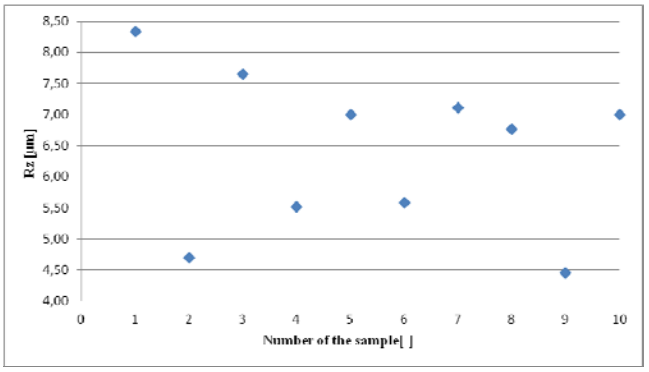

Figure 4. Values of the parameter R_z for the samples

During the tests is used universal car putty produced by Novol Company (Figure 5). This putty is one of the many putties used in car body repair and has a good adhesion to various substrates. Examined universal car putty is relatively hard and has little flexibility [5]. The car putty consists of two mixed in appropriate proportions ingredients. To measure the proportion of the ingredients, electronic scales is used.

Figure 5. Universal car putty produced by Novol Company [5]

The sample with an ultrasonic transducer is mounted in a special holder (Figure 6). Next, the car putty coating is applied on the surface. During the studies is used the ultrasonic transducer DS 12 HB 1 - 6 made by Karl Deutsch Company and the flaw detector UMT – 15. The ultrasonic transducer is linked to the sample during the time of experiment with an oil. Every 3 seconds during the test, the ultrasonic parameters are recorded.

The duration of the experiment is equal 60 minutes for one of the sample. It means that the time of experiment is twice longer than the curing time given by the manufacturer of car putty. According to the information from the Novol Company, full properties car putty achieves after 20 to 30 minutes of the cure time at 20 Celsius degrees. Observed parameter is first echo height of the ultrasonic wave reflected from the bond's board. On the base of this changes are determined the differences in gain of signal and the reflection coefficient.

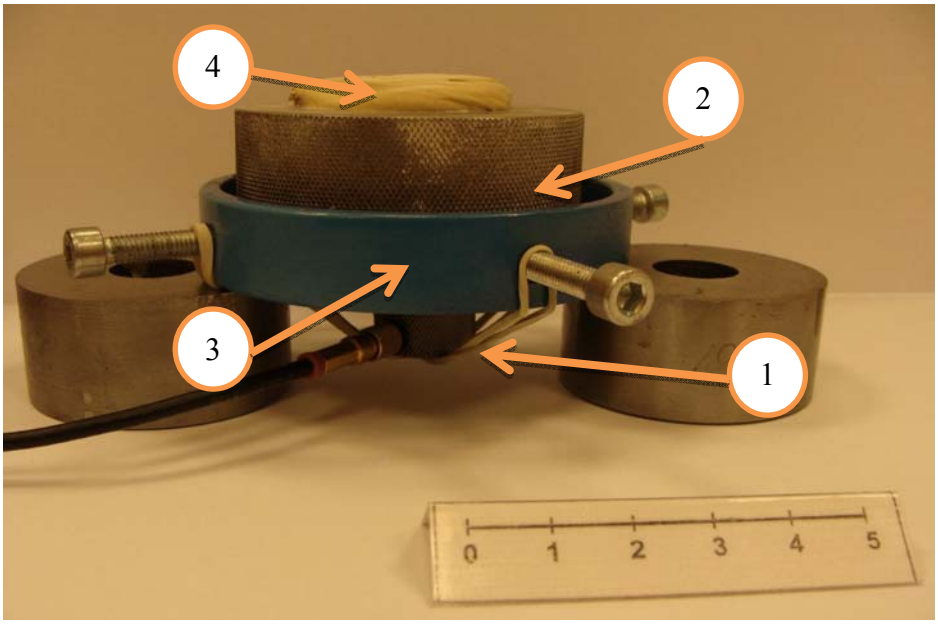

Figure 6. Measuring system: 1 – ultrasonic transducer, 2 – sample, 3 – holder, 4 – car putty

3. Results of research and conclusions

The example of the changes of ultrasonic gain and reflection coefficient are presented in Figure 7 and 8. The received results are similar for all samples. An average value of gain of the ultrasonic signal rises in around 30 minutes to around 1,063 of the initial value. Next, this value remains constant till the end of the test.

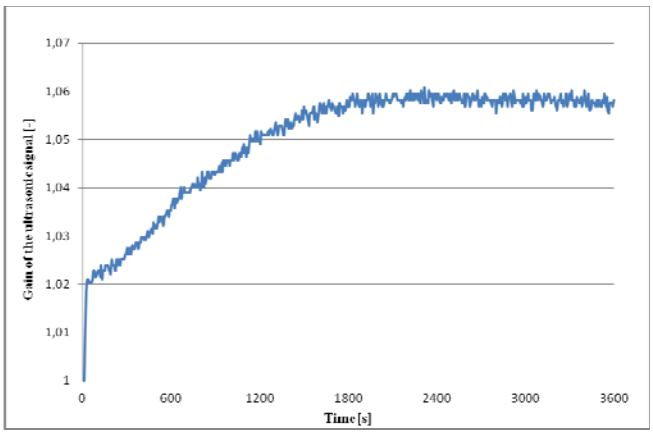

Figure 7. Example of the changes of the gain of ultrasonic signal for selected sample

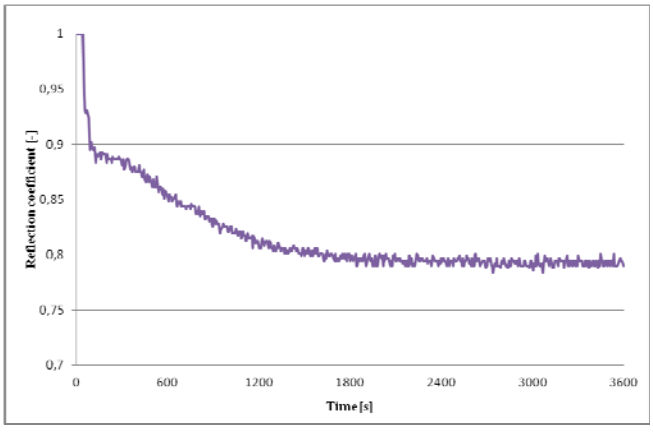

Figure 8. Example of the changes of the reflection coefficient for selected sample

The maximal received during the research worth of gain of the ultrasonic signal is 1,08 of the initial value. The lowest received value of ultrasonic gain after 30 minutes from the beginning of the test is around 1,055 of the initial value. The differences of the gain of ultrasonic signal not exceed 8% of the initial value for all of the samples. The value of reflection coefficient is equal 1 at the beginning of the experiment. Next, an average value of the reflection coefficient declines in around 30 minutes to the worth 0,78 of the initial value. The minimal achieved value of the reflection coefficient during the tests is equal 0,725 of the initial value. In the Figures 9 and 10 are presented the average, minimum and maximal values of gain of the ultrasonic signal and reflection coefficient for all of the samples. If the value of reflection coefficient is smaller, the adhesion between car putty coating and car body sheet is better.

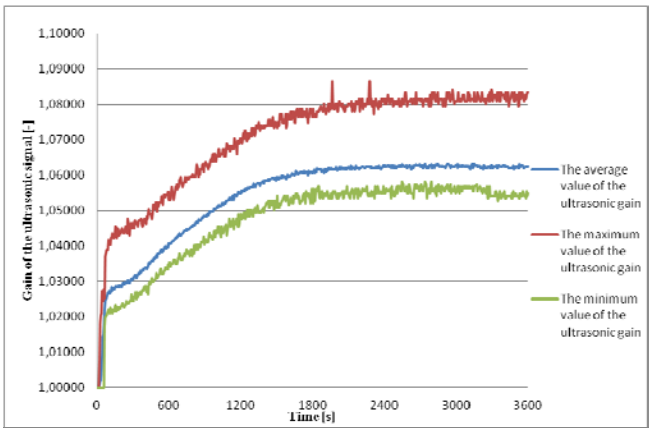

Figure 9. Changes of the gain of the ultrasonic signal in the cure time

Based on the carried out experiment, below are presented main conclusions:

- After 30 minutes from the beginning to the end of the experiment, values of the two checked parameters are almost on the same level, this means that there were not significant changes in the board of the bond.

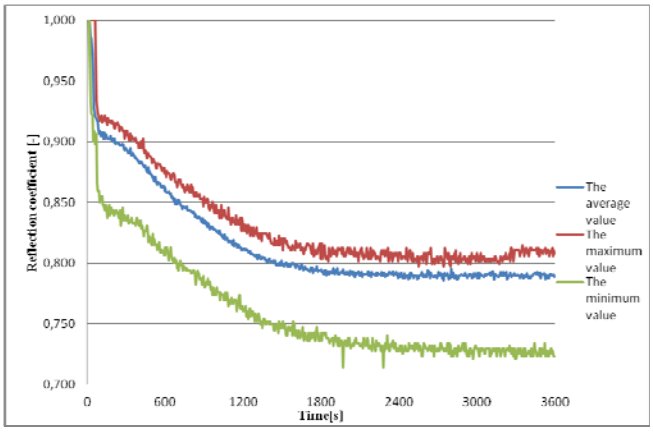

Figure 10. Changes of the reflection coefficient in the cure time

- Curing time of adhesive bond takes around 20 to 30 minutes in 20 Celsius degrees. This information is given by the manufacturer. The research confirms this time because significant changes of the ultrasonic parameters were observed only from the beginning to 30 minutes of the experiment.
- Presented method can be used to check the curing process between car putty coating and steel substrate. Variations of the gain of ultrasonic signal and reflection coefficient evidence of changes in the board of adhesive bond type car putty coating-steel substrate.

The next step of our work will be comparison the received results for universal car putty to results for other car putties produced by different manufacturers. Also research on car body sheet are planned.

4. References

[1] Biestek T., Sękowski S.: Methods of test for metallic coatings. WNT, Warsaw 1973 (in Polish).
[2] Jósko M.: Methodological aspects of evaluation of regenerative coatings adherence using an ultrasonic method. Publishing house of Poznan University of Technology, Poznan, 2002 (in Polish).
[3] Pilarski A.: Evaluation of adhesion strength of laminated connections. PhD dissertation. IPPT-PAN, Warsaw 1983 (in Polish).
[4] Mańczak R.: The study of degradation of car putty coatings with the substrate steel using an ultrasonic method. PhD dissertation, IMRiPS, Poznan 2012 (in Polish).
[5] http://professional.novol.pl/produkty.php?id=5 – the manufacturer's website, 13.06.2012