Jakub KOWALCZYK, Dariusz ULBRICH, Marian JÓSKO, Ryszard MAŃCZAK
Politechnika Poznańska, Instytut Maszyn Roboczych i Pojazdów Samochodowych
ul. Piotrowo 3, 69-965 Poznań, Poland
e-mail: jakub.kowalczyk@put.poznan.pl

INFLUENCE OF SURFACE PREPARATION OF GLUED PARTS ON STRENGTH OF JOINT

Summary

In the article, considerations of the impact of surface preparation of glued machine parts on the mechanical strength of the adhesive connection are presented. The research was carried out on a number of cylindrical samples in the laboratory and samples made of steel sheet reflecting industrial conditions. The surface of the substrate was prepared in four different ways: sandblasting, degreasing, oil contamination of the surface and covering an area of glued parts of grease. The relationship between the mechanical strength of adhesive joint and contamination of the surface of bonded parts was defined, as a main result of the research.
***Key words**: strength, bonding, steel*

WPŁYW PRZYGOTOWANIA POWIERZCHNI KLEJONYCH ELEMENTÓW NA WYTRZYMAŁOŚĆ POŁĄCZENIA

Streszczenie

W artykule przedstawiono rozważania dotyczące wpływu przygotowania powierzchni podłoża klejonych elementów maszyn na wytrzymałość mechaniczną połączenia adhezyjnego. Badania zrealizowano na szeregu próbek krążkowych w laboratorium oraz próbkach wykonanych z blachy stalowej odzwierciedlających warunki przemysłowe. Powierzchnię podłoża klejonych elementów przygotowano na cztery różne sposoby: piaskowanie, odtłuszczenie, zaolejenie powierzchni, pokrycie powierzchni klejonych części smarem plastycznym. W wyniku zrealizowanych badań wyznaczono zależność między wytrzymałością mechaniczną połączenia klejowego a zanieczyszczeniem powierzchni podłoża łączonych elementów.
***Słowa kluczowe**: wytrzymałość, klejenie, stal*

1. Introduction

Adhesive joints have been widely used since the forties of the twentieth century in the construction of machines, including agricultural machinery, motor vehicles and other equipment, which are used by people in everyday life [5, 7, 8]. Adhesives are chemical substances able to joining materials, sealing the connection and providing balanced stress distribution in the entire bond.

Joining mainly occurs as a result of the adhesion forces, mechanical adhesion and cohesion of the adhesive. The adhesive does not require particularly high mechanical processing, which is mostly limited to grinding the surfaces for jointing. Execution of high-quality adhesive connection is related to compliance with the technological regime during the surface preparation of glued samples, preparation and applying of the adhesive, and heating of the joint, if it is provided by manufacturer of adhesive [1].

Destructive testing methods of bonded joints are methods that allow to specify the quality of the connection, but at the same time cause bond destruction. They are relatively well known and described in national [4, 9, 10, 11, 12, 14], and foreign [2, 3, 13] literature. Basic destructive evaluation methods are mechanical methods (e.g. tensile and lap joint tests). The usual destructive method used for testing adhesive joints is method which allows to determine their resistance to shear or tear [14] forces. Destructive methods are widely used as research methods to evaluate both the adhesive properties, as well as control of correctness of adhesive technologies (surface preparation, preparation of the glue and others).

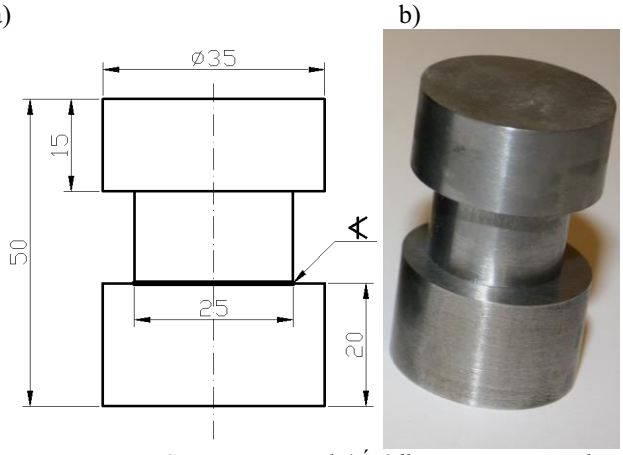
The problem of appropriate surface preparation of the substrate of bonded parts is important and it often occurs in industrial applications, e.g. on a production line of car body of motor vehicles. Taking into account the above considerations, the main objective of the research was to determine the effect of surface preparation of the bonding substrate on the mechanical strength of the adhesive bond. Research was conducted in two stages. The first test consisted of joints made in accordance with the standard (laboratory test). In the second stage of the experiment there was a connection that reproduce the actual conditions occurring during the production of car body of motor vehicles.

2. Materials and methods

In the first stage of research (laboratory tests), on circular samples (Fig. 1), made of steel, the surfaces were prepared in 4 different ways. For the first series (10 samples), surface of the adhesive connection was sandblasted by synthetic corundum. The surface of the second batch of samples was cleaned and degreased. For the third series of the samples, the thin oil layer was applied on the surface. While, during preparation of the fourth series of samples, on the surface, a small amount of grease ŁT-42 was applied. For bonding all samples during the experiment, the adhesive Sikaflex 221, commonly applied in the manufacturing stage of motor vehicle bodies construction process was used. This adhesive is characterized by the fact that it does not require heating in order to achieve the required quality of adhesive joint.

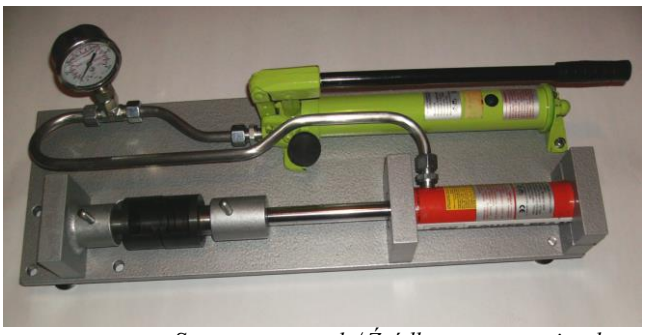
Samples prepared in 4 measuring series were destroyed on the device, available in the laboratory of Department of Motor Vehicles and Road Transport of Poznan University of Technology (Fig. 2).

a) b)



Source: own work / Źródło: opracowanie własne

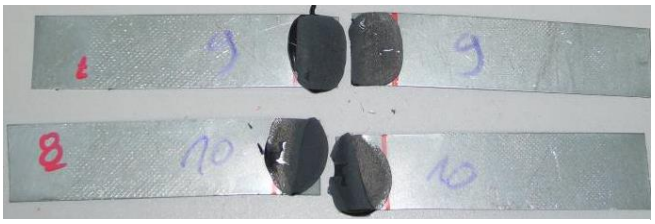
Fig. 1. Samples used during the laboratory tests: a) geometrical parameters, b) general view
Rys. 1. Próbki użyte podczas testów laboratoryjnych: a) parametry geometryczne, b) widok ogólny



Source: own work / Źródło: opracowanie własne

Fig. 2. Device used to assess the mechanical strength of the adhesive connections
Rys. 2. Stanowisko do oceny wytrzymałości mechanicznej połączeń klejonych

In the second stage of the study, samples in accordance with industrial conditions were prepared - a combination that is made at the production line of automotive vehicle bodies (Fig. 3). Five samples for each series (preparation of the bonded surfaces was the same as in the laboratory tests) were performed. Samples were made of a body sheet, which is used by one of the vehicle manufacturers and have dimensions of 28 x 117 x 0,75 mm. The surface on which the Sika 490/7 adhesive used by car manufacturer was applied, had dimensions of 20 x 20 mm. Prepared adhesive connections were heated for 20 minutes at 180°C. Samples prepared according to the above conditions were torn in testing machine, and the results of stress are presented in the next section of this paper.



Source: own work / Źródło: opracowanie własne

Fig. 3. View of samples used in the second stage of the experiment
Rys. 3. Widok próbki użytej w drugim etapie badań

3. Results of research

As a result of research, a series of relationships between surface preparation of samples and the mechanical strength of the adhesive bond was obtained. These relationships are shown in Fig. 4 to 7 [6].

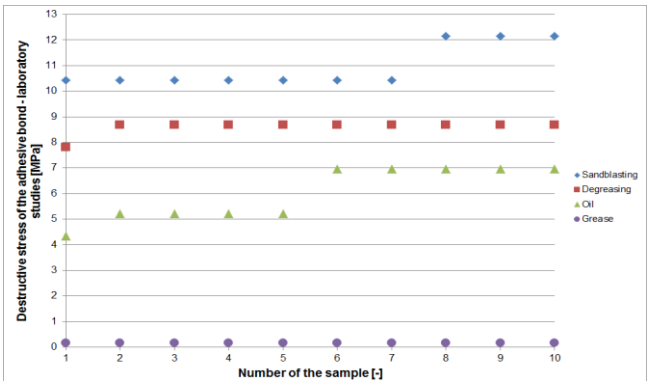


Fig. 4. Results of destructive stress of the adhesive joint for all of the samples obtained during the laboratory research [6]
Rys. 4. Wyniki badań niszczących połączeń klejowych dla wszystkich próbek podczas badań laboratoryjnych [6]

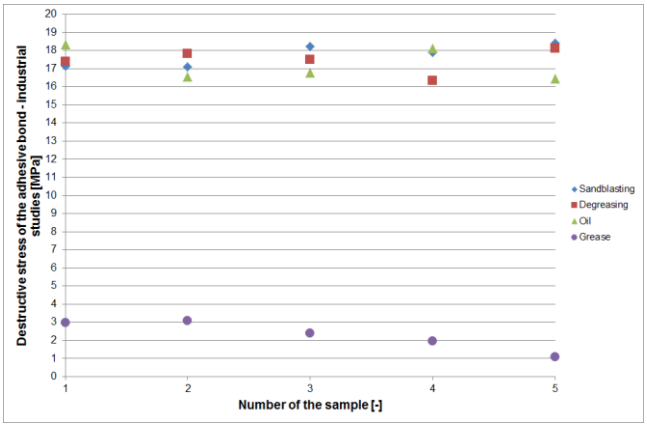


Fig. 5. Results of destructive stress of the adhesive joints for all of the samples obtained during the industrial research [6]
Rys. 5. Wyniki badań niszczących połączeń klejowych dla wszystkich próbek podczas badań przemysłowych [6]

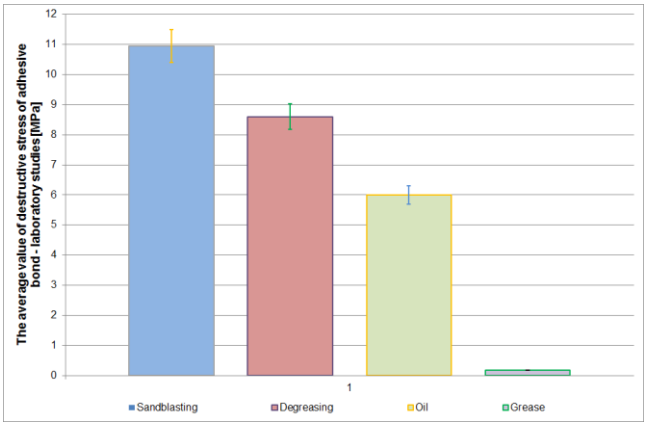


Fig. 6. The average value of destructive stress of the adhesive joints obtained during the laboratory studies [6]
Rys. 6. Średnia wartość niszczących naprężeń połączenia klejowego otrzymanego w badaniach laboratoryjnych [6]

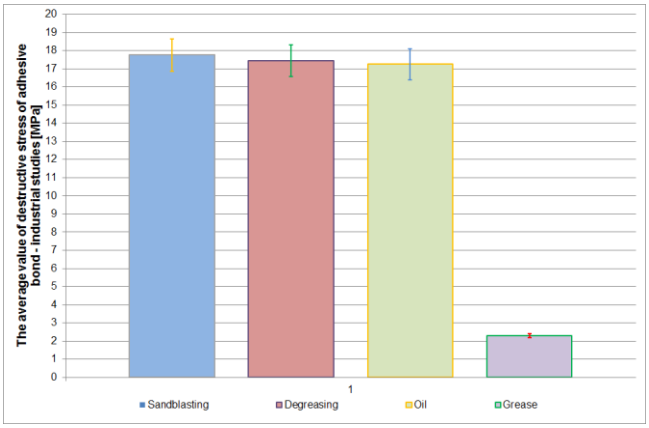


Fig. 7. The average value of destructive stress of the adhesive joints obtained during the industrial studies [6]
Rys. 7. Wartość średnia niszczących naprężeń połączeń klejowych w badaniach przemysłowych [6]

Based on the research results, it should be noted that the average value of destructive stresses for circular samples was lower than the results of these stresses for samples made from the body sheet. This difference is probably caused by using two different adhesives and industrial samples (also heating of this samples during manufacturing process, which significantly increased the strength of the adhesive bond). For samples of body sheet, only a surface covered with grease, reported lower (about 2 MPa) destructive stress values. For the remaining cases (sandblasting, degreasing, oil) stress values were similar (around 17 MPa). Larger differences between the average stresses (different methods of preparation of the surface of the substrate of glued elements) were observed for the cylindrical samples prepared in the laboratory. To summarize the results of the research it should be noted that the required quality and durability of the adhesive connection is largely dependent on the method and accuracy of preparation of surface elements for gluing process.

4. Conclusions

On the basis of the studies (the impact of surface preparation of bonding elements on the mechanical strength of the adhesive bond) the following conclusions can be drawn:

- Nowadays produced adhesives used for bonding sheet (as opposed to previously produced), are characterized by oil absorption, which may remain after machining of steel sheet and minor amounts (by industrial research 3g/m^2) does not significantly degrade the strength of the joint.
- Research carried out on circular samples (prepared according to the standards) should be repeated on samples from industrial conditions in which the adhesive bonds are formed on the production line.
- The work carried out confirmed that preparing surfaces for bonding of such samples, which will not be heated, should use not only cleaner, but also an activator of the surface.

Destructive methods (tensile and lap joint tests) give unambiguous information about the state of connector. However, these methods are not suitable to control all joints in industrial conditions. Therefore, it seems important to propose and develop non-destructive methods which will permit to assess the quality of large amounts of joints, even of all the glued joints occurring in the machine. In case of a positive assessment of adhesive joint, machine could be used in further exploitation.

5. References

[1] Adams R.D.: Adhesive bonding Science, technology and application. Woodhead Publishing Limited, 2005.
[2] ASTM D 2095 Standard Test Method for Tensile Strength of Adhesives by Means of Bar and Rod Specimens.
[3] ASTM D882-02 Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
[4] Czaplicki J.: Klejenie tworzyw konstrukcyjnych. Warszawa: Wydawnictwa Komunikacji i Łączności, 1987.
[5] Kuczmaszewski J.: Fundamentals of metal–metal adhesive joint design. Lublin University of Technology: Polish Academy of Sciences, Lublin Branch, 2006.
[6] Maciuszek D.: Wpływ zanieczyszczenia powierzchni blach karoseryjnych na jakość połączenia klejowego. Niepublikowana praca magisterska. Biblioteka Politechniki Poznańskiej, 2010.
[7] Mirski Z., Piwowarczyk T.: Klejenie metali. Przegląd Spawalnictwa, 2003, 6, 10-18.
[8] Mirski Z., Piwowarczyk T.: Klejenie w budowie pojazdów samochodowych. Przegląd Spawalnictwa, 2004, 5/7, 68-72.
[9] PN-59/C-89301. Kleje do metali. Oznaczanie wytrzymałości na odrywanie.
[10] PN-69/C-89300. Kleje do metali. Oznaczanie wytrzymałości na ścinanie.
[11] PN-69/C-89302. Kleje do metali. Oznaczanie wytrzymałości na oddzieranie.
[12] PN-69/C-89304. Kleje do metali. Oznaczanie wytrzymałości na zginanie.
[13] Pocius A. V., Chaudhury M.: Adhesion Science and Engineering. 2002, Vol. 1. The Mechanics of Adhesion, Elsevier.
[14] Rudawska A., Kuczmaszewski J.: Klejenie blach ocynkowanych. Lublin: Wydawnictwa Uczelniane, 2005.