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Decreasing the Adhesion Effect of Surfaces Using Graphite Pellicle Deposition Through Electric Discharges in Pulse

TOPALA Pavel[a*], BESLIU Vitalie[b] and MARIN Laurentiu[c]

Alecu Russo Balti State University, Department of Physical and Engineering Sciences

Pushkin Str. 38, MD-3100, Balti, Republic of Moldova

[a]pavel.topala@gmail.com, [b]besliuvitalie@mail.ru, @yahoo.com

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Abstract. The paper aims at studying the phenomenon of adhesion between the graphite pellicles deposited through electric discharges in pulse (EDI) with metal surfaces subjected to processing on the one hand and on the other hand – the adhesion of this pellicle with a polyurethane adhesive. Experimental research has shown that, when the surfaces are not treated, the shear occurs in the adhesive, when the test pieces are covered with graphite pellicles the shear occurs on the surface that separates the pellicle from the adhesive. It has been stated experimentally that graphite pellicles deposited through electric discharges in pulse decrease the adhesion between the mating surfaces by at least 40% compared to the not treated surfaces.

Introduction

Experimental tests on increasing the sustainability of punches, in particular, and of other components of glass molds have currently been carried out in industry. The increase of the sustainability of these parts is achieved by depositing graphite pellicles on their active surface applying electric discharges in pulse. The formation of graphite pellicles causes surface partial hardening and at the same time serves as a solid ointment, and, as a result, intensifies the operational performance of the processed pieces [1-4]. The study of the wear of treated and untreated punches has demonstrated the following: as a result of the operation in a technological cycle, the punch diameter coated with graphite has not reached the size of the initial diameter (as a result of the deposition by electric discharges in pulse the graphite pellicle thickness is about 7-10μm); the diameter of the plunger that was not treated with graphite pellicle decreased reaching a disastrous state of the wear under the same conditions of exploitation. This allows us to state that the punches coated with graphite still possess reserves of operating in technological cycles. In some of their works [3], the authors assume that one of the phenomena that can lead to increasing the plunger sustainability is the phenomenon of graphite pellicle adhesion to the glass mass and consequently to the basic metal surface, but these have not been investigated yet. That is why this paper aims to study this phenomenon.

The experimental research that is to be described in this paper has proved that the graphite pellicles deposited by applying electric discharges in pulse decrease the adhesion between the mating surfaces by approximately 1,7 times compared to the surfaces that are not treated using electric discharges in pulse with graphite electrodes [5]. Thus it is expected to determine in the nearest future the optimum regimes of processing in order to obtain a maximum anti-adhesive effect of different types of adhesives with graphite pellicles deposited on conductive surfaces by electric discharges in pulse which would prove a good stability in the process of functioning.

Materials and methods of experimental investigations

The experimental investigations have been carried out in the air at atmospheric pressure at room temperature, using samples made of OL37. The tool electrode was made of pyrolytic graphite connected to the discharging circuit of the current pulse generator in the function of a cathode.

Under these circumstances it eroded at a maximum level and ensures the possibility of forming a homogenious graphite pellicle of maximal continuity. In order to determine the adhesion of graphite pellicles to the material surface, the metal specimens treated by applying electric discharges in pulse and the untreated ones were stuck to each other with an adhesive on a square surface with a 1cm side and were then subjected to traction tests in order to determine the shear tension.

To do the experimental research we have used a series of metal specimens made of stamping sheet (type A3 - for deep stamping) obtained by rolling at an industrial scale, the brand of the material being OL37 and a polyurethane adhesive with high compatibility that determines good adhesion to metal stands.

The specimens were made by mechanical discharge using a guillotine. We chose this technique that does not involve heating of the material after the yielding so as not to cause changes in the crystalline structure of the material. These specimens have dimensions of 26x100x2 mm. The tool-electrodes are pyrolytic graphite wands with a diameter of 4 mm and a length of about 50 mm.

The experimental investigations concerning the graphite deposition were carried out in a normal air environment, in conditions of sub excitation of electric discharges in pulse. In order to succeed in making the experiments we used the power supply that has the following parameters: energy released in the interstice W_S = 0 to 4.8 J, energy accumulated by capacitors Wc = 0-12J, capacitors voltage Uc = 0 - 200V, capacity C = 100-600 μF at the step 100μF, interstice S = 0.05 to 2.5 mm, discharge frequency f = 0-50Hz, pulse duration = 0-250 μs. Due to these parameters possessed by the power supply we can ensure the functioning of EDI in the regime of “hot” electrode spots (with melting surfaces subjected to processing) and in the regime of "cold" electrode spots (without melting the surface subjected to processing, although they occur at nanometer level) .

To identify the changes that appeared in the adhesion properties as a result of graphite pellicle application this was done by comparative measuring of the assembly detachment forces realized with the help of polyurethane, a strong adhesive, between a set of test pieces treated with graphite and test pieces without treatment.

Shear tests were conducted on a HECKERT FPZ 100 dynamometer (Germany). The device is a notable one and provides a domain of forces between 100 N to 10 kN and the traction speeds are between 1 and 100 mm / min.

To do the research on shear the specimens were prepared in the following way: using an adhesive tape, a 20x20 mm area is selected and it must be in the center of the treated portion (figure 1). The thickness of the tape is 0.26 mm that determines the thickness of the adhesive layer with the help of which everything is done.

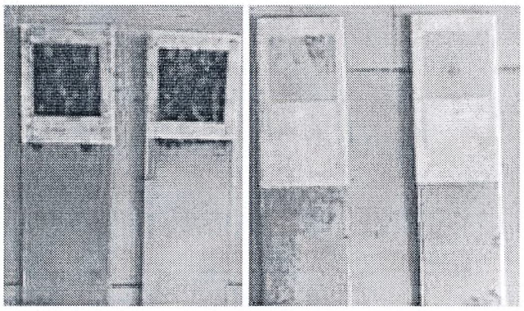


Fig.1. Specimens prepared to adhesive

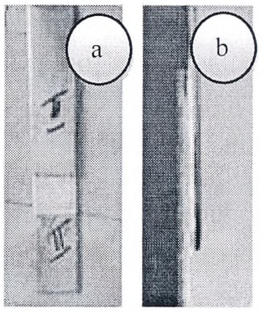


Fig. 2. Assembled specimens: a-general view, b – view from the left

A small amount of polyurethane adhesive is poured in the space obtained after the central space has been cut out so that the space created by cutting out the adhesive tape for tracing could be filled with adhesive (figure 2). After the evaporation of the solvent from the adhesive receipt, in about 10 minutes, two test pieces overlap so that the space obtained by cutting the adhesive tapes could overlap perfectly. In this way, the surface of adhesion of the two test pieces will be 4 cm^2. The test pieces manufactured by sticking with polyurethane adhesive shown are left for conditioning in the laboratory atmosphere for 24 hours. After conditioning the specimens are subjected to traction tests through shearing. In the present paper, we have used three types of assemblies through sticking: untreated specimens overlapping untreated specimens, untreated specimens overlapping treated specimens, treated specimens overlapping treated specimens.

Results of experimental investigations

Graphite pellicles deposited by pulsed electrical discharges, 7-8μm thick, react physico-chemically [3, 4] with the metal surface leading to its special adhesion. A first method to check the theory referring to the creation of an anti-adhesive pellicle on the metal surface as a result of the treatment with graphite realized by electrical discharges consisted in the production of some specimens for the verification of shearing forces that consist of two metal plates stuck by applying a structural adhesive, as described above.

According to modern standards, a structural adhesive is an adhesive used for the development of some structures - component assemblies- which cannot be unstuck unless you destroy the structure. It follows that the adhesion realized by this adhesive is stronger than the resistance of stuck components. The structural adhesives are used for the production of some structures that cannot be discomposed into their components. Thus a definite structure is produced. Under these conditions the adhesives that are used to produce the structure must possess sticking characteristics of outstanding internal resistance.

The assemblies made with the obtained structural adhesive were subjected to shear resistance tests. As a result of shear tests the following values were obtained for the stuck assemblies as shown in Table 1.

Table 1
The values of shearing voltage for different ways of sticking specimens

Both test pieces are untreated daN/cm^2			Mixed treated test pieces daN/cm^2			Both test pieces are treated with graphite daN/cm^2		
86.4	85.80	83.7	62.1	58.6	62.0	49.6	51.2	50.4

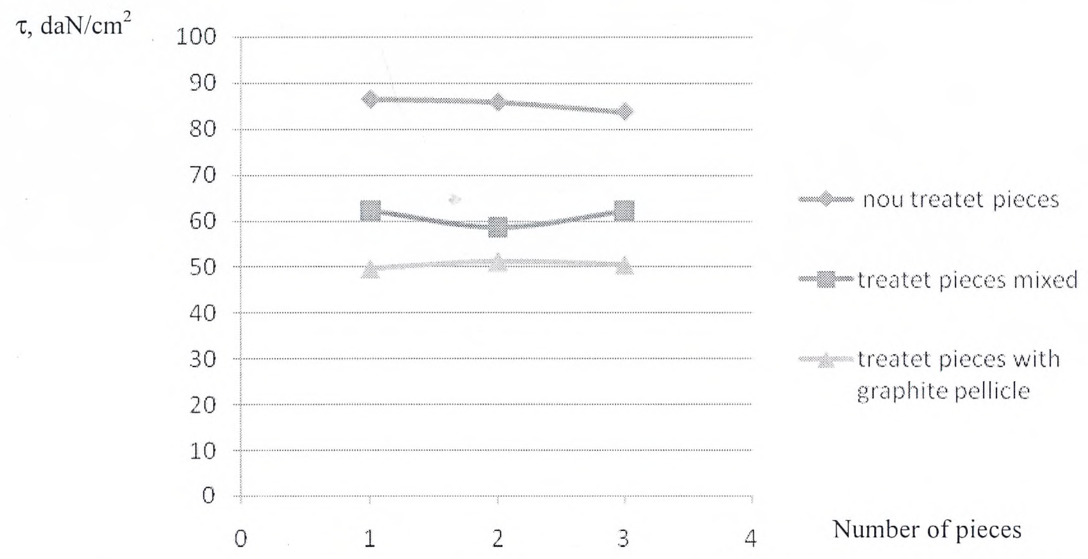


Fig. 3 The dependence of the shearing voltage on the way of sticking the test pieces.

As a result of the traction of assembled parts by sticking, we can see that the untreated specimens possess higher values of shear voltage than the others and constitutes about 85 daN/cm^2, the specimens treated in a mixed way have an average value of 60daN/cm2 which tells us that the graphite pellicle deposited on one of the samples reduces the adhesion between the adhesive and the metal surface. In the last variant, in which both surfaces are coated with a graphite pellicle, the shearing voltage decreases to about 50daN/cm^2, this constitutes a reduction of adhesion by 40% compared to the untreated specimens (Figure 3).

We can also notice that the specimen shearing occurs in two ways (fig.4): in the first variant, the breaking would occur inside the adhesive (fig.4,b) that is typical of specimens which were not treated with electric discharges in pulse with graphite tool-electrodes; in the second variant, typical of specimens treated with electric discharges in pulse, the breaking would occur at the surface that separates the pellicle from the polyuretanic adhesive.

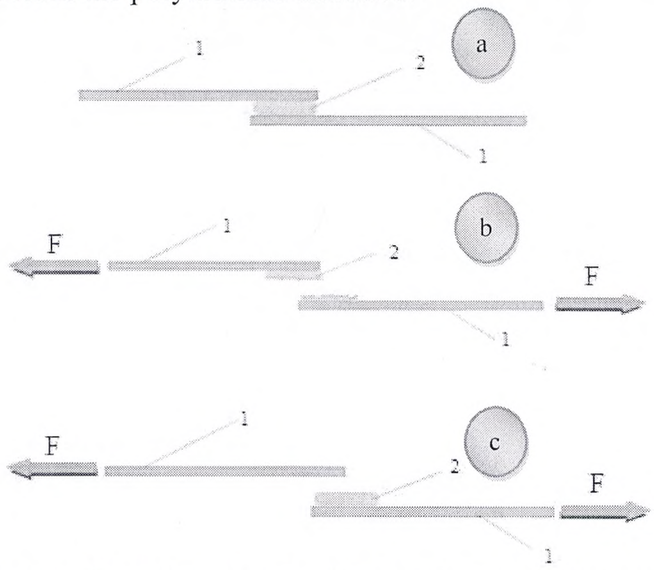
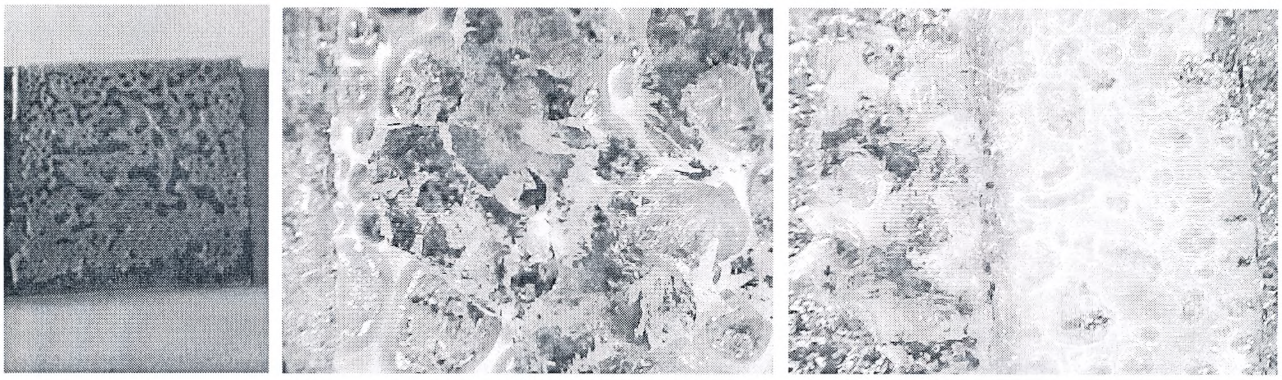


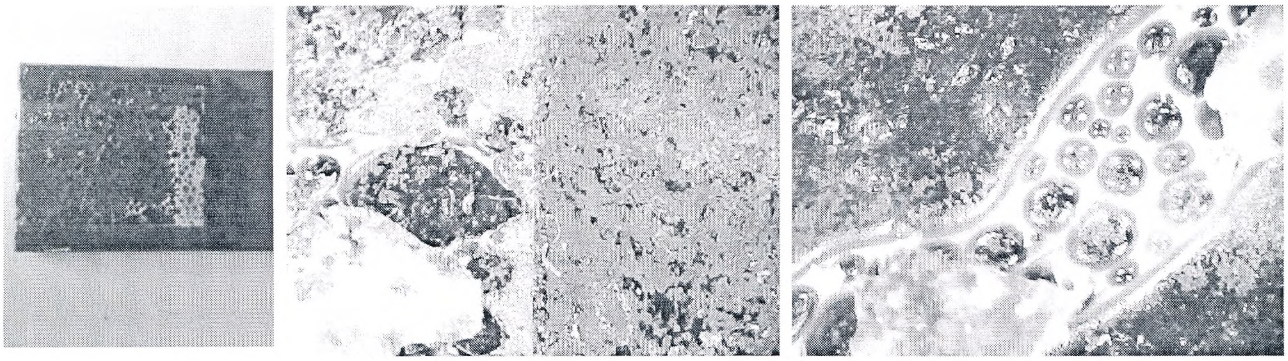
Fig.4. The main scheme of breaking at assembly shearing: a- initial state; b- final state of untreated specimens; c- final state of untreated specimens treated with EDI; 1- metal plate, 2-structural adhesive.



a b c

Fig.5. The structure of the assembly without superficially treatment by EDI after shearing: a – general view, b, c – image on the microscope x80

The surface morphology research of treated and untreated specimens with EDI after shearing comes as confirmation to these desiderata. When the specimens were not subjected to superficial treatment of electro deposition all assembly divisions were produced by breaking in the adhesive mass which is shown in the images of Figure 5, this points to a strong adhesion to metal adhesive supports. From Figure 5, we can assert that the assembly breaking occurs in the adhesive mass; this is stated through the mass of adhesive over the entire active area of the specimen (light color). In this case, the greatest breaking forces were stated, over 80 daN/cm^2.



a b c

Fig.6. The structure of the assembly superficially treated by EDI after shearing: a – general view, b, c – image on the microscope x80

If specimens are treated with EDI the structure split occurs on the adhesive support Figure 6 graphite due to the application of some forces mass tangent to the adhesive mass. Thus the whole mass of adhesive or a large part of it will remain one of the supports. It is asserted in this case that the adhesive interior resistance is stronger than the adhesion to the metal support; the structure is not ruined after it is broken up into its components and the adhesive does not function as a structure adhesive. The determined forms are up to 50% - about 50 daN/cm^2 compared to the situation of the specimens that were not superficially treated.

Figure 6 demonstrates what was asserted through the observation of a large space of dark color where the breaking occurred at the interface. We may better see a portion where the electro-deposition treatment did not occur 100% continuously – the portion of light color –where a breaking occurred in the adhesive mass; in the other portions, where the superficial treatment of electro deposition occurred in the corresponding way, the splitting of the specimen occurred at the interface – the portion of dark color.

The images made with the help of the microscope demonstrate these statements; in fig.6, c d, we can very well see the remaining portion of the structural adhesive – the portion of light color, in contrast with the surface of dark color where the adhesive splitting occurred at the adhesive – metal interface. All this allows us to assert that the graphite pellicles deposited on the metal surfaces with electric discharges in pulse possess anti-adhesion properties that confirm the assumptions made in the previous works.

Conclusions

The results of our investigation make it possible to conclude that when we use graphite pellicles deposited by applying EDI the shear occurs at the surface that separates the adhesive and the metal surface compared to the case when the pellicle is not used and the shear occurs in the adhesive mass; in this way, we could assert that the polyurethane adhesive does not function as a structural one; the graphite pellicles deposited by electric discharges in pulse reduce the adhesion between mating surfaces by about 40% compared to the untreated surfaces; thus we may assert that one of the reasons why the durability of punches and other pieces in the glass industry increases is the phenomenon of anti - adhesion obtained by producing graphite pellicles applying electric discharges in pulse.

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