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# Application of Chemography Method to Study Surface Damage Phenomena

*The problems solved by the chemography method based on fixing oxidative reactions of ultra-low concentrations on the surface of solids are discussed. This method makes it possible to fix physical defects (microcracks, destruction, violations of structural homogeneity) and the energy (residual stresses) state of the surface layer of materials under operating conditions under the action of thermobaric loading. The change in these parameters is associated with the degradation of the cutting surfaces and, as a result, with a change in the rate of the reactions taking place. Applied chemography phenomena as a method of visualization of a destructive layer, a network of surface micro cracks in studying the processes of destruction materials, including nonmetallic ones, is shown. The main advantages of this method are the possibility of assessing the level of residual stresses and periodic visualization of surface defects due to the state of the studied materials, including nonmetallic ones. A relationship has been established between the presence of defects, the level of residual stresses, and the intensity of emerging photo molecular fluxes. In the applied aspect, the method makes it possible to evaluate the performance of cutting plates, and to study the formation and development of a network of microcracks by the intensity of the chemographic effect.*

***Keywords:*** *chemography, surface condition, microcracks, residual stresses, diagnostics*

## 1. INTRODUCTION

Studying the oxidation processes of a workpiece made of some semiconductors and metals (such as Si, Ge, GaP, Ti, Cu, In), found [1] that under certain condi–tions, surface oxidation processes can create a hidden image of the surface of these workpieces in the film emulsion. The open effect of registration of the heterogeneous reactions of low intensity on the surface of a solid body is called chemography.

Studies [1, 2] have shown that in the vast majority of cases, the chemographic effect is not associated with a single chemical reaction or the presence of a specific reagent-impurity (although some materials are excep–tions: for example, aluminum and its alloys. Impurities allow us to visualize the chemographic effect, over–coming the thickness of the $Al_2O_3$ oxide film always present on the surface). It is well established that the open effect is based on the chemical interaction of silver bromide molecules with the products of hetero–geneous oxidative reactions that occur on the surface of a solid. Due to the similarity of the effect of active molecules on silver bromide molecules and the action of light, surface reactions were called photo molecular fluxes (FMF).

We can assume that FMF in the chemographic effect form molecules of the same elemental composition. Researchers [1] believe that these are intermediate products of multistage heterogeneous reactions that lead to the formation of a specific oxide.

The consequence of this interaction is the appearance in the photo emulsion a layer of metallic silver atoms (like the method of nuclear emulsions). Despite the uncertainty of the elemental composition of products capable of reacting with bromine silver, it was found that they are in ultra-low concentrations. The conducted in-depth studies allow us to conclude that their concentration makes $10^{-12}...10^{-16}$ m.h. and corresponds to the limiting case of dilution, when the probability of encountering a molecule emitted by the surface of a solid body, similar to itself during the observation period is zero. It is evident that this almost completely eliminates the mutual influence of moving particles, resulting from which the trajectory can change.

Experiments have shown that one of the main products of heterogeneous reactions is atomic hydrogen H+, which can emit from the oxidized part of the surface and displace bromine from the AgBr compound, forming the AgH compound.

It is possible to assume that the activity of the surface will be affected by its stress state because, in this case, the surface will have a certain reserve of excess energy in the elastic layer.

## 2. SETTING OBJECTIVES

The range of problems that can be solved using the method of chemography is quite wide. First, these are the tasks related to changing the state of the surface

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layer of materials capable of chemographic effect. This change occurs both in the processing of materials and in the degradation of surfaces that receive different types of dynamic loads and thermal effects [3].

The importance of predicting the reliability of the product's functioning is noted in works [4,5]. Such tasks are especially relevant for aviation and critical engineering [6].

For mechanical engineering, it is known that high-quality and reliable operation of the tool is ensured by its proper control before use, rational operating conditions, and the absence of accidental disturbances that disrupt the normal course of the technological process. Predicting tool performance and construction of appropriate failure models will eliminate (or mini–mize) emergencies, especially in automated production. While traditional methods - X-ray diffraction micro–analysis, ultrasonic testing, and energy dispersive microanalysis- are expensive and require special equ–ipment, the use of witness samples is not always possible in production conditions. The use of chemo–graphy can be an alternative method that can effec–tively predict the condition of the cutting surfaces and the development of damage over time.

Another applied aspect is the problem of describing the development of damage during the processing of materials by powerful liquid streams or streams of free and compacted abrasive.

## 3. METHODS OF EXPERIMENTAL RESEARCH

To detect the latent image on the surface of a solid body and improve its quality and resolution, samples of test materials require prior preparation. This prepa–ration is reduced to cleaning the surface from oxides by chipping, grinding, and polishing with abrasive micro powders or by etching in HF. At the time of chemo–graphic exposure, the test sample with the photo–graphic film should be placed in an opaque chamber (Fig. 1), designed so that the surfaces of the photo plate and the sample were parallel to each other and located at a distance of $10^{-3}...10^{-4}$ m, there must be a liquid or gas.

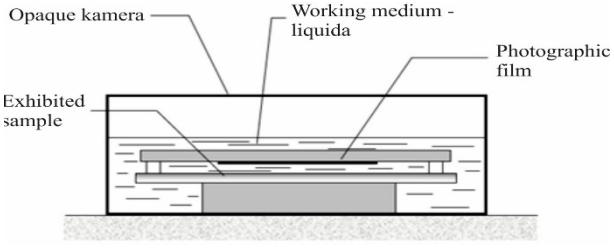



**Figure 1. Scheme of the camera for chemographic exami–nation of samples**

During the exposure, the photo emulsion is processed by a stream of products of heterogeneous reactions emitted from the investigated surface with the formation of a latent image in the photo emulsion [8]. FN-64 sheet negative panchromatic photographic film and FP-32 photo plate were used in the experiments. The design of the experiments was based on the assumption that after the development of the photo plate, the optical density of the illuminated part is proportional to both the time of chemo-graphic exposure and the density of the FMP. The increase in the gap between the exposed surface and the photo plate had only one consequence – the loss of the outlines of the image elements due to the diffusion nature of the FMP propagation. The optical density of the image elements was measured using a photometer MF-4. Still, scanning the resulting image on the HP SJ1100Pro and subsequent image processing by appropriate software was more accurate. When estimating the density of the obtained surface image, the time of chemographic exposure $\tau$ was taken into account.

When studying the influence of the external phy–sicochemical factors on the state of the solid surface, the test sample exposed to this factor was exposed on the same film as a control sample, which was not affected by this factor. After developing the photo–graphic film, the optical density of the prints on the photographic film obtained from the exposure of test ($D$) and control samples ($D_0$) was measured, and the ratio $S_{fi} = D/D_0$ was calculated. Thus, after measuring the relative optical density of the image on photo–graphic film, it is possible to estimate the change in the chemographic activity of the test sample under the influence of a certain factor because the influence of other factors during exposure was taken into account automatically.

As a result, characteristic curves $S_{fi}(\lg t)$ were constructed for some materials (Fig. 2). It is obvious that the intensity of the loss of chemographic ability of the sample after surface preparation in different metals differs. Therefore, surface exposure should be perfor–med immediately after its preparation to detect minor defects.

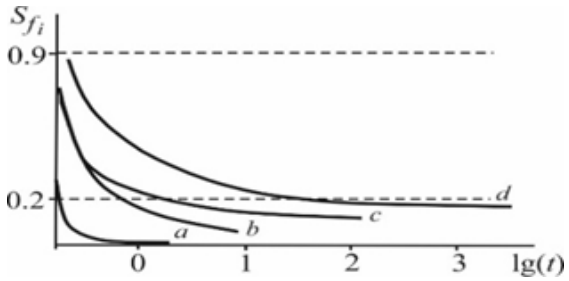



**Figure 2. Characteristic curves for some materials**

**a – aluminum AL6; b – titanium; c – copper; d – steel 45**

Several samples of ferrous, alloy, and non-ferrous metals, as well as several cast iron brands, were selected for experimental research. This choice was due to the need to establish the resolution of the method and its ability to detect certain changes in the surface layer's structure, microgeometry, and energy properties. The chemographic effect was evaluated on the cylindrical bodies' front surface (samples) ∅25x30 mm size and the prismatic bodies 10x30x50 mm. The surface preparation of the bodies of rotation was performed with a thrust cutter equipped with a plate of hard alloy T15K6, sharpened by the recommendations [5] to achieve the purity of the surface *Ra* 3.2.

The final surface treatment of the prismatic bodies was performed by grinding to ensure the surface roughness *Ra* 2.5. This created the conditions for esta–

blishing the required working gap between the test surface and the photo emulsion at the level of 2…40 μm, which is sufficient to obtain minimal diffusion and a high rate of heterogeneous reactions, and, since then, satisfactory chemo-graphic image quality.

Authors [6] used an approximate procedure for estimating mode I stress intensity factors in case of mul–tiple surface cracks in a three-dimensional elastic body.

In paper [9] was focused on developing a compu–tation procedure for strength analysis of damaged structural components concerning fatigue and fracture mechanics.

To eliminate inhomogeneities and possible defects of the mechanical processing of samples, a parallel study of their surface layer was performed on a profile graph-profilometer type PRP-10D and an instrumental microscope type MIM-8 with a resolution of x(100… 1000). The profilogram was taken at a reference length of 5 mm along a radial line passing through the center of the test specimen. Thus, they were able to determine the real surface profile and calculate all its charac–teristics (according to [10], such as the level of *Ra*, the maximum deviation from the midline, the height of the protrusion, and the depth of the depression, etc.). The microscope was additionally diagnosed with possible surface defects – microfractures of the layer developed microcracks, etc. The study was also subjected to ready-made tool products coated with TiN coatings. The thickness of the coating was measured with a thickness gauge NOVOTEST TP-1, the resolution of the device with a sensor Φ-0.3 ± 3% of the measuring thickness of 10…300 μm. Next, we compared the results of chemographic imaging and traditional research methods. The results were attributed to the brand of material. For all materials, the surface was exposed for 10 s in a water bath at the same distance between the surface and the photo emulsion. The treatment of the photographic film was performed with chemical solutions with a guaranteed ability to reproduce eclipses on oxidized silver.

We were experimenting with such a complex allowed to minimize the effects of random nature, which can impair the quality of research and disrupt the impact of priority factors. The degree of illumination of the film emulsion was determined using a computer scanner while also controlling the non-uniformity of illumination by degree and plane.

## 4. RESEARCH RESULTS

Examples of chemographic images of different surfaces are given in Fig. 3. The results of the analysis of sample chemographic prints are shown in the table. 1. and illustrated in the diagrams of Fig.4. It is established that the brand of the material causes the chemographic effect in the case when the assessment is performed by the degree of illumination of the photographic material. Using the statistical package STATGRAPFICS Centurion [6] allowed us to identify a reasonably close correlation between the degree of illumination and the amount of carbon in the material under conditions of almost the same roughness as the treated surface.

However, it was impossible to link the non-uniformity of illumination in the intensity (degree), and plane with the material's chemical composition–the variance analysis allowed the flow of the obtained data to be reduced to one general population (Fig. 4).

A comparison of the profile with the obtained che–mography proved a very close relationship between the change in the surface profile and the presence of the illuminated spot on the photographic film in the appro–priate place. A certain number of illuminated spots did not correspond to the location of a sharp change in the surface profile, but this proportion was not more than 16%.

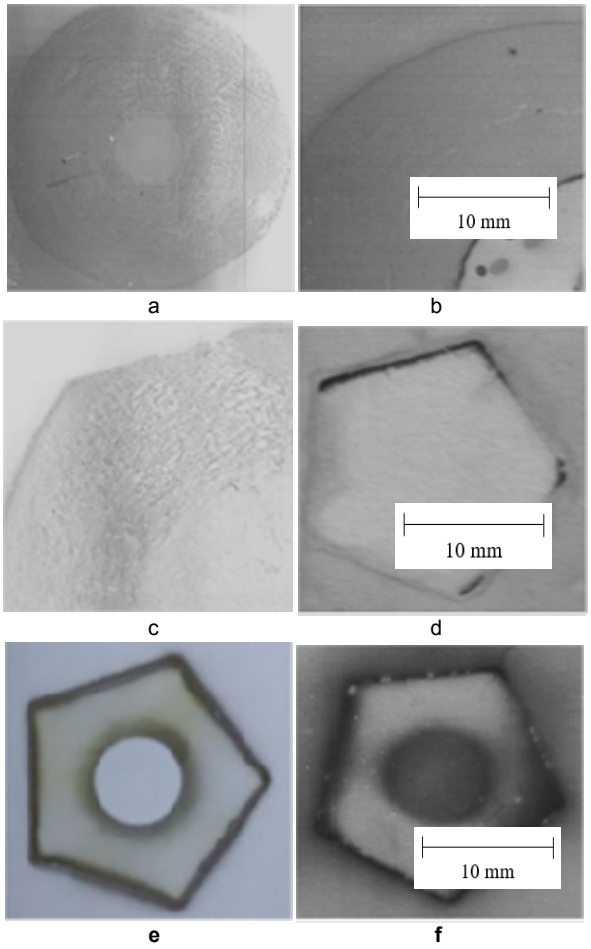
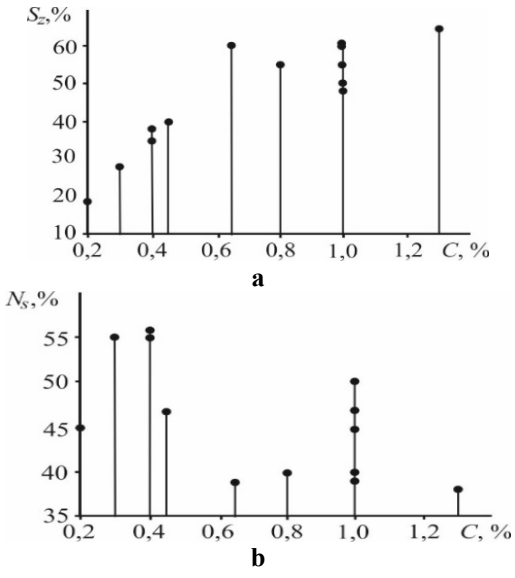
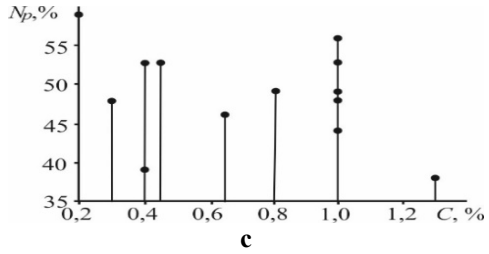



**Figure 3. Chemographic prints of sample materials: a – Steel 45; b – D16; c – AL9; d – NC332; e, f – T15K6 + TiN (new (e) and used (f))**






c

**Figure 4. The degree (a) and non-uniformity (b, c) of the illumination of the photographic material when exposing samples of differing in carbon content (see table 1)**

Since chemographic prints differ in the optical density of the image, it is advisable to use the tech–nique of averaging shades of gray.

Thus, to assess the degree of influence of a particular factor on the chemographic image, we moved to the relative blackness index, which was calculated by the formula $l_c = F_i / (100 - F_{\min})$, where $F_i$ - flowing blackness of a point on the analyzed surface (%); $F_{\min}$ – an area of light background, in % relative to the accepted level of white. The index $I_c$ is better compared to the parameter $S_{fi}$.

This allows us to determine the optimal exposure time $\tau_e$ by the obtained level of the relative blackness index as a function of time $\tau$. It was found that the exposure for a time $\tau_e$ = 20 min makes it possible to obtain the maximum value of the image's contrast and to detect individual defects both on the surface and in the near-surface layer (Fig. 5).

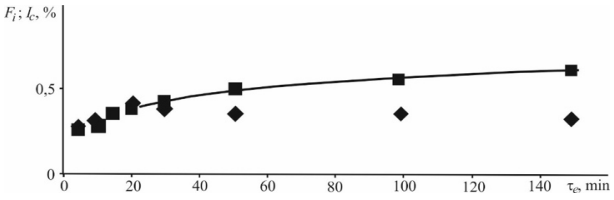



**Figure 5. Change in blackness when changing the expo–sure time (■ – *index $I_c$*; ◆ – *flowing blackness of a point $F_i$*)**

Determining the maximum possible resolution of the method is carried out, which allows for predicting the depth of layer damage by the detected defects. Thus, our chemography procedures allowed us to establish the patterns of changes in the resolution of the method from the temperature of the liquid at a fixed exposure. It was established (Fig. 6) that at $T$ = 20 °C, defects with sizes exceeding 100 μm were recorded.

Defects less than 50 μm cannot be uniquely identified. Increasing the temperature to 80 °C allows for fixing minor defects at the level of 30–80 μm, ma–king it possible to identify the developing microcracks.

Thus, the following is proved: a) different materials in the reference comparison have a distinct degree of illumination; b) illumination is inhomo–geneous in density and the plane of research and is conditioned, mainly, with microgeometry of a surface; the limit level of roughness for metal samples is the roughness *Ra* 1.6 μm; the reduction of roughness against the specified level does not cause significant differences in chemo–graphy; c) the degree of illumi–nation correlates with the amount of carbon in the test sample; d) the existence of a surface defect is accom–panied by a sharp change in the density of illumination at the site of the defect, with the minimum size of the fixed defect 0.05 mm.

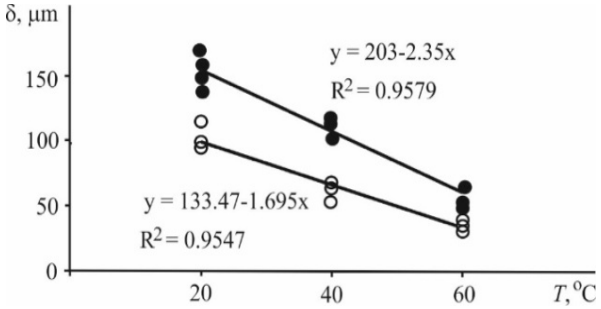



**Figure 6 – Change in the size of the detected defects depending on the fluid temperature (● – *non-metal;* ○ – *metal)***

## 5. APPLICATION OF THE CHEMOGRAPHY METHOD TO STUDY THE PHENOMENA OF THE SURFACE LAYER DESTRUCTION

The surface of the material, due to a certain impact, has a certain roughness.

It is known from surface physics that any bend on the surface has an excess of energy due to a certainly increased number of radicals located in the near-surface layer of molecules. However, the surface areas on the micro projections on the micro-recesses will not be in equal energy conditions. Preliminary studies show that in chemography, the centers of heteroge–neous reactions can be located both in the tops of micro projections (zone A) and microcavities (zone_B).

**Table 1 – The results of the evaluation of the chemographic effect of the experimental samples**

| Material | Level of illumination, $S_z$, % | Uneven. Light up. for the degree of $N_s$, % | Uneven. Light up. by area $N_p$, % | Material | Level of illumination, $S_z$, % | Uneven. Light up. for the degree of $N_s$, % | Uneven. Light up. by area $N_p$, % |
|---|---|---|---|---|---|---|---|
| 1. St3* | 28 | 55 | 45 | 11. HVG steel | 48 | 48 | 44 |
| 2. Steel 20* | 19 | 45 | 39 | 12. Steel 2X13** | 50 | 59 | 48 |
| 3. Steel 40* | 35 | 56 | 40 | 13. Steel 9XS** | 55 | 53 | 56 |
| 4. Steel 45* | 40 | 47 | 40 | 14. Cast Iron18-36* | 70 | 55 | 39 |
| 5. Steel 40X** | 38 | 55 | 56 | 15. AL9 | 35 | 46 | 57 |
| 6. Steel 65G** | 60 | 39 | 70 | 16. D16 | 39 | 49 | 45 |
| 7. Steel U8*** | 55 | 40 | 80 | 17. L68 | 80 | 53 | 68 |
| 8. Steel U10*** | 60 | 47 | 81 | 18. Copper el. | 55 | 49 | 10 |
| 9. Steel U10A*** | 61 | 50 | 20 | 19. Hard alloy T15K6 | | | |
| 10. Steel U13*** | 65 | 38 | 58 | | 35 | 38 | 45 |

Types of steel and other metal given according to:
*DSTU ISO 2651:2005; **DSTU ISO 683-17:2008 (ISO 683-17:1999, IDT);***DSTU 3833-98 (GOST 1435-99); other – DSTU ISO 1190-1:2007, DSTU ISO 209-1:2002

The ingress of water molecules into the micro-wells and their subsequent orientation can significantly activate oxidative surface processes, the location of which will be affected by areas of illumination on the film. The oxidation intensity can be pretty high, which, taking into account the resolution of the method and the significant distance *h* between the film's surface and the body, will cause the appearance of much larger spots on the film. However, in such experiments, there are several limitations associated primarily with the ability of the material to oxidize over time. This ability is shown only by metals. For non-metal materials, it is needed to use a metalization film adding to the surface layer by the deposition methods. As a metal for deposition, it is advisable to use electrical copper.

## 6. ESTIMATION OF RESIDUAL STRESSES BY CHEMOGRAPHY

It was found that the degree of illumination of the photographic material directly depends on the features of technological transitions that were performed to obtain a prototype. For example, surface treatment with a sig–nificant cutting power causes an increase in the degree of illumination of the photo plate by 15…40% at a time when the micro geometric parameters of the surface for all compared samples remained unchanged. From the above, we can conclude that a certain role in the visua–lization of heterogeneous surface reactions is played by the energy parameters of the surface and near-surface layers – in particular, the stress state of the surface.

The chemographic effect is mainly related to the magnitude of residual stresses in the surface layer rather than the degree of deformation of the crystal lattice of the material or the presence of crystal defects, vacancies, dislocations, etc., whose activity increases significantly when applied to the surface.

To assess the change in the chemographic effect depending on the residual stresses, a number of experi–ments were performed, the essence of which is as follows:

The surface of two massive samples of hardened to 55 HRC steel 40X with a surface roughness index *Ra* 1.25 was affected by a jet of liquid with a pressure of $p$ = 180 MPa on a plate with a radius of 2 and 5 mm. The effect lasted 1 minute. The fluid pressure in the hydr–aulic system was not enough to cause any significant destruction of the sample: it is known [7] that for metals, the pressure should reach 600–900 MPa. After that, the samples were exposed for 20 min with periodic removal by grinding of metal layers with a thickness of 0.05 mm from the surface of each sample. The experiments were repeated twice. As a result, a change (decrease) in the effect of chemographic illumination of the film with inc–reasing thickness of the removed layer was found. Pos–tulating a hypothesis about the influence of residual stre–sses on the intensity of FMP (the degree of illu–mination of the film in chemography), we calculated the values of the final stresses (Fig. 7) by the known formula [8]:

$$\sigma_r^0 = \sigma_\Theta^0 = P_c \left[ \left(\mu - \mu'\right) - \frac{\mu - \mu'}{\left(r_m^2 + z^2\right)} z \right] \quad (1)$$

and compared them with the degree of illumination of the material. Additionally, the value of residual stresses on the control sample was established experimentally using an X-ray diffractometer DRON-3M.

Comparison of the degree of illumination of the material (as a percentage of the gray density set by the PPWIN program) with the calculated values of residual stresses at a depth of up to 1.5 mm proved the exis–tence of a close correlation between these two factors ($R$ = 0.958). Processing of statistical data was carried out according to [11]. Comparison of the controlled parameter with the experimentally obtained value of residual stresses gave a more significant difference – up to 15%. However, this accuracy can be considered satisfactory, which allowed, using the methods of regression analysis, to obtain a simple linear model of the dependence of the light intensity on the values of residual stresses for the exposure time of 20 minutes:

$$I_s = 32.21 + 1.764\sigma_0 \quad (2)$$

provided the maximum values of residual stresses up to 35 MPa.

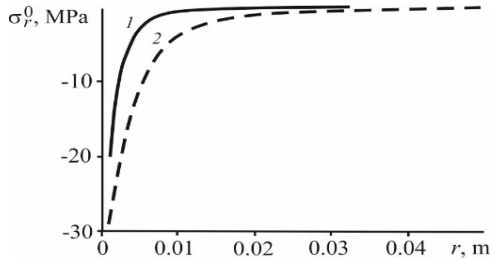



**Figure 7. Change of residual stresses in experimental samples on depth (theoretical 1 and experimental 2 data)**

Because the degree of illumination of the film is proportional not only to the intensity of the FMF, but also to the exposure time (linear dependence), increasing the voltage limit can be obtained by reducing the exposure time (for example, reducing the exposure time to 10 mi–nutes). The graph of the obtained model is given in Fig. 8.

## 7. EXAMPLES OF USE AND DISCUSSION OF THE RESULTS

*Hydrojet cleaning of surfaces.* Using the given depen–dence on the standard, it was possible to estimate the residual stresses formed in the surface layer of the metal product when removed from the surface of the highly elastic PVC film by a jet of liquid flowing from the salt nozzle $d_c$ = 1.0 mm under pressure $p$ = 120 MPa.

Analysis of the obtained chemographic image (Fig. 9, *a*) allowed us to establish the following.

The zone of formation of residual stresses, which occurs when a fast jet flows on the treated surface, is smaller than the area directly covered by the jet impact. Its diameter is approximately 0.5–0.8 $d_c$.

The final stresses formed in the surface layer are compressive and reach a maximum value in the center of the application of the jet load with a gradual decrease with distance from the center.

The decrease in the magnitude of the final stresses is inversely proportional to the square of the distance

from the center $r_i$ and is almost directly proportional to the flow rate of the jet from the nozzle $v_c$.

The existing surface roughness causes the deviation of the zone of the existence of the final stresses from the correct circle.

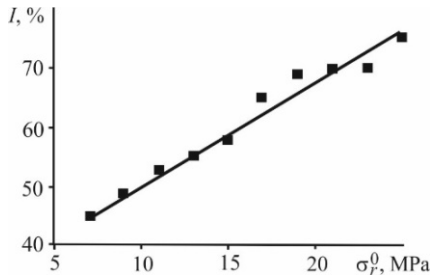
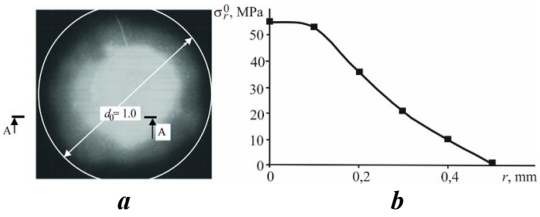



**Figure 8. Dependence of FMF on values of residual stresses (markers marked experimental data)**

The larger the roughness parameter, the smaller the zone of occurrence of final stresses, and the area is more different from the correct circle.

From equation (*1*), the values of residual stresses (Fig. 9, *b*) were determined. It is established that for thin products, for example, profiled sheet blanks; such stresses can cause warping, the prevention of which is to reduce the pressure of the process fluid.




*a* *b*

**Figure 9 – Chemographic image of the stressed zone of hydraulic influence (a) (top view, from the side of the jet) and the value of the calculated residual stresses at the intersection AA (b)**

*Obtaining probabilistic models of failures for hard-alloy plates of the TC brand.* Having a chemographic image of the initial plate (Fig. 3, *d*, *e*) and comparing it with the reference, you can assess the condition of the material and predict the period of operation of the plate. In this case, the criterion of defects and imperfections of the structure may be the parameter of the blackness index, the maximum value of which indicates a minimum of structural violations and internal defects.

For the equation

$$P(t)=\left[0.5+\Phi\left(\frac{d_{c\max}-\bar{d}_c-\gamma_c t}{\sqrt{\sigma_{d_c}^2+\sigma_{y_c}^2 t^2}}\right)\right]\cdot \left\{1-\left[0.5-\Phi\left(\frac{D_{k\max}-D_{\bar{k}}-\gamma_{Dk}t}{\sqrt{\sigma_{Dk}^2+\sigma_{\gamma Dk}^2 t^2}}\right)\right]\left(1-e^{-\lambda_D t}\right)\right\}e^{-\lambda_d t}P^z(t) \quad (3)$$

with the parameters that determine the damageability of the plate, chemography allows establishing λ – the flow of failures due to the destruction of the surface layer of the plate and its failure, while other parameters – $\gamma_c$, $\gamma_D$, $\sigma_c$, $\sigma_D$ can be easily determined by metro–logical measurements (scattering of geometric para–meters that determine the size, wear rate on the front and rear surfaces).

The main hypothesis is the hypothesis of increasing the density and area of chemographic darkening of the controlled surface before the onset of critical damage.

If the failure rate $\lambda$ is determined based on statistical observation of the operation of *N* plates with *m* batches, then based on [8], most sudden failures will obey the exponential law of the form $P(t)=e^{-\lambda t}$, and the distribution density function will have the form $f(t)=\lambda\cdot e^{-\lambda t}$. In this case, the parameter of the failure rate can be obtained based on $\lambda = 1/T_{cf}$, $T_{cf}$ – the average time of onset of a sudden functional failure, in this case – the fragile destruction of the plate surface.

A detailed study of the chemographic imprint of the plate, which worked for some time *T* and had worn cutting edges compared to the chemographic image of microelectronic, was obtained on a raster microscope type REM. It is established that the average time of failure can be associated with the darkening of the surface during chemographic examination, considering that $T_{cf}=f\left[1/\left(I_{T_2}-I_{m_1}\right)\right]$, ie, the darker the plate when comparing the two chemographic paintings received after a certain time, the less time will be before the failure. If we consider the area of the eclipse *w*, the dependence will be similar.

The change in the dark zone area for the carbide plate T15K6 is almost linear, which allows us to postulate an equation of the form $T = b_0 + b_1 w$. However, the coefficient $b_1$, which determines the growth of the controlled parameter, is not constant but depends on the plate's operation intensity.

Taking into account the chemographic pictures of the initial state of the plate and the state after a 60-min operation in different conditions, the regularities of the predicted time before the onset of sudden failure were obtained (Fig. 11).

At this time, the parameter was calculated $\lambda=1/T_{cf}$, and then – $P(t)$ and $f(t)$. Statistical processing of the sample was performed, and its compliance with the one-parameter exponential distribution law was chec–ked. The test was performed using $\chi^2$ Pearson's test.

Thus, we have shown the expansive possibilities of the chemography method, which, unlike the known ones, does not require expensive equipment, is simple to implement, and quickly makes it possible to obtain mo–dels of the reliability of machine parts and cutting tools.

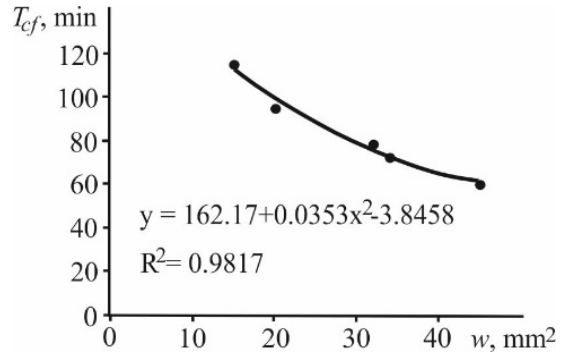



**Figure 11. Change in the predicted time of failure $T_{cf}$ de–pending on the change in the area of blackout of the plate w**

## 8. CONCLUSION

The possibility of using chemography as a method of visualization of the destructive layer and the network of surface microcracks in the study of the processes of destruction of materials, including nonmetallic ones, the main advantages of this method are noted: simplicity of execution, the possibility of estimation of the level of residual stresses, visualization of various surface defects, caused by a condition of investigated nonmetallic materials. The relationship between the state of the investigated surface and the intensity of the emerging photo molecular fluxes, which fixes bromine silver, has been established.

In the applied aspect, the research allows us to propose a new, highly effective method for assessing the performance of hard-alloy inserts by changing the intensity of the chemographic effect recorded on the surface of the cutting inserts during the period of durability. This effect, determined at first by the initial imperfection of the structure of the surface layer (the presence of surface micro defects), changes with the degradation of the cutting surface during cutting. In this case, an incipient network of microcracks and changing residual stresses in the surface layer are recorded. Since the morphology of the working plate and the structure during cutting do not change, the chemography method is effective and adequate.

The possibility of using the method for studying the mechanism of destruction of materials is proved. At the same time, on materials (including those not capable of oxidative reactions, however, with applied conductive films), the opening of the surface layer and its active degradation due to the manifestation of crack formation), it is possible to establish the pattern of crack bifurcation, evaluate the parameters of the proposed Griffith regularities, taking into account the loading conditions of the surfaces.

The possibility of determining patterns of the stress state of the surface layer on some materials that satisfy the solutions of the Hertz problems for the contact of two bodies is shown.

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## ПРИМЕНА МЕТОДЕ ХРОМАТОГРАФИЈЕ ЗА ПРОУЧАВАЊЕ ПОЈАВА ПОВРШИНСКОГ ОШТЕЋЕЊА


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У раду су анализирани проблеми који се могу решити применом методе хроматографије. Ова метода омогућава да се поправе физички недостаци (микропукотине, деструкција, нарушавање хомогености структуре) и енергетско стање (заостала напрезања) површинског слоја материјала који су у радним условима под дејством термо–баричног оптерећења. Ова промена се јавља како при обради материјала тако и у деградацији повр–шина. Приказана је примена феномена хрома–трографије као методе визуелизације деструктивног слоја и мреже површинских микропукотина при проучавању процеса деструкције материјала, укљу–чујући и неметалне материјале. Утврђен је однос између стања испитиване површине и интензитета насталог фотомолекуларног флукса. У примењеном аспекту, метода омогућава процену перформанси резних плоча, проучавање формирања и развоја мреже микропукотина по интензитету хромат–рографског ефекта.