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ANAEROBIC GLUE FOR MAKING JOINTS IN VACUUM TECHNIQUE

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When developing a new type of high vacuum aluminium valve, we were looking for a simple and reliable technology ensuring the firmness and vacuum tightness of various constituent parts. From the economical point of view, we see that besides welding and brazing, also the use of adhesives becomes interesting for making the joints. The compatibility of joined metal parts and the thermal properties of the materials must be taken into account. We have tested the adhesive strength, degassing and permeation through many non-demountable joints made with different glues. This contribution presents some typical constructions and the results of testing of the proposed joining technology.

1. *Introduction*

With the development of new adhesives, the glueing is becoming an important joining technology in vacuum technique. When using this method, adhesive reactions can take place at room temperature, and, according to the type of the glue, the hardening is possible with or without the presence of air or oxygen. The application of adhesive joints for electrical feedthroughs and metal-to-glass or metal-to-ceramics seals has been known for several years.

We have applied this technique often in the production of vacuum elements such as valves, fittings, small size chambers etc. A simple flat glued joint has not an exceeding firmness but with an appropriate design, it can support considerable loading.

The practical and essential reasons why adhesives are applied in modern constructions are as follows:

- possibility of joining metals and non-metals;
- reduction of production costs;
- possibility of repair;
- no deterioration of basic materials;
- light-weight construction.

New and better adhesives have eliminated many doubts about the usability of this joining technology and have enlarged the field of application.

Due to the constructive and technological advantages, glued joints are increasingly interesting in the vacuum technique, especially in the production of elements which are not subjected to heating. In the application, some special parameters should be taken into consideration: firmness, leakage, permeation and ageing.

Many different vacuum components such as valves, fittings, etc have already been made by glueing in our Institute. We have usually used the glue paste of Kemis-Radomlje (Slovenia) and satisfactory results have been regularly attained. As a manufacturer, we must to know the quality of our products with high reliability. Therefore, we have performed many experiments to test glueing methods and adhesives.

2. *Materials and methods*

The contact surfaces of experimental pieces to be glued were cylindrical. We finished them by turning on a lathe. The essential parameters assuring good quality of joints are the following:

- gap width between surfaces to be glued: 0.05 - 0.08 mm;
- length of a contact area: 30 - 50 % of the diameter;
- surface roughness: R_a = 0.6 - 2 μm (N6, N7);
- the used adhesive: one-component, meta-acrylate based, anaerobic, hardening without air. Producer Kemis-Radomlje, type VS 653, intended for protecting and fixing the machine elements. It can be heated up to 120 °C;
- deposition: simple by little staff or brush;
- possible materials to be glued: metals, alloys, ceramics and glasses;
- surface preparation: usual degreasing and thorough cleaning (freon, ultrasonics, ...); glass and ceramic surfaces must be activated, before glueing, with a special solution (named L 415) of the same adhesive producer.

We manufactured different specimens, small size, mainly KF25 vacuum components (see Fig. 1), made of stainless steel, Al-alloys, copper, glass and Al_2O_3 ceramics.

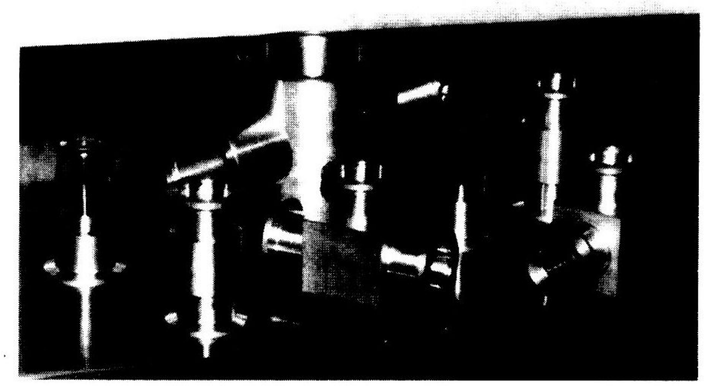

Fig. 1. Examples of glued elements.

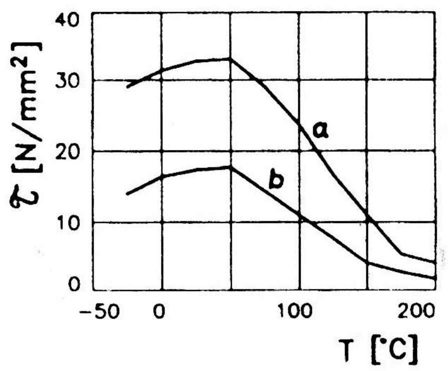

Fig. 2. Measured shear stresses of adhesive films at different temperatures: (a) for stainless steel, (b) for aluminium.

Besides cleaning, the essential phases of technology are: the deposition of adhesive and insertion of the inner part into the bore in such a way that the film of the glue would not contain dry segments and air bubbles. The joints are left at room temperature for a day to harden.

3. Results and discussion

a) Firmness. The shear firmness was recognized to be the most significant mechanical characteristic of glued joints. Special test joints, with the same adhesive film geometry as the mentioned components, were prepared for measuring the strength of the joints. The external piece was fixed and we applied a torsion moment to the inner one. From the measured adhesive area and the torsion moment, the shear stresses were calculated. Curves in Fig. 2 show the results for the samples made of stainless steel and aluminium; one can see from the characteristics the best behaviour in the range of room temperatures. Measured shear strenghts are satisfactory when compared to the standard construction of the joints assuming ordinary usage.

b) Tightness. The samples were tested by the helium leak detector "Ultratest UL100 plus" (Leybold-Heraeus). For 94 % of the samples we did not find a leak greater than 10^{-9} mbar ls^{-1}, which is the limiting sensitivity of the instrument.

c) Degassing. Degassing of the adhesive was tested by measuring the pumpdown time of glued surfaces in a vacuum chamber evacuated by a diffusion pump system. Before experiments, the apparatus was locally heated to 80 °C and pumped down one day. When changing the samples, we have allways filled the system with dry N_2 to minimize the adsorption on the inner walls.

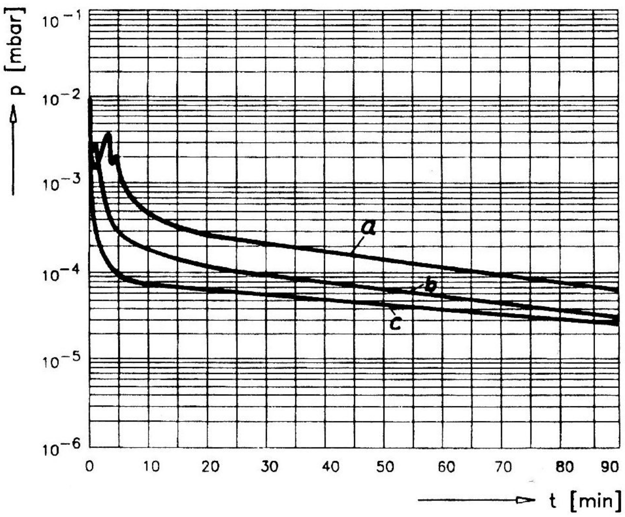

Fig. 3. Pumpdown of the test chamber filled with samples of 120 cm² hardened adhesive: (a) cold procedure, (b) thermally treated and (c) empty vessel.

To measure the degassing of the adhesives only, we had to eliminate the pressure background. For this reason we had to find the difference between pumpdown times of the empty recipient and of the vessel filled with glued samples. Our first experiments did not show any difference. Therefore, we decided to enlarge the adhesive area which was exposed to vacuum. Special parts of stainless steel sheet metal (4 cm × 10 cm) were prepared and sticked together on the whole surface. After hardening, they were separated and some of these samples of about 120 cm^2 visible adhesive area were placed in the recipient. We recorded the pumping diagram. The same testing procedure was repeated with the empty vessel. We tested also the samples which had been heated about 30 minutes at 100 °C. Results are presented in Fig. 3. Pumpdown curves are shifted due to the adhesive degassing. From the results, it is possible to estimate the degassing rate. It is slightly greater than from clean metal surfaces. For most glued joint applications, the exposed ring area is at least 5000 times smaller than the surfaces in our experiments. We conclude that the gas desorption of the glued joints is negligible in ordinary use.

4. *Conclusions*

The performed experiments confirm our practical experience with glued joints. Small components, for medium and high vacuum range, made using this technology are satisfactory regarding the firmness and tightness. They are not suitable for heating over 120 °C. At 200 °C the used adhesive gets soft. Thermal treatment increases the firmness of glued joints and reduces the adhesive degassing. Results are completing our studies of the characteristics of the adhesive pastes and their use. They are also important for the improvement of glued joint technology in vacuum technique.

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ANAEROBNO LJEPILO ZA SPAJANJE U VAKUUMSKOJ TEHNICI

Pored zavarivanja i lemljenja, također ljepila pružaju mogućnost čvrstog i nepropusnog spajanja vakuumskih dijelova. Usklađenost metalnih dijelova i drugih materijala i njihova toplinska svojstva moraju se pažljivo razmotriti. Ispitali smo čvrstoću lijepljenja, otpuštanje plinova i propusnost mnogih trajnih vakuumskih spojeva lijepljenih različitim ljepilima. Opisuju se tipične konstrukcije i rezultati ispitivanja spojeva.