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# TECHNOLOGICAL ASPECTS ON GLASS ASSEMBLED BY GLUING ON THE METAL SUPPORT

**Gábor PINTYE, Gheorghe ACHIMAŞ, Gavril PATAI**

**Abstract:** *Accelerated development of engineering sciences in recent years has led to the need for new manufacturing methods, moreover, current industrial competition requires new methods of rapid manufacturing and acceptable cost. Assembling glass by sticking on the metal support is made using a synthetic adhesive, which is relatively a new method. Bonding with adhesive synthetic materials has gained in the last decade a wide field of use when gluing sheet metal parts, non-metallic or combined, especially in light construction and fine mechanics, but also in mechanical engineering. Instead of metal layer or fitting alloy, comes a thin layer of adhesive which, after application, hardens and takes external forces through the mechanical strength due to the mass cohesion and adhesion between the adhesive and the surfaces to be joined.*
***Keywords:*** *gluing, adhesive, contact surfaces, jointing, assembly.*

## 1. INTRODUCTION

Gluing (Fig.1) is defined by the permanent joining of two solid bodies using adhesive, united parties need not necessarily be of the same material. The joint connection is composed of materials to be bonded and the adhesive. Glued joints strength results primarily from two types of forces: inner strength, cohesion of joint materials and effects of forces, adhesion (adhesion) occurring at the interface surface of materials to be bonded and adhesive. [3]

**Definition of adhesion** - adhesion are the main forces or mechanisms underlying adhesive with each substrate, the term refers to all the mechanisms of adhesion or forces located in a thin layer (boundary layer) between the substrate and the adhesive itself.

**Definition of cohesion** - cohesion forces are all forces and mechanisms that have the adhesive itself. Cohesive force is the force of attraction that occurs between atoms of solid substance and molecules of the liquid (adhesive). [11]

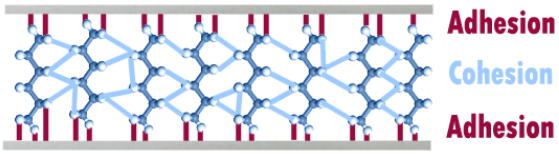



Fig. 1. The main scheme of gluing. [8]

The technology of adhesive bonding does not require high critical temperatures that can affect the status of piece surfaces, thermal effects intensity and strain concentrations are avoided. The considerable reduction of the weight of bonded parts, by almost 25%, is combined with the aesthetic aspect of the outcome part and the advantage of reducing the manufacturing cycle, whole parts of the structure can be joined in one operation. Moreover, it simplifies the design and operational maintenance. The result of adhesive joints is impermeable and pressure-tight, while the intermediary adhesive layer possesses vibration damping properties, electrical insulation and soundproofing. In order

to obtain bonding with the synthetic adhesives, in general, it does not require expensive equipment. [1]

## 2. Gluing procedures

### 2.1. Gluing processes are classified

- After the aim followed:
  - Joint gluing;
  - Load gluing, sealing.
- After execution mode:
  - Manual gluing;
  - Semi-mechanized gluing;
  - Mechanized gluing;
  - Automatic gluing.
- After duration of the polymerization:
  - Quick gluing (0 - 30 min.);
  - Medium gluing (30 min. - 24 h.);
  - Durable gluing (24 - 72 h.).
- After the application:
  - Flux gluing;
  - Vacuum gluing;
  - Gluing in humid environment;
  - Simultaneous gluing;
  - Progressive gluing.

### 2.1. Classification by type of bonded joints

Head to head joint - glued joint formed between the faces of the parts to be joined (Fig.2).

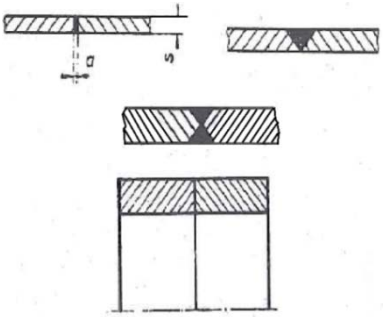


Fig.2. Head to head joint.

Head to head joint, diagonal - head to head joint assembly wherein the front faces of the parts to be joined are cut in diagonal, parallel to each other (Fig.3).

Head and head joint with flat strip (junction plate joint) - head to head joint reinforced with one or two flat stripes (Fig.4).

Overlapping glued joint - glued joint formed by partial overlapping of the side surfaces of the parts to be joined (Fig.5).

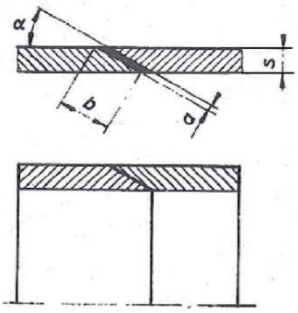


Fig.3. Head to head joint, diagonal.

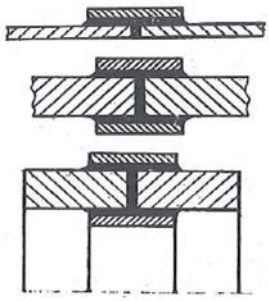


Fig.4. Head and head joint with flat strip.

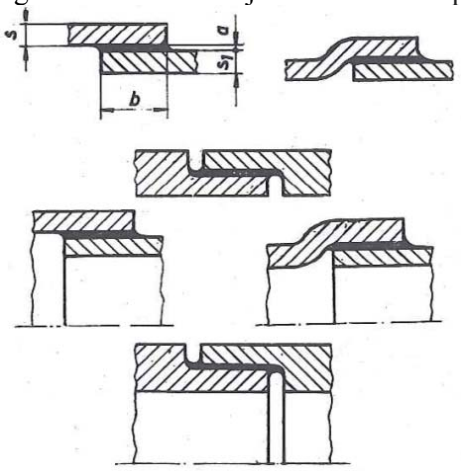


Fig.5. Overlapping glued joint.

T- joint - glued joint formed by overlapping under a right angle, the front surface of one of the pieces on the side surface of the other part (Fig.6).

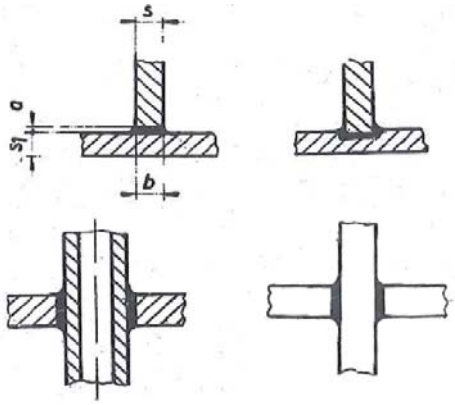


Fig.6. T- Bonded joint.

Bonded joint in angle - bonded joint where combined parts form an angle different to 90□ (Fig.7).

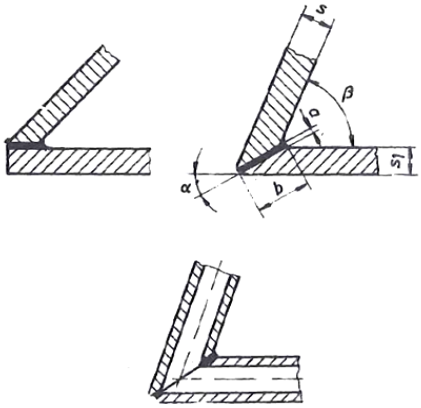



Fig.7. Bonded joint in angle.

Bonded joint in steps - head to head bonded joint by overlapping the joint pieces (Fig.8).

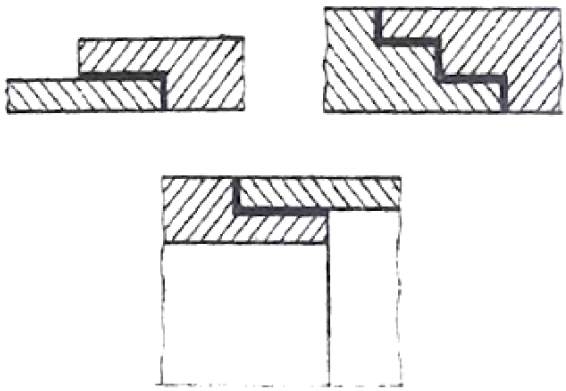


Fig.8. Joining glued in steps.

Joining glued by flanging - joining glued a sheet assembled by flanging preliminary (Fig.9).

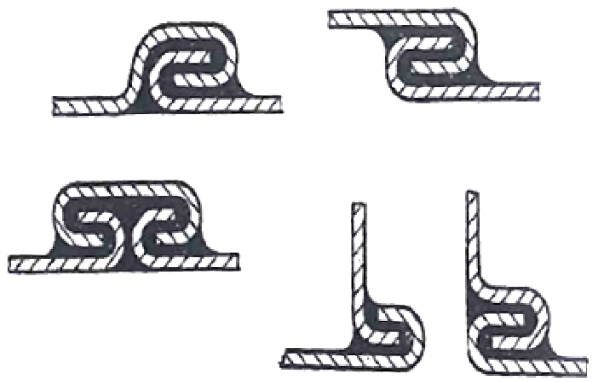


Fig.9. Bonded joint by flanging

Contact bonded joint - glued joint in the contact area of parts (Fig.10).

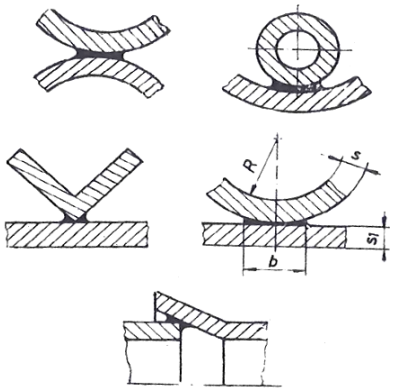



Fig.10. Contact bonded joint.

Uniform dilatation bonded joint - joining formed by bonding the materials with close thermal expansion coefficients.

Uneven dilatation bonded joint - joining formed by bonding the materials with different expansion coefficients. [2]

## 3. ELEMENTS OF CALCULATION

Generally, the adhesive gluing joints must, on the one hand, take into account the low resistance of the adhesive to the metal parts at the same application, and on the other hand, to reduce the tops of tensions (Fig.11).

At the simple overlapping joint, as in the case presented, supplementary flexural tension occur, the smaller the length of the overlapping the stronger.

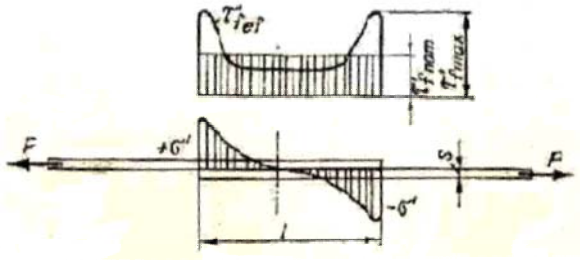



Fig.11. The distribution the peak voltage by overlapping [5]

$$F = s \cdot b \cdot \sigma_{tnom} = l \cdot b \cdot \tau_{fnom}, [N] \qquad (1)$$

where "b" is the specimen width (the width of glue area)

$$\sigma_{tnom} \leq \sigma_{at} \qquad (2)$$

- tensile strength test for specimens

$$\tau_{f\,nom} \le \tau_{a\,f} \tag{3}$$

- shear to layer in adhesive

$$l = s \cdot \frac{\sigma_{at}}{\tau_{a\,f}}, [mm] \tag{4}$$

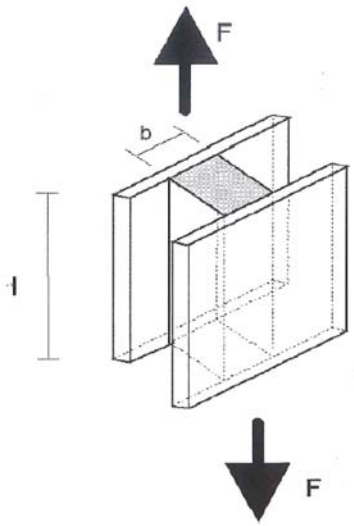



Fig. 12. Specimen according to SR EN 15434+A1. [8]

$$F = \int_A \tau \cdot dA = \tau \cdot A \tag{5}$$

$$\tau = \frac{F}{b \cdot l}, \quad [N] \tag{6}$$

Where "F" is shear force, [N];

$\tau$ - Shear stress, [N/mm$^2$];

b - Width of adhesive, [mm];

l - Length of adhesive, [mm];

A – Area, [mm$^2$].

$$\Delta_S = \frac{F \cdot l}{A \cdot G}, \quad [mm] \tag{7}$$

Where: G is shear modulus, [N/mm$^2$] ;

$\Delta_S$ - elastic deformation [mm].

Pure shear stress is related to pure shear strain, denoted „γ" - gamma, by the following equation. [7]

$$\tau = \gamma \cdot G \tag{8}$$

To this end, a combination of head to head sheet metal (Fig.2.) is not recommended, in the same section, the adhesive layer is bearing a weight much lower than metal. On the contrary, the head to head aslant joint is very good as it allows continuous flow of force lines, provides a larger area of the adhesive layer and takes over by combined unified effort, which includes shear (Fig.3.).

Of simple overlapping joints, the operation using bevelled edges machines is more expensive, but superior to that with straight edges (Fig 5.) by smoother passing of lines of force.

In the group with junction plates (Fig.4.), the best in terms of resistance is bevelled edges, which eliminates additional flexural tensions and minimize tension peaks. Jointing with two junction plates with straight edges, frequent, provides symmetric loading, but maintain the effects of stress concentration.

**Adhesive bonded joints resistance.**

By joining the synthetic adhesives are to consider the following basic characteristics:

- Tensile strength (Fig.13, a);
- Tensile strength in flexural;
- The shear breaking strength;
- Resistance to separation under load uniformly distributed (Fig. 13, b) or uneven (Fig. 13, c) gluing surface; Resistance to separation by debarking (Fig. 13, d) worst; such a request is complex in nature, consisting of traction, compression and the shear;
- Fatigue strength;

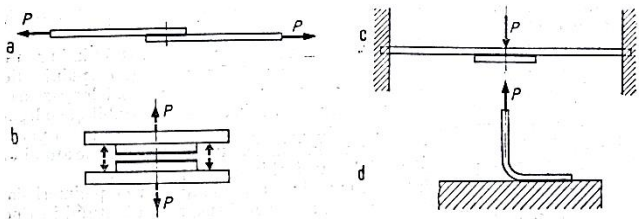



Fig.13. Verification of resistances: a.) by traction, b.) at separation under load uniformly distributed, c.) at separation under load unevenly distributed, d.) at peeling.

Addressing the issue confirmed by calculation that the most favorable distribution of tensions occurs when the ratio of transverse elastic

modulus of the adhesive G and longitudinal elastic modulus E of the joined parts is minimum, namely, rigid parts are glued with a soft adhesive.

Also tension peaks occur at the request of separation by peeling. [5]

At the combination by overlapping strong flexural moments occur, the tension of the adhesive mass is complex, as overlapping shearing unitary forces, of traction in the direction of force and perpendicular peeling on the direction of loading.

Degree of utilization of gluing is expressed by the ratio of the actual unitary effort of tension in the base material, when tearing at the time of joining and its resistance to breaking increases to overlap ratio for all basic materials and adhesives.

## 4. BONDED JOINT TECHNOLOGY

Almost all metals and alloys can be glued together or with almost any non-metallic material for example: wood, rubber, glass, cork, plastic, ceramics, concrete - without the harmful effects of parts in the case of using special adhesives, even when the base materials possess different coefficients of thermal expansion.[4]

In this particular case we have studied the gluing assembly between a metal substrate and a glass ceramic.

The metallic support is made of the two types of materials:

- Stainless sheet steel - 304-2B ASTM, (X5CrNi18-10, numeric symbol 1.4301 (Fig.14);
- Sheet steel - DC 04 EK-M - EN 10209, numeric symbol 1.0392.

The surface the metal support made of sheet steel is treated with a protective layer of paint applied in electrostatic field (Fig.15).

Glass-ceramic polycrystalline material is produced by controlled crystallization of base glass.

Fig.14. The metallic support made of stainless steel sheet and assembled by bonding with ceramic glass.

Fig.15. The support metallic made of steel sheet and assembled by bonding with ceramic glass.

All thermal properties of the glass are important in technology due to the fact that during its production, the glass is heated, melted, cooled, heat treated in a very wide range of temperature.

In these heat treatments glass is crystallized, to the glass base composition is added "heterogeneous germs" – natural particles of of other nature, generally ceramics, these germs help and control the crystallization process.

The joint is done using a synthetic adhesive "Silicone". Silicone is an extremely adaptable and flexible material.

Links with silicone may be much stronger than traditional systems that rely on physical bolts or welding.

**The silicone metal support used for bonding glass: S 95 Novasil**

**Characteristics**

- Neutral-curing 1-component silicone sealant and adhesive;
- Cures at room temperature;
- Excellent adhesion on many substrates, partly in combination with primer;
- Very good steam and humidity resistance;
- High adhesion strength;
- Especially matched viscosity;

**Fields of application** Bonding and sealing of glass ceramic hobs.

**Important information**

Before applying this product the user has to ensure that the materials in the area of contact (solid, liquid and gaseous) are compatible with it and also amongst each other and do not damage or alter (e. g. discolour) each other. As for the materials that will be used at a later stage in the surrounding area of the product the user has to clarify beforehand that the substances of content or evaporations do not lead to an impairment or alteration (e. g. discolouration) of the product.

During the curing process of the material reaction products of the cross linker are released.

Must be ensured a good ventilation during application and curing.

After curing the product is completely odourless, physiologically harmless and unmodified.

The required vulcanization time prolongs with increasing thickness of the silicone layer. One-component silicones must not be used for full-surface bonding applications unless special constructional prerequisites are met. [10]

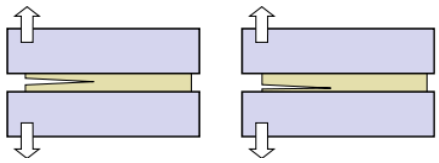
**Work phases**

a. Visual inspection of metallic support a -6-
the settlement of soldering device.
b. Applying silicone using a pneumatic pistol and positioning the glass.
c. Removing the metallic sticking out of gluing device and each 12 pieces.
d. For correct settlement of the bottle the support will use weights that also ensure pressing during polymerization.
e. Storing parts glued in a room that is conditioned for optimal polymerization technology prescribed in the fiche.
f. After polymerization is loosen the stack and cleaned the excess glue stuck, then send to the next assembly department.

## 5. DEFECTS OF BONDING JOINTS.

There are several factors that may contribute to joint damage. Sunlight and heat can weaken the adhesive. Solvents can damage or dissolve the adhesive. Physical Applications can also cause separation surfaces. When subjected to loading, de bonding may occur at various locations in adhesive bonding. The most important types of fracture are:

- **Fracture cohesion** - is achieved if a fissure propagates in the bulk polymer constituting the adhesive. In this case, both adherent surfaces after de bonding will be covered by fractured adhesive. The crack can propagate in the center layer (Fig. 16, a), or in the vicinity of an interface (Fig. 16, b). In this case, cohesion fracture can be said to be "close to the interface cohesion".



a.) b.)

Fig.16. Fracture cohesion

- **At the interface fracture** – de bonding takes place between adhesive and adherent (Fig.17.). The many cases, the occurrence of fractures occur in some adhesive interface having less resistance to fracture. The character from the interface of the fractured surfaces is usually to identify the exact location of the crack path in the interface.

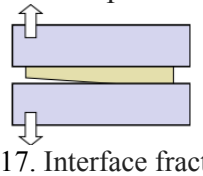


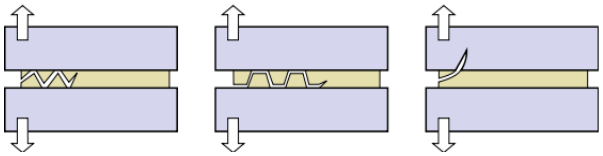
Fig.17. Interface fracture.

- **Other fractures**

- Mixed type, which occurs when the crack propagates in some places in cohesion and other at the interface (Fig. 18, a).

Mixed fractured surfaces can be characterized by a certain percentage of adhesive areas and cohesion.

- The type of fracture which occurs in alternative to the case in which the cracks jump from one interface to alternative, (Fig. 18, b). This type of fracture occurs in the presence of tensile pre-stress (before curing) of the adhesive layer.



a.) b.) c.)

Fig.18. Other types of fractures: a) mixed, b) alternative, c) random.

- The fracture can occur randomly (Fig.18, c), also if the adhesive is harder than the adherent of contact surface. In this case, the adhesive remains intact and still attached to the substrate and other remains. [9]

The bonding technology as in other technology areas known to occur or semi nonconforming parts that do not meet quality requirements, for example: Deviation from planarity, being the most important (Fig.19);

- Application of patchy thickness of the adhesive (Fig.20);
- Incorrect positioning of the glass;
- Contact surfaces cleaned according to technological of prescriptions, reducing joint resistances;
- Failure to comply the solidification time and incorrect application of pressing force.

The use of adhesives as bonding materials has a number of advantages over other materials and technology, but also has a number of disadvantages:

- Temperature resistance;
- Polymerization time (solidification);
- Aging;
- Safety and environmental protection.

Fig.19. Verification of planarity.

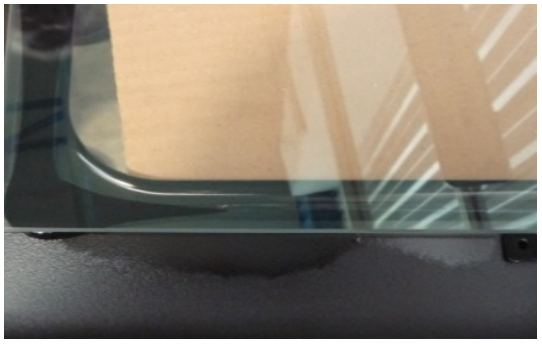


Fig.20. Application of patchy thickness of the adhesive

Loosen bonded joints was found that rupture does not occur any time in the contact area between Port-adhesive, but close to it in a low resistance layer cohesion.

This weak boundary layer may be a rigid layer of metal oxide on the metal surface, or a small molecule impurity molecule on the metal surface. Weak boundary layer thickness and composition depend on the type of soldering materials and surface preparation mode. This makes the weak boundary layer theory very useful because strength bonded joints set with mechanical analysis, where the rupture site, the existence or absence of weak boundary layer decisively influence the measurement results. [6]

## 6. CONCLUSIONS

Identification of structural elements for the connection process by bonding with synthetic adhesives is influenced by various factors which play a key role in order to achieve a quality joint.

The most important factor influencing the quality of joints is determined by adhesion (adhesion) due to effects of forces occurring at the contact surface between material and adhesive. We noted that the surface roughness determines the size of the adhesion and cohesion forces, thus increasing tension strength, flexural and detachment by peeling.

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**ASPECTE TEHNOLOGICE PRIVIND ASAMBLAREA PRIN LIPIRE A STICLEI PE SUPORT METALIC**


**Rezumat:** *Dezvoltarea accelerată a ştiinţelor inginereşti din ultimii ani, a condus la necesitatea utilizării unor noi metode de fabricație, de asemenea, competiția industrială actuală are nevoie de metode noi de fabricație rapidă şi cu costuri acceptabile. Asamblarea prin lipire a sticlei pe suport metalic se face utilizând un adeziv sintetic, care este relativ o metodă nouă. Lipirea cu adeziv pe bază de materiale sintetice a câştigat în ultimul deceniu un câmp larg de utilizare, la îmbinarea tablelor sau pieselor metalice, nemetalice sau combinate, îndeosebi în construcția uşoară şi mecanică fină, dar şi în construcția de maşini. În locul stratului de metal sau aliaj de lipit, intervine un strat subțire de adeziv care, după aplicare, se întăreşte şi preia forțele exterioare prin rezistența mecanică datorită coeziunii din masa lui, cât şi prin adeziunea dintre adeziv şi suprafețele de îmbinat.*



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