DRAFT WORK FOR BONDING HONEYCOMB PANELS, AIR

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This thesis provides a brief theoretical background on bonding and honeycomb panels in aerial engineering. It tries to analyze the current trends in production and repair of honeycomb panels from metal and non-metal materials. It further describes the selection of necessary appliance, adhesive, adhesive lutes and special tools. The aim of this work was to plan a workstation for the production and repairs of honeycomb panels by adhesive and hardening with autoclave positioned at working table. Designed workstation is graphically presented by a necessary visual presentation. The work contains also photo-documentary.

K e y w o r d s. Bonding, adhesive, honeycomb panel, repair, workstation.

1 INTRODUCTION

Nowadays, especially composites and honeycomb panels are increasingly replace commonly used materials, because of weight loss. In particular, the expansion of the use of honeycomb panels, as a special kind of composite materials, which are characterized by high stiffness in bending at a relatively low weight in aircraft structures, brought with it problems of bonding of these materials.

The thesis was created using the recommended literature, using the extensive resources available on the Internet that deal with this topic in detail. Also, realization thesis greatly helped professional consultation with employees helicopter service centre ATE Poprad, similar to those used in repair work practice.

The work is divided into three main chapters. The first two chapters are the focus on theoretical issues. The third chapter focuses on the practical part of the problem.

2 BONDING

In the literature and practice, there are several known bonding theory. Many survive from the past, others occur without significant changes in bonding technology mainly because it is not currently available suitable mathematical or experimental apparatus to verify some hypotheses.

Each structurally strong bonding joint can be considered as a set of five layers bound to each other, where the rate of adhesion of each layer to the adjacent layers and the layers themselves cohesion may significantly affect the overall quality of bonding joint (Fig. 1).

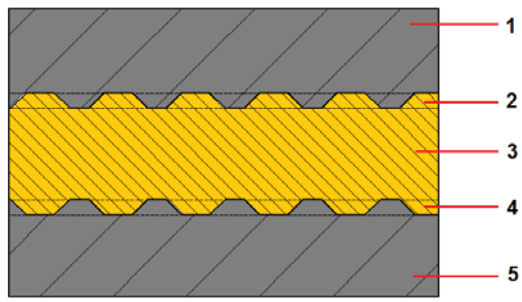


Fig. 1 Schematic structure of the bonding joint

The layers are:
1 bonded material to one side of the joint;
2 micro-layer, in which the adhesive and roughness (pores) surface bonded materials overlap on one side of the joint;
3 own adhesive film;
4 micro-layer, in which the adhesive and roughness (pores) surface bonded materials overlap, on the other side of the joint;
5 bonded material on the other side of the joint.

The joint of such a structure may arise only under certain conditions. In particular, the adhesive must be selected. The selected adhesive must be evenly applied to one or both contact surfaces to be thoroughly wetted. After the conclusion of the sheet shall be adhesive joints evenly tier, must penetrate into microscopic pores and create a surface active film. Consequently, it is necessary that the adhesive has passed from the liquid phase to solid or from solid to liquid and back to solid phase, depending on the type of adhesive [1].

2.1 Factors affecting bond strength

These are the following factors:
1. Selection of a suitable adhesive
2. Adjustment of bonded areas
3. Applying the adhesive
4. The thickness of the bond
5. Type of loading
6. Surface roughness
7. Curing time
8. Errors in the adhesive layer
9. Impact high and low temperatures

2.2 Advantages and disadvantages of bonded joints

Bonded joints are compared with other methods of creating permanent joining a number of advantages. But like any technology, the bonding in addition to its advantages it also has its disadvantages.

Advantages: we can connect the same material, or completely different, regardless of their thickness, can be mounted in most cases carried out at relatively low temperatures, the joint is gas tight and watertight, sealing cap creates a reliable, connection is non-releasing, resulting in a more uniform distribution of stress over the bonding area, thus eliminating the local concentration of stress, bonding reduces the weight of the whole structure, connections can be arranged, or adapted in colour, is bonding over other joining techniques with relative ease.

Disadvantages: The bond strength is often low compared to other joining techniques; places high demands for equality and purity of the surface bonded panels; bonded joints are most sensitive to stress in peel and torsion; the maximum bond strength is achieved after some time; the adhesive can be contested by some chemicals; are generally not suitable for connection with the cyclic stress; bonding in an industrial sense is difficult to workstation; with respect to health must be complied with strict security measures [2].

3 HONEYCOMB PANELS

Honeycomb panels to advise the group of sandwich structures with honeycomb core. An example of a honeycomb panel is shown on Fig. 2.

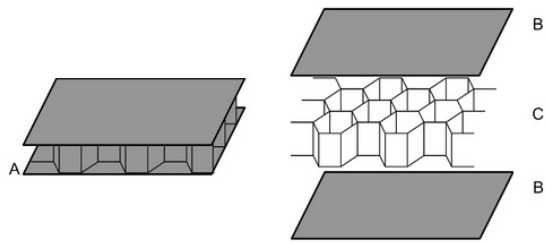
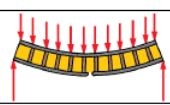
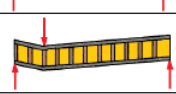
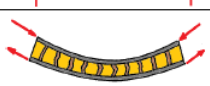
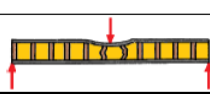


Fig. 2 The structure of the honeycomb panel
A - honeycomb panel, B - skin C - honeycomb core

3.1 Damage to honeycomb panels

Damage and deformation air honeycomb panels are dependent on the relative strength and stiffness of the skin, core and grip.

Tab. 1 Damage to honeycomb panels [3]

Buckling mode	Cause	Mode shape
General buckling (instability)	Insufficient bending stiffness, or insufficient core shear rigidity	
Face wrinkling	Thin face, and Low adhesive strength	
	Thin face, and Low core strength	
	Very thin face, and Large core cell size	
Face failure	Lateral pressure Low face strength	
Core shear buckling	Insufficient core shear strength	
General core compression buckling	Insufficient compressive core strength	
Concentrated core compression buckling	Insufficient compressive core strength	

3.2 Check of honeycomb panels

In the area of maintenance is necessary to exercise inspection of these panels. To assess the quality control of such a honeycomb panels before and after the repair is performed non-destructive methods of diagnosis.

We distinguish 3 fundamental inspections honeycomb panel:

a) Visual inspection of the panel.

b) Sound inspection panel (acoustic impedance)

c) Inspection the core panel

In carrying out these checks must be strictly adhered to working practices reported by the manufacturer [4, 5].

3.3 Repairs of honeycomb panels

Repairs of honeycomb panels must be carried out to repair the panel had the same strength as the undamaged panel, or that its strength was approaching. At the same time the weight gain must be minimized.

The first step of repairs is to remove the paint from the damaged panel area. The second step is to cut out the damaged part and then cleaning the cavity after excision of the damaged part of the honeycomb panel. It is then necessary to prepare the panel surface for bonding.

By the extent of damage to honeycomb panel differentiate the types of repairs. There is certain boundary limits damage. In the case of one-sided damage of the skin with the limits of damage according to Fig. 3 can be done easily repair filling, grinding and repainting. [4].

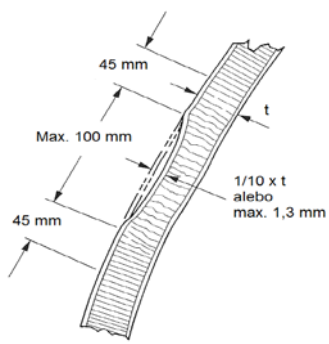


Fig. 3 Repair of skin honeycomb panel

Repairs pierced honeycomb panels also depend on the extent of damage. One-sided pierced into diameter 40 mm was carried out according to Fig. 4.

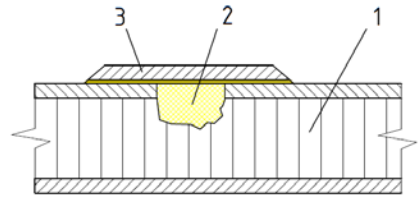


Fig. 4 One-sided pierced into diameter 40 mm

1 - panel, 2 - composition of the VKV-9;
3 - patch + adhesive VK-9.

It is possible to eliminate the one-side pierced into diameter 100 mm. Repairs are carried out in the same manner as in the case of pierced to 40 mm, with the difference that is necessary to use analogue honeycomb insert. The manner of repair is shown in Fig. 5.

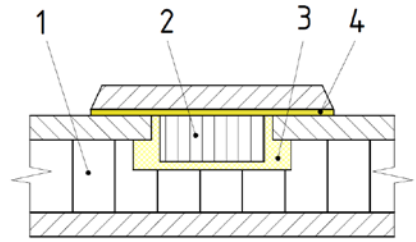


Fig. 5 One-sided pierced into diameter 100 mm

1-panel, 2-analogous honeycomb insert;
3-composition VKV-9, 4-patch + adhesive VK-9.

Damage through the entire thickness of the panel with a diameter of 6-40 mm is repaired according to Fig. 6. The repair is one side covered with PVC film coating, which are thrust washers. After curing the adhesive composition of the item to remove the foil, the area cleans up and sticks the patch.

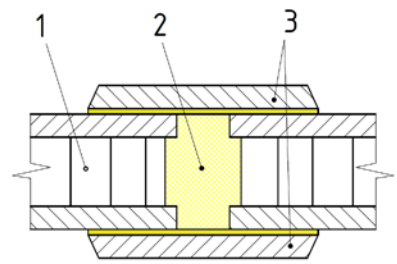


Fig. 6 Both-side pierced into diameter 40 mm

1 - panel, 2 - Composition VKV - 9, 3 - patch + adhesive VK - 9

Repair of both-sided pierced from 40 to 100 mm are repair in the same way as both-sided

repair a pierced in 40 mm. The repair is necessary to use analogue honeycomb insert. The repair procedure is shown in Fig. 7.

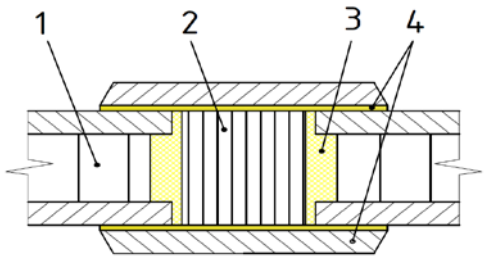


Fig. 7 Both-side pierced into diameter 100 mm
1-panel, 2-analogous honeycomb insert;
3-composition VKV-9, 4-patch + adhesive VK-9.

In the case when it is not possible or necessary to use the methods of repair using overlapping patches also depend on the extent of damage. If the skin is smaller pierced (up to 25mm), just simply fill the cavity and then sanded surface, and repaint. If size is bigger breakout than 25 mm but less than 75 mm, then the cavity is filling, but the last layer, which replaces the cover, is of reinforced plastic. If the size range 75 to 150 mm cavity is filled layers of reinforced plastic, which is also the opening blinding. If the diameter of the defect site exceeds 150 mm replaces the damaged honeycomb analogous honeycomb insert according to Fig. 8.

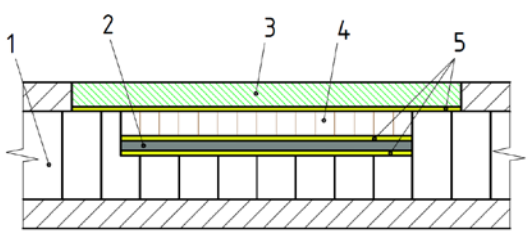
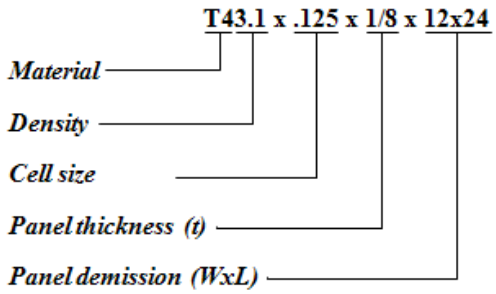


Fig.8 One-sided damage into 150 mm
1 - panel, 2 - aluminium foil,
3 - patch of reinforced plastic,
4 - honeycomb insert, 5 - adhesive.

In carrying out these repairs are necessary to ensure clean working environment with the highest standards and comply with specific procedures repairs [4, 6].

3.4 Marking of honeycomb panels

Schematic of a code:



Example: **T43.1 x .125 x 1/8 x 12x24** = T4 – aluminium honeycomb panel; 49,7 kg/m^{-3} (3.1 lb/sq in) – density; 3,2 mm (0.125 inch) – cell size; 3,0 mm (1/8 = 0,12 inch) – panel thickness t; 305x610 mm (12x24 inch) – panel size (width x length) WxL [4].

4 DRAFT WORK FOR BONDING HONEYCOMB PANELS, AIR

Draft work and desk dimensions are based on the dimensions of analysis used honeycomb panels, which are currently used in aviation technology. Input parameters for the design of the desk are therefore the maximum dimensions of honeycomb panel, 1300 x 1800 mm, with maximum thickness of 90 mm.

Final version of the proposed work table for bonding of honeycomb panels with using an autoclave curing placed in desk is shown in Fig. 39.

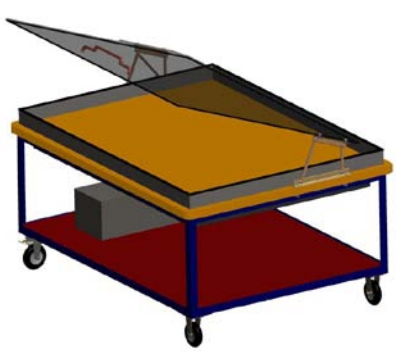


Fig. 9 The final design of desk

The main dimensions of the desk are shown in Fig. 10. Below are described the main

parts of the desk, which are divided into two units, to mechanical and pneumatic parts.

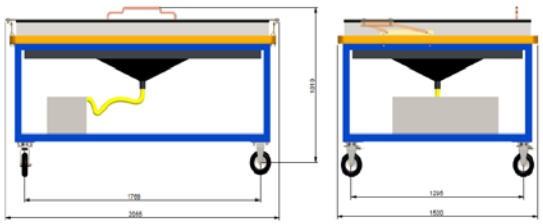


Fig. 10 The main dimensions of the desk

As seen in Fig. 9 and Fig. 10 main support structure of the desk is a frame that is welded. At the bottom of the frame are welded holders for mounting the wheels. The top is fitted and bonded work desktop. The bottom plate is fitted and bonded the cover blowing air through the suction hose is connected to the pump. Vacuum pump with gauge models is only schematically shown. The top of the worktop is fitted and bonded the upper frame cover which is provided with a profiled seal. The work surface is even with standard screws attached a simple mechanical hinge, which is used for opening or closing the workspace desktop. Top cover is made of transparent material, which among other things, prevents ingress of dirt and other objects in the workspace desktop. The top cover is also provided with a profiled seal, the conclusion rests on the door frame cover. It is attached to the hinge for opening and closing. The top cover is attached handle for opening and closing the workspace desktop.

4.1 Selection vacuum pump

The exhaust air from the working area was chosen oil vacuum pump ORFE PA 0040. Type pump and the suction were chosen based on comparison to assess the performance of vacuum pumps used in similar work. Selected oil vacuum pump is a rotary type that is used in various industrial applications. The vacuum pump is compact and has a direct connection to the body to pump motor. The vacuum pump is air cooled. Pumping speed is up to 40 m^3 per hour and achieves an absolute vacuum of 0.5 mbar (millibar). This type of pump is also easily accessible as it is produced in the Czech Republic.

5 CONCLUSION

The submitted article is based on the diploma work of the same name. The introduction examines the current state of knowledge. It focuses on theoretical knowledge creation bonded joints and knowledge of current methods of repair of honeycomb panels aeronautical metallic and non-metallic materials. The result of this thesis is the design work for bonding honeycomb panels, air with using the autoclave curing, which is located in the workbench. The contribution of their own design work includes the production, simple manufacturing process and specific conditions for use in aviation maintenance technology. The entire design is implemented in 3D parametric CAD system CREO.

BIBLIOGRAPHY

[1] OSTEN, Miloš : Lepení plastických hmot. Praha : SNTL, 1974. 152 s.

[2] FOLTA, Jiří. : Hodnotenie pevnosti lepených spoju v konstrukci autobusu : Bakalářska práce. Pardubice, 2008. 54 s.

[3] WITEHEAD, S. – McDONALD, M – BARTHOLOMEUSZ, A. : Loadin, Degradation and Repair of F – 111 Bonded Honeycomb Sandwich Panels : Preliminary Study. Melbourne : DSTO, 2000. 73 s.

[4] STRUCTURAL REPAIR MANUAL : Agusta A119/A109 Series-SRM

[5] OLYMPUS : Nondestructive Bond Testing for Aircraft Composites. [online] [cit. 2012-02-17]. Dostupné na internete:<http://www.olympus-ims.com/cs/applications/non-destructive-bond-testing-aircraft-composites/#/>

[6] MORAVEC, Milan : Základy technológie opráv lietadiel (2. časť) : Opravárenské technológie, Vsošl Košice ,1995,

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