STRENGTH OF ADHESIVE BONDING JOINTS FOR CLASSICAL AND PROGRESSIVE MATERIALS USED FOR CAR-BODY DESIGN

PEVNOST LEPENÝCH SPOJŮ KLASICKÝCH A PROGRESIVNÍCH MATERIÁLŮ POUŽÍVANÝCH PŘI STAVBĚ KAROSÉRIE

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Abstract
This paper deals with the application possibilities of new – progressive materials in the area of car-body design. By using new materials, where also belong aluminium and its alloys, there is necessity to test use properties of individual adhesive joints, namely under shearing loading and peel test in dependence on adhesive and lubricant used during stamping technological process. Sheet stampings as car-body component parts are produced by drawing and using aluminium alloys means certain problems with regard to their processing technologies and subsequent assembling.

To evaluate strength of adhesive bonding joints of sheets from aluminium alloys is necessary to measure reliable data, to verify jointing methods and compare them with steel materials which are commonly used for car-body design.

Key words: Adhesive bonding, Adhesive joint, Aluminium Alloy, Car Body

1. INTRODUCTION INTO ADHESIVE BONDING TECHNOLOGIES
Bonding technology is growing more and more important method for jointing metals, plastics or combine systems in almost all industrial branches. With comparison with classical methods for material jointing (screwing, riveting and welded joints) are not basic material mechanical properties influences by notch effect of hole for jointing parts. By welding there is often problem about jointing different kinds of materials and outer surface quality of welded parts. Important characteristics of bonding is efficiency and economy – namely in automotive and aircraft industry also mass reduction of bonded parts.

2. CAR-BODY BONDING
During car-body design and production is not nowadays just to “convectional” jointing technologies for stampings. Important role for jointing individual car-body parts plays bonding technology – possible application of adhesives are shown in fig. 1. These days using adhesives do not serve only for sealing function, anti-acoustic or anti-vibration barriers but are also using like structural jointing types which into great extent influence strength and stiffness of car-body and thus its safeness and whole comfort.

For ca-body design are up to now using the most thin (namely steal) sheets which are subsequently jointed mainly by welding. However nowadays there is still increasing tendency to use just bonded joints due to their advantages which represents for jointing of car-body parts. Properly design of bonded joints can in many cases both get out problems with welding and also give the whole construction other profitable properties.
Structural bonded joints taken place in automotive industry in many variants both from the design point of view and from the functional loading point of view. Precondition for fine strength and sufficient bonded joints capacity represents mainly suitable joint design. Bonded joints are known for their very high shearing strength. Tensile strength is much lower and the worse properties are given under peel loading (see fig. 2). Principles about suitable using of bonded joint are given firstly by character of used adhesive and also by requirement to reduce or eventually minimize tensile and peel loading. If there is not possibility to reduce these factors and is necessary to increase joint safety, bonding is combines with other jointing technologies. In many cases are bonded joints used in combination with spot welding (e.g. door trims).

Fig. 1. Adhesives application for car design

Fig. 2. Bonded joint loading: a) tensile, b) shear, c) peel
2.1 Application of aluminium alloys for car-body design

Still more and more strict standards about environmental protection force car producers to design cars with lower content of pollutants and emissions. The heaviest part of car represents car-body and that is why (due to effort to reduce car weight) commonly used steel sheets are replaced by lightweight materials – e.g. aluminium alloys. Aluminium alloys have found place, mainly due to their quite high chemical resistance and low weight, namely in aircraft but also in automotive industry and many others lines. Effort about utmost using and application aluminium alloys in automotive industry leads to idea to produce car from aluminium sheets and about replacement some aluminium casts by aluminium sections and sheets. Because aluminium is still more and more use for car-body design is necessary to focus research for its possible application in the areas not only about processing for car-body stampings production in automotive industry but also for jointing individual parts.

3. AHDESIVES

Because of productivity reasons sheets in series production during stamping are not degreasing before application of adhesive or welding. From such very specific requirement is range of applicable adhesives very restricted only on adhesives which are not very sensitive compared with lubricants and ensure sufficient adhesion and joint strength despite of certain surface lubricant layer thickness. Steel sheets produced from smelting industry are against corrosion protected by slash which should have for given surface also proper technological properties. Lubricant amount is commonly set in the range 1 up to 3 g.m⁻². In some cases is before stamping because of improvement tribological properties necessary onto sheet surface in some areas apply different technological lubricants (following technological difficulty and required surface quality of stamping).

Reinforcement adhesives are cured during paint baking in paint shop. For trim adhesives is effectively using rapid partial curing by means of induction heating during assembling and final adhesive curing is finished during baking in paint shop.

Character and adhesive composition used for car-body design is closely connected with required joint function. According to this criterion is possible to divide for sealing, reinforcement and strength purposes.

4. EVALUATION OF BONDED JOINTS STRENGTH

The main aim of experimental part was to evaluate bonded joints strength from aluminium alloy according specific requirements of automotive industry [2]. In the frame of cooperation with renowned car producer from Czech Republic ŠKODA AUTO a.s. our Department of engineering technology on Technical University of Liberec deals with evaluation of thin sheet bonded joints using for car-body.

4.1 Experiment condition

Substrates:
- aluminium alloy sheet – according EN - AW 6016
- steel sheet DX 54D + Z100MBO – according EN 100142
- HDG – hot dip galvanized surface
4.2 Evaluation of bonded joints strength

Was carried out test of bonded joints strength under shearing according norm VW PV 12.35 [4]. In fig. 4 is shown testing sample. As a result from test is shearing strength $T$ [MPa]. In addition was tested strength of bonded joints by means of peeling method according ISO 11339 [5] – testing sample is in fig. 4. As a result from test was mean peeling strength $F_s$ [N/mm].

4.3 Bonded joints failure type evaluation

For evaluation bonded joint quality is another possible criterion to evaluate bonded joint failure type according ČSN ISO 10365. Basic failure types are shown with course of peeling test in fig. 5.

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**Fig. 3.** Sheet surface morphology for aluminium alloy (left) and steel substrate HDG (right)

**Fig. 4.** Samples for shearing test (left) and peeling test (right)

**Fig. 5.** Basic failure types of bonded joints (left) and peeling test (right)
5. CONCLUSION

Measured results proved presumptions about lower strength of bonded joints from aluminium alloys with comparison to steel sheets both under shearing loading (see fig. 6) and also for peel test (see fig. 7). Such reality is also because due to lower mechanical properties for tested aluminium alloy, however measured values fulfill parameters of bonded joints utility properties.

It is really necessary to remind that bonded joints test quality results to a great extent depend on many parameters which influence final values like e.g. amount and type of used lubricants, type of used substrate and its surface morphology. With respect to these and many others influences can be stated that for each combination of lubricant, substrate and adhesive have to be tested. Great number of parameters makes testing of bonded joints quality very difficult and there is necessity to carry out another testing and deepening knowledge about individual factors influence and their combination onto bonded joints properties with respect to specific requirements from automotive industry.

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LITERATURE


