МАШИНОСТРОЕНИЕ

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UNUSUAL APPLICATION BONDING OF ALUMINIUM AND ITS ALLOYS

This post is aimed at a wide range of use of bonding materials. With the development of industrial technologies, the efforts of designers to develop the most effective method of joining materials transformed into practice. Contributions have been incorporated into most common ways of connecting bonding, pressure bonding and friction stir spot welding. For these types of bonding is appropriate to use materials from aluminum and aluminum alloys. Development and innovation bonding techniques are widely applied in the manufacture of car bodies as well as for use in the repair industry. Application of aluminum and its alloys are largely made to improve the mechanical properties such as strength and stiffness of structures, while maintaining weight. The paper contains the results of the stir spot welding, where the role played by geometric factors tool for bonding strength and the injection strength.

Keywords: aluminum, aluminum alloys, adhesive, pressure bonding, friction stir spot welding FSSW

1. Introduction

With the development of industries are increasingly at the forefront of getting the implementation of the various types of technologies in the field of materials joining. So how in the world, both in our effort to provide designers many advantages achieved by new methods, becomes prosperous. Hence the aim of technical development in industry is to fulfill the conditions and requirements for reducing costs and increasing the life of the individual components, which is an effective contribution to the company. Guarantee for the fulfillment of these objectives is the right choice of material with specific advantageous properties. These materials meet the requirements of aluminum and its alloys. The most common methods of joining materials in the automotive industry as laser welding, ultrasonic welding, resistance spot welding, bonding, pressure bonding, in many cases, a combination of techniques. Application of aluminum and its alloys are widely applied in the manufacture of car bodies. A big positive is to achieve strength, toughness and corrosion resistance. as well as life extension. Last but not least is the advantage of saving materials with lower weight.

2. Prospective materials for bonding

Automotive, and aerospace industry due to special materials development, gradually reducing the share of conventional alloys, Fe and increases the use of light metals. Most attention is given to an alloy of aluminum and magnesium for use in internal combustion engines and the chassis. Titan also provides easier design of castings and parts in internal

combustion engines (sheets, castings and profiles chassis) as structural materials for aerospace applications. [1]

2.1. ***Advantages and disadvantages of using aluminum alloys and their comparison with steels***

Advantages

- As a rule, have better mechanical properties while maintaining weight.
- Ability to significantly increase yield strength by heat treatment after forming (cure).
- Better absorption of impact energy and better resistance to corrosion.
- Cheaper production profiles (hot extruded) and better noise reduction.
- The possibility of highly productive casting of complex components.
- Less power (cost) necessary to form (printed, hydroforming).

Disadvantages

- The high price (3-6 x higher than for steel structures).
- Problematic joining (riveting, welding, gluing, crimping, soldering).
- Inferior formability.
- Aging and relaxation at elevated temperatures.

3. Selected options combining advanced materials

3.1. ***Bonding materials***

Combining metal bonding in comparison with other methods of combining many advantages, consisting in the possibility of combining different, each not weldable metals, uniform and carrying tension reinforcement structure in place where riveting or welding reduces the material strength. Glued joints are tight against the pressure and vacuum and there is no overheating of the bonding structure such as welding. Attention is paid to assessing the impact on surface quality adhesive joints. Adhesive strength is determined by physical and chemical properties of adhesives and joining materials. As each technology has a number of disadvantages bonding either reach full strength until after the hardening of the service, low resistance to elevated temperature or high purity requirements of glued parts. [1]

3.2. ***Adhesive bonding surface-treated sheets***

For the emergence of high-quality bond, it is necessary that the adhesive well-wetted surface material, thus ensuring maximum contact area. Well-bonded joints resist shear stress, less stress and tension in at least peel, respectively layering adhesive joint and are relatively little impact resistant severe shock. Different metallic materials should have very different values of modulus of elasticity and coefficient of thermal expansion. Selected metals should have a homogeneous surface, to achieve at every point of the surface of the same characteristics. This method of joining is largely similar to spot welding [1].

3.3. ***Pressure bonding materials***

Traditional methods of bonding materials, such as resistance spot welding or laser welding is not always possible to ensure the required quality of communication, it is therefore necessary to consider alternative methods of bonding materials. One relatively new method of joining materials, we can point to incorporate forms of bonding is the bonding pressure. [2]

Advantages:

- connection is created without additional material and without auxiliary fasteners (rivets, screws, etc.),

- bonding is energy efficient and damaging the protective layer bonded materials,
- material is compacted in place and reinforced joint, mechanical cracks arise,
- bonding process itself is very fast, running cold,
- resulting joints become watertight or airtight.

3.3.1. *The most commonly used methods of bonding pressure*

3.3.1.1. Connecting with trim

It is a one-step process divided into two phases: pruning and subsequent retraction contoured parts. The joint is created between the punch and matrix, which consists of a fixed anvil and two flexible side plates Fig. 1. The first phase, i.e. shearing, occurs when the surface cut punch along its two parallel edges, while parts of the contoured surface creates called bridge. Then comes the second phase of the process, which are clipped parts of sheets pressed between the punch and anvil fixed, until the width of the compressed often greater than their original width after trimming. This creates the resulting connection. Joining is then characterized by the punch penetration depth and height of retraction contoured sheet metal parts [1].

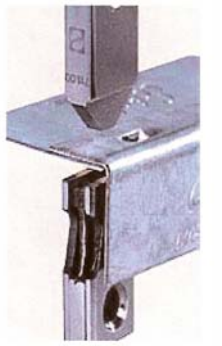


Fig. 1. Connecting with trim [1]

3.3.1.2. Conecting unrivet

The principle lies in the depression of materials between punches and dies, which also consists of a fixed anvil and flexible segments, usually two or four Fig. 2. These segments are used to move materials to the sides, thereby Jamming materials and the resulting joint actually occurs. The disadvantage of this coupling is more complicated structure matrix tool [1].

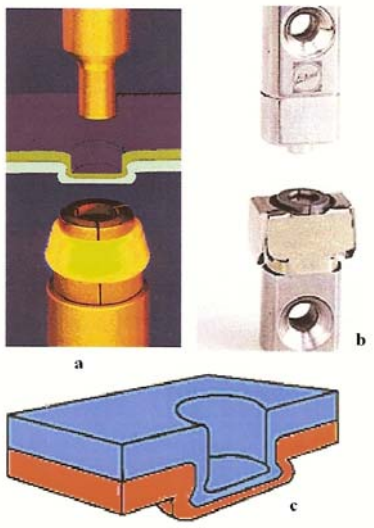
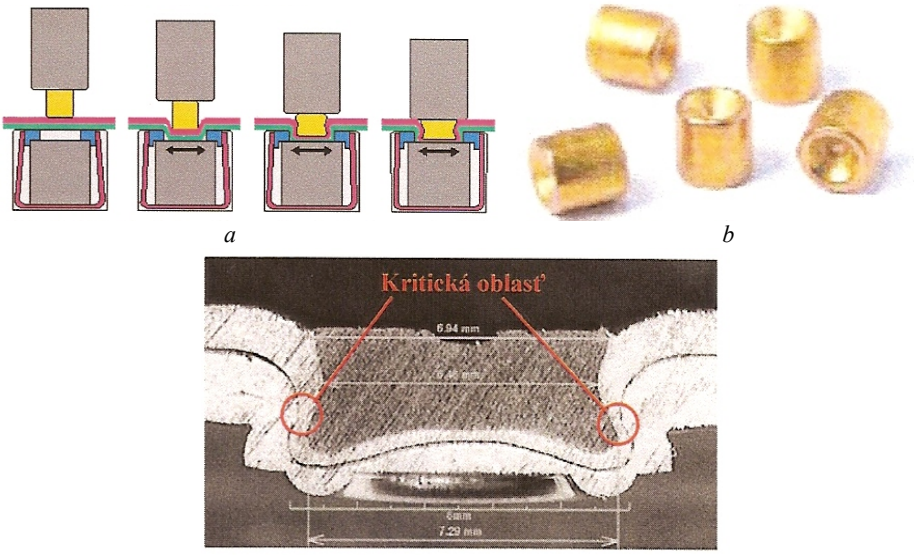


Fig. 2. Connecting unrivet [1]
a – function of punch and die, *b* – punch and die,
c – cut unrivet joint

3.3.1.3. Pressure connection with riveting

Pressure bonding with specially shaped the die and using rivets. The principle is similar to joining TOX - point, only instead of the punch is employed in bonded materials injection thread. Thus, the pressure created joint achieves high levels of resistance, because the yarn is placed directly in the circuit Fig. 3, thereby increasing the strength in the critical area of serviceie in place with the greatest thinning. [3]



a *b*

c

Fig. 3. Pressure connection with riveting [3]: *a* – principle of pressure bonding with riveting, *b* – rivets used in die bonding with riveting, *c* – cut pressure joint with rivet

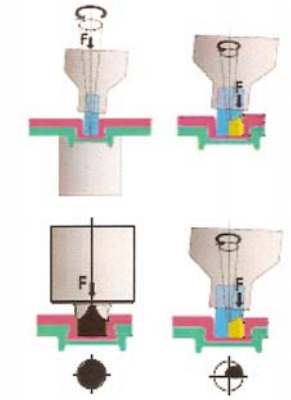


Fig. 4. The principle of rotary pressure bonding [3]

3.3.1.4. Rotary pressure bonding

The principle of this method lies in the pressure bonding material between the pressing punches and dies while employed part punch is rotating around a vertical axis and also tilted at an angle. As a result, the tilt is punch contact surface between the materials joined and punches reduced by about 70 to 80 % compared to conventional pressure bonding method TOX - the point where the compression force is significantly lower (up to 30 %), Fig. 4. It is used in aviation and space industry. [3]

3.4. *Friction stir spot welding*

Recently, this technology is Friction Stir Spot Welding (FSSW) between the latest alternatives spot welding of Al - alloys. The principle of this method is based on the welding material by rotating the tool by which the material is agitated and creates requesting

service. Tool to axially symmetrical shape, is composed of clamping parts and labor. Working part is the face of the instrument with pins Fig. 5.

Welding process consists of three stages:

- Touch the instrument with welded plate, breach the surface layer and gradually nesting material into the tool. The influence of nesting material into the instrument there is friction and deformation of material, which generates heat, reducing the mechanical strength of the material and increasing its plasticity.
- The actual welding, where the entire pin is embedded into the welded material and agitated at the same time it creates a bond. The face of the instrument touches the surface of welded steel pins and ensures the formation of printed material and the intensification of stirring.

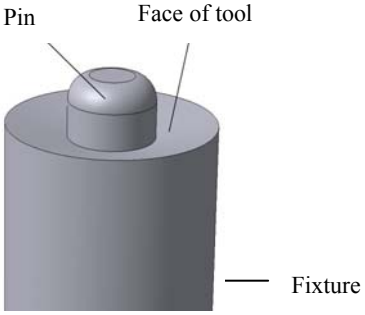


Fig. 5. Tool used technology FSSW [4]

- The third stage ends slide instrument from the point of welding. [4]

Because the instrument remains in the weld indentation whose dimensions are the dimensions of the tool pin, the bearing surface of the weld around the shape of the annulus and the diameter of the blended average indentation in contact welded plates. The technological parameters has the greatest impact of the geometry of the working tool pin.

3.4.1. Welding test

Welding tests are intended to track the impact of the working of the tool geometry on the strength of welded joint and the size of the blended and injection field strength. Welding tests were carried out on sheets of thickness 2 mm with dimensions 150 × 50 mm. Sheets were created to lap weld and welds were subjected to a tensile test at a stress in shear and metallographic investigation, which followed the shape of the blended area was measured and blended the support surface.

This technology has been used drilling equipment and control parameters of displacement, velocity, maximum power and the injection of the final position of the instrument was provided with new computer software. For welding of Al - alloys have been used a tool made of tool steel. Fig. 6 are shown the various working parts of the geometry tools. [4]

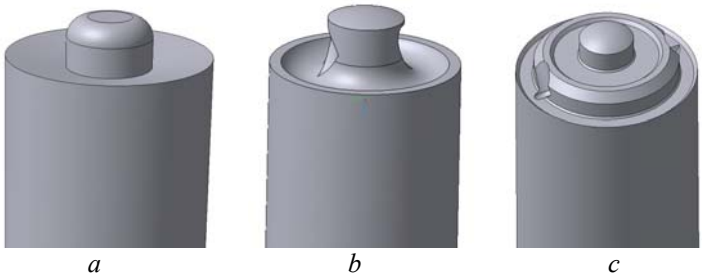


Fig. 6. Geometry of the working parts of instruments [4]:
a – tool A, *b* – tool B, *c* – tool C

The course forces the injection is graphically illustrated in Fig. 7. Tool A and B has a similar effect of the injection force. After the initial contact with the material instrument to force increases to a certain limit, where the heat reduces the strength of material and its plasticity. After overcoming local maximum constant power tool penetrates into the material. Material increase in resistance to penetration of the instrument there is an increase of heat, thus increasing the plasticity. After contact with the printed material there to face the rise of the maximum power injection. Pin is at the moment immersed in the welded material and the tool abuts the front surface of the plate. Rotating tool remain in this position, the time needed to eject from the following material.

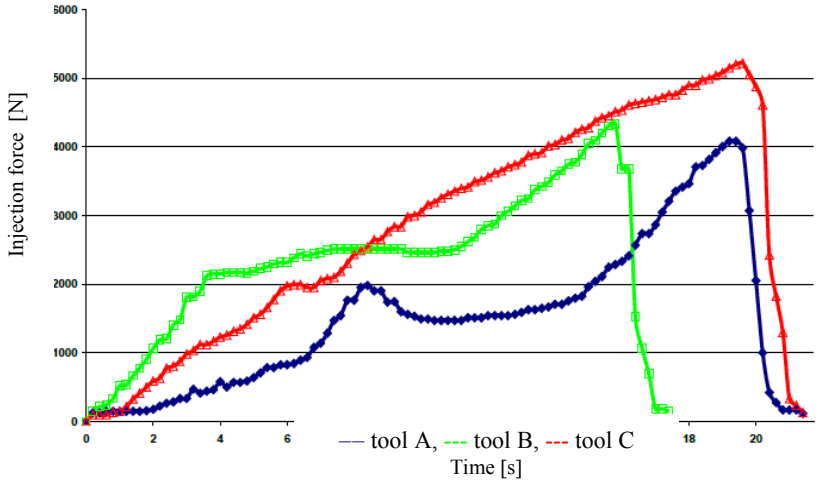


Fig. 7. The course of the injection force when used for welding tool geometry [4]

The course forces penetration instrument C is similar instruments during the A and B until the achievement of local maxima. Hold time constant was short and after the first maximum force increased to a maximum value. This change in strength during the injection was triggered by a stepped pin geometry and bursts its diameter was changed from 4 mm to a double value [4]

Fig. 8 is a graph of forces needed to rupture and annular width of the blended area. The test was carried out by tensile shear test, which is increasingly reflected the impact of tool geometry.

B instrument with a simple geometry of the task was unable to provide sufficient mixing of the welded material, where the contact surface area was 6.11 mm^2 Fig. 8 b, where the maximum shear strength of welded joint has reached the minimum value of 0.71 kN. Strength of welded joints using the tools A and C is significantly higher. The cylindrical geometry of the instrument and provide significant mixing of welded materials blended surface area was 22.78 mm^2 Fig. 8 a with the resulting joint shear force 4.65 kN. Weld joint has created a tool support surface C 14.17 mm^2 Fig. 8 c with a maximum value of 3.14 kN shear force. While he C pin tool with a stepped geometry to penetrate the material only first degree, the tool has penetrated deeper into the material.

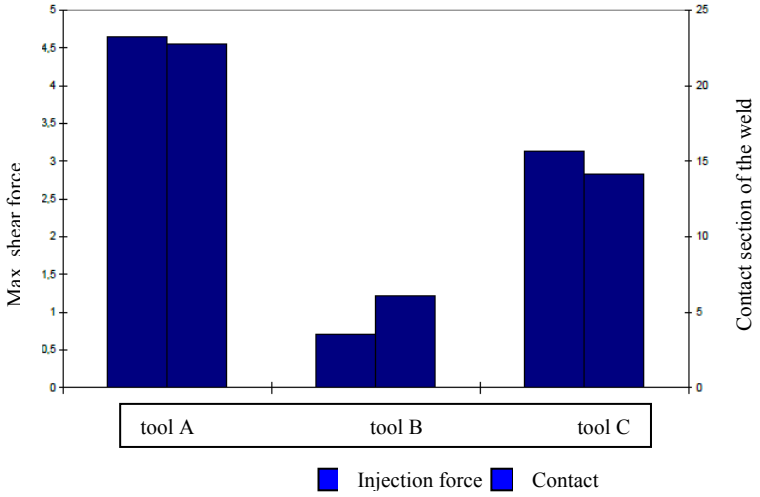


Fig. 8. Forces needed to rupture and annular width of the blended area [4]

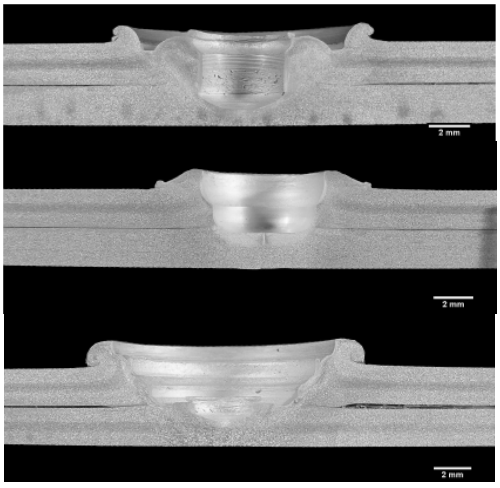


Fig. 9. Structure splices for use [4]: a) tool A, b) tool B, c) tool C

4. Conclusion

Combining low weight alloys especially aluminum and its alloys with conventional materials used in the automotive repair industry but also, as well as renovations. Application of these materials can achieve many advantages, for which designers are constantly trying in unconventional ways of linking mentioned in the paper.Applying technology FSSW today is of great benefit to industry. The main advantages are reduced weight, material savings and increased corrosion resistance. Achieved strength of welded joints, while slightly behind fortresses of resistance spot welds, but this shortcoming can be improved or removed by mutual optimization of welding parameters (tool rotational speed, speed and power injection) and geometry of the working tool.

References

1. DILLINGER, J. a kol. 2007 Moderní strojírenství pro školu a praxi. Praha : Europa-Sobotáles cz. s.r.o., 2007.
2. KAŠČÁK, Ľ. 2004. Príspevok k hodnoteniu vlastností spájaných hlbokoťažných plechov. Doktorandská dizertačná práca. Košice 2004.
3. Katalóg firmy TOX-Pressotechnik.
4. BLAŽÍČEK, P. a kol. 2008. Vplyv geometrie nástroja na pevnosť spoja vytvoreného trecím bodovým zváraním s premiešaním. Bratislava : VÚZ – PISR, 2008.

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Нетрадиционные виды соединения алюминия и его сплавов

Рассматриваются вопросы соединения различных материалов. В частности, уделяется внимание контактной сварке материалов из алюминия и (или) алюминиевых сплавов. Такие соединения актуальны, например, в автомобильной промышленности. Показано, что можно выполнить технологический процесс сварки таким образом, что механические свойства соединяемых материалов возле контакта (пятна) сварки улучшаются.

Ключевые слова: алюминий, алюминиевые сплавы, клей, склеивание давлением, точечная сварка трением

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INFORMATIONS ABOUT PROPERTIES OF THERMOMECHANICALY PROCESSED STEELS AFTER APPLICATION OF OTHER PRODUCTION PROCESSES

This contribution deals with steels that have high-strength steels and with chosen technological properties in field of welding, mechanical working and machining.

Practically by the mentioned cases it is necessary to take care, that by technological processing of the mentioned steels the temperature will not exceed, that could cause the degradation of the mechanical properties. This eventuality is most possible by welding and cutting materials like Armox and Hardox event. Weldox. The contribution shall be referred to the results of specific tests