TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2011, 11A, 216-224

STRENGTH OF GLUEWELD SEALS MADE OF DISSIMILAR STEELS

Aleksandr Serebrjakov

Volodymyr Dahl East Ukrainian National University, Lugansk, Ukraine

Summary. The results of experimental studies on technology trial and properties of glueweld seals, made with resistance spot welding on steels that are used to produce the rolling stock locomotives and wagons side sections and sections of the roof, including dissimilar joints are shown.

Key words: welding, glueweld seal, strength, corrosion resistance

INTRODUCTION

The rolling stock locomotives' and wagons' side sections and sections of the roof are constructed with the corrugated sheet siding, 1,5mm thick, and stiffness frame elements, that consist of bent skirts and Zeta Profile varying lengths, 2,0 mm.

To produce them different materials are used. For example, to produce the side wall of diesel train passenger car sheets of steel 10Х13Г18ДУ and sections of steel 09Г2С are used.

Sections are the building framings, working with buffing loadings. Therefore, during their manufacture there are special requirements to the technology of weld joints are including their density, because these sections protect rolling stock from the environment influence.

These designs have a lot of welds. They vary in their length, continuity and spatial position and are executed generally with semi-automatic welding gas-shielded atmosphere.

OBJECTS AND PROBLEMS

Presence in the construction a large number of welds causes an increase in its deformation during the welding process, and the residual strain exceeds the level permitted by the specifications [3]. It is hard to apply effectively in such construction existing activities to reduce the because of the complexity of their distribution [15].

In addition, intermittent welds do not have integrity. So after welding additional step of sealing the connection is made. When welding steel 10Х13Г18ДУ as electric arc, and by contact welding problems with its weldability [4,10,9,12].

While this constructions are produced the resistance spot welding may be implemented, but the compounds that are obtained in this way, also have some disadvantages [17]. One of them is the lack of tightness of the joint. There is a way of fastening sheet cladding to the frame by hydro impermeable rivets using putty Polyurethane-50FC. But this method also has some disadvantages[7].

To solve these problems spot welding by adhesives use is proposed. Glueweld seals have several advantages over joints, that are made with electric arc or by contact welding. The main are – impermeability of joints and lower level of residual strain.

In theory, glueweld joints on aluminum and its alloys are studied sufficiently and in practice are widely applied [1,2]. Glueweld seals on steels of especially the dissimilar joints are insufficiently studied.

Development of production bases of steel resistance spot welding by adhesives.

Prepare materials for welding. To perform glueweld joints of high quality it is very important to prepare materials' surface. There are a lot of ways to prepare surface of the same material. For research based on an analysis of published data and test results when developing welding mode [1,5,6,19] the following technique of surface preparation for welding is chosen and implemented.

For austenitic steel 10Х13Г18ДУ only degreasing with an organic solvent № 646 was used. The use of chemical method surface preparation of sheet steel in a production environment will be with difficult due to large sized sheets sheathing module framing of rolling stock.

For 09Г2С steel a chemical treatment etching in an aqueous solution of hydrochloric acid (200-220 g / l) with adding the katapina (5-7 g / l) was used. Etching time 20-30 minutes at solution temperature 18-30ºС followed by washing in cold water. Neutralization of residual hydrochloric acid with aqueous $NaCO_3$ (5 g / l). Solution temperature is 50-60 º C, soaking time 2-3 minutes followed by rinsing in cold water and drying.

Weld samples were performed on a point-phase machine AC-type MT-1614 with a nominal welding current 16 kA and compression force of the electrodes 6.3 kN.

Welding conditions, wherein sufficiently high quality weld on the samples is achieved are the followings [13,14,16]: Compression load 0,44 kN at the air pressure in the system 3,0 MPa, time compression, welding and forging respectively is 1,2, 1,6, 0,3 s. The diameter of the working part of the electrode used is 10 mm, diameter of the resulting indentation electrode is 8mm.

Selecting the type and brand of glue. The choice of adhesive to get glueweld seals of given design is difficult, because the large range of adhesives, but there is no universal.

When selecting adhesive the nature of the bonded materials is taken into account, glueweld seals operating conditions (operating temperature, current load, service time, environment etc.) technological application of the adhesive, the cost of adhesive.

Besides adhesive should not worsen the properties of glueweld seals, particularly corrosive. Therefore, the pH of the adhesives, recommended to connect the specified materials, should be close to 7 in accordance with ГОСТ 9.902-81.

Given the rolling stock sections temperature and operating environment, epoxy adhesives were selected to make the research. Epoxy adhesives are convenient and practical for use. They are available for use with environment temperature variation from 0 to 35 º C unpretentious to the preparation of the surface bonded materials, have low toxicity. Can be, both hot and cold hardening. Have a wide range of viscosity.

Despite the best properties of hot curing adhesives (longer-term viability of the glue and higher bond strength) to manufacture steel sheet plating of rolling stock the use of cold curing adhesives is appropriate, because they have more than a simple technology application. Due to the large size of welded sections hardening of the adhesive hot-curing at temperatures 110-180ºC additional and energy consuming equipment, is require; that will lead to higher production costs. Therefore, the cold curing adhesives produced by the industry at present were selected to study.

Table 1 shows the main characteristic of used adhesives - ultimate strength at shift of glued joints under described conditions.

Table 1. **Ultimate strength at shift of glued joints of some materials, Mpa**

Material	Test Temperature, ºC	Brend of Glue		
		UP-5-207	UP-5-207-1	UP-5-240-1
Oily steel 08кп	25	25	-	-
Degreased steel 3-sured		28	25	38
Steel 3 after 10 thermal cycles	-50 to + 150	25	22	36

You can make the following preliminary conclusions on the strength of adhesive stamps: the greatest strength has glue UP-5-240-1 at temperatures up to +50ºC; Glue UE-5-207 is most versatile and can operate at high temperatures. Also in studies we apply epoxy adhesive, consisting of a resin EPOXY-531 and hardener TELALIT-410. Its mechanical properties are unknown.

In compiling of cold curing adhesives the important point is the ratio between the adhesive and hardener. Adhesives were prepared in the same proportions, recommended by passport data [2].

Since the thickness of adhesive layer affect the weld strength, when preparing it for welding should seek to ensure adhesive layer within 0,05 - 0,16 mm. When applying glue in these studies thickness provides within 0,1-0,2 mm. Adhesive was applied to each side of connected surfaces. Preparation of adhesive and welding was performed at a temperature of 15-20 º C.

In compiling cold curing adhesives important point is the ratio between the adhesive and hardener. Lack of hardener leads to incomplete drying of the glue. The excess cause unwanted aggressive influence pasted on the materials. The content of curing agent affects the ultimate strength of the adhesive joint. Adhesives for this research are prepared in the following proportions, presented in table 2.

Table 2. **Ratio of resin, filler and hardener for making glue**

Component	Ratio of parts by weight of components for the preparation of the following brands of adhesives			
	UP-5-207	UP-5-207-1	UP-5-240-1	EPOXY-531
Resin	100	100	70	100
Filler	-	-	30	-
Hardener	25	25	10	20

Since the thickness of the adhesive layer affects the joint strength, when preparing it for welding we should strive to ensure the adhesive layer within 0,05-0,16 mm. When applying the glue in this research thickness was provided within 0,1-0,2 mm. Adhesive was applied to each side of the jointed surfaces. Preparation of adhesive and welding was performed at a temperature of 15-20 º C.

Research on glueweld seals' strengh. For these five groups of similar samples 4 in each group were welded from the investigated steels. These are the following groups: 1 - welded samples without glue; 2 - glueweld samples with the use of glue brand UP-5-240-1; 3 - glueweld samples with the use of glue brand EPOXY-531; 4- glueweld samples with the use of glue brand UP-5-207-1; 5 - glueweld samples with the use of glue brand UP-5-207.

Destruction of samples were carried out on tensile testing machine P-20 with a maximum load of 200 kN recording on tape the nature of the load changes.

The test results, as average for all groups of samples, shown in table 3 and figure 2.

Table 3. **The value of the breaking load (kN) samples with welded and glueweld seals under static tension**

Steel Brand	Glue Brand				
	Без клея	UP-5-240-1	EPOXY-531	UP-5-207-1	UP-5-207
09Г2С	23.2	33.4	36.2	36.3	34.5
10Х13Г18ДУ	27.3	32.6	39.7	37.6	35.1
10Х13Г18ДУ + 09Г2С	24.3	32.9	37.4	35.8	34.8

According to the results of destroyed samples investigation the following was subsisted.

1. Destruction of glueweld seal made of steel 09Г2С occurs at the welded point, and on the adhesive interlayer. Welded point is destroyed by shear without significant tearing of the base metal. The diameter of the destroyed contact detail – the welded and gluewelded seals have almost the same detail and come up to 6,5- 7mm. . Destruction of glueweld seal made of steel 10Х13Г18ДУ was more complex. None of the seals was destroyed at the weld points, and was destroyed by the heat-affected zone. The destruction of welded seal made of dissimilar steels occurs at the welded point with tearing of the base metal (only steel 09Г2С is tired out).

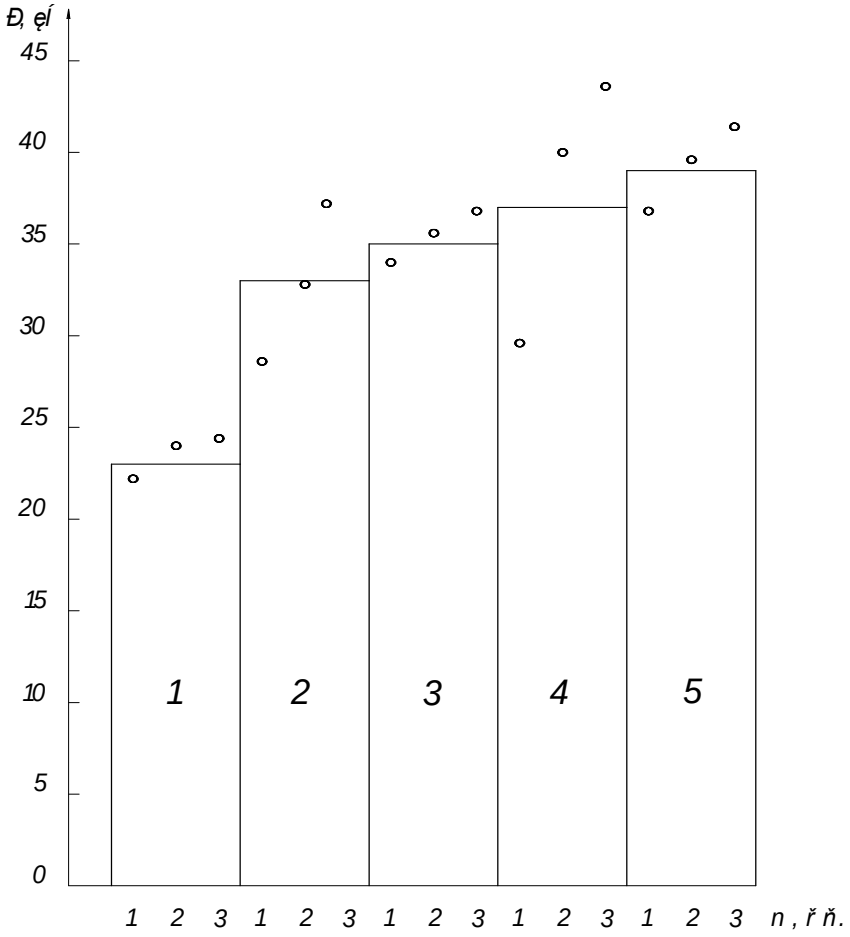

Fig. 1. The results of the samples destruction at stretching the steel 09G2S: 1 – Weld Seal; 2 – Glueweld seal with Glue UP-5-240-1; 3 – Glue UE-5-207; 4 – Glue UP-5-207 -1; 5 – Glue EPOXY-531

2. In the heating zone the glue is burnt out at the weld point. Diameter of glue burnout varies from 10 to 16mm. Each zone has a burning glue evaporating channel, through which the combustion products of glue get out. This phenomenon leads to deterioration of the adhesive layer and reduce seam leakage. This phenomenon is minimal (mostly absent) when applying the glue UE-5-240-1 EPOXY-531.

3. Molten core of glueweld seal when applying the glue UP-5-207 has on its perimeter splashes of metal.

4. When welding on the adhesive interlayer it is stated that the glue with hardener hardens within a few minutes after welding.

5. Glueweld seal on the researched joints under static stretching is stronger in 1,4-1,7 times than the same weld type. The greatest strength have seals, welded with the glues EPOXY-531 and UP-5-207-1. Welded and gluewelded seals on the 10Х13Г18ДУ steel have slight difference in strength while stretching. But glueweld seal shows more stable results in strength when testing.

Nature of the observed changes in the load is shown in Figure 2.

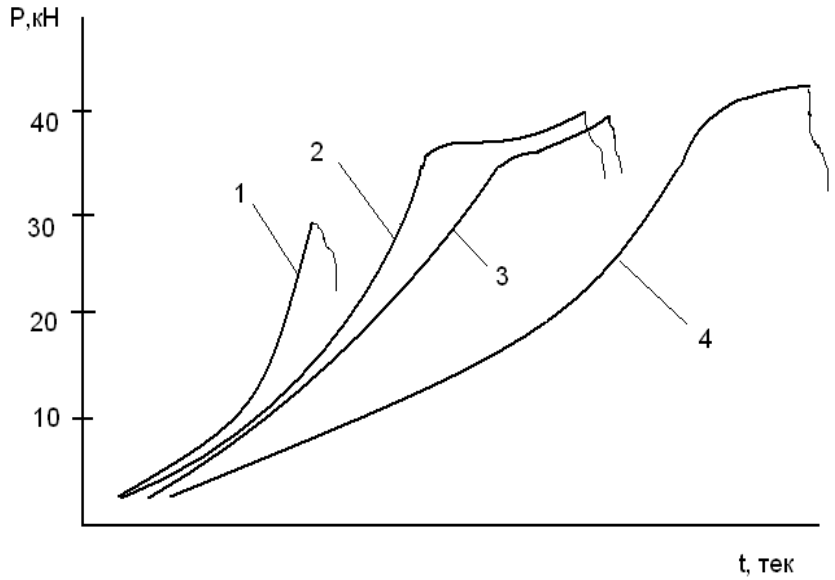

Fig. 2. The destructive nature of the force change under static stretching in the seals: 1 – Steel 10Х13Г18ДУ 1,5 mm thickness; 2 – Steel 10Х13Г18ДУ 1,5 mm with steel 09Г2С 2,5 mm; 3 – glueweld seal made of steel 10H13G18DU 1,5 mm; 4 – glueweld seal made of steel 10Х13Г18ДУ 1,5 mm with steel 09G2S 2,5 mm

The figure shows, that the variation in load at welded and gluewelded seals is different. Nature of the load changes of weld seal (presented in Figure 1) has a gradual increase of breaking force to complete destruction of the sample. Nature of the load changes of gluewelded seal (presented in Figure 2) has also a gradual increase of breaking force. The destruction speed increases until the loading to 30 kN and then begins to fall. In the area of markers 33-34 kN speed drops to almost zero. This fading of destruction force lasts about 5 seconds. Further speed of applied destruction force begins to gradually rise to a complete destruction of glueweld seal.

It can be assumed, that the breaking load "freeze" in this area could be caused by plastic deformation of the seal. The presence of the adhesive increases the yield plateau. This phenomenon confirms the higher resistance to the breaking load of glueweld seals compared with welded.

6. The nature of glueweld seals destruction depends on the thickness of the welded plates. Plate with 2,5 mm thickness under static stretching are not deformed, and

spotwelds are cut. Plate thickness 1,5 mm in the process of destruction have the plastic deformation and spotwelds are tired out from the basic metal;

7. Strenght of glueweld seal made of dissimilar steels (Steel 09Г2С + Steel 10Х13Г18ДУ) is determined by the strength of steel 09Г2С (less durable). The steel 09Г2С plate under static stretching is destroyed.

8. Epoxy adhesives provide a lasting seals of steels, used in the research, and are suitable for use at glueweld seals. The strength of adhesive joint depends on thickness of adhesive layer, it should be not more than 200 microns. The glue EPOXY-531 is able to penetrate under the overlap of the joint to a depth of more than 25mm, that enables its use to correct defects in the adhesive layer;

9. Glueweld seals, performed using the resistance spot welding, have a smaller area of the heat affected zone compared to the seals without adhesives. It follows that the construction, produced by this method, will have a smaller residual strain and stress, than in fusible welding.

All this makes the use of glueweld seals in the manufacture process of rolling stock sheet-sections preferable, than electric arc welding methods and welding without adhesives.

Glueweld Seals Corrosion Properties. To determine the corrosion properties accelerated 30 day tests of singletons glueweld seals were carried out in the hostile environment – 3% NaCl solution. Width of the lap joint – 20mm. After holding in hostile environment the weld points were drilled, and the samples were destroyed on the adhesive interlayer.

The examination of the samples showed of corrosion traces presence in the places of the combustion products of glue, where the porosity of the adhesive layer is formed. Under the adhesive layer in all the glueweld seals no traces of corrosion were found. Consequently, the presence of such a defect as porosity reduces the joint corrosion resistance.

Glueweld Seals Impermeability. Testing the glueweld seals on the impermeability of the joint was carried out on samples, welded using all four brands of glue. Weld points were affixed along the sample. Width of the joint lap – 25mm. On one side of lap of the welded samples purified kerosene was applied with the filling gun. On the other side of the lapping chalky solution was put with the brush and was let to dry before the test.

After some time where the chalk solution was deposited, in some samples there were spots of kerosene near the weld points. After the destruction of these samples porosity was found near a weld point. In other places of lapping, without the presence of this defect there was no penetration under the lapping. Consequently, the porosity reduces not only the corrosion resistance, but also the impermeability of the glueweld seal.

CONCLUSIONS

Depending on the materials to be welded strength of the glueweld point seals exceeds the strength of the appropriate welded joints in 1,4 - 1,5 times. The adhesive

layer in the welded joint increases the plastic flow of the seal before break and makes it more like plastic compared with welded joints without glue.

Weldability of resistance spot welding austenitic steel 10Х13Г18ДУ and dissimilar joints from this and low-carbon steels using adhesives is better in comparison with welding without adhesives.

Glueweld seals have a higher corrosion resistance in the case, if the impermeability of adhesive layer is not affected. Glueweld seals has full integrity weld under the circumstances the weld lapping is less than 25 mm.

The most technologically advanced to use in weld joints of sheet cladding and frame modules of rolling stock is a cold curing epoxy adhesive DP-5-240-1.

REFERENCES

1. Shavyrin V.N., Ryazantsev V.I. 1981.: Glueweld Constructions. – Moscow: Mashinostroenie, 168 p.
2. Feldman L.S. 1973.:Nondestructive Quality Control of Glueweld Seals. – K., "Tehnika, 188 p.
3. Gedrovich A.I., Gal'tsov I.A., Tkachenko A.N. 2001.: Experimental study of the deformation modulus sidewall car diesel train. Resource-saving production technology and processing the material pressure in mechanical engineering, Sat-to Scient. work-Lugansk: Publishing V. Dahl EUNU, p.146 -152.
4. Gedrovich A.I., Gal'tsov I.A., Basov G.G., Tkachenko A.N. 2003.: Peculiarities of welding of austenitic, chrome manganic steel 10H13G18DU. Resource-saving production technology and processing the material pressure in mechanical engineering, Sat-to Scient. work-Lugansk: V. Dahl EUNU, p.131-146.
5. Serebryakov A.I., Neykov A.G. 2003.: Glueweld seals on steels. Resource-saving production technology and processing the material pressure in mechanical engineering, Sat-to Scient. work-Lugansk: Publishing V. Dahl EUNU, p.213-218.
6. Kardashov D.A., Petrova A.P. 1983.: Polymer adhesives, Creating and Applying. – Moscow: Khimiya, - 256 p.
7. Basov G.G., Melnikov N.P., Tkachenko A.N.. 2003.: Creation and implementation of specialized equipment to manufacture parts and nodes of rolling stock made of chrome-manganese steel in procuring welding production at HC “Luganskteplovoz”. Resource-saving production technology and processing the material pressure in mechanical engineering, Sat-to Scient. work-Lugansk: Publishing V. Dahl EUNU, p.87-95.
8. Kovachik L.A. 1985.: Bonding of metals and plastics: translated from Slovak / Ed A. Freidin. – Moscow: Khimiya, 240 p.
9. Gedrovich A.I., Galtsov I.A., Basov G.G., Tkachenko A.N. 2003.: Peculiarities of welding of austenitic, chrome-manganese steel 10Х13Г18ДУ. Resource-saving production technology and processing the material pressure in mechanical engineering, Sat-to Scient. work-Lugansk: Publishing V. Dahl EUNU, p.101-118.
10. Konyukhov A.D. 1998.: Highly doped corrosion - resistant steel for car bodies of passenger cars.// VESTNIK ARSRIRT, №4. p. 34 – 39.
11. Stepnov M.N. 1985.: Statistical methods for mechanical testing processing results: Reference. – M: Mechanical Engineering, 232 p.
12. Gedrovich A.I. Galtsov I. A. 2001.: Study pecularities of stress and deformation creation in weld joints stainless steel 10Х13Г18ДУ. – Automatic welding, № 10., p. 34-37.
13. Gedrovich A.I., Galtsov I. A., Druz O. N., Tkachenko A. N. 2002.: The behavior of austenitic steel 10Х13Г18ДУ after the welding thermal-cycle. // V.Dahl East Ukrainian National University Newletter №7(53) p. 70-73.

14. Gedrovich A. I., Galtsov I. A., Zhidkov A.B., Tkachenko A.N. 2002.: Welding of austenitic steel 10Х13Г18ДУ (ДИ-61У) when manufacturing diesel and electric trains on HC “Luganskteplovoz”. // « Welder », №6(28). p. 10-11.
15. Sagalevich V.M. 1974.: Methods of welding deformations and stress eliminating. – Moscow: Mashinostroenie, 248 p..
16. Gedrovich A. I., Basov G.G., Tkachenko A.N., Gal'tsov I.A. 2004.: Interconnection of phase composition and residual stress field when welding stainless steel 10Х13Г18ДУ. // V.Dahl East Ukrainian National University Newletter №3(51) p. 135-141.
17. Popkovsky V.A., Berezienko B.P. 1987.: Resistance spot welding mode parameters influence on distribution of residual stresses. – Automatic welding, №11, p. 9-12.
18. Gotalsky Y. N. 1981.: Dissimilar Steels Welding. – K.: Technology, 184p.
19. Dzhenigs K. U. 1975.: Preparation of metal surfaces for gluing. Technology for manufacturing laminated structures / Trans. from English. M.: World, p. 70-89.

ПРОЧНОСТЬ КЛЕЕСВАРНЫХ СОЕДИНЕНИЙ ИЗ РАЗНОРОДНЫХ СТАЛЕЙ

Александр Серебряков

Аннотация. Приводятся результаты экспериментальных исследований по отработке технологии и свойствам клеесварных соединений, выполненных контактной точечной сваркой на сталях, используемых для изготовления боковых секций и секций крыши кузовов локомотивов и вагонов подвижного состава, в том числе разнородных соединений.

Ключевые слова: сварка, соединение клеесварное, прочность, стойкость коррозионная

.