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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 *selected thermomechanical materials in terms of changes in their properties after welding in active gaseous shield. In this method the results of tests of basic mechanical properties by the tensile strength test, by the hardness test and the impact strength test are mentioned. In conclusion there are the results of specific test and the comparison of the strength characteristics of chosen processed steels.*

Keywords: technological properties, welding, welded joint

Chapter 1

On the present different industry demand development and testing of quality materials to enable the production of lighter components and constructions, to be stronger and tougher. Trend of these requirements meets the research of high strength materials that are designed to result in greater structural strength, lower weight, the possibility of higher loads and longer life than conventional steel. Into the group of high strength steel we primarily include types of steel that are thermomechanicaly processed as steel ARMOX 500, 600, HARDOX 500, 600 in the form of armour and abrasion-resistant plates. These materials are classified for their strength, mechanical and effective performance as leading materials represented in the engineering industry.

One area which is important to deal with in aspect of applicability of these steels is not only the area of machining but also welding. Welding conditions, also the difficulty and suitability for welding is defined by the weldability of the steels.

Distribution of thermomechanical treatment of steels:

Group of hardened steels	Trademarks	Basic mechanical properties	Technological properties
High-strength structural steels	WELDOX DOMEX	Re = 700 ÷ 1100 MPa	Weldability Bendability
Abrasion-resistant steels	HARDOX XAR	hardness 400 ÷ 600 HB	Weldability, Machinability Bendability
Armored steels	ARMOX	hardness 340 ÷ 600 HB	Weldability
Tool steels	TOROX	hardness 33 HRC, 44 HRC	Machinability Thermal stability

WELDOX is construction high-strength metal plate. Its essence lies in achieving the fortification level, while maintaining the best weldability.

DOMEX is a modern structural steel with high strength in the form of hot-rolled metal plate. Weldability of this steel is very good and it can be used in all welding methods. This steel is not subject to crack under heat or under cold.

DOMEX:

- very good formability in relation to high-strength
- good weldability for the low content of alloying elements
- good strength by impact at low temperatures
- suitable for laser cutting
- suitable for hot-dip galvanizing

Welding:

The Goal at the welding of metal plate WELDOX is to ensure adequate strength of the weld and to achieve toughness weld satisfactory. At the welding steel Weldox we can use all the usual methods of arc welding, that are intended for normal welding plates and steels with high strength. The choice of supplementary materials) is based on requirements that are different in each case placed on the mechanical properties of the weld. By the welding basic electrodes should be used and filler material that contains hydrogen ≤ 5 ml/100 g of the weld metal, there is no need to weld with austenitic filer metals and in protective atmospheres.

Bendability:

When bending Weldox the most important is the excavation radius. For these steels, the recommended bend radius of the embossing plate should be the same or smaller than the required bend radius. Opening angle must be so big to allow sufficient deflection. Bending angle has on the necessary strength and cushioning sheet less impact than the width of the hole punch and steel quality. Cushioning of the sheet can be compensated by bending with the same number of degrees.

By rolling we apply the rule that the bent sheet metal with small bend radius should be rather bend perpendicular to the rolling direction.

Gas-tight metal can adversely affect the form and surface quality on the side of the sheet, where the tensiel stress will be.

HARDOX

Hardness of the steel is a simple measure of its abrasion-resistance. It is produced with an average hardness 400 and 500 HB. This steel has the same hardness in the middle and at the plate surface and this contributes to the high effective life. Pure starting material, low levels of impurities are able to combine high hardness with good toughness. Because of the high purity of the steel and the same quality steel HARDOX 400 and 500 can be treated with appropriate tools even if the steel has high hardness.

HARDOX:

- higher hardness
- higher abrasive-resistance
- very high strength
- good toughness
- easy processability – welding and machinability

Welding:

Chemical composition with low carbon equivalent and with effective heat treatment results in good weldability. Hardox steel metal plates can be welded to a thickness of 50 mm.

At the welding of the plates Hardox has to maintain hardness and HIZ achieve satisfactory strength in this thermally influenced area.

Hardox should be welded with soft basic electrodes. The soft basic electrode is additional material with the characteristic stress in polling lower than 500 MPa. These electrodes reduce the level of residual strain in the weld and reduce the tendency of material to crack in the cold. If the weld is subjected to considerable wear the hard electrodes can be used to cover the weld bead. In the following case Hardox can be successfully welded by using austenitic stainless consumables in cases where the sheet is thicker than 60 mm and the product can not be preheated above ambient temperature, but heat input must be at least 1,5 KJ/mm.

Bendability:

Purity, good flatness and homogeneous quality of steel plates Hardox are good prerequisites for the formation by low temperatures. Tools without rough edges and fine grind of the burnt edges ensure reliable production. Because the sheets are of high strength a lot of pressure is required for their bending, in case of metal breaking, scrap of the material will depart in the direction of bending.

Machining:

Hardox can be machined with tools with interchangeable plates on non-vibrating equipment. Sheets may also be drilled on robust radial drills. Such tools must be used with solid, Hss-Co drills. Using appropriate tools may also be sheets Hardox aligned and recessing. At the cutting, especially in turning may result long-chips. This is caused to the high purity.

ARMOX

Armour Armox is kind of highly effective protective sheet passing extensive ballistic tests which meet strict international criteria.

Welding:

In terms of welding contain low content of alloying elements and thus represent a weldable material.

By welding of high strength steels it is important to minimize the risk of cold cracks. On the basis of chemical composition carbon equivalent is an important indicator that indicates the tendency of steel to harden in HIZ and susceptibility to cold crack.

Danger of undesirable cracks can be minimized by appropriate choice of filler material with low hydrogen content, pre-heating eventually after-heating of the welded joint, with the constructional solution and with the technological procedure and also with perfect cleaning of the welded areas.

Feritic and austenitic cores of the additional material is recommended, that have characteristic stress in pulling max. 550 MPa and a max. hydrogen potential from 5 ml/100 g of the welded metal, i.e. cores, that are covered with material with a complex slag system. The pre-heating temperature of 150-175 °C is recommended for electrodes with a ferritic core. Austenitic electrodes don't request pre-heating over the ambient temperature in the case that the power input for the welding min. 1,5 kJ/mm. ambient temperature shouldn't fall under 15 °C.

Splitting:

Steel splitting is possible with oxygen, plasma, with abrasive water streem eventually with a laser or a grinding wheel. By splitting the steel with oxygen by a thickness bigger than 20 mm it is important to use pre-heating, which prevents the cold crakes. The temperature of the pre-heating is choosen from 170 °C ± 30 °C.

Splitting with abrasive water streem is the best qualitative method to split Armox steel and is recommended for all devided thicknesses.

Cutting:

For the Armox plasma-, laser- or gascuting is usable. They should be made by a min. temperature of 15°C to avoid cracking. Plasma- or lasercuting is preferred by metal plates, that are thinner than 10 mm, to preserve platitude. For metal plates thicker than 15 mm and harder than 450 HB pre-heating with a temperature 150 – 200 °C should be applied. For hardness greater than 550 HB water streem cutting is recommended.

Chapter 2

Mechanical testing of welded joints of selected types of thermomechanical steel:

Samples designed in accordance with standard STN EN 895 with respect to tensile test equipment INSTRON 5500R in laboratories FST.

Welding method:

- basic material: HARDOX 500, ARMOX 500
- welding procedure by: STN EN ISO 15 609-1
- welding method: 135 /MAG/
- welding type: BW – abutting joint
- welding position: PA
- additional material: ϕ 1,0 OK Autrod 12.58
- shielding atmosphere: 82 % Ar 18 % Co_2
- shielding gas/addition: M 21 STN EN 439
- flow: 180 – 200 A
- voltage: 22 – 24 V

Mechanical properties of selected types of steel sheet material by suppliers reported

Type	Hardness	Strength properties		Tensibility	Impact toughness	Carbon equivalent
	HB Brinell	$Rp_{0,2}$ [MPa]	Rm [MPa]	A5 [%]	KC [J]	CEV [%]
HARDOX 500	470-530	1300	1550	8	30	0,50
ARMOX 500T	480-540	1250	1450-1750	8	25	0,67

Real values of mechanical properties determined by standard test STN EN 10 204 – 3.1

Type	Hardness	Strength properties		Tensibility	Impact toughness	Carbon equivalent
	HB Brinell	$Rp_{0,2}$ [MPa]	Rm [MPa]	A5 [%]	KC [J]	CEV [%]
HARDOX 500	478	1341	1581	8	31	478
ARMOX 500T	527	1390	1694	11	40	527

Values of mechanical properties of filler material OK Autrod 12.58

Protective gas	Rm [MPa]	A5 [%]	KV [J]
M21	515	26	140

The resulting values of tests of the weld joint: Tensile strength test

	R_m [MPa]	A_5 [%]
HARDOX 500	585	8,5
ARMOX 500	605	26

Hardness test

	Basic material	HIZ	Middle of the weld	HIZ	Basic material
HARDOX 500 HV10	450	265	193	291	465
ARMOX 500 HV10	460	259	193	294	466

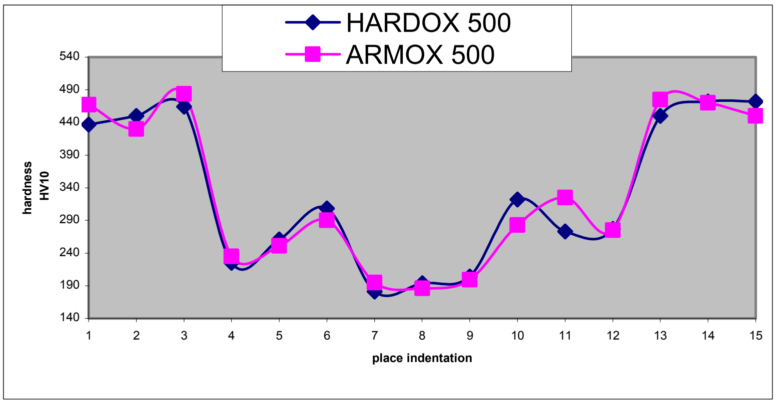

Fig. 1. Graph hardness of the weld joint

Impact strength test

	Dimension [mm]	So [cm^2]	Temperature [°C]	Notch location	KV [J]
HARDOX	55×10×10	0,8	20	WM-VWT0/1	107
500	55×10×10	0,8	20	HAZ-VHT1/1	135
ARMOX	55×10×10	0,8	20	WM-VWT0/1	108
500	55×10×10	0,8	20	HAZ-VHT1/1	138

During the thermomechanical welding of the metal sheet we have to take into account that even with the recommended supplementary materials, we get a high drop of mechanical properties, which we have to take account in production of special technology.

For example, using additional material the mechanical properties of the weld joint decreased significantly compared with the mechanical values of the basic material. Mechanical properties of welded joints can be compared only with the mechanical values of weld metal filler material, which in our case is about 33% of tensile strength and hardness of base material. It follows that in practice for welding of thermomechanical treated high strength materials it is declining in particular hardness and strength of the welded joint but the tendency to maintain a flexible plastic properties at the level recommended by the filler material.

Conclusion

The paper presents results of tests of selected materials, which presented three welded joints of each material which is low in order to confirm statistically the reliability results.

Technically, it is known that the weld seam is the weakest link of welded structures question is how big the difference between the tensile strength of base material and weld joint is.

In the case of welding-type thermomechanical processed materials HARDOX 500 and ARMOX 500 the difference between strength and hardness of base material and weld joint using filler material OK Autrod 12:58 and the above parameters of welding a decrease of up to about 66% in tensile strength and hardness.

Because of the significant sudden drop in hardness in the weld joint we can assume that by the thermomechanical welding materials already at relatively low temperature differences during welding can cause further tempering in the transition area - HIZ it can cause considerable loss of tensile strength and hardness, especially by the dynamic load of special equipment it can bring adverse effects.

Accordingly, it is necessary for the welding of thermo-mechanical processing of sheet metal to use welding methods with the greatest concentration of heat at the top speed to minimze the welding thermal effect.

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Свойства обрабатываемых сталей под действием различных технологических процессов

Рассматриваются вопросы, связанные с влиянием технологических процессов (сварка, механическая обработка и др.) на технологические свойства обрабатываемых конструкционных материалов.

Оценка влияния технологических процессов на изменение свойств конструкционных материалов производится по анализу температуры материала при его технологической обработке. В частности, превышение некоторой критической температуры может существенно ухудшать свойства сталей, в частности, сталей Armox, Hardox, Weldox. Излагается метод, позволяющий исследовать механические свойства материалов (прочность, твердость и др.) при их обработке. Приводятся результаты испытаний для стальных материалов.

Ключевые слова: технологические свойства, сварка, спаянное соединение

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