Co-funded by the
Erasmus+ Programme
of the European Union

Erasmus+

A MODULE
Introduction to the problems of welding

Refining weld metal

Refining weld metal

- This is a reduction of impurities in the weld metal.
- Biggest impurities are phosphorus and sulfur. Both elements deteriorate the properties of the weld metal.
- Sulfur is the cause of hot and crystallization liquidation cracks in the weld metal and is a major cause of lamellar cracks in welded joints.

Refining weld metal

- Phosphorus increases the susceptibility to leaky cracks in the form of low melting eutectic and causes cold embrittlement.
- Greater reduction of phosphorus content in the weld metal only allow basic slag.
- Reduction sulfur and phosphorous content in the weld metals of the molten base of additive materials causes their high plastic properties, especially at low temperatures.

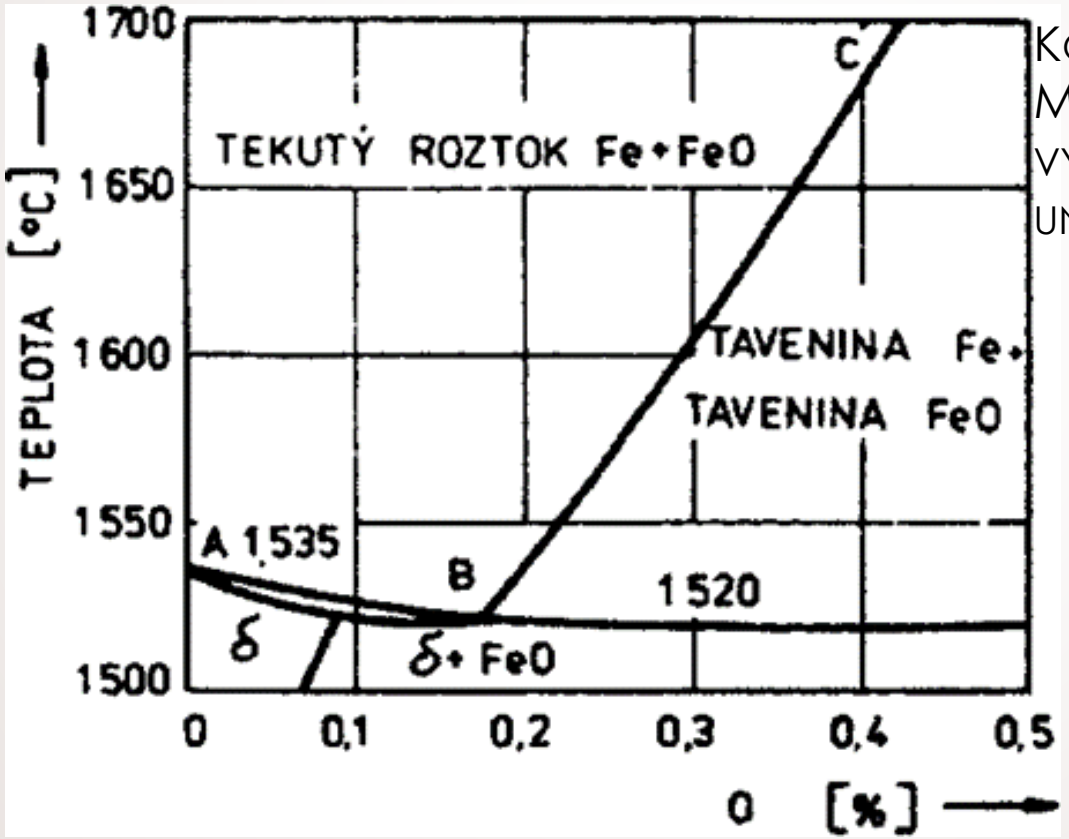
absorption Gas in welds

- During welding, weld metal absorbs gases, in particular oxygen, nitrogen and hydrogen.
- Gas absorption in the weld metal
  - When fusion welding processes, weld metal can absorb some gases. They are primarily oxygen, nitrogen and hydrogen.
  - Source these gases may be the ambient atmosphere, the combustion fumes of heating the process gas, decomposition products of packaging electrodes and fluxes impurities in a protective atmosphere, rust, paint, grease and the like.
  - These gases may cause weld porosity, changes in the mechanical properties of the weld metal or cause cracking of welds.

Oxygen absorption

- Oxygen dissolves in the steel in the form of FeO.
- In solid state, the solubility of oxygen in iron negligible.
- Yippee however, considerable liquid state. At the eutectic temperature of 1520° C is about 0.18%.

equilibrium diagram Fe FeO in melting temperatures



KOUKAL, J., SCHWARZ, D., HAJDÍK, J. MATERIÁLY A JEJICH SVAŘITELNOST. 1. VYD. OSTRAVA: VŠB – TECHNICKÁ UNIVERZITA OSTRAVA, 2009. S. 49.

oxygen absorption

- During welding, the solubility of oxygen in iron mainly due to the welding technology.
- At welding oxy-acetylenovým neutral flame is of the order of 0.03% to 0.05% with an average content of 0.20% FeO, Which corresponds to saturation of pure iron with oxygen at 900 ° C.
- When arc welding oxygen content is influenced primarily by the type and thickness of the container, the intensity of current and arc length.
- AT acidic and rutile packaging varies the oxygen content in the weld metal of between 0.05% to 0.1%.
- AT basic envelops the oxygen content in the weld metal is less than 0.05%.

oxygen absorption

- Oxygen acts on the mechanical properties, depending if it is dissolved in the steel, or is contained in the steel as inclusions.
- IN dissolved state oxygen acts directly on the mechanical properties.
- WITH increasing the oxygen content decreases strength and hardness of the weld metal.
- elongation changes very little. Notch toughness decreases sharply.
- When oxygen contained in the weld metal in the form of inclusions (oxides) reduces coherence weld.
- Content oxygen in the weld metal can be reduced by up weld metal dolegujemeElements with high affinity for oxygen, so-called deoxidation elements. They are mainly Si,Mn, Al and Ti.

hydrogen uptake

- Hydrogen like steel oxygen absorbed (absorbed) during welding.
- His source may be ambient atmosphere or, more commonly humidity packaging electrodes and fluxes.
- Danger hydrogen absorption in the weld metal is greater, the more the electrode casing or the flux absorbs water from the surrounding atmosphere, it is hygroscopic.
- Therefore You must be coated electrodes before welding fluxes and dried.
- For perfect drying basic electrodes is recommended by

hydrogen uptake

- Rutile and acidic electrodes are dried at lower temperatures to avoid degradation of the components of the package already during drying.
- After drying the electrode must be kept prior to use at a certain temperature, or is used within a certain period, usually 4 hours.
- prescribed holding temperature is reported in a number of texts in the range 80 ° C to 100 ° C.
- flux is dried by type in the temperature range 200 ° C to 800 ° C.
- Manufacturer additional material is required for the package of additional material or otherwise prescribe the mode of its drying.

hydrogen uptake

- The source of hydrogen in the weld metal can be further grease residues of organic materials or corrosion products on the welded surfaces.
- IN Radical condensed water in the cylinder can be a source of hydrogen as protective gas.

Hydrogen can be present in two forms:

- molecular state (H_2) As gas inclusions at the grain boundaries or lattice faults (often under high pressure), or also in the form of bubbles CH_4 and H_2O,
- a hydrogen ion H^+ (Proton) dissolved interstitially in the lattice of iron.

hydrogen uptake

- The characteristic properties of the hydrogen ion H + is its easy diffusion grid iron, even at normal temperature.
- solubility Hydrogen in the iron according to the standard EN ISO 3690 specifies at most 100 g ml-1 of the weld metal.
- The alpha iron can be dissolved max. 5 ml 100 g-1 atom, the iron ymax. 8 ml 100 g-1 of hydrogen.
- IN overheated weld metal at 1800 ° C 33 ml 100 g -1.
- Difference the solubility of hydrogen in the weld metal and the solidified weld is considerable and this difference results in problems in ferritic steels, which causes the hydrogen-diffusible.
- According to capable of hydrogen diffusion in weld we determine the degree of hydrogen.

Levels of hydrogen

Diffusive hydrogen content (ml / 100 g of weld metal)			Levels of hydrogen
	>	15	AND
10	<	15	B
5	<	10	C
3	<	5	D
	<	3	E

hydrogen uptake

- For basic electrodes for arc welding may be used in Step B to D according to the manufacturer's specifications of the electrode.
- AT rutile or cellulose electrodes to be used in Step A. In cored electrodes with a flux or metal cartridges may be used grade B to D according to the manufacturer's location.
- Combination wire and flux for submerged arc welding can be classified in Steps B through D, but most typically is level C.
- Degree the hydrogen content must be determined for each combination of wire and flux.
- AT welding consumables in protective atmospheres most commonly used step D.
- inclusion Such additional materials but also certain basic cored wires and covered electrodes in Step E required to make special evaluation (measurement).
- For Plasma welding is to be made a special assessment.

hydrogen uptake

- The hydrogen diffusion is capable of causing the formation of pores in welds, causing the particular defect known as "fish eyes" (fish eyes) And is the basic cause of cold hydrogen induced cracking in welds.
- At weld solidification rapidly decreases the solubility of hydrogen.
- HydrogenWhich exceeds the solubility limit at a given temperature is extruded from the grid iron is collected at the free surfaces (error structure) and molecular hydrogen is recombined to H2 while increasing the volume.
- hereby mechanism of generating porosity in the weld metal "fish eyes" are formed in the welds at high contents of hydrogen capable of diffusion at slow gradual loading of a welded structure of the elastic limit.
- They are not therefore ascertainable at welds methods of nondestructive testing immediately after welding.
- fish the eye do not adversely affect the mechanical properties of welded joints of welded structures stress below the elastic limit.

hydrogen uptake

- Fish eye can be observed at the welds as a white quarries, hydrogen induced cracks circular shape with a diameter from 1 mm to 10 mm.
- Most often resulting in welds in the vicinity of the inclusions, wherein the increased concentration of hydrogen recombination sites.
- inclusions on fracture surfaces are usually dark in color that contrasts with the white flat circular cracks.
- Whole gives the impression of a fisheye lens.

hydrogen uptake

- The most dangerous defect which causes hydrogen in welded joints are cold, hydrogen induced cracking sometimes called "Braked quarries".
- This name reflects the fact that the formation of cold hydrogen induced cracking can occur even in a few hours or days after welding.
- cause cracking the change in volume upon the recombination of hydrogen which cause a local pressure increase and the voltages at points where the hydrogen recombination occurs.
- Total voltage induced recombination of hydrogen and a stress generated by a welding process may be sufficient to produce cold cracks.

Of defects in welded joints caused by hydrogen can zbránit following measures, which typically combine with each other:

a) the use of additional materials having low hydrogen diffusion,
b) perfect protection of the weld metal from exposure to the ambient atmosphere,
c) preheating welds,
d) the use of larger diameters additional materials and high values of the intensity of the welding current,
e) heater welded joints,
f) heat treatment below the Ac1 temperature.

nitrogen absorption

- To weld metal nitrogen receives mainly from the surrounding atmosphere when the lack of protection of the weld puddle.
- The It can be caused by too great a distance from the burner melting bath, a large length of the arc, a small amount of protective gas, protective gas turbulence in the gas nozzle, etc.
- Also solubility of nitrogen in the slag is dependent on temperature.
- liquid iron may be at 1800 ° C in equilibrium absorb up to 0.04% nitrogen.
- At transform the iron solubility of nitrogen in iron sharply increases.
- IN region austenite solubility of nitrogen in iron unlike hydrogen decreases with rising temperature.

nitrogen absorption

- At ambient temperature, the solubility of nitrogen in iron about 0.001%.
- welds made neutral oxy-acetylenovým flame typically contain 0.02% nitrogen.
- welds made acidic and rutile electrodes contain about 0.03% to about 0.04% nitrogen.
- welds made basic electrodes about 0.02% nitrogen.
- At using molten flux when welding 121 may expect the nitrogen content in the range of about 0.002% to 0.003%.
- in Welds performed sintered ceramic flux and 0.003% to 0.007%.

nitrogen absorption

- With increasing content of nitrogen in the weld metal, the values Re, rm and HV10.
- mildly decreases ductility of the weld metal and sharply reduce the value of impact energy and impact toughness of the weld metal.
- Also in the weld metal can be iron nitride precipitating from a supersaturated solid solution cause a phenomenon called the "aging steel".