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SOLDERED VERSUS WELDED JOINTS OF SMALL PRESSURE VESSELS

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Abstract
Subject of this study is examination of welds and soldered joints of small pressure vessels that are the part of the air pump. Study deals with generally theses and problems with welding and soldering pressure vessels. In study are by metallographic classificated welds and soldered joints, including hardness progression classification. In fine are comparison between results of welds and soldered joints.
Key words: Pressure tanks, 97/23/EEC, soldering, welding

1. INTRODUCTION

On faculty of mechanical engineering VŠB–TU Ostrava, department of mechanical technology – institute of welding were solved questions like welded versus soldered joints on component of small pressure tanks (fig. 1). Small pressure tanks (capacity to the 50 liters and rated operational pressure to the 45 bars) are used above all near these plants: air-conditioning, domestic appliance, technology of industrial cooling, compressors technology and air cooling. All tanks have certificate CE and suit severe needs EC directive for compressive arrangement (97/23/EEC). This directive includes totality technical needs on compressive arrangement. Their performance has that minimum limit connection diversification with production, assembly and usage of compressive arrangement.

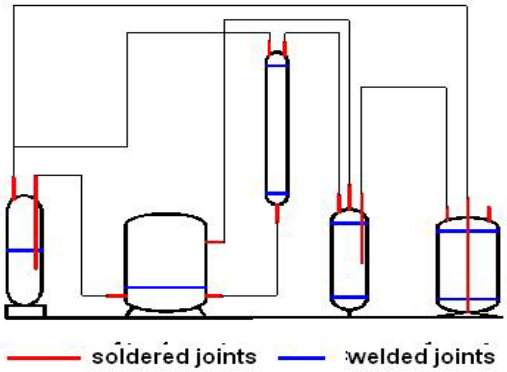

Fig. 1 Diagram of welded and soldered joints of small pressure tanks

2. WELD OF COMPONENT OF SMALL PRESSURE VESSELS

To correct understanding and orientation in problems pressure vessels establishes technical standard CSN 69 0010-1.1: Terminology and definition of pressure vessels. Pressure tank is can whose walling functions pressure working matters. Can immutability his stand or is portable eventually mobile and is still or temporarily connected to source of pressure and disserve to transport liquids and gases [1].

Is admissible used all of fusing welding method tested in production of pressure vessels on the basis authorized welding process WPQR after CSN EN ISO 15607, professionally welded and soldered by welders and solders qualified after CSN EN 287-1 and CSN EN 13133.

Using autogenous welding is admissible only for parts with thickness tube wall at the outside 6 mm and in the event of assembly and repair service work to the 8 mm. Pressure vessel and their parts are weld preferably in environment, where ambient temperature no decrease below 0 °C. If we weld at temperature below 0 °C, we have to use preheating, with the exception of austenitic steels. At welding and immediately after must be weld protect before fast cooling, e.g. before draft and influences of unfavourable atmospheric conditions [3]. Individual parts of displacement compressor to compressing gas are produced from thin steel plates about maximum thickness 10 mm, with usage hydraulic pressure (deep drawing). After thorough remove rust and degreasing are individual parts welded in special welding (fixative) preparations by welding robots. Welds are made by peripheral welding technology 135 (MAG).

Basic material is steel usual quality to drawing and cold moulding **St 13** (according to CSN 41 1301). Act about unalloyed steel special features for mild as far as deep draw. Filler material is solid wire **Wirpo SDA 2** (according to DIN EN 440: G 42 4 C G3 1/G 46 4 M G3 1), which were made by firm Wirpo s.r.o. for welding in Ar-CO_2 or CO_2 atmosphere. Act about unalloyed wire for universal construction welding or welding pressure vessels in mixed argon atmosphere (M21) or in clean CO_2 atmosphere. Chemist and mechanical properties used basic and filler materials displays table 1. Were used wire average 1 mm and welding parameters: U = 24 V, I = 250 A, v = 0.37 m.min^{1}, bead length l = 340 mm, welding time t = 55.4 s.

Table 1. Basic and filler materials used for welded joints

	Chemical composition					Mechanical properties	
	C	Mn	Si	P	S	Rm	Re
	[%]	[%]	[%]	[%]	[%]	[MPa]	[MPa]
St 13	≤ 0,08	≤ 0,4	-	≤ 0,025	≤ 0,025	280 - 370	≤ 225
Wirpo SDA 2	0,06 - 0,12	1,3 - 1,6	0,7 - 1,0	≤ 0,025	≤ 0,025	500 - 650	≥ 420

3. SOLDER OF COMPONENT OF SMALL PRESSURE VESSELS

To correct understanding and orientation in problems of soldering there has been technical standard CSN 05 0040 Soldering: Soldering metals: Fundamental terms. Soldering is caused by metallurgical jointing metal part of molten solder, whereas soldered surface aren't soaking area, but only soaking by used solder. Useful is using soldering for jointing combination of iron and nonferrous materials, at jointing complicated products from creep resistant, fire-resistant and corrosion-resistant steels and alloys with high tensile strength and everywhere there, where isn't possible to use from metallurgical or technological aspects fusion welding [1].

To the biggest advantage of soldering belongs to especially: high work productivity, possibility of collective production of soldered joints, high reproducibility of results and dimensional accuracy soldered parts. Joint rises at lower temperatures than at welding, that it highly makes itself felt at the level of internal tensions and structural changes of basic material. At determination if use soldered joints is necessary look, that the soldered joints have smaller tension strength, are in sharp complicated and demand bigger work difficulty in preparation and positioning of soldered parts [2].

Small pressure vessel after welding completes quality control. Further are affixed fittings (copper piping, flanges), that are in the end solder to vessels. To the mouth in pressure vessels were fit copper mouthpiece that will solder by silver hard solder. Detail mouthpiece is on figure 2.

Fig. 2 Detail soldered joint copper mouthpiece of pressure vessel

To soldering is used silver hard solder **BrazeTec Ag34Sn** with soldering flux **BrazeTec FH 10** (according to CSN EN 1045). Solder and soldering flux are suitable for all type of steels, copper, nickel and their alloys. Solder has very good qualities and her field of application covers all technologies of hard soldering. Chemist and tensile properties of solder are mentioned in table 2.

To the next parameters belongs to: wire average 1.5 mm, working temperature 710 °C, melting interval 630 – 730 °C, running temperature of soldered joints without fall of tensile strength 200 °C, density 9 g.cm^{-3}.

Table 2 Chemical composition and mechanical properties used solder

	Chemical composition					Mechanical properties	
	Ag	**Cu**	**Zn**	**Sn**		**Rm**	**Tensibility**
BrazeTec	[%]	[%]	[%]	[%]		[MPa]	[%]
Ag34Sn	34	36	27,5	2,5		360 - 480	12

From small pressure vessels were by plasma in sufficient distance from plasma heat affected zone carved segments over weld and around copper mouthpiece. Subsequently were saw the segments of on smaller proportions by circular saw bench with cooling and after it were imbed to the dentakrylate tablet for macrostructure and microstructure measuring near weld and soldered joints and micro-hardness measuring of weld after CSN EN 1043-2: Micro-hardness examination of weld. Micro-hardness was measured after Vickerse at load HV 0.5 (5 N). Line of punctures is placed always midway thickness of basic material (2 mm) and distance between single punctures was 250 μm.

4. EXAMINATION OF WELDED AND SOLDERED JOINTS

Recommended distances among punctures are less than at metering of classical hardness. For these reasons makes it possible to metering micro-hardness better determine maximum and minimum hardness [4].

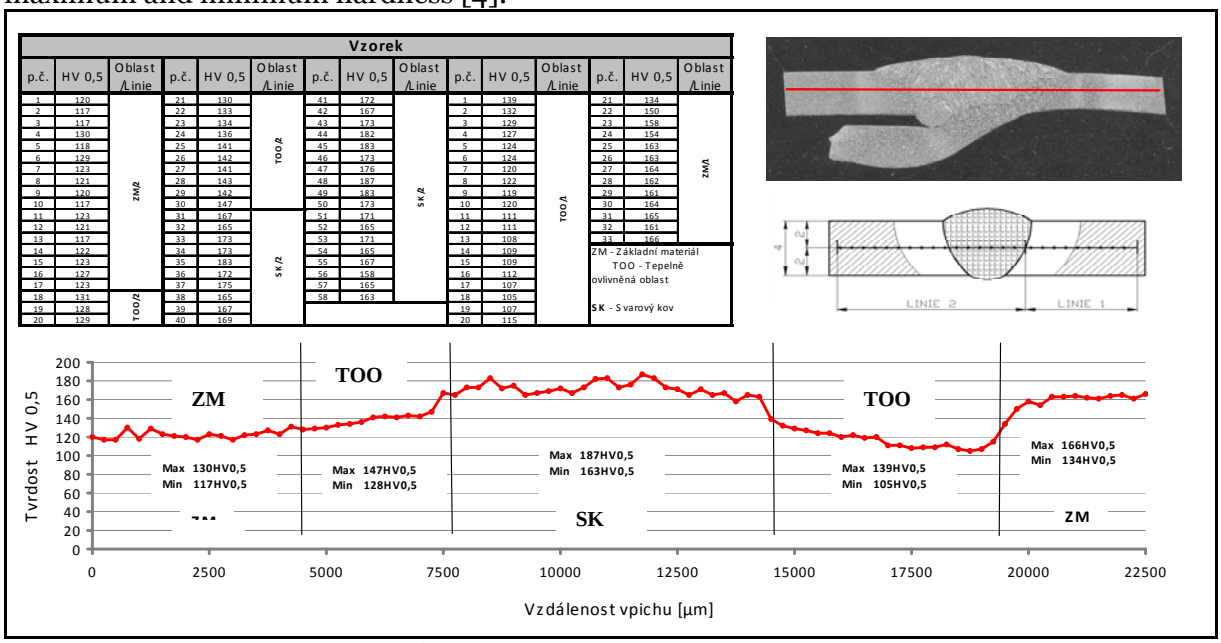

Fig. 3 Behavior of hardness measurement near pressure vessel weld

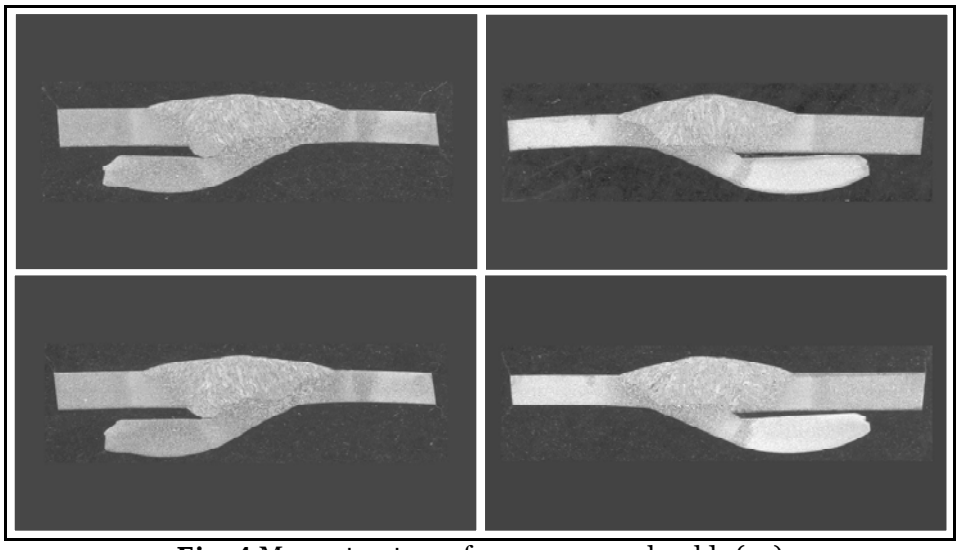

Fig. 4 Macrostructure of pressure vessel welds (4x)

Weld of small pressure vessel is suitable, if hardness HV 10 (for welds unalloyed steel type C, C- Mn with yield strength to the 350 MPa) is biggest difference hardness Δ HV 10 ≤ 100 and absolute hardness material is HV 10 ≤ 300. Hardness was measured in double lines. From melting zone over heat affected zone (HAZ) to the basic material right and left over weld metal, HAZ and again to the basic material. According to figure 3 are in weld metal measured hardness to the extent 163 ÷ 187 HV 0.5 and in HAZ intervals 105 ÷ 147 HV 0.5. Resulting behaviour and hardness dimension near on all measured specimens is possible account suitable.

Metallographic examinations (macro and microstructure) check integrity (scratches, boils, cold joints, slag inclusions, unfused weld root etc.) and single region structure in weld.

At weld macrostructure evaluation, heat effected zone, basic material it is possible as well watch incomplete penetration in weld root. In weld macrostructure (fig. 4) aren't nor in weld metal nor in heat affected zone any scratches, voids or other mistakes. Weld specimens no average any false mistakes, it is possible is then account suitable.

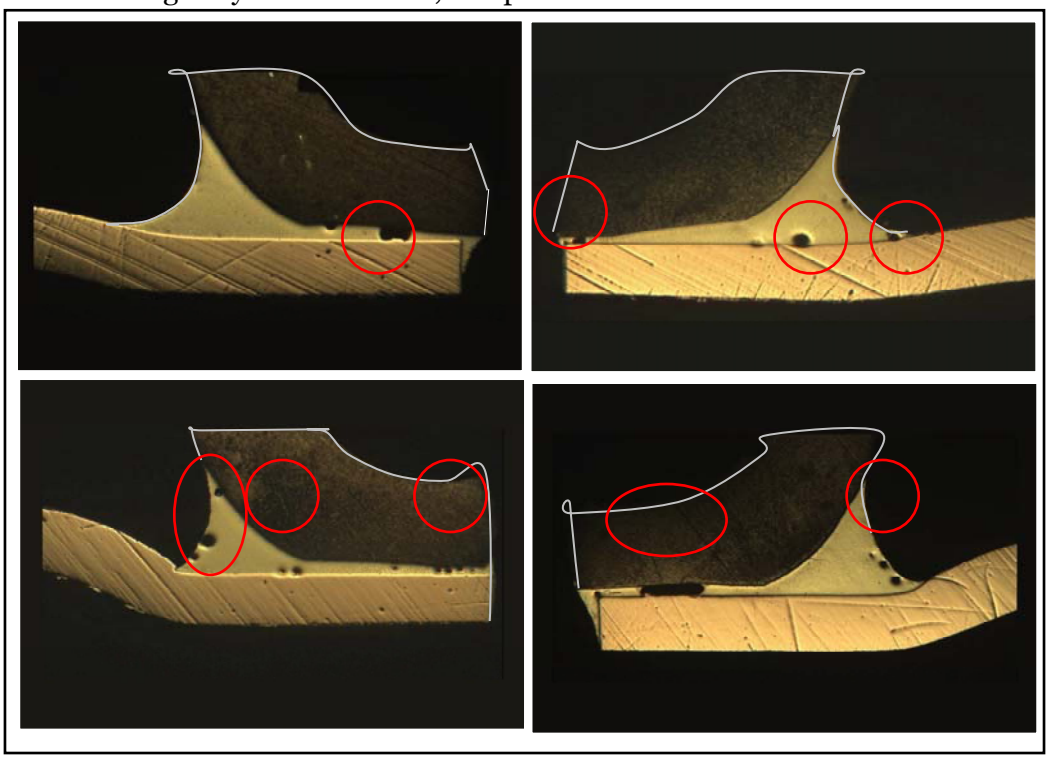

Fig. 5 Solder joints macrostructure (4x)

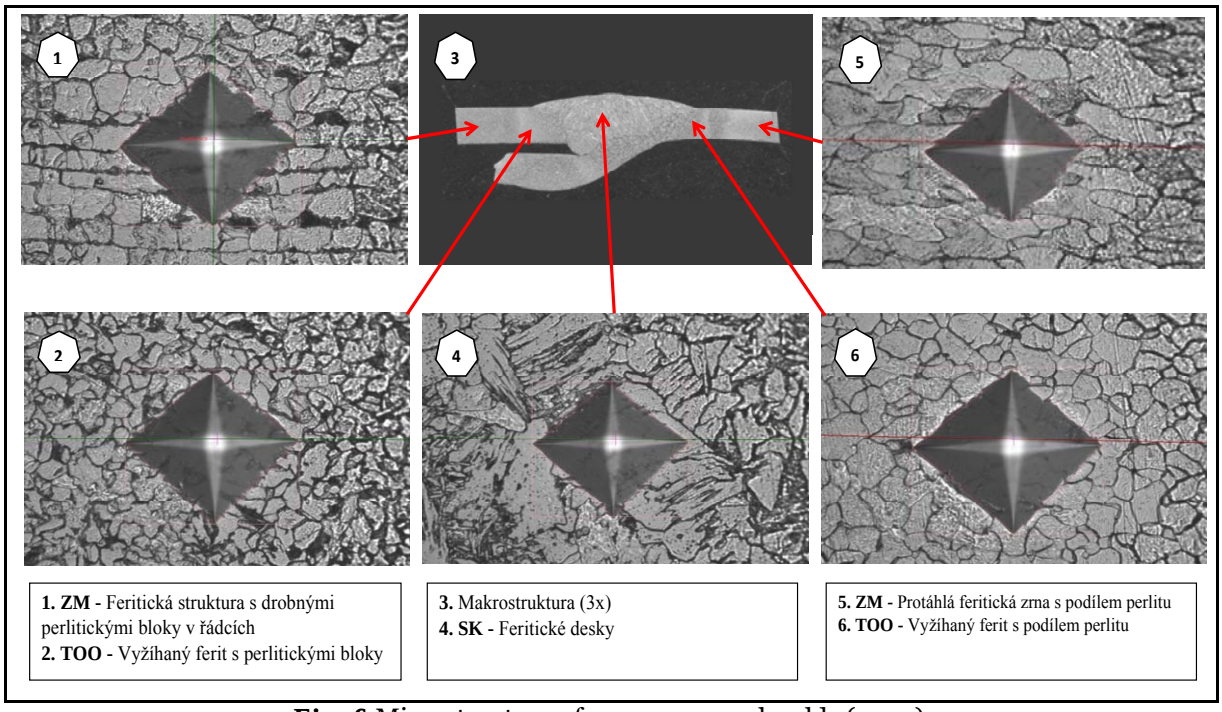

Fig. 6 Microstructure of pressure vessel welds (250x)

In soldered joints macrostructure (fig. 5) exist in solder gas voids and hydrophobic seats. Soldered joints specimens it is possible on the part of macrostructure account unsatisfactory.

On the part of microstructure evaluation near welds (fig. 6) has basic material ferritic structure with fine pearlitic blocks in order (vertical spacing). On opposite side are ferritic grains gently prolate influenced by deformation near finished the weld surface. In HAZ exist to annealed ferritic structure with pearlitic blocks. In weld metal is perceptible ferritic plate orientated to heat sink.

Weld specimens it is possible on the part of microstructure account suitable.

Microstructure evaluation near soldered joints (fig. 7) isn't necessary do, since soldered joints already don't meet at macrostructure evaluation.

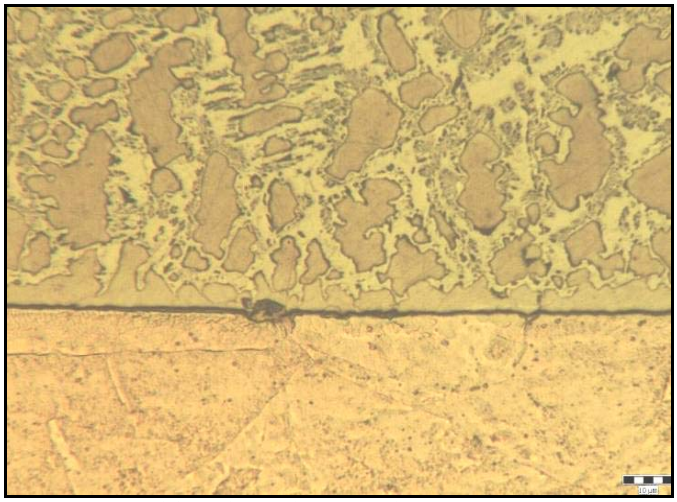

Fig. 7 Soldered specimens microstructure (375x)

Pressure vessels are controlled on test bench. Examination is made by dry compressed air about pressure 60 bar. Test bench are fully automatized and all parameters are choicely supervised. This system provides guarantee excellent mechanical product immunity and tightness and makes it possible to attendance easy quality appreciation. After pressure vacation is to the tank applied nitrogen, which increases their corrosion resistance [3].

5. CONCLUSION

After metallographical evaluation and study welds hardness behaviour shows welds of small pressure vessels like suitable. Like restrictive can be vertical spacing of pearlitic blocks in ferritic structure, because vertical spacing is able to in perpendicular direction to weld bring down weld tensile strength.

It is possible then tell, that the technology 135 (MAG) with filler material Wirpo SDA 2 behind welding parameters U = 24 V, I = 250 A, v = 0.37 $m.min^{-1}$, is suitable for welding pressure vessels from unalloyed low-carbon steels St 13.

Detailed soldered joints analysis of small pressure vessels were discovered mistakes like voids and cavities in solder and hydrophobic seats. All soldered joints made by low - smelting solder were discovered like unsatisfactory. To prevention rise of defects in soldered joints was recommended carry out careful surface finish before soldering, use at soldering protective atmosphere, eventually use other filler material inclusive other soldering flux with better flow and capillarity.

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