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Turkish Journal of Materials

Mechanical and Microstructural Investigation of Dissimilar S235 and S32205 Steel Sheets After TIG Welding

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Received: 11.12.2023; Accepted: 18.12.2023; Published: 31.12.2023
Turk. J. Mater. Vol: 8 No: 2 Page: 10-14 (2023) ISSN: 2636-8668
SLOI: http://www.sloi.org/sloi-name-of-this-article
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ABSTRACT S235 unalloyed steels are broadly used in structural and constructional applications while UNSS32205 duplex stainless steel alloys are preferred especially in bridges, marine and pulp, paper production industries. These two distinct types of steel alloys can be both used in applications especially for economical considerations assuming that high alloyed UNS S32205 steel is more expensive as compared to S235 alloy. These alloys can be joined together with fusion welding operations such as Tungsten Inert Gas Welding technique. Welding of these alloys are referred as white and black welding technique as a result of white and black designating stainless and low alloyed steels respectively. In this study, S32205 and S235 steel sheets both having thicknesses of 3mm were joined by TIG welding with pure argon shielding gas. Micro-structural investigations, micro-vickers hardness and tensile tests were made on raw materials and welded joints. As tensile and micro-vickers hardness tests are both considered, dissimilar welded joints exhibited close hardness and strength values with raw materials.

Keywords: S235 steels; S32205 steels; Dissimilar welding.

Cite this article: A.B. Başyiğit, A. Gül, H.İ. Kurt. (2023). Mechanical and Microstructural Investigation of Dissimilar S235 and S32205 Steel Sheets After TIG Welding. Turk. J. Mater. 8(2) (2023) 10-14.

1. INTRODUCTION

S235 structural steels are generally used in areas such as industrial buildings, bridges and railways, breakwaters at sea, shipbuilding, poles carrying intercity electrical cables, oil and offshore gas platforms, multi-purpose commercial buildings that need to impose satisfactory static load on the building [1]. They are selected for their low costs related with low amounts of alloying elements. S32205 duplex stainless steel alloys are used where superior corrosion resistance and adequate mechanical strength values close to carbon and low alloy steels. They are more expensive than other types of stainless steels depending on their production techniques [2,3]. These two different types of steel alloys may be used together because of economic reasons. There are lots of joining applications related with dissimilar alloys but fusion welding processes provide sufficient weld metal strength values as compared to other joining techniques.

In this study S235 unalloyed steel sheet with S32205 duplex stainless steel sheet having both thicknesses of 3mm are joined by TIG welding method under pure argon shielding gas. Mechanical and micro-structural developments on weld regions of samples are investigated throughly.

2. EXPERIMENTAL

Chemical composition of experimental materials obtained from Amatex Spectromaxx brand argon optical spectrometer is given in Table 1. Chemical compositions of experimental materials are consistent with the standard documents [4, 5].

Table 1. Chemical composition of experimental materials.

Experimental Alloy	C	Mn	Si	P	S	Cr	Mo	Ni	N	Fe
S235	0.19	0.2	0.3	0.030	0.035	--	--	--	--	Bal.
S32205	0.02	0.8	0.4	0.008	0.004	23.9	3.8	6.9	0.3	Bal.

Experimental materials are machined by water jet technique both before and after the welding operation for preventing samples from heating and also having smooth surfaces. Water jet machining parameters are given in Table 2.

Table 2. Water jet machining parameters.

Experimental Alloy	Lateral speed (mm/min)	Abrasive feed rate (g/min)	Nipple distance (mm)	Operating Pressure (MPa)	Abrasive dimension (mesh size)
S235	350	220	3	380	80
S32205	300	220	3	380	80

TIG welding operation parameters are given in Table 3.

Table 3. TIG Welding parameters.

Experimental Samples	Shielding Gas	Welding Current (amperes)	Welding Voltage (volts)	TIG Rods [6,7]	TIG Rod Diameter (mm)	Welding Pass
S235-S235	Argon	80-90	13	SG2	1.2	2
S235-S32205				308L		
S32205-S32205				308L		

Samples are prepared according to the standard documents [8, 9]. The machined samples by water jet method before and after the TIG welding operation are given in Figure 1.

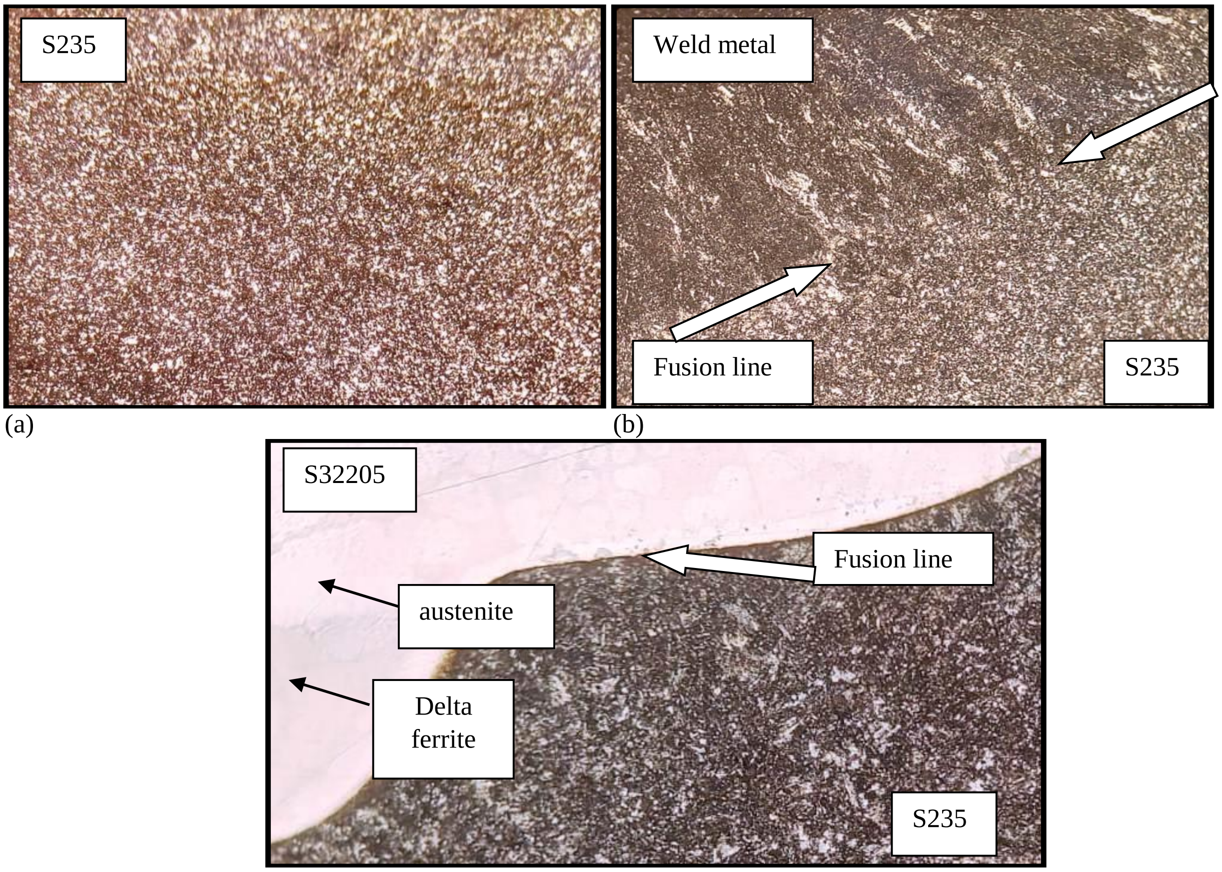
Figure 1. Welded samples machined for tensile testing.

Micro-structural investigations are made for comparison of welded samples with raw materials. Tensile testing is applied on both raw materials and welded samples according to ASTM A370 standard [10]. Micro-vickers hardness testing method is made by adjusting 0.3 kg of unit load cell [11].

3. RESULTS AND DICCUSSION

3.1. Micro-structural investigations

Microstructures of samples are given in Figure 2.



(a) (b)

(c)

Figure 2. Microstructures of (a) S235 base metal, (b) S235-S235 weld region, (c) S235-UNS S32205 weld region (100X).

Dominant ferritic and pearlitic structure is visible in Figure 1-(a) in S235 structural steel alloy base metal microstructure. Lighter regions represent ferrite and darker regions are pearlite in the microstructure of Figure 1-(a). In the upper regions of fusion line in Figure 1-(b) needle like weld metal microstructure is visible. Duplex microstructure (delta-ferritic-austenitic) is seen in weld metal microstructure in Figure 1-(c). Lighter regions are austenite and darker regions are ferrite in the microstructure in Figure 1-(c).

3.2. Micro-vickers hardness surveys

Micro-vickers hardness testing is applied both on unwelded (raw) and welded samples. Test results are given in Table 4.

Table 4. Microvickers hardness test results of samples

Samples	**HV**$_{0.3}$							
	**Weld Metal**			**HAZ**			**Mean Values**	
	1	2	3	1	2	3	**Weld Metal**	**HAZ**
S235-Raw	167-168-171						***169***	
S32205-Raw	296-297-297						***297***	
S235-S235	179	178	179	184	180	181	***179***	***182***
S32205-S32205	290	290	291	300	301	299	***290***	***300***
S235-S32205	291	293	288	302	298	300	***291***	***300***

The highest hardness values are obtained from the duplex alloy sides among the all samples in consequence of having higher amounts of chromium, nickel, molybdenum and nitrogen elements as compared to S235 alloy providing strengthening effect of carbides and precipitates on those regions with the welding cooling effects [2,3].

3.3. Tensile Testing of Samples

Tensile testing results are given in Table 5. As seen from the Table 5, raw (unwelded) materials exhibited consistent mechanical strength values with the standards and documents [1,4,5].

Table 5. Tensile test results of samples

Samples	**Yield Strength [MPa]**	**Tensile Strength [MPa]**	**Elongation [%]**
S235-S235-1	365,62	497,93	26,28
S235-S235-2	372,00	503,12	31,03
S235-Raw-1	390,15	511,63	25,43
S235-Raw 2	355,85	504,90	33,89
S32205-S32205-1	297,53	450,25	24,03
S32205-S32205-2	352,34	524,76	24,51
S32205-S235-1	408,00	521,75	22,21
S32205-S235-2	406,86	524,21	23,26
S32205-Raw-1	455,20	640,11	25,15
S32205-Raw-2	460,10	645,21	24,95

As the welded samples have been taken into consideration all of the samples have been qualified from the tensile testing. The minimum required tensile strength values from the standard documents are obtained on raw materials including welded samples [1-5]. Mechanical strength values of dissimilar welded samples are found between S235 and S32205 raw alloys.

4. CONCLUSIONS

Two distinct groups of S235 structural low alloy and S32205 duplex stainless steels can be joined together by TIG fusion welding process.

The highest hardness and tensile strength values are obtained from duplex stainless steel sides of welds in consequence of having more hardening effective alloying elements such as chromium, molybdenum, nitrogen and manganese as compared to unalloyed S235 steel.

Duplex (ferritic-austenitic) microstructure is seen in S32205 alloy weld regions while ferritic-pearlitic microstructure is dominant in S235 alloys weld regions.

ACKNOWLEDGMENTS Authors would like to present their thanks to MKE Weapon Factory Staff for their precious supports especially Mr. Mehmet Kalkan and Mr. Veli Güngör. Authors also present their thanks to organizing committee of 'The 5th International Conference of Materials and Engineering Technology' (TICMET-23) in the selection of this study which was presented in the conference organized on 13-16 November 2023 at Karadeniz Technical University, Trabzon, TÜRKİYE.

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Biographies

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