Effect Of the Microstructure On Weldability of Dual Phase Steel

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Abstract

The results of this research work showed that the increase of the cooling rate will increase the amount of martensite that will reduce the weldability of the dual phase steel. The low percentage carbon enables water to be as a suitable quenching medium for production of the dual phase steel of better weldability than the quenching medium of a salt solution

The results also showed that the increased annealing time causes growth of the austenite grain size without affecting its amount. Annealing for a period of more than 10 minutes produces a structure of polygonized ferrite-martensite, while annealing for 10 minutes or less the structure will be polygonized ferrite – pearlaite with small amount of martensite. Bearing in mind that the weldability depends on the amount of the martensite phase its distribution within matrix.

تأثير البنية المجهرية على قابلية اللحام للصلب الثنائي الطور.

الخلاصة:

أوضحت نتائج البحث إن زيادة معدل التبريد يزيد من كمية المارتنزايت، وهذا بدوره يخفض من قابلية اللحام للصلب الثنائي الطور. ولكن نسبة الكاربون المنخفضة جعلت من الماء كوسط تقسية مناسب لأنتاج الصلب الثنائي الطور وبقابلية لحام أفضل مما لو كان وسط التقسية المحلول الملحي.

كما أوضحت النتائج إن زيادة زمن التلدين يزيد من نمو جسيمات الأوسيتايت المتكون ولا يزيد من كميته، حيث عندما يكون زمن التلدين أكثر من (10) دقائق فأن التركيب هو عبارة عن فرايت مضلع – مارتنزايت ولكن عندما يكون الزمن (10) دقائق أو اقل فأن التركيب يكون عبارة عن فرايت مضلع – بيرلايت مع كمية قليلة من المارتنزايت. أما قابلية اللحام فهي تعتمد على كمية طور المارتنزايت وتجانس توزيعه ضمن أرضية المعدن الأساس.

Introduction

Weldability of metal in fusion welding is their ability to fuse under the effect of the heat then solidify and produce a joint compared of the similar or dissimilar metals without cracking. The weld zone should be given special consideration , it should be stable for long periods under the complex machining conditions , such as high temperatures , pressure , high alternating stresses , corrosive conditions . All these conditions may lead to the deterioration of the metal or the weld, or transition zone between the weld metal and base metal [1, 2]. Steels containing high percentage of carbon means high probability of brittle martensite formation in the heat effected zone (HEZ) with high hardness and tensile strength and of low ductility and low toughness , this mean an unweldable structure [2,3] . The weldability of metals and alloys means production of joints free of defects, reflected in their mechanical properties suitable for engineering applications, such as tensile and yield strength for tolerating external loads, hardness for wear resistance and ductility for flexibility and impact loading [4] . The main structure of dual phase steel consists of ferrite and martensite .The high hardness is due to the presence of martensite within the ferrite matrix which is responsible of ductility , therefore this type of steel is known for its strength and deformability which enable its use and production of automobile parts of complex design [5,6]. The stability of retained austenite enhances the ductility without affecting the tensile strength. Retained austenite of grain sizes (2–6)µm is relatively unstable and it will transform at small distortions to martensite . Smaller austenite grain sizes will resist transformation to martensite; will increasing transformation of retained austenite to martensite the strength of dual phase steel will increase. The homogeneous elongation will batter when the retained austenite exceeds 10% [7] . One of the main property of the dual phase steel in its low yield point and its progressive yielding due to the formation of high number of mobile dislocations by the martensite phase in the ferrite phase . These dislocations do not need high stresses for their movement during plastic deformation , therefore the stress-strain curve will be more progressive and flatter without sharp yield point [8] , but with increasing volume fraction of martensite , the dislocation density in the ferrite phase will increase loading to higher strength of the dual phase steel [9,10] .

Experimental Procedure:

Low carbon steel of commercial type with the chemical composition shown in table (1) , was used in this research work .

Element	C	Si	Mn	P	S	Cr	Mo	Ni	Cu	V	Fe
%	0.1	0.123	0.35	0.07	0.046	0.07	0.007	0.71	0.57	0.02	rem

Table (1) : chemical composition of the low carbon steel.

The steel was heat treated in a medium size electric furnace , type ESFI-PID carbolite will a maximum temperature of 1200 ºC . The specimens were heated to 850 ºC and held for 15 minutes for homogenization , then they were quenched , the quenching media were oil , water and salt solution , then the specimens were annealed at (850 ºC) for periods of 5 , 10 , 15 and 20 minutes . Examination of the micro stress here showed that dual phase steel can be obtained by quenching in water or salt solution . The matrix structure was ferrite phase embedded in it islands of hard martensite was more in specimens quenched in salt solution when compared with those quenched in water . The volume fraction of martensite was estimated by using point counting method from optical micrographs (fig. 1) shown the details 4 of the microstructures after various heat treatment processes . The specimens quenched in oil , Did not show martensite formation . Sample of dual phase steel were prepared in standard form for tensile testing To concentrate the stress within the weld metal , a notch with angle (45º) , depth , of (3mm) and root radius of (0.1) mm was cut . Some of these samples are cut at the middle and butt welded by manual are welded using electrode of (3) mm in diameter , 60 amperes and 230 volt .

Tensile test was carried out on tensile test machine type instron 1195 with capacity out on of 10 ton and strain rate of (6.67) *10 /sec . Vickers hardness test was used to measure the hardness of the specimens . The readings were taken from weld metal zone (HEZ) . Impact strengths were also measured after versions heat treatments .

Results and discussion:

1 –Microstructure:

The microstructure of the low carbon steel after heat treatment showed a Matrix structure of ferrite phase included in it small spurs of cementite(Fe_3C) addition to small particles of pearlite at grain boundaries . But the Microstructure of the dual phase steel showed matrix structure of ferrite and the martensite phase distributed within the ferrite phase . These microstructures were observed in the steel specimens subjected to quenching in water and salt solution . Quenching in salt solution gave more martensite then quenching in water . While quenching in oil did not produce any martensite due to low cooling rate and low carbon content , Instead it lead to grain growth of ferrite and formation of cementite along the grain boundaries and the pearlite appeared on long islands at the intersection of the grain boundaries of ferrite . The martensite formed by quenching in salt solution produced acicular martensite distributed more homogeneously within the matrix when compared with the martensite formed by quenching in water . Increasing the annealing period causes austenite grains growth and during quenching a certain percentage . Remains as retained austenite [7] . It was observed that the annealing period of more than (10) minutes produce after quenching in water , polygonized ferrite and martensite , while annealing period of (10) minutes or less produces polygonized ferrite and pearlite with small amount of martensite . With changing the annealing period , The ferrite grain size varies . It grown with increasing annealing time , and the annealing time has its main affect on the uniform distribution of martensite within the ferrite grains , as shown in figures (3 , 4) .

2–Weldability:

Weldability is the ability of the metals and their alloys to melt needs the effect of heat and then solidify for bonding there similar or dissimilar parts . These joint produced showed be stable for long periods under seven working conditions . So the main purpose of weldability of metals and alloys is to produce welding joints free of defects , particularly cracks besides that the mechanical and chemical requirements showed be satisfied for engineering applications , while include the tensile strength , hardness , elongation to resist external load , were resistance and impact loading . . The results show that the tensile strength increasers with increasing cooling rate due to the formation of longer volume fraction of martensite within the ferrite structure . It is will known that martensite has higher strength than ferrite and pearlite phases . decreasing martensite grains will further increase the strength of structure , because smaller grain size means more obstacles against dislocation movement . Similar results were obtained for hardness , namely , hardness increase with increasing cooling rate , while the impact strength decreased with increasing cooling rate .

Therefore the specimens quenched in salt solution gave the least impact value , while these specimens quenching in water showed butter toughness results and good strength and hardness . These results is included in table (1) with the strength of dual phase steel . The best weldability results were obtained after annealing for (15) minutes which produces optimum grain size and butter mechanical properties . Reducing the annealing period resulted in dimension of the martensitic phase that means no steel with dual phase behavior .

Toughness Joule	Hardness Kgf/mm^2	Tensile Stress (Mpa)	Volume Fraction of Martensite	Annealing Time(min)	Cooling Rate
6	131.6	177	-	15	Oil
7.2	141.3	194.6	15.2	15	Water
6.7	157	200	18.8	15	Salt Solution
-	-	-	-	5	Water
-	-	-	-	10	=
7.2	141.3	194.6	15.2	15	=
6.6	137	182.3	15.4	20	=

Table(1) Mechanical Properties of Dual-Phase Steel with Different Cooling Rate and Annealing Time.

Conclusions :

1 – The volume fraction of martensite increase with its size decreases with increases the rate of cooling . There cooling in salt solution produced high hardness and reduced toughness . Cooling in water resulted is butter weldability of dual phase steel concerning strength , hardness and toughness .

2 - In annealing for (10)minutes or less , the structure of the steel will be polygonized ferrite – martensite – pearlite , while annealing for period more than (10) minutes produces a structure composed of polygonized ferrite – martensite . Increasing the period , results growth of austenite grains which leads To coarse martensite after quenching , causing brittlement . The optimize weldability of dual phase steel was at annealing for (15) minutes .

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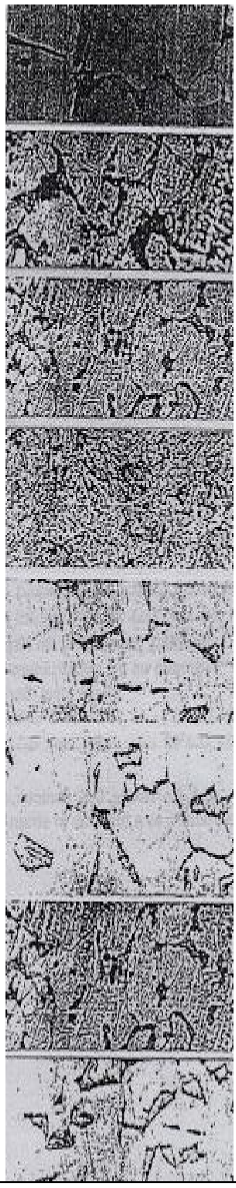

Fig. (1-a) The Microstructure of Low Carbon Steel As Received Before Treatment .

Fig. (1-b) The Microstructure of Annealing Steel With (850) C at (15) min. With Oil Quenching.

Fig. (1-c) The Microstructure of Annealing Steel With (850) C at (15) min. With Water Quenching.

Fig. (1-d) The Microstructure of Annealing Steel With (850) C at (15) min. With Salt Solution Quenching.

Fig. (1-e) The Microstructure of Annealing Steel With (850) C at (5) min. With Water Quenching.

Fig. (1-f) The Microstructure of Annealing Steel With (850) C at (10) min. With Water Quenching.

Fig. (1-g) The Microstructure of Annealing Steel With (850) C at (15) min. With Water Quenching.

Fig. (1-h) The Microstructure of Annealing Steel With (850) C at (20) min. With Water Quenching.

Figure (1) Microstructure Of Steel Before and After Heat Treatment With Different Cooling Rate and Annealing Time

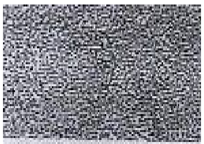

Fig. (2-a) The Microstructure of Welding Reign

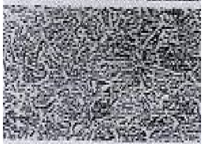

Fig. (2-b) The Microstructure of Grain Growth

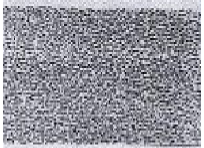

Fig. (2-c) The Microstructure of Normalizing Reign

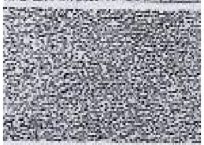

Fig. (2-d) The Microstructure of Rycrestalizision Reign

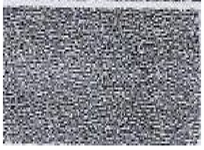

Fig. (2-e) The Microstructure of Base Metal Reign

Fig. (2) The Microstructure of the Welding Reigns.

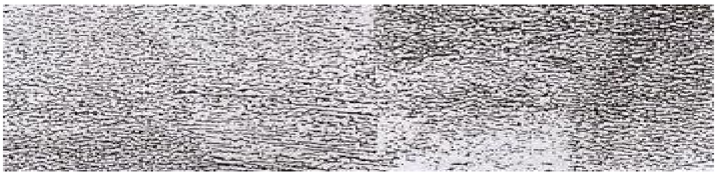

Fig. (3-a) The Microstructure of Welding Reign with Thickness Direction.

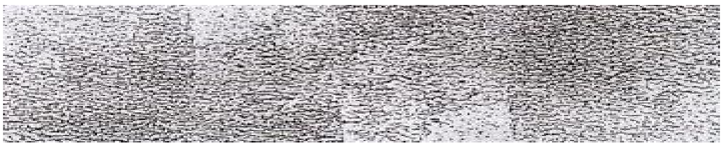

Fig. (3-b) The Microstructure of Welding Reign with Surface Direction.

Fig. (3) The Microstructure Of Welding Reigns