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Mechanical Properties of Maraging 250 SteelWelded byLaser and Tig Methodology

[1]MANABHANJAN SAHOO,
Gandhi Institute of Excellent Technocrats, Bhubaneswar, India

[2]SOUMYA RANJAN SAHOO,
Adarsha College of Engineering, Angul, Odisha, India

***Abstract*:- Maraging metal steels are known for their high strength and durability without losing ductility. Aging means the process of heat treatment. The 250 steel treated as ultrahigh is considered to be ultrahigh strength due to its yield potential greater than 1700 MPa and is part of a collection of high-quality materials that are of interest to technological development, especially the aeronautics and aerospace industry. For this purpose good stamina must be delivered, resistance to fatigue and acceptable strength. In this phase of the 250 maraging metal probes will be made the strength and hardness of laser-binding T-250 metal bonds, which is intended to determine the tendency of aging temperatures in microstructures and mechanical properties of the joints. These tools are used in the aerospace industry such as high-strength steels, engine casings and arrows, landing gear structures, among others. There are several studies on the process of laser welding of this material, which makes it important to study the possibility of welding these devices. Comparisons between traditional TIG-Tungsten Inert Gas welding processes and LBW - Laser Beam Welding will be made. Examination of the mechanical properties was used for rigidity, showing that the welding metal could be burned with minimal loss in machine parts, with the advantages of laser welding process.**

Keywords:- Laser welding; TIG welding; maraging steel; maraging 250; mechanical properties, microstructural characterization.

INTRODUCTION:

Maraging steels (portmanteau of "martensitic" and "aging") are metals (steel alloys) known for their high strength and durability without losing ductility. Aging means an extended process of heat treatment. These metals are a special category of ultra-high-dense metals that derive their energy not from carbon, but from rain from intermetallic chemicals. The key to mixing nickel is 15 to 25 wt% nickel. Second blending materials, including cobalt, molybdenum and titanium, are added to produce intermediate barriers. The actual development (by Bieber of Inco in the 1950s) was made at 20 and 25 wt% Ni steels where small amounts of aluminum, titanium, and niobium were added; the rise in the price of cobalt in the late 1970s led to the construction of non-cobalt roadblocks. Typical, non-harmful markers contain 17-19 nickel 17-19 wt%, 8-12 wt% cobalt, 3-5 wt% molybdenum and 0.2-1.6 wt% titanium. The addition of chromium produces flawless anti-corrosion signals. This also indirectly increases durability as it requires less nickel; high-chromium, high-nickel steels are generally austenitic and cannot convert to martensite when treated with heat, while low-nickel steels can convert to martensite. A variety of low-quality nickel alloys are derived from alloys of steel and manganese as well as small additives of aluminum, nickel and titanium when using composites between Fe-9wt% Mn to Fe-15wt% Mn. Manganese has a similar effect to nickel, which means it strengthens the austenite phase. Therefore, depending on its manganese content, Fe-Mn metals can be completely martensitic after extraction from high austenite temperatures or may contain stored austenite

MARAGING STEEL COMPOSITION

Element	Grade 200	Grade 250	Grade 300	Grade 350
Iron	Balance	Balance	Balance	Balance
Nickel	17.0-19.0	17.0-19.0	18.0-19.0	18.0-19.0
Cobalt	8.0-9.0	7.0-8.5	8.5-9.5	11.5-12.5
Molybdenum	3.0-3.5	4.6-5.2	4.6-5.2	4.6-5.2
Titanium	0.15-0.25	0.3-0.5	0.5-0.8	1.3-1.6
Aluminium	0.05-0.15	0.05-0.15	0.05-0.15	0.05-0.15
Tensile strength (Mpa)	1379	1724	2068	2413

Physical Metallurgy: There has been a lot of extensive discussion about metals made of cross-sectional metals, including a completely good review. The standard method of heating heat made of repeating metals is about 1500º F, the air is heated to a room temperature, and then it is about 900 ° F.

Solution-Annealed Maraging Steels : Holding Solutions Although 18% of the Ni maraging stairs are fully operational above 1350 ° F6 high temperatures are often used to ensure that rain enters the solution and that any remaining pressure is removed .7 In cooling, austenite converts to carbon low carbon-nickel martensite with a cubic structure on the body that has no evidence of

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tetragonality.1 Microscopy of the thin film showed that the structure could not be opened by 3 thick dense layers.8,9 This type of martensite is soft (about Rc 30) and difficult. 10 Since austenite to martensite tranformation occurs at low temperatures (MS 18Ni (250) approx. 310 ° F) where propagation-controlled processes are unpopular, forms martensite with an irreversible shear process. the real advantage is that martensite is formed at all levels of cooling and therefore at all phase sizes.6 Typical reinforcement concepts do not apply to maraging steels. Although it builds up at low temperatures, iron-nickel martensite can be heated to high temperatures before converting to austenite .Main controls use this hysteresis to amplify martensite

Age hardening: The average solid age temperature is between 450 and 550 ° C while the longevity is 4-12 h; subsequent cooling is performed in the air. However the time and temperatures used for the collapse of road metal are very important to find the final steel structures.

MATERIALS AND METHODS:

Grades of maraging steel:

Metal strikes are usually defined by numbers (200, 250, 300 or 350), indicating the estimated strength of thousands of pounds per square meter; the required structures and structures are described in MIL-S-46850D. High concentrations are high in cobalt and titanium alloy; That family is known as 18Ni steels, from their percentage of nickel. There is also a family of robbers who do not have cheap cobalt but not so strong; One example is Fe-18.9Ni 4.1Mo1.9Ti. There have been Russian and Japanese studies on the alloys of Fe-Ni-Mn maraging.

Heat treatment cycle:

The metal was first glued to about 820 ° C (1,510 ° F) for 15 to 30 minutes in small sections and 1 hour with a size of 25 mm of heavy parts, to ensure the construction of a fully strong structure. This is followed by cooling the air or turning off the room temperature to form a soft, highly removed martensite. Subsequent aging (excessive hardening) of the most common alloys for about 3 hours at a temperature of 480 to 500 ° C reveals a good dispersion of the intermediate Ni3 (X, Y) phases between the fragments left by the martensitic transition, in which X and -You can have solute substances added to such rain. Excessive degradation leads to a decrease in the strength of key, flexible, and compliant foundations, leading to their deterioration and alteration of Lave-related compounds such as Fe2Ni / Fe2Mo. Excessive heat treatment causes martensite to rot and return to austenite. New invention of maraging steels has revealed other intermetallic and crystallographic stoichiometries interactions with parental martensite, including rhombohedral and complex Ni50 (X, Y, Z) 50 (Ni50M50 in notation easily made).Physical properties:

- Density: 8.1 g/cm³ (0.29 lb/in³)
- Specific heat, mean for 0–100 °C (32–212 °F): 452 J/kg·K (0.108 Btu/lb·°F)
- Melting point: 2,575 °F, 1,413 °C
- Thermal conductivity: 25.5 W/m·K
- Mean coefficient of thermal expansion: 11.3×10−6
- Yield tensile strength: typically 1,400–2,400 MPa (200,000–350,000 psi)[13]
- Ultimate tensile strength: typically 1.6–2.5 GPa (230,000–360,000 psi). Grades exist up to
- 3.5 GPa (510,000 psi)
- Elongation at break: up to 15%
- KIC fracture toughness: up to 175 MPa·m$^{1/2}$
'Young's modulus: 210 GPa (30,000,000 psi)
- Shear modulus: 77 GPa (11,200,000 psi)
- Bulk modulus: 140 GPa (20,000,000 psi)
- Hardness (aged): 50 HRC (grade 250); 54 HRC (grade 300); 58 HRC (grade 350)

EXPERIMENTAL PROCEDURE:

Materials

The 250 wide metal frame used for this purpose was made with a VAR processor measuring 280 x 140 x 3.3mm in a heated, frozen area. The chemical composition is shown in Table 1. The laser welding process is automated, in this case, it has not been used for filling. In the TIG welding process, the filling is complete, and the chemical composition of the filling is shown in Table

Table:maraging steel composition and filler

Elements	Maraging 250 Content (wt%)	Filler Content (wt%)
C	0.006	0.006
Ni	18.48	17.85
Mo	4.86	4.68
Co	9.24	8.76
Al	0.09	0.076
Ti	0.66	0.60
S	0.002	<0.001
P	0.003	<0.003
Si	0.03	0.09
Mn	0.014	0.015
Cr	0.060	--

Procedure:

The laser burner used a 2 kW wave wave fiber made by IPG Co Laser radiation produced with 50 µm fiber diameter made of ytterbium. Doped fiber is connected to

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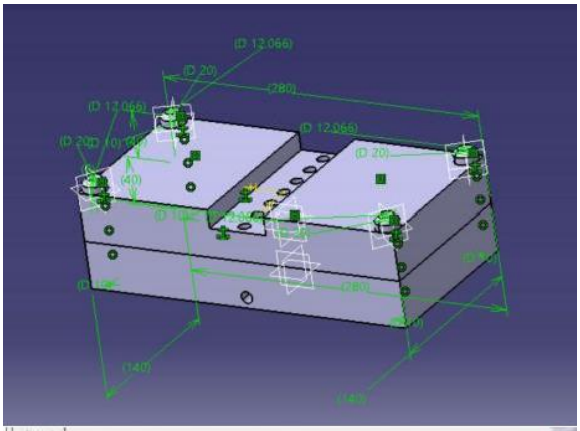
the fiber process by 100 A µm diameter and 10 m long, which is also connected to the Optoskand processing head. The focal length was 157mm with a minimum area width of 100 µm. Pure argon gas is used at a flow rate of 30 l / min to protect the sample against oxidation. The protective gas is supplied by 47 with an inner circular tube 3 mm directly above the glowing surface. Smooth sampling was performed over the CNC table. Laser burners based on previous experiments, used a laser speed of 180 cm / min and a laser power of 1800 W, concentrated in the sample area and used argon at 30 l / min as a protective gas. In the TIG process components, the MERKLE BALMER Insquare P 421 model, the plasma module IMERKLE BALMER PT 11, the BMI STA / GTAW wire feeder and the longitudinal welding device using DC weld equipment directly. The TIG welding process is done by hand by a skilled burner. The parameters used in the TIG process are specified in the Table provided below.

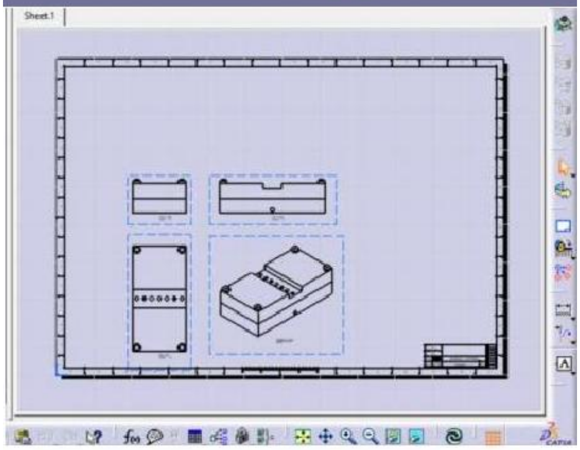
Table 4.1.2 - TIG welding parameters used in the process

	TIG WELDING
Current (A)	185
Welding speed (mm/min)	160
Wire feed speed (m/min)	1680
Protecting gas flow rate (l/min)	12
Flow of plasma gas (l/min)	12
Purge gas flow rate (l/min)	12

Types of power tests are cut from welded plates according to standard ASTM E8. Strength tests protected the specimens, with each welding process divided into two groups - excluding heat treatment and heat treatment of aging. In the treatment of aging heat, a temperature of 480ºC was used and the samples remained there for three hours and this was cool in the air. The small structure of the welded samples was analyzed by optical microscopy (Zeiss Epiphot 2000), using the following reagents: I) modified Fry (150ml H2O, 50ml HCl, 25ml HNO3 and 1g CuCl2), II) Nital 5% and III) Solution -metabisulfite sodium (10g to 100 ml H20). Microstructure images obtained by scanning the Electron Microscope. Microhardness ratings for samples and heat treatment without reference to mixing with 48 affected temperature zones. Measurements were made using a Vickers microhardness tester (Future-Tech FM-700) using loads of 100 gf for 10 s. Measurements were made when cutting weld beads of 0.5 mm from the surface of the weld and 0.1 mm between inserts.

DESIGN:





TEST WELD PIECE.

ANALYSIS:

Microstructural Analysis:

Analysis of mechanical design projects was performed on two samples. The first is in the form of a weld and the other is in the form of PWHT. In the whole sample microstructure was detected in three distinct areas eg metal cell, junction area and HAZ. The composition of Microosta as weld samples as in the case of weld is shown in figs. 6. It was noted that the multi-column grain was distributed over the meeting place. Bullets are found shrinking in this area compared to other parts. Figure 6 (b) shows the HAZ region and the boundary of the visible weld connector. A clear boundary can be seen between the metal and the base metal. It also shows complete penetration and complete durability of the material. The HAZ region also has half the grain but is much smaller compared to the FZ

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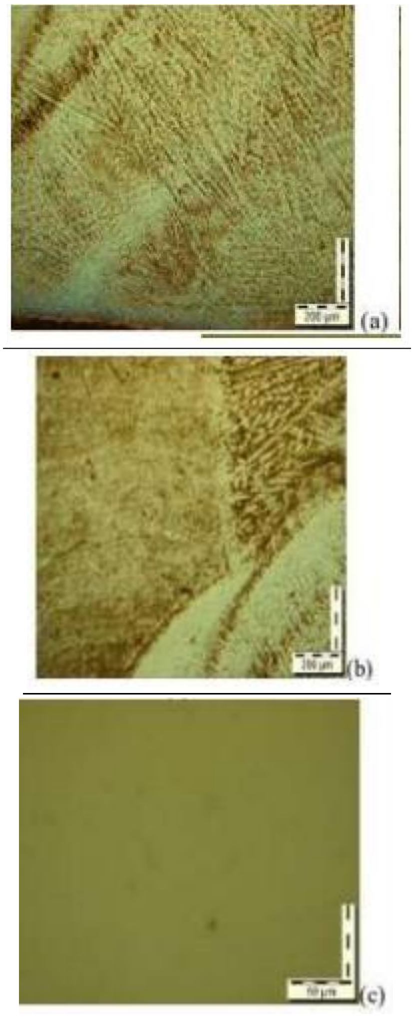


Microhardness Review:

Microhardness values of the work piece were taken from three different regions namely base material, fusion zone, HAZ of both samples clearly shown in fig. 8. The hardness value of weld materials varies in range from 272 -458 HV. The hardness level of HAZ varies from 295-492. The maximum strength of the parent metal is in the range 301-473. Grain size also affects the hardness of the object in the following way - fine grain size by heat treatment improves the amount of hardness while hard grains have lower hardness. The hardness value of HAZ is found to be greater than the connecting point in the weld position In HAZ the grain size decreases due to its distance from the fusion zone. While in the fusion zone a small coarser formation changed from austenite phase during cooling. In some cases the formation of a small number of effects of austenite recovered to a lower degree of HAZ hardness compared to the hardness of the metal.

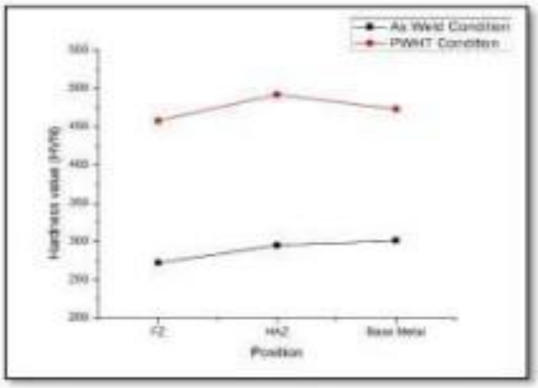
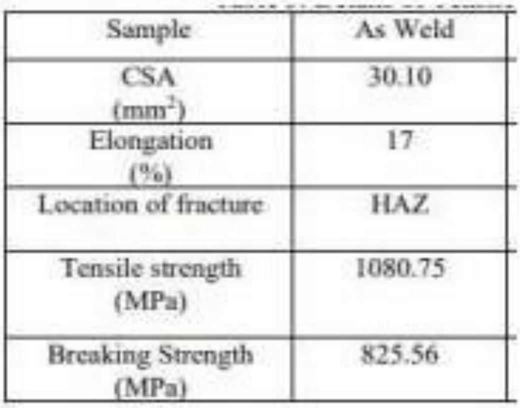


Fig.8: Graphical representation of hardness value

Tensile force: The final strength of a material depends on the structure of the grain within the material. The strongest reduction was due to the formation of solid grains in heattreated samples. The coarser grain structure was constructed due to the slow cooling rate which was largely due to the high temperature input. The amount of solid energy obtained from a universal test machine as a weld condition

Details of tensile test:



Sample	As Weld
CSA (mm^2)	30.10
Elongation (%)	17
Location of fracture	HAZ
Tensile strength (MPa)	1080.75
Breaking Strength (MPa)	825.56

Broken tensile test pieces

RESULT:

The results of the severe tests are shown in Table 5.1. It should be noted that there was no significant difference between yield and energy limits obtained from the two types of welding used in this study. Similarly, the metal ductility is maintained even after the welding process. This

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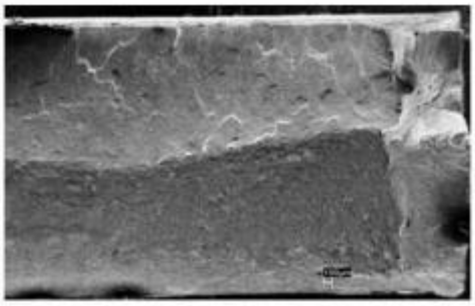
fact proves that good weldability is reflected in this metal range. Analysis of the fractured areas shows that these are in the form of ductile, forming dimples (Figure .b). As a result of the decline of the compound (FZ) or temperature-sensitive area (HAZ) The next FZ, in most cases, explosions have begun in this region and later spread until the last split (Fig. .B). This situation is shown in Fig. The robbery was welded through the TIG process, the broken area resembled the two types of welding used.

Table:Mechanical properties after aging of maraging 250steel

Maraging steel aged	Yield strength(Mpa)	Tensile strength1(MPa)	Elongation%
No weld	1672+/-33	1950+/-28	9,7+/-1,2
Welded(LBW)	1620+/-39	1857+/-47	8,5+/-1,4
Welded(TIG)	1651+/-38	1835+/-75	8,6+/-1,7

a)



b)

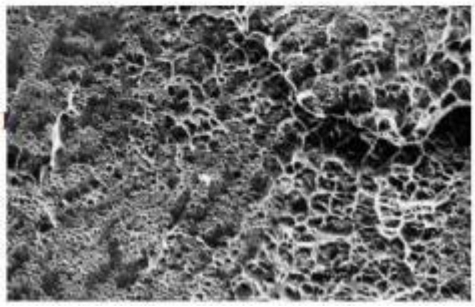
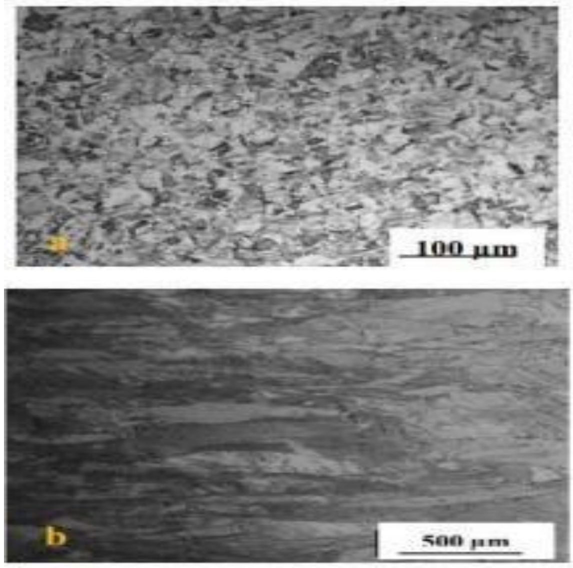


Fig:SEM - showing the fracture surface of welded maraging 250 steel: a) macroscopic appearance - plastic strains and b) microscopic appearance - dimples on the surface.

DISCUSSION:

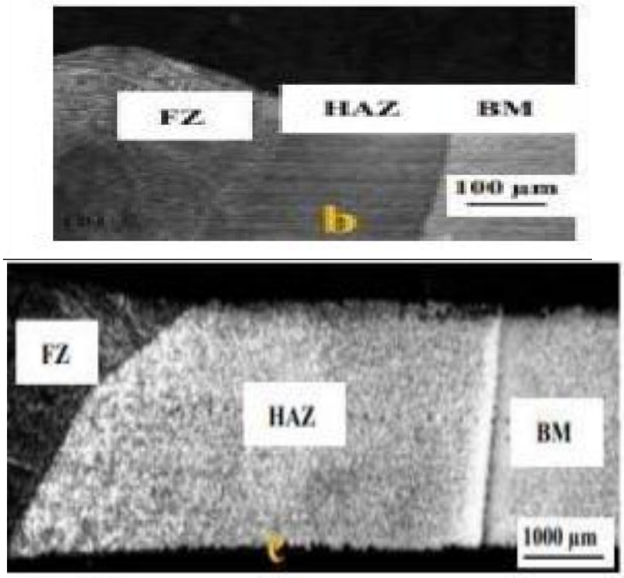
Microstructure and hardness:

The figure provided.a shows the first standard structure of molten metal, with a low hardness of martensite, with a hardness of around 380 HV, the grain size found under ASTM E112 was 8.9. Figure 6.1.b shows a microstructure file after 480 ° C for three hours, the weight increased to about 600 HV.



. Optical Microscopy - Maraging 250; a) solutionised and b) aged.

After welding the concrete, three different areas are identified: compact zone (FZ), area affected by heat(HAZ) and basics (BM - temperature range). Figure5.2 shows the welds made by these three nominees methods. It notes that the regions formed by FZ and HAZ due to laser welding (LBW) (a) are almost ten times there are similar regions formed by the TIG (b) welding process.



Optical Microscopy - Maraging 250 welded: a) LBW process, b) TIG process .

In the composite area the formation of martensite and dendritic structure occurred due to subsequent cooling mixing. Figures in Figure 6.3 show the combined area (FZ) in the two welding processes used. The hardness of the base material is approximately 380 HV, the combined area was found to be slightly lower in hardness, approximately 350 HV of the two heating systems used. This reduction occurs due to the formation of martensite with low hardness and due to the formation of reclaimed austenite, which is located in very large areas concentration of solute in dendritic areas, fig. 6.4 indicates the presence of

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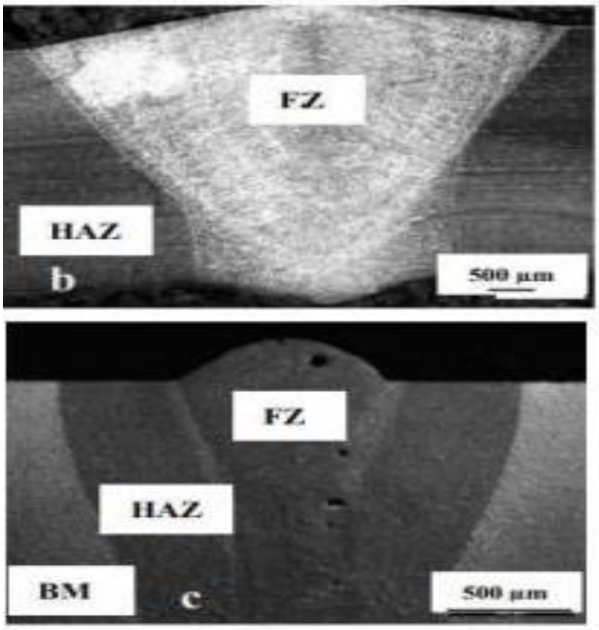
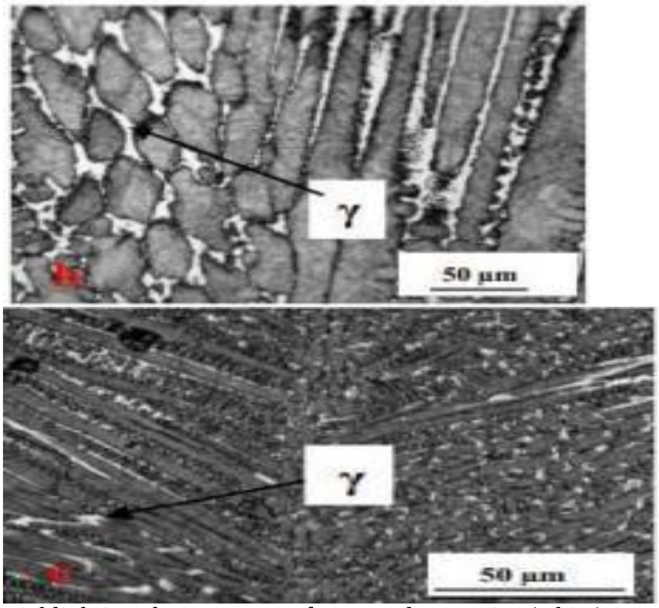
austenite (γ) in FZ. After old age there are a significant increase in the amount of hardness, reaching approximately 520 HV in TIG process and 580 HV in LBW weld. In HAZ near FZ something very important is happening, grain growth due to heat and cracking often begins in this region.

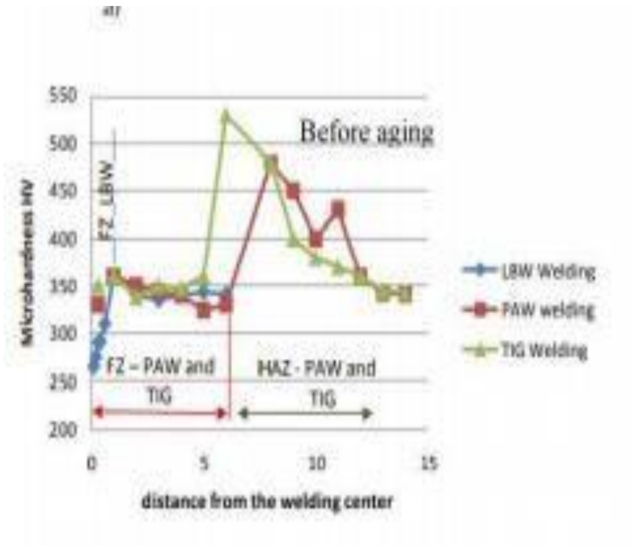


Optical Microscopy - Maraging 250 welded: a) LBW process, b) TIG process .

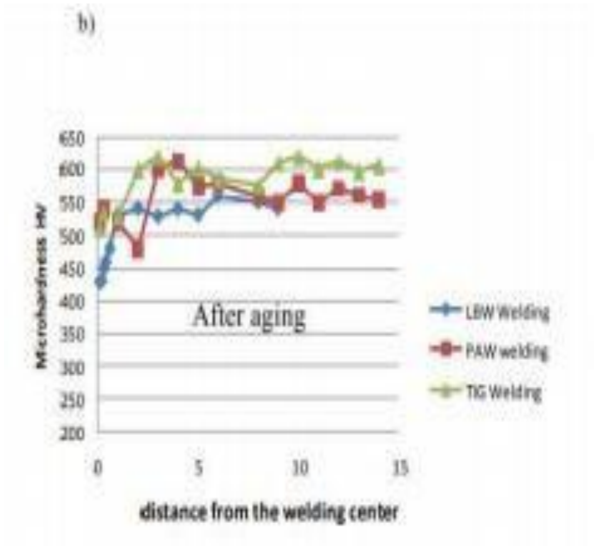


Highlighting the presence of reversed austenite (white) in the FZ:
a) LBW process and b) TIG process.

Microhardness measurements performed on welded samples showed a decrease in hardness in FZ. The metal extraction process by TIG, due to the increase in HAZ, there is also a decrease in the hardening circuit. Post-treatment of aging that occurs at critical rates in HAZ and ZF after recovery has been found to be below baseline. After aging, the hardness levels in the TIG temperature gradually decrease with LBW heating, especially in the mixed area, as shown in Figure.



Graphics of hardness; a) before aging and b) after aging at 480 °C for 3 hours.



CONCLUSION:

1. The three methods used for welding were the successful use of 300 loot, but it is important that they cause aging after the welding process.
2. The reduction in yield and strength was less than 5% due to the welding process with a loss of about 20% ductility.
3. Decreased electricity levels may be associated with the formation of austenite in the composite area during the welding process.
4. During the cracking of the cracks it was usually initiated in a visible connection between the covered area and the temperature of the affected area, spreading in the region of low hardness of the metal.
5. Although the HAZ and FZ issued by the TIG welding process are larger than those produced by the LBW process this difference does not affect the machinery of the welding machine.

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