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EFFECT OF SHOT PEENING AND MICROSTRUCTURE PROPERTIES OF Ti 6AI-4V AND TITANIUM GRADE 2 OF LASER WELDED JOINTS

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ABSTRACT

The present study shows the effect of plasma ion nitriding and shot peening process on the microstructure, tensile, bending strength and hardness of Ti 6AI-4V AND TITANIUM GRADE 2 joint materials by employing laser welding (A-LW). Double shot air blast shock peening DABSP was achieved on the Ti 6AI-4V AND TITANIUM GRADE 2 to analyze the strength in the pre-peening and peening weld treatment. After welding process, tensile failure occurred in the fusion zone of the material joint for both pre peening and peening process. It was confirmed that the yield and tensile strength of the welded joints improved significantly after DABSP in the weld and heat affected regions of the weldments. The investigation of samples prepared by prepeening, peening and plasma ion nitriding were conducted at the fusion zone by employing scanning electron microscopy, X-ray diffractometry and transmission electron microscopy techniques. Residual stress analysis was carried out on the materials coupons using X-ray Diffraction analysis. The present study expressed that the CrN is not formed after performing plasma ion nitriding and shot peening which resulted in better tensile and bending strength.
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1.INTRODUCTION

Titanium alloys are metals that contain a mixture of titanium and other chemical elements. Such alloys have very high tensile strength and toughness (even at extreme temperatures). They are light in weight, have extraordinary corrosion resistance and the ability to withstand extreme temperatures. However, the high cost of both raw materials and processing limit their use to military applications, aircraft, spacecraft, bicycles, medical devices, jewelry, highly stressed components such as connecting rods on expensive sports cars and some premium sports equipment and consumer electronics.

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Although "commercially pure" titanium has acceptable mechanical properties and has been used for orthopedic and dental implants, for most applications titanium is alloyed with small amounts of aluminium and vanadium, typically 6% and 4% respectively, by weight. This mixture has a solid solubility which varies dramatically with temperature, allowing it to undergo precipitation strengthening. This heat treatment process is carried out after the alloy has been worked into its final shape but before it is put to use, allowing much easier fabrication of a high-strength product.

Titanium alone is a strong, light metal. It is stronger than common, low-carbon steels, but 45% lighter. It is also twice as strong as weak aluminium alloys but only 60% heavier. Titanium has outstanding corrosion resistance to sea water, and thus is used in propeller shafts, rigging and other parts of boats that are exposed to sea water. Titanium and its alloys are used in airplanes, missiles and rockets where strength, low weight and resistance to high temperatures are important. Further, since titanium does not react within the human body, it and its alloys are used in artificial joints, screws and plates for fractures, and for other biological implants. See Titanium Orthopedic implants.

This alloy has good biocompatibility, and is neither cytotoxic nor genotoxic.Ti-6Al-4V suffers from poor shear strength and poor surface wear properties in certain loading conditions:[8Bio compatibility: Excellent, especially when direct contact with tissue or bone is required. Ti-6Al-4V's poor shear strength makes it undesirable for bone screws or plates. It also has poor surface wear properties and tends to seize when in sliding contact with itself and other metals. Surface treatments such as nitriding and oxidizing can improve the surface wear properties.

1.1 ENVIROMANTAL IMPACTS

Enviroment impacts on project mainly avoiding the corrosion effective on the marine materials that immersed in the salt water. Due to the action of the salt in water that may affect the surface of the metal. Hence the corrosion leads to so many system failures and loss to human life and cost. Due to surface modification of the metal which has to increase the tensile and bending strength to avoid breakage and increases the breaking point

2. LASER WELDING

The laser beam welding is mainly used for joining components that need to be joined with high welding speeds, thin and small weld seams and low thermal distortion.

The high welding speeds, an excellent automatic operation and the possibility to control the quality online during the process make the laser welding a common joining method in the modern industrial production.

The application range covers finest welding of non-porous seams in medical technology to precision spot welding in electronics or the jewelry industry, to deposit welding in tool and mold-making and welding complete car bodies in automobile construction. However, new and efficient production processes are often not possible without the advantages of laser technology. Thus, diverse sheet thicknesses and qualities are turned into tailored blanks by welding and resistance spot welding is replaced by laser seams.

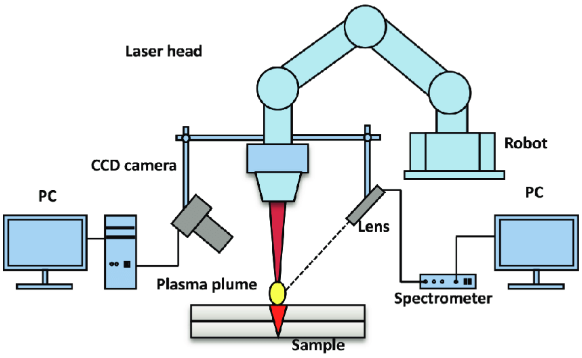

Figure 2.1 Laser welding machine

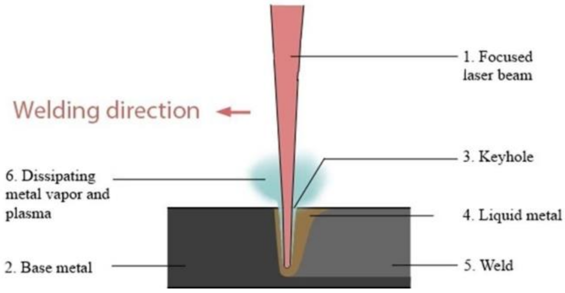

Figure 2.2 Laser welding process

Laser beam welding (LBW) is a welding process which produces coalescence of materials with the heat obtained from the application of a concentrate coherent light beam impinging upon the surfaces to be joined. The focused laser beam has the highest energy concentration of any known source of energy. The laser beam is a source of electromagnetic energy or light that can be pro jetted without diverging and can be concentrated to a precise spot. The beam is coherent and of a single frequency.

Gases can emit coherent radiation when contained in an optical resonant cavity. Gas lasers can be operated continuously but originally only at low levels of power. Later developments allowed the gases in the laser to be cooled so that it could be operated continuously at higher power outputs.

The gas lasers are pumped by high radio frequency generators which raise the gas atoms to sufficiently high energy level to cause lasing. Currently, 2000-watt carbon dioxide laser systems are in use. Higher powered systems are also being used for experimental and developmental work. A 6-kw laser is being used for automotive welding applications and a 10-kw laser has been built for research purposes.

There are other types of lasers; however, the continuous carbon dioxide laser now available with 100 watts to 10 kw of power seems the most promising for metalworking applications.

The coherent light emitted by the laser can be focused and reflected in the same way as a light beam. The focused spot size is controlled by a choice of lenses and the distance from it to the base metal. The spot can be made as small as 0.003 in. (0.076 mm) to large areas 10 times as big. A sharply focused spot is used for welding and for cutting. The large spot is used for heat treating.

The laser offers a source of concentrated energy for welding; however, there are only a few lasers in actual production use today. The high-powered laser is extremely expensive. Laser welding technology is still in its infancy so there will be improvements and the cost of equipment will be reduced. Recent use of fiber optic techniques to carry the laser beam to the point of welding may greatly expand the use of lasers in metal-working.

3. MATERIAL

Ti 6AI-4V sheets

The most common market for 6AL-4V is aerospace. Lightweight grade 5 titanium is well suited for applications such as compressor blades, discs, and rings for jet engines; airframe components; pressure vessels; rocket engine cases; helicopter rotor hubs and critical forgings requiring high strength-to-weight ratios. Ti-6AL-4V titanium round bar stock is also age hardenable by heat treatment to achieve even higher strengths. This biocompatible material is also well suited for medical implants. Its mechanical and physical properties allow good capacity for titanium to join with bones and other tissue.

Ti	Titanium	90%
Al	Aluminum	6%
V	Vanadium	4%
C	Carbon	< 0.10%
O	Oxygen	< 0.20%
N	Nitrogen	< 0.05%
H	Hydrogen	< 0.0125%
Fe	Iron	< 0.3%

Physical Properties of grade 5 titanium

Non-magnetic. A two-phase alloy, containing both alpha and beta phase crystalline structures. This high strength grade can be used at cryogenic temperatures to about 800˚F (427˚C).Ti-6al-4v bar to AMS 4928 requires 120,000 psi minimum yield strength at room temperature. This grade of titanium can be used in the annealed condition or in the solution treated and aged condition. Ti 6al-4v Grade 5 Titanium bar bar stock has outstanding corrosion resistance to most media including nitric acid in all concentrations to boiling point; seawater; and to alkalis in all concentrations to boiling point. Stress corrosion cracking may occur if chlorine salts are present on stressed parts subsequently subjected to high temperatures. Ti 6al-4v Grade 5 Titanium has acceptable oxidation resistance up to 1000°F (538˚C). Density: 0.163 lbs/in3, 4.43 g/cm3

Mechanical Properties of Ti-6Al-4V

- Hardness of stock is typically 300 BHN. The strength and hardness of the mill-annealed product may be increased by approximately 20% after an aging heat treatment.

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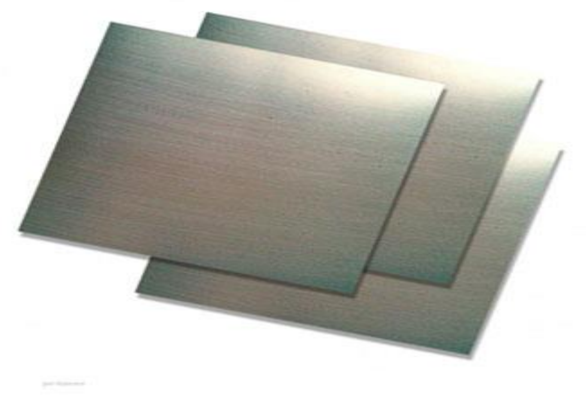
- After aging at 975-1025˚F (524-552˚C), Ti 6al-4v Grade 5 Titanium bar typical yield strength is 150,000 psi and typical hardness is 360 BHN.
- Machinability Rating: 22% of B-1112
- Typical stock removal rate: 30 surface feet/minute

Figure.3 Base materials Ti-6Al-4V

Titanium

Titanium Alloy Grade 2 is "unalloyed" titanium offering an excellent balance of strength and ductility. The material has good toughness and is readily weldable. This material is very corrosion resistant in highly oxidizing and mildly reducing environments. The material is castable and is often utilized in cast valves and fittings. In plate form, the alloy is also used explosively boned to make clad plate. The alloy is available as castings, wire, welded tube, pipe, plate, sheet, strip, forgings, bar, and billet.



Base materials TITANIUM GRADE 2 sheets

4. LASER WELDING SETUP

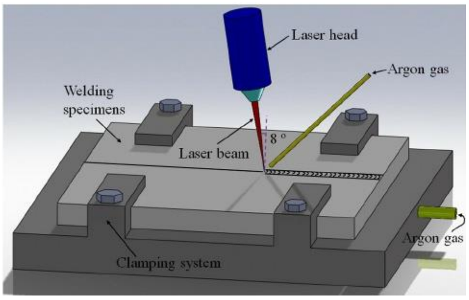


Figure 4.Laser welding setup

The laser beam welding is mainly used for joining components that need to be joined with high welding speeds, thin and small weld seams and low thermal distortion. The high welding speeds, an excellent automatic operation and the possibility to control the quality online during the process make the laser welding a common joining method in the modern industrial production. The application range covers finest welding of non-porous seams in medical technology to precision spot welding in electronics or the jewelry industry, to deposit welding in tool and mold-making and welding complete car bodies in automobile construction.

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JOINING CONFIGURATION

4.1 BUTT JOINT

A butt joint is a joinery technique in which two members are joined by simply butting them together. The butt joint is the simplest joint to make since it merely involves cutting the members to the appropriate length and butting them together. Usually, a butt-welding joint is made by gradually heating up the two weld ends with a weld plate and then joining them under a specific pressure.

This process is very suitable for prefabrication and producing special fittings. Afterward, the material is usually ground down to a smooth finish and either sent on its way to the processing machine, or sold as a completed product. This type of weld is usually accomplished with an arc or MIG welder. It can also be accomplished by brazing. With arc welding, after the butt weld is complete, the weld itself needs to be struck with a hammer forge to remove slag before any subsequent welds can be applied.

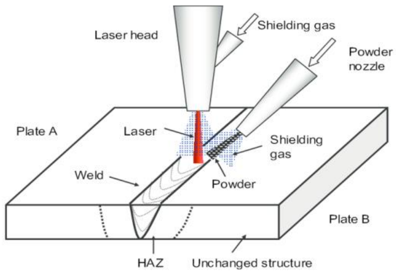

Figure4.1Butt joint.

5 DOUBLE SHOT PEENING PROCESS

Peening a surface spreads it plastically, causing changes in the mechanical properties of the surface. Its main application is to avoid the propagation of microcracks from a surface. Such cracks do not propagate in a material that is under a compressive stress; shot peening can create such a stress in the surface.

Shot peening is often called for in aircraft repairs to relieve tensile stresses built up in the grinding process and replace them with beneficial compressive stresses. Depending on the part geometry, part material, shot material, shot quality, shot intensity, and shot coverage, shot peening can increase fatigue life up to 1000%.

Plastic deformation induces a residual compressive stress in a peened surface, along with tensile stress in the interior. Surface compressive stresses confer resistance to metal fatigue and to some forms of stress corrosion. The tensile stresses deep in the part are not as problematic as tensile stresses on the surface because cracks are less likely to start in the interior.

A study done through the SAE Fatigue Design and Evaluation Committee showed what shot peening can do for welds compared to welds that didn't have this operation done. The study claimed that the regular welds would fail after 250,000 cycles when welds that had been shot peened would fail after 2.5 million cycles, and that failure would occur outside of the weld area. This is part of the reason that shot peening is a popular operation with aerospace parts. However, the beneficial prestresses can anneal out at higher temperatures.

6 MECHANICALPROPERTIES

6.1 TENSILE TESTING

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The material is then tested for measuring the depth of penetration, presence of cracks in the weld area and keyhole in the welded portion. Tensile studies attested that all the tensile failures occurred at the fusion zone for all the cases (Fig. although the average hardness of the parent metal and the fusion zone of the weldments exhibited almost same values. The formation of coarse ferritic grains along with the widmanstätten austenite would be a reason for the failure occurring at the weld zones. Similar observations were reported by the authors in the earlier studies [18]. However, the tensile properties of the A-TIG welds are satisfactory as the values are similar or nearer to parent metal. It is evident from the studies that SiO2flux weldments resulted in better average tensile strength (833.5 MPa) compared to other fluxes

6.2 PROCESS

The test process involves placing the test specimen in the testing machine and slowly extending it until it fractures. During this process, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample. The elongation measurement is used to calculate the engineering strain, ε, using the following equation:

$E = \Delta L / L_0 = L - L_0 / L_0$

where ΔL is the change in gauge length, L_0 is the initial gauge length, and L is the final length. The force measurement is used to calculate the engineering stress, σ, using the following equation:

$\text{Stress} = F_n / A$

where F is the tensile force and A is the nominal cross-section of the specimen. The machine does these calculations as the force increases, so that the data points can be graphed into a stress–strain curve.

6.3 TENSILE SPECIMEN

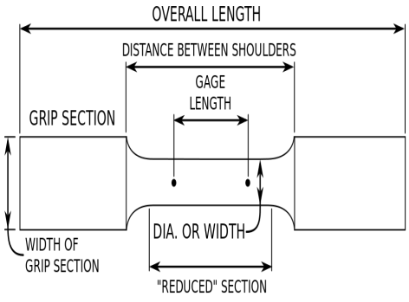

Figure 6.3 Tensile Diagram

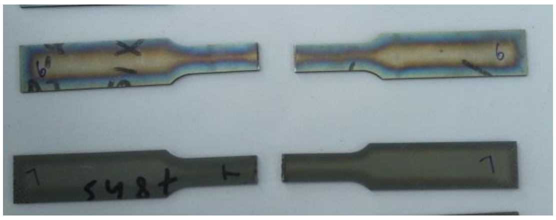

Figure 6.3.1Tensile specimen

6.4 BENDING TEST

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The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. It is often used as a quality control test for butt-welded joints, having the advantage of simplicity of both test piece and equipment.

6.5 PROCEDURE

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No expensive test equipment is needed, test specimens are easily prepared and the test can, if required, be carried out on the shop floor as a quality control test to ensure consistency in production.The bend test uses a coupon that is bent in three points bending to a specified angle.

The outside of the bend is extensively plastically deformed so that any defects in, or embrittlement of, the material will be revealed by the premature failure of the coupon.The bend test may be free formed or guided.The guided bend test is where the coupon is wrapped around a former of a specified diameter and is the type of test specified in the welding procedure and welder qualification specifications. For example, it may be a requirement in ASME IX, ISO 9606 and ISO 15614 Part 1.

As the guided bend test is the only form of bend test specified in welding qualification specifications it is the only one that will be dealt with in this article.The strain applied to the specimen depends on the diameter of the former around which the coupon is bent and this is related to the thickness of the coupon 't', normally expressed as a multiple of 't' egg 3t,etc.

Figure 6.5.1 Universal Bending machine

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Figure 6.5.2 Bending specimen

7. CONCLUSION

Bead on trial studies inferred that the use of oxide surfactant increased the depth of penetration and reduced the bead width considerably compared to the ones without flux addition. The depth of penetration enhances with a rise in the welding current while employing SiO2 flux as surfactant. 3Successful, defect-free welds of 5 mm thick plates of Ti-6Al-4 V could be established by employing double sided, activated flux TIG welding. Both the fine grained and coarse grained heat affected zones were observed in the weldments owing to the double passes. The formation of α’ structure of long narrow martensitic needles with α platelets and Widmanstätten α in the prior β grain boundaries were observed in the fusion zone. A slight formation of basketweave appearance in the fusion zone attested that ATIG welding employs moderate cooling rates and heat input. 6 The presence of prior β grain boundaries lowered the tensile ductility of the weldments; however the tensile strength of the welds is observed to be superior than the base metal, owing to the persistence of acicular α′ and Widmanstätten α platelets

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