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Evaluation of Tensile Properties of Stainless-Steel Welded Joints

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KEYWORDS

Arc welding, Universal testing machine, butt joint, stainless steel, Metal engravers, tensile strength, Amplitude, Frequency, impact strength, flexural strength, hardness test, crack analysis.

ABSTRACT:

Residual stress in welded materials is a significant challenge for researchers today. Techniques like heat treatment and shot peening can reduce residual stress but require specialized equipment and time. Recently, vibration has been explored as a way to lower residual stress in welds. The goal of this work is to improve the mechanical properties of arc welded joints, including tensile strength, hardness, impact, and flexural strength, by applying vibrations during welding. When joining similar materials by arc welding, different requirements must be met. The first case characterizes welding two pieces to form a butt joint when vibration is applied to the material itself but not the electrode holder. The second case is welding with vibration on the electrode holder but not the material. The third case has vibration on both the material and electrode holder during welding. Frequencies are tuned so vibrations can be selectively applied. After welding, the joint undergoes mechanical testing. Tensile and flexural strength are measured with universal testing equipment. The tensile test determines strength and elongation capacity. Yield and ultimate tensile strengths are also obtained. Input vibration parameters like amplitude and frequency are used to develop regression equations that predict the mechanical properties of the welded joint. This analysis relates vibration inputs to outputs like joint tensile strength.

1. INTRODUCTION

Welding joins materials by applying heat, pressure, or both. Industries like construction, automotive, aerospace, and manufacturing use welding to fuse metal or thermoplastic parts[1]. The welding process requires equipment like a welding machine, electrodes, gas, or filler material depending on the technique.

The most common welding joint types each have advantages and disadvantages. Butt joints, where two materials meet end-to-end, produce strong homogeneous connections when welded on both sides [2]. Lap joints overlap and weld materials on one side for security. T-joints weld materials at right angles, either on one or both sides depending on needs. Corner joints, welded on both sides, ensure strong consistent links. Edge joints weld parallel materials on one or both sides for strength. Groove joints have channels to be filled with welding material, forming robust unified connections [3]. Various welding techniques are used each with pros and cons. The most popular are MIG, TIG, stick, flux-cored, submerged arc (SAW), gas, laser, and ultrasonic [4]. MIG uses a consumable wire electrode and welding gun to join thin and thick metals for construction and automotive. TIG utilizes a non-consumable tungsten electrode for precise, high-quality welds in aerospace, automotive, and medicine [5]. Stick welding's flux-coated consumable electrode makes it versatile for heavy metals in construction and maintenance. Flux-cored uses electrode wire filled with flux for semi-automatic welding of thick metals in construction and ships. SAW's deep penetration welds employ granular flux protection ideal for thick manufacturing and construction metals [6]. Older gas welding remains flexible using oxygen and acetylene for automotive and plumbing. Laser welding utilizes focused high-power lasers for precision welds in

aerospace, medicine, and electronics. Automotive, medical, and packaging benefits from ultrasonic welding of materials through high-frequency vibrations [7]. The weld joint type affects a structure's vibration resistance when welding components that will vibrate during use. Different joints transfer loads differently, impacting resistance. Butt joints, joining components end-to-end, are prone to cracking or bending under vibration due to stress concentrations at the weld. Lap joints overlap components and have more contact area, making them less vibration-sensitive than butt joints, unless misaligned. Corner joints, joining components at right angles, can also crack or bend under vibration due to geometry-induced stresses. T-joints join one part perpendicular to another; with greater contact area than corners, they had better resist vibration unless misaligned. Vibrations in welding joints can result from certain welding conditions and equipment. The design, process, and parameters all play a role in vibrations. Mechanical vibrations from misalignment, imbalance, or worn parts add damaging stress. Rapid expansion and contraction of the weld puddle leads to acoustic distortions. Electromagnetic vibrations from high-frequency welding may also deform welds. Heating and cooling the metal causes thermal expansion and contraction that can warp or break joints. To reduce harmful vibrations when using vibration welding equipment, proper design, setup, and parameters are critical. Monitoring and mitigating mechanical, acoustic, electromagnetic, and thermal vibrations enables high-quality welds.

Vibrations can severely damage welded joints. Both mechanical and metallurgical vibrations negatively impact welded connections in various ways. Mechanical vibrations reduce joint strength, flexibility, and durability by creating porosity, lack of fusion, and cracks. They also damage the fit and function of the joint. Metallurgical vibrations alter the microstructure and characteristics of the weld metal and heat-affected zone. This changes the mechanical properties of the joint. Vibrations affect weld cooling as well, which impacts heat-affected zone hardness and durability. The frequency, intensity, range of vibrations, welding process, joint design, and materials being welded all influence the degree of damage to welded joints. The occurrence, sufficiency, and duration of vibrations, as well as the welding method, boundaries, and materials, affect welded connections. The impact of vibrations on welded joints depends on their frequency[13]. High-recurrence vibrations may induce tiny cracks and abnormalities in the welded joint, whereas low-recurrence vibrations can mutilate and prevent combination. The amount of vibrations also affects welded joints. Higher abundance vibrations may induce larger welded joint deformities, whereas lower sufficiency vibrations may not. The impact of vibrations on welded joints is also determined by vibrations. Longer vibrations may create massive abnormalities in the welded joint, whereas shorter spans may not. Vibrations on welded connections may also be affected by welding methods and limits. Some welding methods, such as gas tungsten circular segment welding (gtaw), may be more vibration-sensitive [14]. Vibrations on welded connections may also be affected by welding limits like speed and intensity. Welding materials also affect joint vibrations. Aluminum and titanium amalgams may be more sensitive to vibrations. There are many ways to reduce welded point vibrations. Using a vibration-damping substance between the welding hardware and workpiece is preferable. Vibration-damping materials absorb and disperse vibration energy to reduce effects on welded joints. Typical vibration-damping materials include elastic, foamy, and viscoelastic. Welding installations or dances may reduce the effects of vibrations on welded connections. Welding equipment and methods maintain the workpiece steady during welding, reducing bending and vibration-related flaws[15]. In addition to vibration-damping materials and welding setups, other methods may reduce the effects of vibrations on welded connections. Reducing welding speed or increasing intensity may reduce joint vibrations. Using a lower-recurrence welding method or one with reduced electromagnetic impedance may also reduce the effects of vibrations on welded joints.

Welding joins metal parts together. Heating metal pieces to melting point and connecting them with filler material is welding. The welding process includes preparation, tack welding, welding, and post-welding[16]. To ensure good welding, the arranging step involves cleaning and aligning the metal parts. Tack welding uses tiny, intermittent welds to join metal parts. The welding step uses filler material to unite metal components. The final steps include cleaning and examining the welded junction for flaws. The quality and durability of buildings with welded joints rely on the junction type. An incorrectly welded junction may

cause structural collapse and disaster. The design of welding gear or the usage of vibrating equipment might induce vibrations during welding. Vibrations may be broadly classified as exterior and inside. Welding gear development causes outside vibrations[17]. Variables including welding machine development, workpiece development, and vibrating instrument use might cause outside vibrations. External vibrations may cause the liquid metal stream to flow erratically, causing porosity, lack of combination, and other welding failures. Inner vibrations occur within the welding gear or workpiece. Inside vibrations may be caused by the electromagnetic field created during welding, the cathode or welding wire vibration, or the workpiece vibration due to heated development and withdrawal. Internal vibrations may create tiny cracks, twisting, and other abnormalities in the welded joint. Both outward and inside vibrations may be grouped by frequency, quantity, and duration. Recurrence is the number of vibrations per unit time, usually expressed in hertz[18]. Vibration size, measured in mm or µm, and duration, measured in flashes or milliseconds are used to describe vibrations. Comparable metal weld connections combine metal parts with comparable compositions. Heating metals to their melting temperatures and fusing them creates a strong connection. T-joints, lap joints, and butt joints are comparable metal weld joints. Butt joints are made by attaching two flat metal pieces end-to-end, whereas lap joints are made by welding their overlaps[19]. T-joints are made by fusing metal pieces perpendicularly. Similar metal weld joints are used in automotive, construction, and manufacturing owing to their many benefits. High strength and durability make them ideal for structural integrity applications. Similar metal weld joints increase material efficiency and waste minimization. However, because metals have varying melting temperatures and react differently during welding, they must be of identical composition[20]. Metal incompatibility may degrade connections and welds. Proper preparation and testing are necessary for good weld junctions.

2. MATERIALS AND METHODOLOGY

2.1 Materials:

Stainless steel is used in medical and home equipment. Its durability, corrosion, and stain resistance, and ease of cleaning make it ideal for industrial and commercial use. Iron, carbon, and 10.5% chromium produce stainless steel[21]. Chromium oxide protects steel against corrosion. By limiting steel interactions with the environment, this layer avoids corrosion and rust. Use determines stainless-steel alloy chromium content. Nickel, molybdenum, and titanium may enhance stainless steel in addition to chromium[22]. Stainless steel is used in many industries due to its flexibility and durability. Its corrosion resistance, strength, and durability make it perfect for construction, automotive, and medical applications. Food preparation and medical facilities benefit from stainless steel's cleanliness and simplicity of cleaning. Its modern, sleek appearance makes it an attractive architectural and decorative material. Heat resistance keeps stainless steel structurally sound at high temperatures. Its properties make it perfect for heat exchangers and boilers. Stainless steel costs more initially, but its long lifespan and little maintenance make it cost-effective. It reduces replacements. Galvanic corrosion and differential thermal expansion resistance favor stainless steel. With the right procedure, metal joins may endure [23].

2.1.1. Types Of Stainless Steel:

Each stainless-steel kind has unique properties. Austenitic, ferritic, martensitic, duplex, precipitation hardening, and high-temperature stainless steel dominate. Iron, chromium, and nickel make up about 70% of stainless steel. Its corrosion resistance and ductility make it ideal for food and beverage processing, kitchen equipment, and architecture. Ferritic stainless steel has poorer ductility and corrosion resistance than austenitic due to greater chromium and lower carbon. Automotive catalytic converters exhaust systems, and architecture employ it. Martensitic stainless steel, the strongest and hardest, has more carbon and less chromium than austenitic and ferritic. Surgical and cutlery tools utilize it[24]. Both austenitic and ferritic duplex stainless steel are two-phase. Strength and corrosion resistance make it useful for chemical processing, oil and gas, and marine applications. Heated precipitation- hardening stainless steel with high chromium, nickel, and copper content may strengthen and harden. In aerospace, military, and medical implant manufacture. High-chromium, nickel, and alloyed stainless steel can withstand heat. Uses include gas turbines, heat exchangers, and high temperatures. Application-specific stainless steel choice requires knowledge of its differences. Strong,

corrosion-resistant stainless steel is easy to clean. It resists corrosion and stains, making it perfect for culinary and outdoor applications. Steel's strength and durability make it useful in building, automobile, and medical equipment. Food preparation and medical applications are easier to clean with stainless steel's flat surface. Chemical processing labs and industries like its chemical durability. Flexible stainless steel has many industrial and commercial uses. Its remarkable durability, corrosion resistance, and cleaning simplicity make it excellent for many applications. Stainless steel will become more prevalent as use and manufacture improve [25].

2.2 Methodology:

2.2.1 Tensile Test:

Tensile mechanical tests evaluate material strength and behavior. Pressing repeatedly breaks samples. Results may reveal ultimate tensile, yield, ductility, and elastic modulus. The goal, equipment, process, and results of tensile testing are addressed. Uniaxial tensile testing measures strength, elasticity, and ductility. With data, engineers may improve structures and components. Tensile-tested metals, polymers, rubber, composites, and textiles. Universal equipment, specimens, and load cells are required for tensile testing. The tensile force from the testing machine to the specimen is measured using load cells. The specimen is usually a gauge-length cylindrical or rectangular bar. The measured sample length is gauge. Test stress depends on specimen's cross-sectional area. Test equipment force and specimen elongation are recorded in manuals or software. Make tensile samples. Standardized samples. During testing, a gauge length extensometer measures gauge length, cross-sectional area, and sample elongation Grip grips prevent specimens from slipping in testing equipment. Test equipment gently loads. This specimen is loaded till breaking. We test force and elongation. We measure ultimate tensile, yield, ductility, and elastic modulus. The stress-strain curve shows material behavior under tension [26].

Check material mechanical parameters, especially ultimate tensile strength. UTS is the material's maximum stress before breaking. UTS forces per area are psi/MPa. The yield strength—the stress at which the material deforms plastically or irreversibly—can be calculated. MPa/psi results. Bend before breaking to test ductility. % elongation or cross-sectional area decrease measures sample ductility. Finally, measure stiffness or stress-induced deformation using elastic modulus. Psi or MPa measures elastic modulus.

Finally, the tensile test evaluates mechanical characteristics under tension. This data helps engineers improve components and structures. Material mechanical characteristics are established through specimen preparation, testing equipment installation, force increase, and data processing. Tensile testing is used in Many industries such as ,Helps pick application-specific materials. Various forces may predict material performance. Testing confirms material compliance with specifications, contracts, and standards. Tensile testing validates product concepts and finds patented features [27]. Quality assurance data lets scientists and engineers compare material possibilities. Finally, tensile testing shows court case material use [36-43].

3. EXPERIMENTAL SETUP AND PROCEDURE

3.1 Experimental Setup:

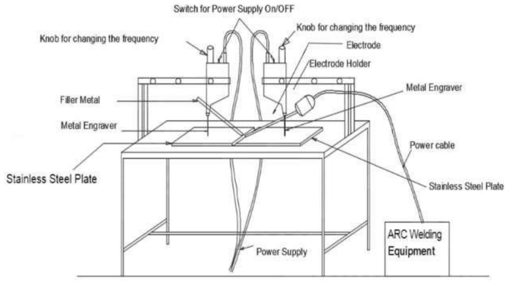

Figure 1 shows the schematic diagram of vibration equipment setup

Experimental Set up Explanation:

1. Setup table
2. Stainless steel plates (2)
3. Tig welding equipment
4. Vibration tester
5. Power supply for the metal engraver
6. Electrode holder
7. Tungsten electrode
8. Metal engraver (2)
9. Filler metal
10. Knob for changing frequency.
11. Switch for power on/off
12. Power cable of the welding equipment

3.1.2 Experimental Procedure:

Many welding procedures link materials. Butt welding joined two stainless steel plates in this investigation. We ground one side of each plate 45 degrees to allow butt welding. Vibratory conditions were studied during butt-welding. This research employed 300*100*5 stainless steel plates for weld specimens [28]. To provide vibrations to welding, two metal engravers were linked to each setup table beams. These metal engravers use electro-dynamic force to translate electrical information into mechanical vibrations. To allow welding, the stainless-steel plates were placed on the setup table base with one end ground at a 45-degree angle. The welding equipment was configured for temperature, voltage, wattage, and other parameters. Earth clamp was connected to table, and electrode was fastened to electrode holder. Next, both metal engravers were powered and turned on. To generate the appropriate vibration, metal engravers' frequencies were modified using knobs. After the metal engravers vibrated the stainless-steel plates, the welding equipment was turned on and exact readings were established for welding the two plates. Plates were vibrated during welding. A vibration tester recorded amplitude, frequency, and velocity simultaneously [44-51].

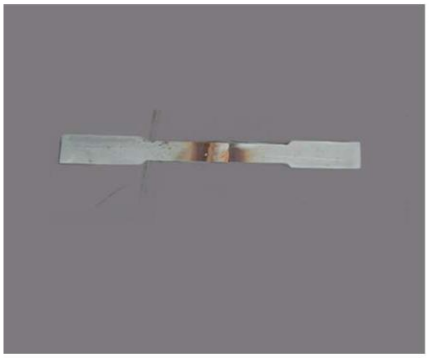

Figure-3 tensile test specimen.

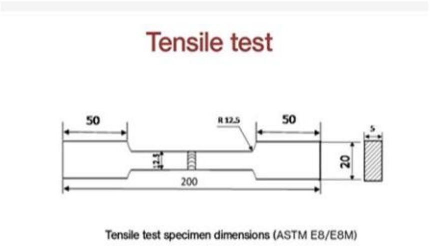

Figure-4 specimen dimensions

3.2 Test Conducted:

3.2.1 Tensile test on universal Testing Machine:

Universal tensile exam Universal tensile testers have loading and control units. The loading unit arranges and loads the test specimen while the control unit monitors load variation and outcomes. Figure shows the left loading unit table and crosshead. The control unit should show load. This loading apparatus has an elongation scale, load frame, and higher and lower crossheads[29]. The load frame has a table, upper and lower crossheads, and single or double support. Higher crosshead clamps one test specimen end, while lower is height adjustable. Two tapered slot and racking jaw crossheads catch tensile test specimens. Upper and lower table elongation scales assess movement. Control devices, hydraulic power, and load measurement are in the control unit. The hydraulic power unit's oil pump supplies non-pulsating oil to the load unit's main cylinder for smooth load application. Electric motor and sump power oil pump. It measures load using an oil-powered pendulum dynamometer and tiny cylinder and piston. When the pivot lever deflects around the piston, a load pointer shows the specimen's load. A load measurement unit knob regulates load application range, impacting machine precision.

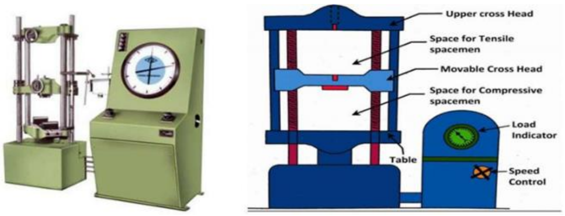

Figure-5 Shows Universal Testing Machine (UTM)

Controls are hydraulic or electric. Electric devices employ switches to move crossheads and regulate the unit, whereas hydraulic systems use right and left control valves or release valves for load application and release The loading unit, control unit, and other components apply and measure load during a universal testing machine tensile test .The Universal Testing Machine (UTM) serves as a crucial tool for evaluating the mechanical properties of various materials. It includes a variety of standard tests, such as tensile, compression, adhesion, pull-out, bending, hysteresis, fatigue, and flexural tests. These tests enable researchers and engineers to assess the behavior and performance of materials under various loading conditions. Figure 5 shows the Components of UTM [30].

4. RESULTS AND DISCUSSIONS

4.1 Work piece - Amplitude Vs Tensile Test Result:

Y = c (0) + c (1)*x +
c (2)*x^2 + ...
Coefficients
C (00) = 403.843620693
C (01) = 1397.90960921
C (02) = -2707.21199608
C (03) = 1423.00131719
Correlation coefficient is 0.99537728605, standard error about the line = 2.27651516279

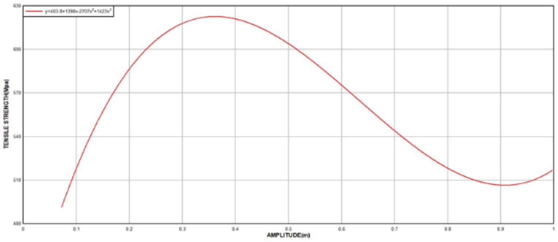

Figure: 6 Graph Represent The Relationship Between Amplitude (M) And Tensile Strength (MPa) of work piece.

As the amplitude increases, the tensile strength of the work piece also increases. The percentage improvement in tensile strength is 0.20967%[31]. The initial percentage improvement is highest at an amplitude of 0.35m and a tensile strength of 620 MPa. At the final amplitude of 0.875m, the percentage improvement in tensile strength is 0.02127% at a tensile strength of 500.65 MPa.

4.2 Electrode - Amplitude Vs Tensile Test Results:

Y = c (0) + c (1)*x +
c (2)*x^2 + ...
Coefficients
C (00) = -635.756889361
C (01) = 22531.5754881
C (02) = -166236.367338
C (03) = 546852.676007
C (04) = -664039.052184
Correlation coefficient is 0.9972459383, standard error about the line = 1.58828941309

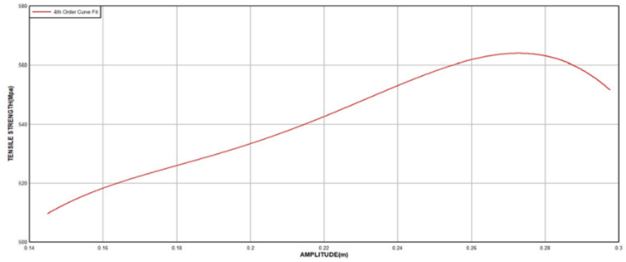

Figure: 7 Graph Represent The Relationship Between Amplitude (M) And Tensile Strength (MPa) of Electrode.

On the electrode, as the amplitude increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.097345% [32]. The initial percentage improvement is highest at an amplitude of 0.27 m and a tensile strength of 565 MPa. At the final amplitude of 0.295m, the percentage improvement in tensile strength is 0.03773% at a tensile strength of 530 MPa.

4.3 M2 – V1, V2, V3 Amplitude Vs Tensile Test Results:

Y = c (0) + c (1)*x + c (2)*x^2 +...
C (00) = -338067.854115
C (01) = 5565649.84574
C (02) = -34296866.6634
C (03) = 93903068.2172
C(04) = -96377124.2971
Correlation coefficient is 0.994696628674
Standard error about the line = 0.370704054469

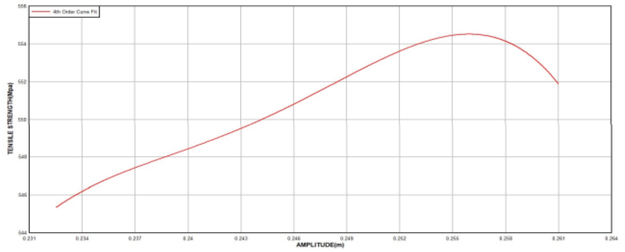

Figure: 8 Graph Represent The Relationship Between Amplitude (M) And Tensile Strength (MPa) of M2 – V1, V2, V3.

When the amplitude increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.06593%. The initial percentage improvement is highest at an amplitude of 0.315 m and a tensile strength of 584 MPa. At the final amplitude 0.33125m [33],the percentage improvement in tensile strength is 0.02763% at tensile strength of 561MPa.

4.4 M4- V1, V2, V3 Amplitude Vs Tensile Test Results:

Y = c(0) + c(1)*x + c(2)*x^2 + ...
Coefficients
C(00) = 82234.1814316
C(01) = -662756.961559
C(02) = 1787867.06362
C(03) = -1604730.55927
Correlation coefficient is 0.995567000804, Standard error about the line = 0.971490834285

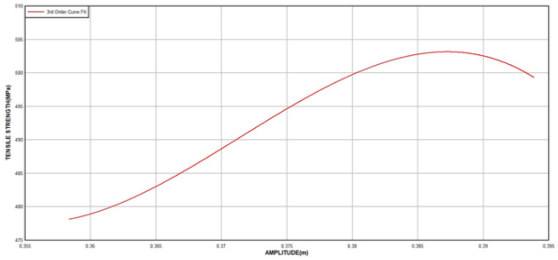

Figure:9 Graph Represent The Relationship Between Amplitude (M) And Tensile Strength (MPa) of M4 – V1, V2, V3.

When the amplitude increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.049204% . The initial percentage improvement is maximum at an amplitude of 0.3875m and a tensile strength of 503MPa[34]. At the final amplitude of 0.39375 m, the percentage improvement in tensile strength is 0.04206% at a tensile strength of 499.25 MPa.

4.5 M6- V1, V2, V3 Amplitude Vs Tensile Test Results:

Amplitude vs tensile strength

Y = c(0) + c(1)*x + c(2)*x^2 + ...
Coefficients
C(00) = 18033.8817968
C(01) = -203001.668042
C(02) = 782292.571511
C(03) = -1002779.84336
Correlation coefficient is 0.990436896568, Standard error about the line = 0.381793136019

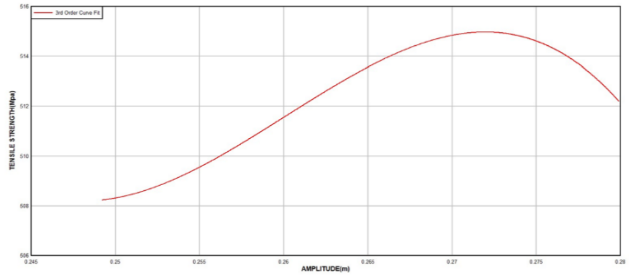

Figure: 10 Graph Represent The Relationship Between Amplitude (M) And Tensile Strength (MPa) of M6– V1, V2, V3.

When the amplitude increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.012621%. The initial percentage improvement is highest at an amplitude of 0.2725 m and a tensile strength of 515 MPa. At the final amplitude of 0.279375 m, the percentage improvement in tensile strength is 0.007804%[35], with a tensile strength of 512.5 MPa.

4.6 Work Piece Frequency Vs Tensile Test Results:

Y = c(0) + c(1)*x + c(2)*x^2 + ...
Coefficients
C(00) = -57425.2198895
C(01) = 45190.6172762
C(02) = -13207.3984438
C(03) = 1712.66593474
C(04) = -83.0626735366
Correlation coefficient is 0.994925586382, standard error about the line = 2.18985818348

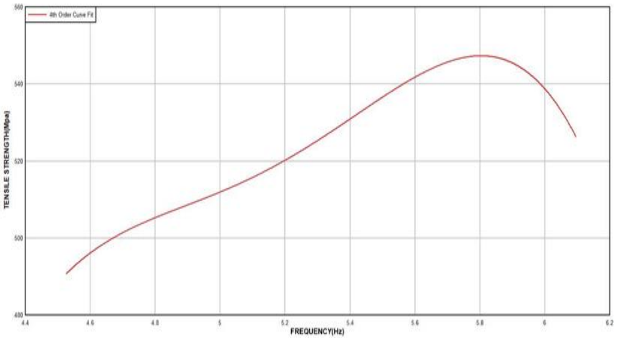

Figure: 11 Graph Represent The Relationship Between Frequency (Hz) And Tensile Strength (MPa) of work piece.

As the frequency increases, the tensile strength of the workpiece also increases. The percentage

improvement in tensile strength is 0.10091%. The initial percentage improvement is maximum at a frequency of 5.8Hz, with a tensile strength of 545 MPa. At the final frequency of 6.1 Hz, the percentage improvement in tensile strength is 0.06666%, with a tensile strength of 525 MPa[31].

4.7 Electrode-Frequency Vs Tensile Test Results:

Y = c(0) + c(1)*x + c(2)*x^2 + ...
Coefficients
C(00) = 499.289190119
C(01) = 0.245335834482
C(02) = -0.000953722165476
C(03) = 2.27172350262e-006
C(04) = -1.77483718544e-009

Correlation coefficient is 0.997246042637, standard error about the line = 1.58825936828

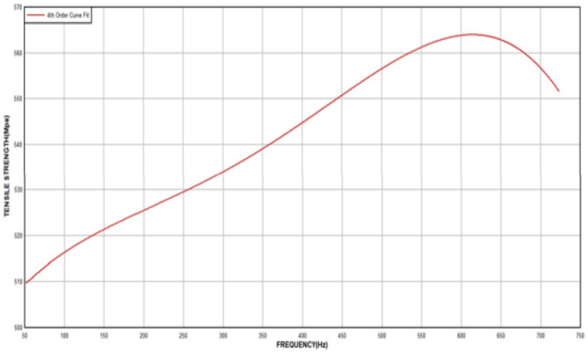

Figure: 12 Graph Represent The Relationship Between Frequency (Hz) And Tensile Strength (MPa) of Electrode.

As the frequency increases, the tensile strength on the electrode also increases. The percentage improvement in tensile strength is 0.114260%, As initial percentage improvement is maximum at frequency 625Hz and tensile strength at 564.5MPa. At the final frequency 724.5Hz[32] ,the percentage improvement in tensile strength is 0.094202% at tensile strength 552MPa.

4.8 M2-V1, V2, V3 Frequency Vs Tensile Test Results:

Y = c(0) + c(1)*x + c(2)*x^2 + ...
Coefficient
C (00) = 2128.30516328
C (01) = -3.83435352932
C (02) = 0.00306760678682
C (03) = -8.08735423287e-007

Correlation coefficient is 0.991430457967, Standard error about the line = 0.414927419365

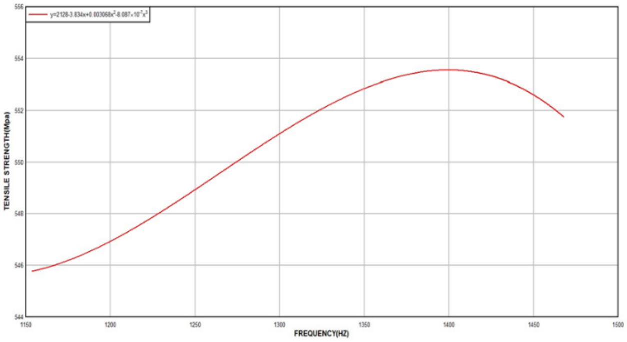

Figure: 13 Graph Represent The Relationship Between Frequency (Hz) And Tensile Strength (MPa) of M2– V1, V2, V3.

As frequency increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.013640%. The initial percentage improvement is maximum at a frequency of 1400 Hz, with a tensile strength of 553.5 MPa[33]. At the final frequency 1470 Hz, the percentage improvement in tensile strength is 0.01087% at tensile strength 551.95 MPa.

4.9 M4- V1, V2, V3 -Frequency Vs Tensile Test Results:

Frequency vs tensile strength
Y = c(0) + c(1)*x + c(2)*x^2

+ ...
Coefficients
C(00) = 813.390284607
C(01) = -1.3671791618
C(02) = 0.00177996338733
C(03) = -7.2333698314e-007
Correlation coefficient is 0.995567000805, Standard error about the line = 0.971490834158

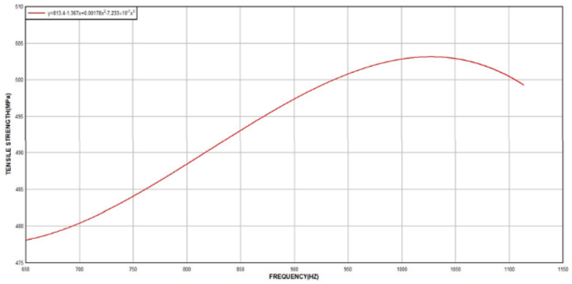

Figure: 13 Graph Represent The Relationship Between Frequency (Hz) And Tensile Strength (MPa) of M4– V1, V2, V3.

When the frequency increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.051536% [34]. The initial percentage improvement is maximum at a frequency of 1025Hz and a tensile strength of 504.5MPa. At the final frequency of 1112.5 Hz, the percentage improvement in tensile strength is 0.042521% with a tensile strength of 499.75 MPa.

4.10 M6- V1, V2, V3 Frequency Vs Tensile Test Results:

Y = c (0) + c (1)*x + c (2)*x^2 + ...
Coefficients
C (00) = 731764.833018
C (01) = -1319.55614027
C (02) = 0.793579747609
C (03) = -0.000159058163813
Correlation coefficient is 0.99043555879, Standard error about the line = 0.381819711185

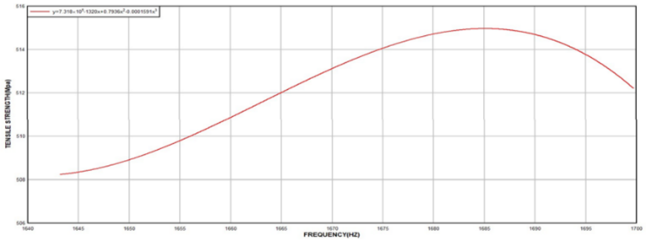

Figure: 11 Graph Represent the Relationship between Frequency (Hz) And Tensile Strength (MPa) of work piece.

When the frequency increases, the tensile strength also increases. As the frequency increases, the tensile strength also increases. The percentage improvement in tensile strength is 0.01258% [35]. The initial percentage improvement is highest at a frequency of 1685 Hz and a tensile strength of 515 MPa. At the final frequency of 1699 Hz, the percentage improvement in tensile strength is 0.007281%, with a tensile strength of 512.25 MPa [52-61].

5. Conclusion

To improve the mechanical properties of welded connections in similar metals, an experimental setup arc welded stainless steel under mechanical vibrations. Examined workpiece, electrode, or both vibrations. Test samples from stainless-steel plate were cut to size using water jet cutting. Increases welded joint mechanical characteristics under mechanical vibrations. Arc-welds stainless-steel under mechanical vibrations on the material and setup. Three conditions: work piece, electrode, both. Workpiece Frequency increases tensile strength. Electrode tensile strength increases with amplitude. Sample tensile testing yielded results. Data analysis and graphing using mechanical parameters employed amplitude and frequency. Tensile, yield, and ultimate tensile strength percentage gains were calculated for each condition. Tensile, yield, and ultimate strengths rose with frequency and amplitude. The initial percentage gain was greatest at certain amplitudes and frequencies, whereas the final percentage improvement was calculated elsewhere.

Work piece Tensile strength rises with frequency. Initial % increase is highest at amplitude 0.35m and tensile strength 620 MPa, therefore 0.20967 is the percentage improvement. At 500.65 MPa, the percentage gain in tensile strength at ultimate amplitude 0.875m is 0.02127.

As amplitude increases on the electrode, tensile strength likewise rises. Tensile strength improved 0.097345 percent. Initial percentage increase is highest at 0.27m amplitude and 565 MPa tensile strength. The percentage gain in tensile strength at 530 MPa is 0.03773 at final amplitude 0.295m.

- Tensile strength rises with amplitude. Initial percentage increase is highest at amplitude 0.315m and tensile strength 584MPa, therefore 0.06593 is the percentage improvement. The percentage gain in tensile strength at 561MPa is 0.02763 at the ultimate amplitude 0.33125m.
- Tensile strength rises with amplitude. As initial % increase is highest at amplitude 0.3875m and tensile strength 503MPa, the percentage improvement is 0.049204. The % gain in tensile strength at 499.25MPa is 0.04206 at the ultimate amplitude 0.39375m.
- Tensile strength rises with amplitude. The percentage gain in tensile strength is 0.012621, with a maximum at amplitude 0.2725m and 515 MPa. The percentage gain in tensile strength at 512.5 MPa is 0.007804 at the ultimate amplitude 0.279375m.
- Work piece tensile strength improves with frequency. 0.10091 percent tensile strength increase Initial percentage improvement is highest at 5.8Hz and 545 MPa. The resulting frequency 6.1Hz improves tensile strength by 0.06666 at 525 MPa.
- As frequency rises on electrodes, tensile strength increases. Initial tensile strength gain is highest at 625Hz and 564.5MPa, hence the percentage improvement is 0.114260. The resulting frequency 724.5Hz improves tensile strength by 0.094202 at 552MPa.
- Tensile strength rises with frequency. Initial tensile strength gain is highest at 1400Hz and 553.5MPa, hence the % improvement is 0.013640. The ultimate frequency 1470Hz improves tensile strength by 0.01087 at 551.95MPa.
- Tensile strength rises with frequency. Initial tensile strength gain is highest at 1025Hz and 504.5MPa, hence the % improvement is 0.051536. The resulting frequency 1112.5Hz improves tensile strength by 0.042521 at 499.75MPa.
- Tensile strength rises with frequency. Tensile strength rises with frequency. Tensile strength increased 0.0128, As first percentage improvement is highest at 1685Hz and 515MPa. The resulting frequency 1699Hz improves tensile strength by 0.007281 at 512.25MPa.

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