Hindawi
Journal of Nanomaterials
Volume 2023, Article ID 9879562, 1 page
https://doi.org/10.1155/2023/9879562

Retraction

Retracted: Influence of Heat-Treated and Vibratory-Assisted Weld Joints on the Mechanical Properties of 304L SS Material

Journal of Nanomaterials

Received 11 July 2023; Accepted 11 July 2023; Published 12 July 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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[1] M. C. Naidu, K. T. Balaram Padal, and G. Eshete, "Influence of Heat-Treated and Vibratory-Assisted Weld Joints on the Mechanical Properties of 304L SS Material," *Journal of Nanomaterials*, vol. 2022, Article ID 1000859, 9 pages, 2022.

Hindawi
Journal of Nanomaterials
Volume 2022, Article ID 1000859, 9 pages
https://doi.org/10.1155/2022/1000859

Research Article

Influence of Heat-Treated and Vibratory-Assisted Weld Joints on the Mechanical Properties of 304L SS Material

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Received 3 August 2022; Revised 22 August 2022; Accepted 3 September 2022; Published 26 September 2022

Academic Editor: Samson Jerold Samuel Chelladurai

Tensile and impact strengths of 304L SS stainless steel weldment prepared at different levels of heat treatments and with vibratory assistance were studied and compared with the conventional process of welding. The results reveal that the microstructures of weld joints after heat treatment and vibratory welded joints attained a fine grain structure, compared with the joints prepared with the conventional process of welding. By increasing the temperature of quenching and vibrations during welding, the grain size is gradually improving. Improvement in the tensile and impact is observed in the heat-treated and vibration-welded specimens. Similarity, in the weld joint properties of post weld heat treatment (PWHT) and vibratory-assisted welding (VAW) are observed. With the VAW technique, high quality weldments are produced and are more suitable than PWHT due to its less cost and time.

1. Introduction

Austenitic stainless steels are a potential material for future nuclear power reactors that will need to meet high structural integrity demands while operating under extreme conditions. Welded joints are crucial components in any installation because they are more likely to contain faults than the base metal, and their physical qualities can differ dramatically from those of a wrought material of nominally similar composition. Because of their superior deterioration resistance, weldability, and formability, austenitic stainless steels are frequently utilized in critical elements of chemical industries. Due to their exceptional robustness in high pressure and temperature sets, these are widely used in nuclear energy plants, gas turbines, and jet propellants [1–4].

"Submerged arc welding" is commonly used to join thick-wall stainless steels in ship construction and pipes [5, 6]. A solid-type filler material is mechanically put into dispersed granular flux in SAW. The flux melts when it comes into contact with the welding arc, and slag is formed that protects and covers the fused metal. In most cases, efficient joining is accomplished by passing current through a large diameter wire. This offers benefit of increasing productivity by allowing for quick solidification and enhancing quality weld by controlling weld heat [7].

Inhomogeneity of the microstructure, concentration of residual stress, brittleness, and worsening of toughness in the welded material are examples of microstructural and mechanical qualities [8]. PWHT (post weld heat treatment) is commonly used. Microstructural and mechanical qualities such as inhomogeneity of the microstructure, concentration of brittleness, deterioration and residual stress of toughness of the welded material are degraded as a result of the input heat [8]. To address such degradation, PWHT is commonly used. However, delta ferrite as a component in austenitic SS material is present, so embrittlement of the welded component may occur owing to post heat treatment transition into another brittle phase, such as the sigma phase. It is critical to

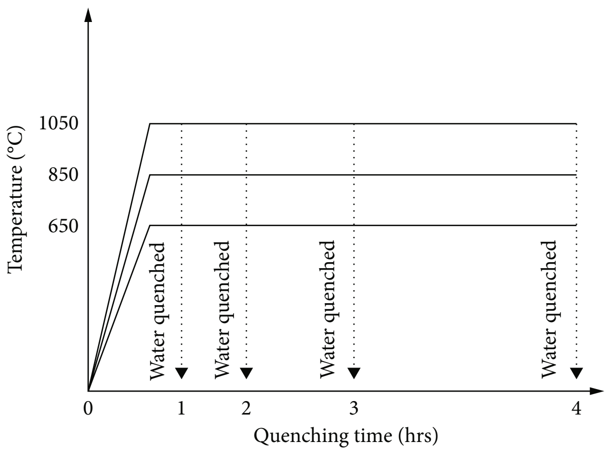


Figure 1: Temperatures vs. quenching time (heat treatment).

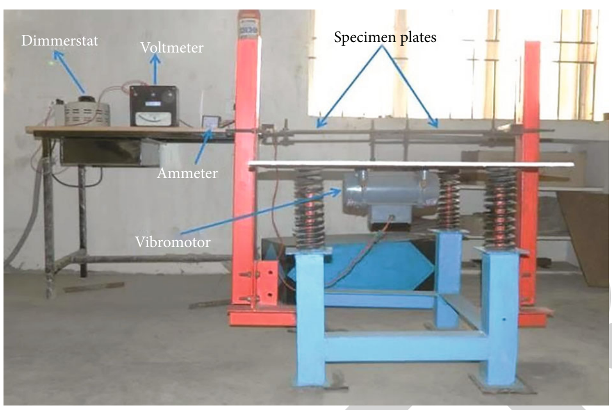


Figure 2: Experimental setup.

Table 1: Vibration factors in terms of vibromotor voltage.

S. no.	Vibromotor voltage (volts)	Frequency (Hz)	Acceleration (mm/sec^2)	Amplitude (mm)
1	50	6077	15.41	0.235
2	60	6159	16.90	0.240
3	70	6241	18.39	0.245
4	80	6323	19.88	0.250
5	90	6404	21.38	0.255
6	100	6486	22.87	0.260
7	110	6568	24.36	0.265
8	120	6649	25.85	0.270
9	130	6731	27.34	0.275
10	140	6813	28.83	0.280
11	150	6894	30.32	0.285
12	160	6976	32.7	0.290
13	170	7058	35.07	0.295
14	180	7139	37.44	0.300
15	190	7221	39.81	0.305
16	200	7303	42.18	0.310
17	210	7384	44.55	0.314
18	220	7466	46.92	0.319
19	230	7548	49.29	0.324

study post heat treatment processes to regulate the content of delta ferrite and hazardous carbides in order to alleviate these difficulties [9]. By homogenizing the weld specimen structure and limiting the production of favorable and hazardous phases, appropriate PWHT can progress mechanical qualities [10–13].

Similarly, the vibrational stress-relief procedure is adapted during welding, with nonresonant and resonant repeated loading process for mild steel of low alloy, and is considered to enhance mechanical characteristics like strength and hardness, but unfortunately, fatigue strength is reduced for the specimens welded with the cyclic loads of the nonresonant process, which shows a disadvantage of the technique [14]. Vibratory stress relief (VSR) is used on stainless-steel weld specimens that have a combined weight of over 34 tonnes and are being tested for cyclic stress and strain. At a resonance frequency of 47.83 Hz, the plate was treated for around 15 minutes. The efficiency of VSR is measured by the number of cycles and the level of dynamic stress. In terms of longitudinal residual stresses, the variations are around an 11% decrease [15]. In order to quantify the vibration energy influence on stress concentration in the heat-affected and weld zones, the "vibratory stress relief" approach is explained and compared to heat treatment. Vibrational stress relief can be used to reduce residual strains generated during the welding process, according to the findings of this study's X-ray diffraction [16].

The effect of residual stresses on the surface stress distribution was investigated using the vibrating stress alleviation method. The "VSR" technique is most typically used to reduce residual flaws in manufacturing processes, and changes in the internal structures are readily observable wherever the strengths of tensile, yield, and fatigue are increased, and the current technique is beneficial for high-end applications for appropriate outcomes [17]. SS plates are used as specimens for the VSR procedure in nuclear reactors. The results reveal that after using the VSR method, residual stress is reduced by roughly 56 percent for the hoist-machine and around 31 percent for the SS plate. It is a different method compared to heat treatment [18]. To evaluate the cyclic strain and stress, the VSR approach was simulated on 304L SS weld-work pieces under repeated loads. According to the experimental findings, cyclic creep physical characteristics are identified at dynamic stresses. Cyclic loading affects creep and its pace. The higher the loading, the faster the creep and the longer it takes for the strain to stabilize. The defects at the weld zone are determined with the X-ray diffraction process at a variety of cyclic amplitude stresses [19]. The result of inelastic body moment was investigated throughout vibratory welding at two frequencies (50 Hz and 500 Hz) to determine the differences in characteristics. With any trend at low frequency, the tensions for

Table 2: Chemical composition 304L SS.

Material grade	Weight % of chemical composition								
	Fe	C	Si	Mn	P	S	Cr	Ni	N
304L	71.045	0.03	0.75	2	0.045	0.03	18	8	0.1

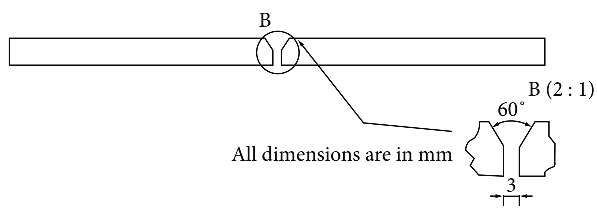


Figure 3: Specimen dimension for welding.

both directions (longitudinal and transverse) are decreased and increased. At peak frequencies, residual-stresses remained constant. As a result, the stiff body motion effect at higher frequencies is thought to be ineffective for reducing residual stress [20]. The diversity in residual stresses created during welding was assessed using a variety of shaft designs. The findings of this study reveal that shear stresses of torsional moment can be used to minimize shaft residual stresses by a moderate amount, that shear stress aids in the transfer of retained austenite to the following stages, and that it influences the amount of residual stresses induced by the effects of the interphase [21]. The vibration effect on the residual stresses induced by the welding process was examined. Vibrations were sent to them across a predetermined temperature range. Three batches are being looked into, each with a distinct temperature range. With no obvious movement, residual stresses were reported to be improved in all three batches. The actions appear to have undesired outcomes, and it is finished that excitations at 400°C and 320°C did not considerably influence the ultimate state of residual stresses, as these do not change significantly with the vibration curve [22].

The impact of vibratory stress on the weld's microstructure and stress distribution was examined. The results show that in the first 5 seconds of vibration, stress levels drop by roughly 75 MPa. The increase in vibrations did not result in a further drop in stress levels after post weld vibratory treatment, and optical microscopy reveals no alterations in the crystal structure. Because of the vibratory treatment, the crystals develop in a specified direction during welding. As a result of the grain refinement, the toughness of the weldment increased by 25% [23, 24]. The effects of transverse oscillation frequency and amplitude on mild-steel weldment characteristics are explored. The findings of excitations produced welds revealed that grain refinement, as seen in the micrograph, is the cause of improved mechanical qualities such as yield, breaking strength, and ultimate tensile strengths, among others.

Vibratory weld conditioning has a great impact on the mechanical characterization of the aluminum alloy weld joints. Hardness and ultimate tensile strength behavior of aluminum weldment was greatly influenced by the vibratory TIG welding. Mechanical properties of aluminum weldment were tested under the impact of voltage input to the vibromotor and time at which it is vibrated. Apart from the several vibratory TIG welding parameters, vibration amplitude is the one which has a significant impact on the weldment properties. Authors observed that in vibratory TIG welding, vibration amplitude improves the properties of weldment [25, 26]. In both thermal stress relief and vibratory thermal stress relief, residual stresses in aluminum 7075 alloys were examined. The outcomes were contrasted with the finite element models. The decrease of stresses was shown to be significantly impacted by the authors' discovery of the thermal vibratory stress alleviation approach. Heat vibratory stress-relieving techniques relieve tension at rates that are, respectively, 20.43 and 38.56 percent faster than those of thermal and vibratory methods.

The impact of vibration stress reduction on the steel butt-welded connections was studied by Ebrahimi et al. The findings showed that whenever the maximum stress frequency reaches its resonance frequency, lengthwise residual may be lowered more drastically. Additionally, the finite element approach was used to compare experimental findings with modeled outcomes, and it was shown that the simulations are often similar to the experimental outcomes [27].

The present study thus investigated the effect of PWHT and vibrational welding on the change of mechanical characteristics like ultimate tensile and impact strength of the welded part of 304L stainless steel produced through the SAW. The resultant effects on tensile and impact were discussed, and a comparison is made between conventional, PWHT, and vibratory-assisted welding.

2. Methodology and Materials

2.1. Post Weld Heat Treatment Process (PWHT). Arc welding was used to determine the hardness of 304L SS steels in this investigation. The shielded metal arc welding technique is used to attach two plates that are 20 mm wide, 200 mm long, and 5 mm thick.

To determine the resistance against indentation of 304L SS weld joints, post weld heat treatment was used at temperatures ranging from 650°C to 1050°C with a 200°C gap, as shown in Figure 1. The temperature variation is 60 min to 240 min, with a 60 min break between them. The created samples are quenched in cold water at each stage to determine the tensile and impact strength of the material at various temperatures and time breaks.

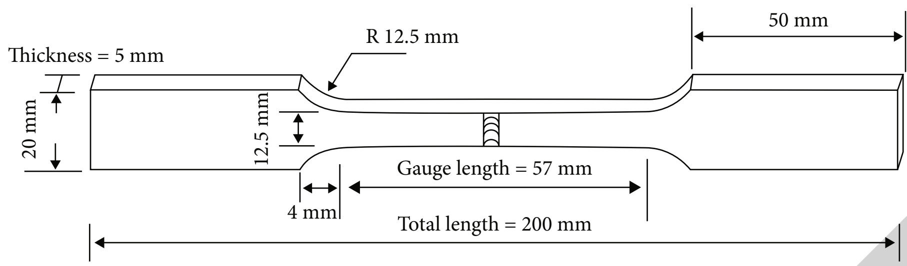


Figure 4: Line diagram of a tensile test specimen.

2.2. Vibratory-Assisted Welding. A table for placing the specimen was attached to four springs, one on each corner. The vibration table was equipped by adding a vibromotor to the vibratory table configuration. An ammeter, voltmeter, and dimmerstat were linked to the vibromotor to produce the vibrations. Figure 2 depicts the experimental setup. To increase the weld joint mechanical characteristics by giving constructive modifications in the microstructure of the weldment region, a supplemental vibratory setup capable of delivering mechanical excitations to the weld pool for "manual metal arc welding" is designed. Different frequencies were applied at varied amplitudes over the length of the weld bead, merely straggling behind the weld torch to physically stimulate the weld pool and generate the desired microstructural outcomes.

2.3. Vibration Parameters with respect to the Voltage of Vibromotor. This configuration generates the necessary frequency in terms of volts. At 70, 150, and 230 V, Table 1 shows the variations in amplitude and acceleration. Various vibration parameters with respect to the input voltage are shown in Figure 2.

Acceleration, frequency, and amplitude cyclically vary with respect to the different levels of voltage of vibration; the root mean square (rms) values of these parameters have been considered for better operating conditions. The frequency, amplitude, and acceleration of specimens have been measured by a vibration tester shown in Table 1. Specifications of the vibration tester are 10 Hz to 10 kHz frequency range, 0.01 to 4 mm amplitude range, and 0.1 to 400 mm/s^2 for measuring vibration parameters.

2.4. Materials and the Weld-Joint Preparation. The foundation material used in this investigation is 304L stainless steel with a thickness of 5 mm. "Carbon (C)–0.03%, manganese (Mn)–2%, phosphorus (P)–0.045%, sulphur (S)–0.03%, silicon (Si)–0.75%, chromium–18%, nickel (Ni)–8%, and nitrogen (N)–0.1%" are the material compositions, as indicated in Table 2. To test the characteristics of vibrations, the weld joints were produced according to standards. 304L stainless steel is utilized in a variety of manufacturing applications due to its excellent formability, strength, and resistance against corrosion. Samples were positioned over the flat surface of the vibration platform for weld joint preparation, and the manual arc welding procedure was used. By changing the dimmerstat and voltmeter during the welding operation, the proper quantities of vibrations were imparted to the specimens. The line diagram of specimen preparation before welding is shown in Figure 3. During the welding operation, vibrations were continuously conveyed to the molten pool.

The vibrations were measured with a vibrometer, which is a particular equipment. Every set of vibration's velocity, acceleration, and displacement is measured. Table 1 shows the various material compositions.

2.5. Tensile Test of Weldment. The tensile strength test is conducted using a universal tensile testing equipment by taking into account a number of variables such as welding current, vibration time to the fusion zone, and DC motor voltage. The dimensions of the test specimens are determined using ASTM D638 standards. Figure 4 depicts the dimensions of the test specimen according to industry standards.

Ultimate and yield strength destructive testing (tensile testing) is used to determine the ductility of metallic materials. It calculates the amount of force required to break the weldments. The extent to which the specimen elongates or expands up to the breaking point is illustrated in the equation below.

$$\epsilon = \frac{\Delta L}{L_0} = \frac{L - L_0}{L_0}, \tag{1}$$

where ΔL is the specimen change in length of the specimen, L_0 is the initial length, and L is the total length of the specimen.

The applied force which is employed on a particular area is supplied by the equation below in order to compute the stress (σ).

$$\sigma = \frac{F_n}{A} \tag{2}$$

2.6. Impact Test. The Charpy impact testing machine is used to perform the impact test on welded specimens. The specimens which were prepared according to ASTM (E23) are presented in Figure 5. The heavy weight pendulum is allowed to hit the specimen from a static height, and a specimen with a notch is introduced into the machine.

3. Results and Discussion

3.1. Tensile and Impact Strength of Heat-Treated Specimens. The samples were prepared in the absence of vibrations and

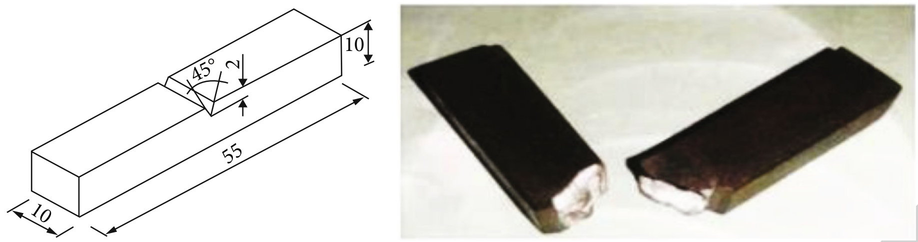
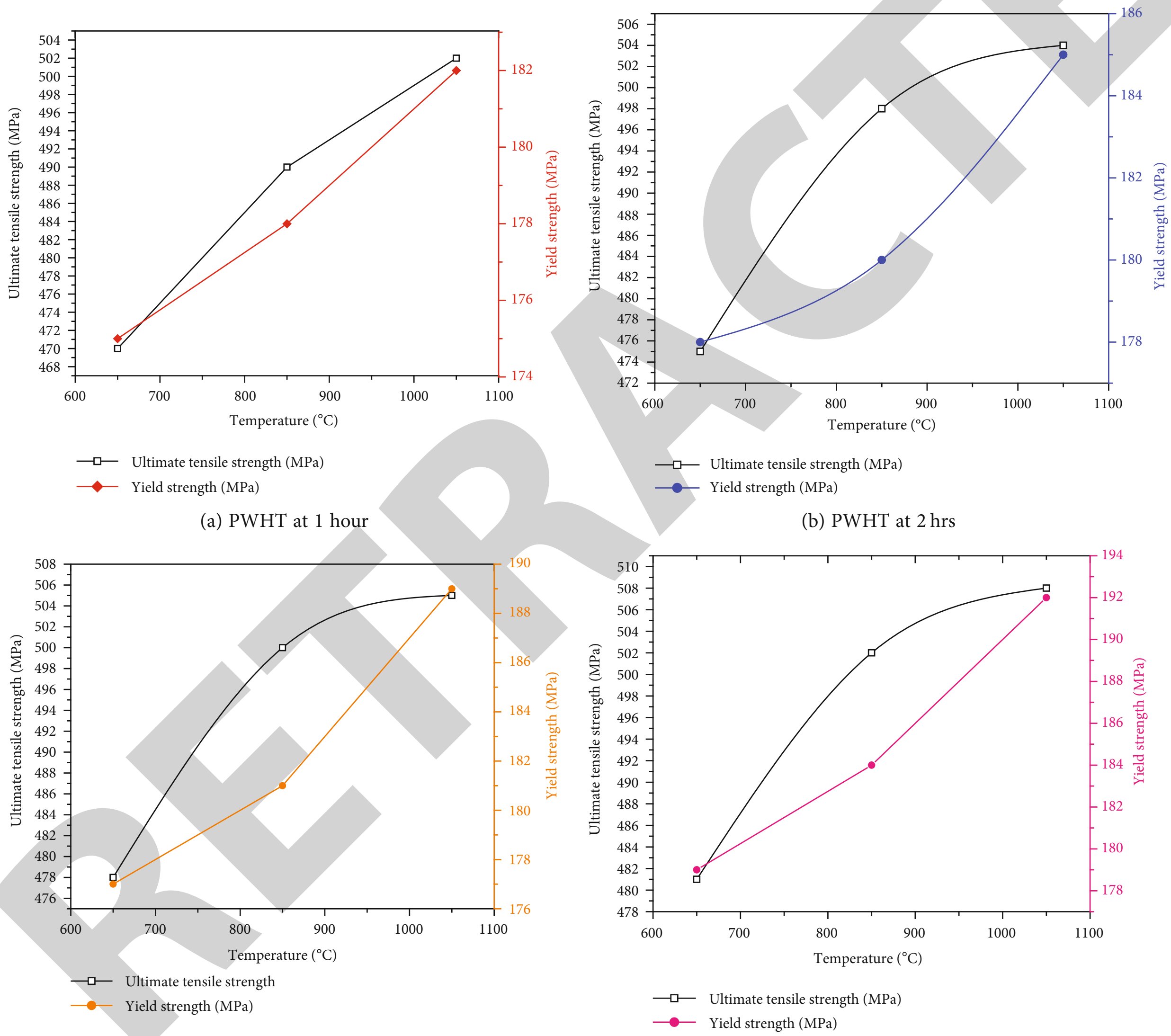


Figure 5: Test sample for impact test.



(a) PWHT at 1 hour

(b) PWHT at 2 hrs

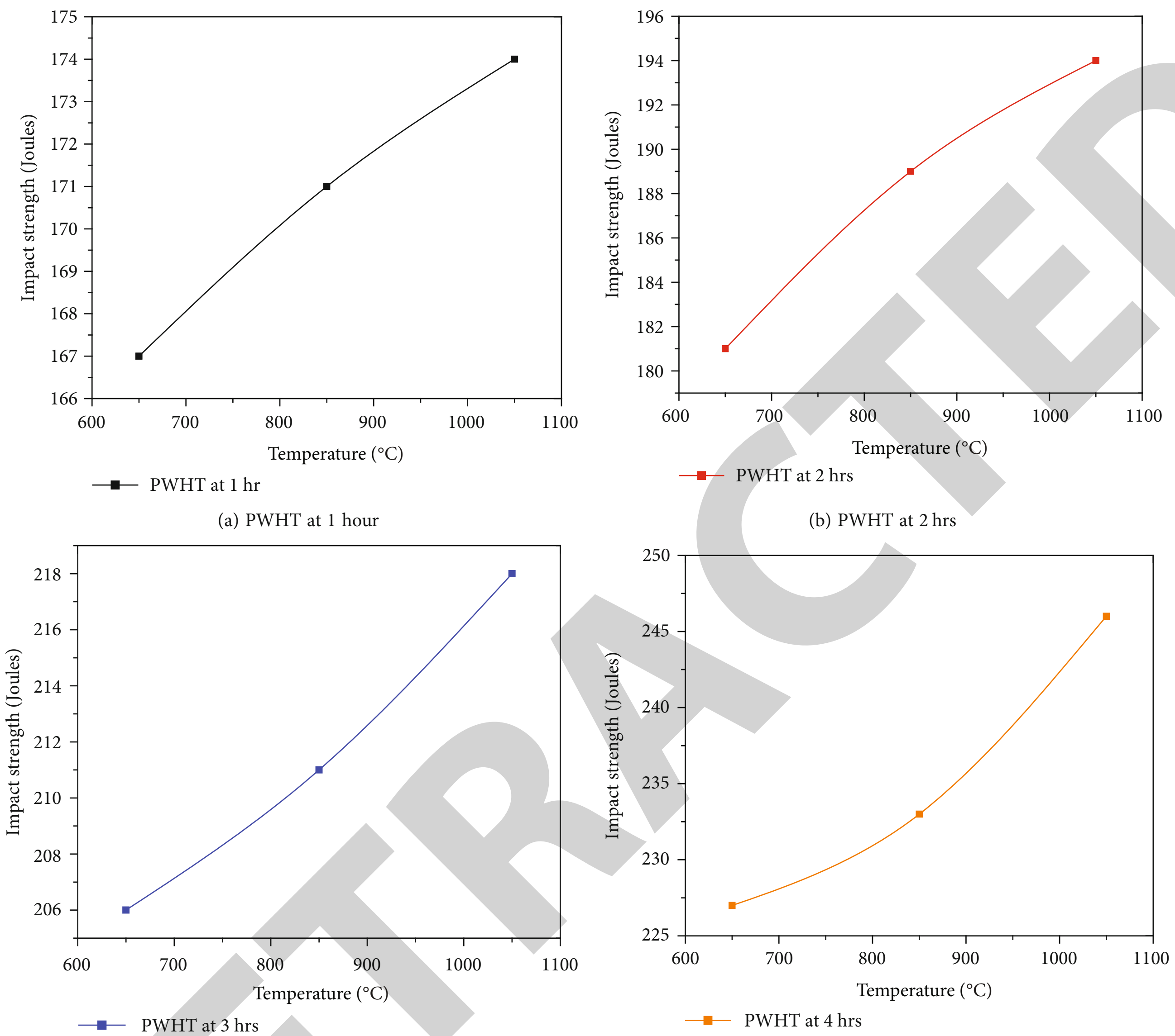
(c) PWHT 3 hrs

(d) PWHT at 4 hrs

Figure 6: Tensile strength of PWHT at different time periods.

moved to the heat treatment after welding method. The method is carried out at temperatures ranging from 650°C to1050°C at intervals of 200°C, with heat treatment times ranging from 1 hour to 4 hours at intervals of 1 hour. When comparing the heat treatment of the weld specimen at 1050°C to the heat treatment at 650°C and 850°C, the results demonstrate that the heat treatment at 1050°C produces better results.

Figure 6 depicts the tensile strength of weld specimens that have undergone a heat treatment process. Specimens were heat treated at 650°C for 60 min to 240 min at an interval of 60 min, 850°C for 60 min to 240 min at an interval of



(a) PWHT at 1 hour

(b) PWHT at 2 hrs

(c) PWHT 3 hrs

(d) PWHT at 4 hrs

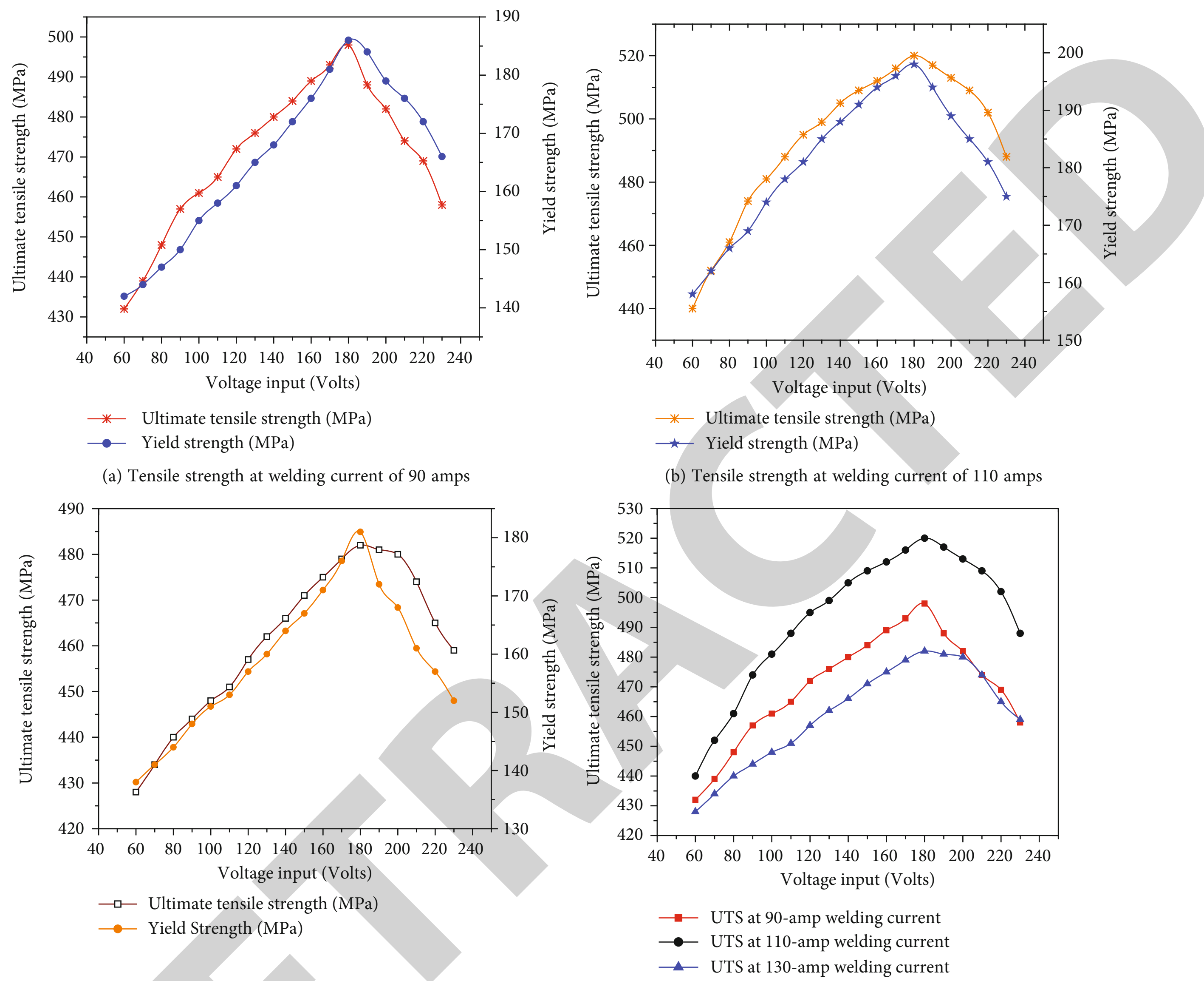
Figure 7: Impact strength of PWHT at different time periods.

60 min, and 1050°C for 60 min to 240 min at an interval of 60 min during the experiment. By comparing the results at various temperatures and times, it has been determined that the material's tensile strength properties are greater at 1050°C and 4 hrs than at other temperatures. PWHT tensile and impact strength values at 650°C, 850°C, and 1050°C for time periods of (a) 1 hr, (b) 2 hrs, (c) 3 hrs, and (d) 4 hrs are shown in Figure 6.

When compared to the lower time intervals, the peak tensile strength value for ultimate tensile strength and yield strength is attained at 1050°C, 4 hrs, which is 508 MPa and 192 MPa, respectively. When compared to other metals, the "HAZ" of 304L stainless steels has reduced thermal diffusivity during the heat treatment process. As a result, the material grade changes from austenitic to martensitic, allowing the metal's HAZ to become weaker.

Similarly, Figure 7 depicts the impact strength of weld specimens that have undergone a heat treatment process. Specimens were heat treated at 650°C for 60 min to 240 min at an interval of 60 min, 850°C for 60 min to 240 min at an interval of 1 hr, and 1050°C for 60 min to 240 min at 1 hr interval during the experiment. By comparing the outcomes at various temperatures and times, it has been determined that the material's impact strength properties are greater at 1050°C and 4 hrs than at other temperatures. PWHT impact strength values at 650°C, 850°C, and 1050°C for time periods of (a) 1 hr, (b) 2 hrs, (c) 3 hrs, and (d) 4 hrs are shown in Figure 5.

Similarly, when compared to the lower time intervals, the peak impact strength value is attained at 1050°C, 4 hrs, which is 246 Joules. When compared to other metals, the "HAZ" of 304L SS has reduced thermal diffusivity during



(a) Tensile strength at welding current of 90 amps

(b) Tensile strength at welding current of 110 amps

(c) Tensile strength at welding current of 130 amps

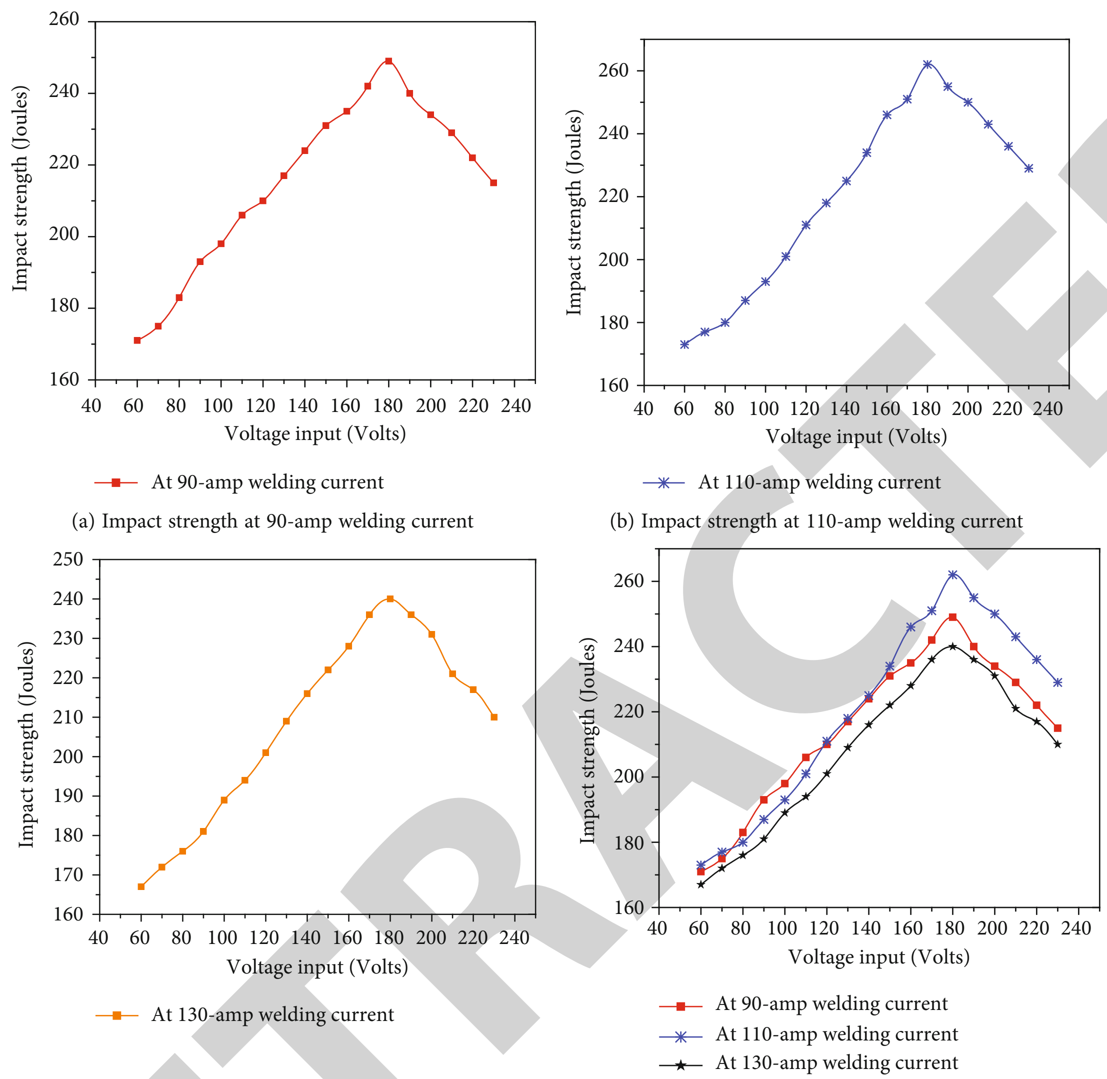
(d) Comparison of tensile strength at different welding currents

Figure 8: Tensile strength of vibratory-assisted weld specimens.

the heat treatment process. As a result, the material grade changes from austenitic to martensitic, allowing the metal's HAZ to become weaker.

3.2. Tensile and Impact Strength of Vibratory-Assisted Weld Specimens. The samples were joined with vibrations by adjusting the voltage to the vibromotor and welding current during the welding operation. The vibromotor voltage is varied from 60 V to 230 V with a 10 V interval, and the variation in the welding current is 90-130 amps with a 20-amp interval. The specimens are welded at 0 voltage input at first, and then, the voltage is gradually increased during the welding process. Voltage of the vibrational motor which varies from 60 V to 230 V with a gap of 20 V at 90-amp, 110-amp, and 130-amp weld current is used. The resistance to elongation, i.e., tensile strength of the weldments, starts off reducing and steadily increasing as the vibrations increase for 90-130 amps from 60 V to 180 V, then drops from 180 V to 230 V. For all 90-130 amps of welding current, the ultimate value of tensile strength is recognized at 180 V of the vibromotor and 110 amps of the welding current, as shown in Figure 8.

Similarly for 90 amps-130 amps of the weld current, the ultimate value of impact strength is identified at 180 V of the vibromotor voltage input and 110 amps of the weld current, as shown in Figure 9. When the tensile and impact strength values of post weld heat-treated specimens prepared with vibrations are examined, it is discovered that, under ideal working conditions, the experiment outcomes of VAS (vibratory-assisted system) or "vibratory-assisted welding" are marginally higher than the those of heat-treated specimens. At 1050°C and 4 hours, the maximum ultimate tensile and impact strength for the heat-treated joints were 508 MPa and 246 J, respectively. At 180 V of the vibration motor and 110 amps of the weld current, the maximum ultimate tensile



(a) Impact strength at 90-amp welding current (b) Impact strength at 110-amp welding current (c) Impact strength at 130-amp welding current (d) Comparison of impact strength at different welding currents

FIGURE 9: Impact strength of vibratory-assisted weld specimens.

and impact strength attained for joints produced with vibrations are 520 MPa and 262 J, respectively. However, conventionally formed weld joints have ultimate tensile and impact strength values of 460 MPa and 201 J, respectively, which are lower than those of the previous two procedures. Both PWHT and VAW are excellent at decreasing residual stresses and other weld flaws and enhancing the tensile and impact strengths of weld joints.

4. Conclusion

"Post weld heat treatment (PWHT) and vibratory-assisted welding (VSW)" improve the tensile and impact strength of 304L stainless steel. PWHT and VAW procedures refine the grain structure, which reduces weld flaws and residual stresses. A comparison of PWHT and VAW is done, and it is observed that vibratory-assisted welding has somewhat higher hardness. Despite the fact that PWHT and VAW provide nearly identical outcomes, PWHT techniques are more time-consuming, costly, and labor-intensive. Post weld heat treatment increases the tensile and impact strengths of 304L stainless steel by 10% and 22%, respectively, when compared to normal welding. The vibratory-aided welding approach increases the tensile and impact strength of 304L stainless steel by 13% and 23%, respectively. According to the current study, vibratory-aided welding is one of the best methods for eliminating weld flaws and improving characteristics.

Data Availability

The data utilized to back up the study's findings are supplied in the article.

Conflicts of Interest

The authors declare that there are no conflicts of interest to declare.

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