

Optimization of process parameters of MIG welding on stainless steel 304 grade using robust design method- A Review

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Abstract

The aim of this research work is to weld the dissimilar metals, stainless steel and mild steel SS-304. Grade Joining of stainless steel finds wide applications in chemical, oil and petroleum industry in the fabrication of pressure vessels and the storage tanks. But the joining of dissimilar metals is a major challenge as the amount of contamination in the weld area is very high which affects the weld properties. MIG welding process is generally applied to the wide range of metals which uses non-consumable tungsten electrode. The tensile strength and the percentage elongation of the welded joint should be higher. The various process parameters selected for joining the metals affect the mechanical properties of the welded joint.

Keywords:-MIG welding, Stainless Steel, optimization, robust design method.

I. Introduction

Welding manner is a two-manner combination. It is the fastest and maximum in your price range technique compared to all of the unfold and fraud. Metal detectors within the production of many merchandise round us include a few ships, railway device, vehicle launch, boilers, nuclear energy vegetation, pipeline production, piping, plane, motors etc. The numerous welding techniques available are: Tungsten Inert Gas (TIG) Welding, Inert Gas Wert (MIG) Welding, Shielded Metal Arc Welding (SMAW), Plasma Arc Welding (PAW), Flux Cored Arc Welding (FCAW), Submerged Arc Welding (SAW), Gas Metal Arc Welding (GMAW), Electro Slag Welding (ESW) and Oxyacetylene (OA) Welding. Welding approaches play an crucial position in the metalworking industry. There are one-of-a-kind varieties of welding, but the maximum widely used kinds are tungsten inert fuel (TIG) and inert gasoline processor (MIG / MAG). In the TIG welding method an inedible electrode is

used but inside the event of MIG welding a corrugated wire is used to join the steel. The metallic fuel heating gadget (MIG) includes an AC motor warmness exchanger, a soluble electrode, a water cooling and tightening tube for the discern steels and fillers inside the place of the joint assembly is a transient warmth source to create a connection between the figure steels. WIG Welding parameters are the most essential factors affecting the high-quality, production and cost of composite compositions. Factors consisting of present day arc, arc voltage and welding velocity and their interactions play a primary function in the welding procedure.

1.1 Technology Method

The Taguchi system is a mathematical technique advanced with the aid of Genichi Taguchi to improve the overall performance and nice of products. Based on Taguchi, the main factor simply before the evaluation became the status quo of the take a look at. Only in this way, it is possible to enhance the first-class of the method. This method can obtain the final output price and reduce the variance from the output value at a decrease fee. He believes that the perfect way to improve exceptional is to build and construct on the product. The important reason of this approach is to create a very good product that isn't steeply-priced for the producer. Taguchi has advanced an experimental layout approach to check how distinct parameters affect the which means and variability of a technique overall performance. The new format that is effortlessly designed through Taguchi consists of the advent of orthogonal layouts to expand pointers

that affect the direction and the variety at which it need to be various. Instead of tackling exploring all possible mixes as a real make-up, the real Taguchi method examines people for integration. The following will permit most of the statistics had to determine which variables are most probable to make contributions to higher productivity the usage of a low-volume trial, therefore saving it slow and assets. Taguchi preparations are normally produced or examined small arrangements normally pass slowly by way of hand; huge-scale editing may be based totally on willpower algorithms. Generally, the order can be bought online. The putting is easily decided on by means of the quantity of suggestions (variable) and the variety of grades (tiers).

1.2 GMAW Welding

Actually Gas Metal Arc Welding, from time to time cited by way of its subtypes steel inert gas (MIG) welding or metallic active gasoline (MAG) welding, may be a welding procedure at some point of which an electrical arc forms among a consumable wire electrode and therefore the work-piece metal(s), which heats the work-piece steel, causing them to melt, and be a part of. Along facet the wire electrode, a protective fuel feeds via the welding gun, which shields the technique from contaminants within the air. Originally advanced for welding aluminium and other non-ferrous substances in the - 1940s, GMAW is that the most common business welding procedure, preferred for its versatility, pace and consequently the relative simple adapting the method to robot automation. Unlike welding processes that do not hire a defensive fuel, like shielded metallic arc welding, it is hardly ever used exterior or in other areas of air volatility. The GMAW setup is as shown in parent.

Here GMAW may be a method during which the supply of warmth is an arc format among consumable metallic electrode and therefore the work piece, and therefore the arc and the molten puddle are protected from infection by using the environment (i.e. Oxygen and nitrogen) with an

externally furnished gaseous guard of gas either inert like argon, helium or an argon-helium mixture or lively like CO₂, argon-carbon dioxide mixture, that is chemically energetic or not inert. Initially GMAW turned into called as MIG Welding because simplest inert gasses were wont to guard the molten puddle. The appliance of this manner becomes restrained to aluminium, deoxidized copper and bronze. Later it were wont to weld ferrite and austenitic steels, and occasional-carbon metallic correctly by way of the usage of energetic gasses in situ of inert gasses and hence became term MAG (Metal Active Gas) welding.

GMAW welding process triumphs over the restriction of the usage of small lengths of electrodes and overcome the dearth of the submerged-arc process to weld in diverse positions. By suitable adjusting the approach parameters, it's possible to weld joints within the thickness variety of one-13 mm altogether welding position.

All the primary commercial metals are regularly welded through GMAW (MIG/CO₂) method, along with carbon steels, low alloy and high alloy steels, stainless, aluminium, and copper titanium, zirconium and nickel alloys.

GMAW (MIG/CO₂) is moreover utilized in mechanized and automatic bureaucracy to eliminate the operator aspect and to extend the productiveness and consistency of exceptional.

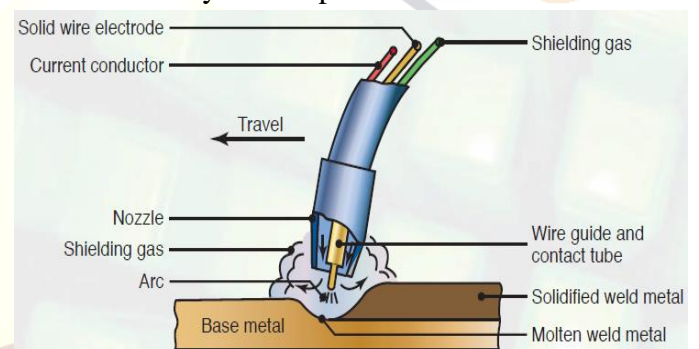


Fig. 1: Schematic Diagram of GMAW Welding System

1.3 ARCS Initiation

Using auxiliary equipment that provides Regular go with the flow of electrons is required for arcs initiation to takes area. The 'touches and draw' techniques used for arc initiation can be used but it results in infection of tungsten electrode. This results in tungsten inclusions in the weld steel, better intake of electrode and within the status quo of unstable arc [13]. Arc initiation in GTAW is finished with the aid of one of the following methods.

1. By contact and draw approach
2. High frequency high voltages deliver
3. Using a low modern pilot arc Arcs can be via contact and draw technique on scraps material.

The arc ought to no longer be began via touching's the tungsten's electrodes to the aluminium work-piece due to the fact this could mark the work or bring about aluminium being picked at the electrode that is in all likelihood to cause an uncontrollable arc and as grimy weld. The preliminary arc needs to be struck on as starting blocks warmth the electrode to its operating temperature. The arcs need to in no way be struck on carbon block because this contaminates the electrode and leads to the formation of tungsten carbide which has and consequences in growing the scale of molten round end. Due to this there may be an boom ins arcs resistance which reduces the currents density.

Another way of beginning the GTAW arc is to use Highs Frequency (HF). HF includes high voltage sparks of many thousand volts that remaining for a few microseconds. HF is regularly utilized in conjugation with AC electricity supply to achieve easy arc initiation without touching the electrode to the work-piece. When excessive frequency high current is superimposed over the everyday welding circuit it quickly ionizes the arc gap between the electrode tip and the work-piece thereby makings it smooth for the electrons emission to take place from the tungsten electrode. Once associate diploma electron/ions clouds are created, present

day cans flow from the electricity supply. After the arc is initiated and stabilized the HFHV current is switched offs and the regular welding circuits comes into operation.

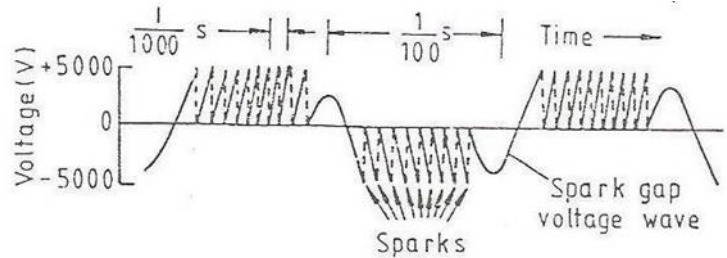


Fig. 2: Basic voltage waveform obtained with high frequency high voltage unit [13].

The high frequency used ranges among 100 KHz and 2 MHz for a voltage of 3000V to 5000V. This approach of arc initiation is very efficient and smooth and gives extended lifestyles to the tungsten electrode. Figure 2 depicts the basic waveform obtained from HFHV arc initiation gadget. Low cutting-edge pilot arc system is rather dependable arc starting up technique which can be used with DC welding gadget. The pilot arc is powered by way of a small auxiliary strength source and offers situations for initiating the welding arc.

1.4 Advantages and Limitations

GTAW manner employs numerous advantages over different welding approaches along with:

1. The potential to weld most metals and alloys; but it isn't used for welding of low melting metals consisting of tin and lead.
2. No slag, which gets rid of publish weld cleaning.
3. No weld spatter and hence a completely easy weld is obtained.
4. All roles welding.
5. Reduced warmness enters thru pulsing.
6. Ability to sign up for skinny base metals because of brilliant manipulate of heat input.
7. The procedure itself does no longer produce any smoke or fumes. Some obstacles of this procedure are:

1. Low deposition quotes; welding thick sections is hence time eating and expensive.
2. The accelerated quantities of ultraviolet rays from the arc purpose the formation of ozone and nitrous oxides.
3. Particles from the tungsten electrode can enter the weld pool and bring a weld disorder or discontinuity.

1.5 Applications

GTAW is applied altogether industrial sectors but is specifically suitable for top first-class fastening. In guide fastening, the highly small arc is good for skinny sheet material or controlled penetration (within the root run of pipe welds). Because deposition price will be pretty low (the use of a separate filler rod) MIG could also be suitable for thicker cloth and for fill passes in thick-wall pipe welds.

GTAW is a trendy purpose welding process for welding of aluminium. Especially at thinner sheet thicknesses the method is qualified. The method is wide used for fastening of pressure vessels, warmth exchangers and pipes where tightness is essential for the reason that method produces welds with very low pore fractions. GTAW is likewise useful for welds with frequently starts and prevents and for quick welds because of top notch fine with low porosity.

GTAW is likewise broadly carried out in mechanized structures both autogenously or with filler twine. However, many 'off the shelf' structures place unit offered for orbital fastening of pipes, employed inside the manufacture of manufacturing facility or boilers. Because the welder has much less manipulate over arc and weld pool behaviour, careful interest must be paid to part preparation (machined as opposed to hand-organized), joint healthy-up and control of welding parameter.

2. Literature Review

SudhirKumar et al. (2019) studies paintings, AISI 1018 metal samples are inserted into the V-butt by way of a blended arrangement the usage of MIG welding. The take a look at layout is Taguchi primarily based Orthogonal Array (L9). The effect of method parameters consisting of present day temperatures, voltages and pre-temperature is studied and the welds are tested the use of X-ray radiographic examination. Weld best is examined in terms of solid metal structures including high energy energy and percentage elasticity. Process parameters are optimized the usage of a Taguchi-based totally grey method.

Himanshu Yadav, et al. (2019) specializes in building overall performance of these frameworks to achieve the best parameter combination of targeted excellent. In the high-quality-tuning of those parameters, the Taguchi method has emerged as the most extensively usual approach by researchers for the throughout the globe.

Ravinder Kumar, et al. (2019) The maximum widely studied Argon and Helium combination is favoured for improved welding nice as it does not respond to every other. Argon and Helium gases protect the welding area from the outdoor and assist keep the arc strong due to low power ionization. Aluminium is lightweight and could be very powerful inside the aerospace, aviation, maritime, car, protection and different industries. TIG welding parameters such as modern-day welding, waft rate and welding voltage are considered to affect the tensile electricity, Hardness and Toughness of the aluminium weld joint. Welding parameters are controlled by electronic manage gadgets. The AC energy deliver prefers using aluminium compared to DC electric power due to the melting of its aluminium melting factor at decrease levels.

Prakash BabuKanakavalli, et al. (2019) mentioned the usage of Taguchi and Gray-related

analytical techniques in figuring out the suitable MIG Welding system standards offered. The Taguchi method is broadly utilized in building valid assessments, even as the gray relationship analysis assists decision-making when thinking about more than one procedures, this aggregate serves as an effective device in figuring out the proper method parameters. In the modern-day welding paintings cutting-edge, voltage, pace, bevel angle have been considered as the enter parameters for combining exclusive metals (AISI1010 and AISI1018), as these influence the output characteristics along with tensile electricity and stiffness; these parameters want to be adjusted.

Ashish Chafekar, in al. (2019) discussed the MIG semi-automated welding gadget according to the ordinary L9 orthogonal array. Process parameters viz. Welding voltage, wire feed price and dynamic are vital for a smart MIG welding machine that is considered flexible. Responses which includes tensile electricity, hardness and thermal conductivity (HAZ) of AA6061-T6 aluminum alloy welded joints had been investigated and adjusted using grey-associated grey be counted analysis. From this multi-reason use, it has been located that modern welding is the maximum critical parameter accompanied by the deliver chain stage and the dynamic electricity of the smart welding device under consideration.

Dharmendra B.V. et al. (2019) discussed some of practical strategies for identifying a fixed of pleasant jet machining (AWJM) parameters for acquiring the removal price (MRR) and the size of the face scale.

Priyanka Devidas Shinde, et al. (2018) supplied the impact of welding parameters such as modern-day welding, welding voltage and flow rate at penetration depth and electricity of the power the usage of the Taguchi technique. Two varieties of oxides MgCO₃ and Cr₂O₃ had been used to check the outcomes of float in the metal access Fe 410

size one hundred × 65 × 6 mm with the aid of GMAW with V-groove weld design mixed. Cr₂O₃ became determined to be the main car leading to excessive penetration. Nine Cr₂O₃ (L9) test runs are used based on orthogonal list. The most important component and the ideal parameter estimates have been identified the use of the ANOVA and S / N ratios. With the electricity of the tensile the dominant item became gift, and then the rate of gasoline go with the flow and electric powered strength respectively. Results had been obtained next to the enlargement outcomes after appearing a confirmation take a look at.

Nabendu Ghosh et al. (2018) mentioned the differences between AISI 409 ferrite stainless steel and AISI 316L austenitic stainless steel, manufactured through GMAW (Gas welding arc welding) the use of ESAB AUTO Rod 316L as a filling twine. Welding is accomplished on the L9 orthogonal direction of the Taguchi street. Three stages of input parameters are selected: present day welding, gasoline go with the flow price and nozzle on the plate stage, selected. After welding, visual inspection and X-ray radiographic examination had been performed at the weld types, to detect similarly deformities and the decrease surface of the weld types made of different stainless steels. Weld high-quality has been assessed in phrases of yield electricity, very last power power and percentage of pliability of the types protected. The observed facts become translated, mentioned and analyzed by means of the grey-Taguchi approach.

Arham Khan, et al. (2018) advanced a Taguchi technique used to build experimental production. The test layout the use of the L₉ orthogonal array turned into used to carry out the cork function. The parameters of the input technique of the cutting-edge GMAW pulse consist of cutting-edge strength, arc voltage; pulse frequency and wire deliver score. The variability of the neighbourhood HAZ reaction and purification is measured in aggregation. After that, a method analysis is executed to find the ideal

mixture of input parameters. In addition, the use of variance evaluation is decided by way of the parameters of each input in the HAZ vicinity and the purification throughout the placement of the garments is decided. A honest quantity of GMAW system mixtures for contemporary process.

Saadat Ali Rizvi, et al. (2018) mentioned in the middle for the development of various welding parameters affecting the usability of SS304H, the Taguchi technique become used to growth welding parameters and the formation of fracture mode was studied. Many exams were done. The L9 orthogonal array (3x3) became used for it. Variation evaluation (ANOVA) and sound signal (SNR), used a mathematical procedure to determine the impact of different heating parameters inclusive of current modern, cable deliver speed and gas waft fee within the SS304H slope. Low hardness and cracking mode were examined for SS304H softness and become determined to result in welding voltage having a high impact and gasoline drift price had a small impact at the strength of the welded joints and appropriate system parameters had been acquired at 23 V, 350 IPM cord velocity and dimension 15 l / min gas flow of solid force and cracking mode changed into a ductile fracture of the tensile test model.

Shekhar Srivastava et al. (2017) produced the outcomes of a variety of processes studied with the temperature of the IS: 2062 small steel plate using a metallic welding system with a steel cord with a diameter of zero.8 mm. A set of experiments became developed to acquire statistics using the Box Behnken Design system for Response Surface Methodology. Based on recorded information, statistical models were developed. In addition an effort become made to reduce the width of the beads and the peak of the beads and to growth the intensity of penetration the usage of the face-turning technique.

Nabendu Ghosh et al. (2017) investigated the outcomes of welding parameters: current welding, waft fee and nozzle to plate distance, maximum electricity (UTS) and Yield Strength (YS) in MIG welding of AISI409 ferrites stainless-steel in AISI 316L Austenitic Stainless Steel substances. The test turned into completed in step with the L9 orthogonal method of Taguchi method. OTS and YS located information have been translated mentioned and analysed the use of the Taguchi Desirability evaluation.

Arunkumar Sivaraman et al. (2017) cantered on the most effective overall performance of the MIG welding procedure for AA219-T87 device the use of a Taguchi-primarily based grey evaluation. Welding enter parameters play an vital function in the high-quality of weld you need. The selected input parameter included modern-day temperature, Voltage and Welding speed. Tests are performed in line with the L₉ orthogonal list. The ANOVA approach has been used to evaluate the fee of features in the fine weldment satisfactory. ANOVA effects have proven that welding modern-day plays a prime function within the pleasant objectives (Transin shrinkage, excessive strength and stiffness) of weldments followed through welding velocity and voltage. Gray courting analysis became used to maximize simultaneous enter parameters considering the dynamics of more than one output.

Kumar Rahul Anand et al. (2017) studied the houses of austenitic stainless steel (AISI 316) equipment and gentle steel fitted with TIG welding. In this paper with the application of Taguchi's performance approach we've got tried to improve the parameters of diverse techniques together with contemporary, voltage and gas glide ratio (GFR) that have an effect on tensile power and joint stiffness. However, the research is primarily based on Taguchi's orthogonal planning technique using variance analysis (ANOVA) to decide the effect of the parameter method and improvements.

Khasempong Songsorn, et al. (2017) The look at was to discover the right situations for metallic sheets blown based totally at the Metal inert gas pulse (MIGBPB) system. The study used the Taguchi approach to layout a general L25 orthogonal array, such as five predominant parameters: 1) cable deliver velocity, 2) arc voltage, 3) waft pace, four) modern top and 5) excessive frequency frequency. Each of these parameters had five tiers, so the test ran 25 instances with three responses (75 tests in total) to achieve MIGBPB functions that have been considered sizable parameters and have been notably indicated, which include: 1) zinc digital camera stability of joint (ZB), 2) the entry factor of the filling metallic in fit-up (ARP), and three) the electricity of the tensile shear (TSS). The effects showed that the MIGBPB standard situations for ARP and TSS-blown steel sheets have been a velocity of 4 meters / minute for cable deliver, 18 V voltages; A journey pace of zero.6 meters / minute, 450 ampere modern-day peak and 35 Hz frequency pulse. For ZB, the detection confirmed a cable deliver pace of 3.25 m / min, arc voltages at 18 V, a speed of 0.9 m / min, a contemporary top of 425 A, and a frequency of 35 Hz to be continually the proper conditions that make the pleasant of the bond tied with zinc joining.

Monika, et al. (2017) determined that the impact of Current, Voltage & Gas Flow Rate on Tensile Strength, and Hardness of Weld Zone & Heat Affected Zone all through the welding method become showed by means of ANOVA using Minitab Software for each reaction was stepped forward. Test results are furnished to represent the proposed technique. Since the observe it has been located that with increasing strength, GFR energy and power decreases however within the event of a hardening, the quantity of stiffness increases due to the higher enter charge.

M. U. Deshpande, et al. (2017) mentioned details of the impact of the welding technique method inclusive of modern welding, voltage welding,

name velocity at access at EN10025 S 235 The variety of mild metallic welding. The evaluation of this study turned into conducted the use of three, three-dimensional Taguchi DOE strategies. Analysis and extension of welding parameters and capabilities, variance analysis, the usage of L₉ orthogonal array and sign to audio volume. The duration of the penetration beyond the intensity of penetration is a chief problem for fillet joints, as penetration determines the electricity of the welded joint.

Harsh M. Patel, et al. (2017) discussed the satisfactory of the weld is quite dependent on the final strength electricity this is strongly stimulated through the various manner parameters within the method. This paper is a have a look at of the evaluation and effectiveness of GMAW system parameters. The exams have been performed based totally on a complete factorial process and focused on controllable necessities.

Amit Kumar, et al. (2016) mentioned the advent of the Taguchi technique combined with a grey analysis to decorate the system of gas arc welding process (GMAW) of AISI 1020 carbon steels of many exceptional traits (particle width, bead top, weld penetration and temperature variety). The orthogonal array of L₉ is used for limb formation. The take a look at is accomplished in keeping with the combination of electrical energy (V), present day (A) and welding pace (Ws). The results confirmed that the welding velocity may be very important within the process manner. By reading the gray dating rankings, the best parameters are observed and key capabilities are identified the use of ANOVA analysis. Welding parameters which include speed, modern-day welding and voltage are made for AISI 1020 equipment using the GMAW technique. To toughen the robustness of the take a look at design, verification checks are accomplished within the selected procedure putting for the appropriate procedure. Views from this direction can assist in small traffic circles, shipbuilding and

shipbuilders and providers to locate the right welding conditions.

Fuheng Nie et al., (2016) has studied the structure of microosting and consequently the structure of pulse steel inert gasoline (MIG) comprising one of a kind members between 4 mm in size made from 6061-T6 forged aluminium alloy plates A356-T6 . Within the check the electricity of the joints reaches 235 MPa that is 83% of that of the 6061 aluminium alloy, and reduces with growing speed of motion whilst maintaining sure welding parameters often. Microstructure, shape and fractography of the joints have been examined via optical microscopy (OM), microscopy (SEM) and electron probe microanalysis (EPMA). The burning of grain boundary and separation took place during a barely melted vicinity (PMZ) at the aspect of the aluminium alloy 6061, and skinny layers of Fe had been discovered inside the slightly melted region on the facet of the A356 aluminium alloy. Minor micro hardness came about inside the heat-affected vicinity (HAZ) close to the A356 aluminium alloy substrate.

K. Nandagopal et al., (2016) tested the thermal effect of Gas tungsten arc. In this paper Gas Tungsten Arc Welding (GTAW) is made between two special titanium materials (6Al4V) and aluminium 7075 with filling substances such as aluminium AA 4047. There are twenty-five welding samples to have a look at mechanical and steel homes. This welding is carried out with three set parameters with five degrees of values. Mechanical capabilities are measured by using a bit of labor. Taguchi is used to increase process parameters to determine the blended power and meeting fine in welded samples and to pick out tactics that have the most effect in this welding process. The ANOVA technique is used to decide the share contribution per parameter of each manner. More errors are investigated by means of weld samples. Electron microscope (SEM) scanning and energy-dispersive

X-ray evaluation (EDX) changed into accomplished to degree matrix and chemical detail residences.

Nabendu Ghosh et al., (2016) Tested visual acuity and X-ray radiographic examination to detect excessive deformity and sub-floor welds made of AISI 316L austenitic stainless steels. The effect of contemporary welding parameters, gas float charge and plate welding variety in the weld nice range of AISI 316L stainless-steel austenitic metal has been studied by using testing and analysis. The gum-fashioned joints have been made the use of numerous present day stages, a gas glide gauge and a nozzle plate to transport the plate. The mechanical homes of steel were investigated for the reduction in yield, the electricity of the very last power and the percentage of elasticity of the sorts added. Visual facts had been translated, discussed and analyzed the usage of the Gray-Taguchi technique.

2.3 Current Activity

As it's been determined in the review of the above literature that these therapeutic alloys are at risk of thermal cracking whilst excessive temperatures are implemented or a high modern price is used it's miles therefore crucial to understand how elements behave at distinctive welding parameters. The 1079 Series MS metallic is heat-resistant or age-enabled offers it excellent strength. The major objective of the present have a look at changed into to attain the consequences of welding parameters such as current welding, gas go with the flow rate and distance radius for MS plate machinery systems. The mechanical functions taken into consideration for the modern-day paintings were Tensile Strength and Hardness. Tensile strength and stiffness are decided the usage of the UTE100, with a ability of 100 kN and a Rockwell hard tester respectively.

3. Conclusions

From this review, it has been concluded that very less research has been done on stainless steel 304



grade using robust design method excellent weld ability and machinability among series of aluminium alloys. It has a wide range of applications that includes shipbuilding, vehicle bodies, rivets, nuclear structure and food processing industry. It has excellent corrosion resistance.

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