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Analysis of variation of hardness in MIG welded stainless steel alloy

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ABSTRACT

AISI 202 SS (stainless steel) has similar mechanical property as compare to AISI 304 SS grade, but its ability to resist corrosion is somewhat less as compare to AISI 304 SS grade in chloride environment. But it is very inexpensive so we can use it in indoor applications like indoor fabrication, automobile trim and application where atmosphere is not a considerable factor. But there is very less research reported on welding of AISI 202 SS grade. In order to find out the weakest locations of the joints and determine the optimum MIG welding parameters, this present work aims to demonstrate its MIG weldability and the emphasis is placed on the relations of the tensile properties and hardness to the welding parameters

Keywords: *MIG, weldinf, ss-202, Aluminum*

1. INTRODUCTION

Welding is often a manufacturing method of forming a permanent joint achieved through the surface fusion of the joining parts, with or without the applying a filler material and a pressure application. The joining materials can be identical or dissimilar to one another. The heat needed to fuse the material can be produced by an electric arc or by gas burning. Because of the higher welding speed, the latter form is often used frequently. Welding is commonly seen as an alternative way for forging or casting in construction and as a substitute for riveted or bolted joints. It is often seen as a repair tool for – for example reuniting a metal at a crack or fixing up a minor portion which has fallen off like a gearing tooth or restoring a damaged surface like a bearing surface.

With the invention of technologies, the current welding advanced technology just before the end of the nineteenth century is used to produce high temperature in the localised region. In general, a heat source is needed to create a high-temperature zone and to melt raw - materials welding, although two metal pieces can be welded without much rise in temperature. Different standards and methods are adopted, and for new and improved method of welding, there is still a continuous search. The demand for the new welding materials having large thickness components increases, mere gas flame welding, usually are welding engineer known, which is not satisfactory and improved as the development in tungsten insert gas welding, metal insert gas welding, laser and electron beam welding [1].

For the binding of various materials such as plastics or alloys, metal in a permanent bonding phase with both the application of pressure or heat is called welding. The workpieces to be combined are melted during interface welding, and after the process of solidification, a permanent joint can be accomplished. In order to form a welding pool of molten steel, often a filler mixture is applied between solidifying materials, which creates a strong bond. Various factors, such as metallurgical shifts, rely on the welding potential of the product that occurs throughout welding, due to the rapid increase in hardness in the welding region, with a propensity to crack forming and oxygen in the air mostly in joint position, due to material reactions there is a degree of oxidation.

1.1 Metal Inert Gas Welding (MIG)

When contact is formed between two smooth areas, a welded joint is produced and both are applied, whether by pressure or by heat, for a bonding. The basic cause of the soldering seems to be the atomic tendency to bond [14]. The fundamental concept of all processes of welding is the interdiffusion between combined materials. Diffusion can occur mostly in liquid, solid, or mixed conditions.

MIG i.e. Metal inert gas arc welding or better known as GMAW i.e. gas metal arc welding uses an electricity consumable, and thus the word metal occurs in the description. Other arc-shielding gas-processes are used for consumable electrodes, like FCAW, which can all be represented as MIG. Although GTAW could be used to weld metals of all kinds, it is much more suitable for thin sheets. The need for filler metal allows GTAW difficult to use when thick sheets ought to be welded. The GMAW provides convenience in this case. Figure 1 offers an overview of the scheme of the MIG or GMAW welding process. The consuming electrode is fed by the feed rollers at a constant rate mostly in form of a wire roller.

The welding torch is attached to a gas supply cylinder providing the needed inert gas. The workpiece and the electrode are attached to the welding power supply. The power source is often of a constant voltage form only. The current obtained from the welding machine is altered by the electrode wire feed rate. Usually, DC arc welding devices are being used for GMAW with positive electrode DCRP i.e. direct current reverse-polarity welding. DCRP improves the rate of metal deposition and also guarantees smooth metal electrode transition and stable arc. With DCSP, the arc appears extremely unbalanced and also provides a significant spatter. Although specific electrodes with mixtures of titanium and calcium oxide as coatings often considered being suitable for welding DCSP steel. Throughout the GMAW process, the metal filler is moved from either the electrode to a joint. Probably depends on the voltage and current used for the electrode, the movement of the metal is conducted in various aspects.

1.2 Equipment of MIG Welding

- Wire feed unit
- Torch
- Work return welding
- DC power output source
- Shielding of the gas supply (usually from the cylinder)

Power Source

The MIG welding is usually carried out on the DCEP, i.e. Positive polarity DC electrode. After all, DCEN is being used (for larger burn-off rates) for certain gas-shielded and self-shielded core wires. The power sources of a DC output represent a kind of transformer-rectifier with nothing more than a flat characteristic (constant VS).

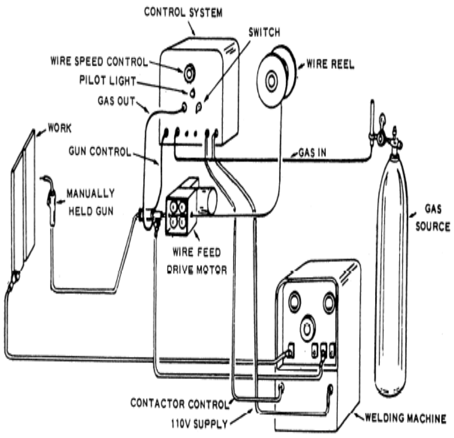

Fig. 1: Metal Inert Gas Welding (MIG)

The much more typical method of power source is being used in this method is indeed a switched primary rectifier with constant features of voltage from both 1-phase 240V inputs and 3-phase 415V. DC output on a 3-phase machine after full-wave rectification is quite consistent. A wide capacitor bank across the output is needed to attain even (smooth) output after complete wave rectification with a 1-phase machine. Due to the cost of this, several low-cost 1-phase devices lack this part and thus have poorer welding characteristics. Switches to the primary winding main transformer can provide voltage output measures of the main power terminals. A further way of creating voltage levels at the output terminals would be to use a Transistor and a Thyristor rectifier rather than a basic diode rectifier.

A continuously variable output voltage is being obtained using the device, that can be especially be useful for robot installations, and the expense of such type of rectifier can be partially offset without the necessity for the main voltage switch or switch and a single tapped primary winding transformer. Many MIG sources of power have a contactor or relay that is being used to turn the ON / OFF output with the MIG torch trigger activity. The turn off the activity of this contactor is usually delayed to enable the welding wire to burn out from the molten welding tank. The thermostat is mounted only at the hot point of the source of power, in series with a contactor coil aim of providing thermal safety to the system.

2. RELATED WORK

Hongtao Zhang et al. 2011 tested the impact of galvanised zinc coating and aluminium coating on fusion metal spreading potential on lap joints of 1Cr18Ni9Ti stainless steel and aluminium alloy 2B50, welded with 4043 Al-Si filler metal using MIG welding – brazing technique. The aluminized coating had a small impact to facilitate the presence of a welded surface and evident micro-cracks between the steel side and compound layer were discovered. The rupture in tensile testing took place at the weld's interfacial layer with a low tensile strength of around 60 MPa. Joints among galvanised steel and aluminium alloy had a better surface image, and Al 4.5 FeSi was really the intermetallic compound near the joint interface throughout the fusion zone area. Due to the heat input, the surface area of the intermetallic compound layer differed to around 5.m to 15.m and the greatest lap joint tensile strength may reach 193.6 MPa whenever the heating rate is 0.846 KJ / cm. Dissimilar materials joints have been made among 2B50 stainless steel and aluminium alloy by MIG welding – brushing with ancillary coating, that also encourages the wetting property of filler metal. As per the sequence features; a thin transitional discontinuous layer has been obviously indicated only at welding interface, the thickness from which differed from about 5.m to 15.m depending on the heat input in the experiments; the intermetallic compound in the seam region near the welding interface was Al 4.5 FeSi; the average lap joint tensile strength was 193.6 MPa when the heat input was 0.846KJ/cm.

Abdul Wahab et al. 2011 analysed the role of welding parameter using some MIG spot welding in welding joints of dissimilar metal. The basis material chosen for welding in this research is austenitic stainless-steel type carbon steel and AISI 316L. The use of filler metal to weld this dissimilar metal seems to be E80S-G, including the use of CO2 as shielding gas. The testing was conducted by considering the input parameter of wire feed, weld current, and feed time. Then doing the experiment the impact of such variables on shear force and spot diameter was anticipated. From the consequence, they reach the conclusion that with increasing welding current, the size of shear force and spot weld increases whereas the sheer force decreases with increased welding time. There have been apparent micro-cracks between the steel base metal and compound layer; crack surface at the steel interfacial layer/welded seam, with a lap joint tensile strength having reached approximately 60 MPa. Sound dissimilar metal joints were acquired between galvanized steel and aluminum alloy with excellent appearance; the joints seemed to have three visible areas: interfacial reaction layer, zinc-rich zone, and the fusion zone. They also discovered that perhaps the expanding welding current, the time of welding will also boost the diameter of the welding zone and reduce the sheer force [1].

R. Sudhakaran et al. 2012 researched processing parameter optimization utilizing PSO to minimalize angular distortion in tungsten arc welded plates of 202-degree stainless steel gas. Angular distortion is indeed a big issue and is most pronounced among different kinds of distortion in plates welded to the butt. For the research, the parameters of the process control chosen seem to be the welding speed, welding current, welding gun angle, and flow rate of the gas. The studies were conducted out by using the technical design of experiments with an adjustable layout of five-level (five factor-based) central composite with full replication methodology. A mathematical model has been developed in which processing parameters were correlated with angular distortion. A code to do the analysis based on optimization was established in MATLAB 7.6. The optimum processing parameters managed to give an angular distortion value of 0.0305 ° which illustrates the effectiveness of the model. The findings suggest that the optimized values are able to produce a weld with minimal distortion for the processing parameters. We arrived at the following conclusions from the research. The quadratic model of second-order can be efficiently used to anticipate angular distortion of the stainless steel 202-grade plates in gas tungsten arc weld. The maximum amount of angular distortion validated with experimental research findings was 10 °, when process parameters like gas flowrate, gun angle, plate length, welding speed at 110 mm/min, and welding current were preserved at 60°, 10 litres/min, 80 amps and 125 mm respectively, and were maintained.[24]

Suresh Kumar et al. 2012, discussed the mechanical properties of austenitic stainless steel 304 with TIG and MIG welded dye penetrate testing. The TIG welding generated the lesser hardness value than that of the MIG welding in this study. The stainless steel TIG welds survive the heavy loads and generated an elevated ultimate strength compared to MIG welds. Austenitic grains have been described in the microstructure and the Dye Penetrate Testing showed no phenomenal indication. The HAZ has been enhanced by adding the welding current. This can be reached the conclusion that the above principles for the process variables will further alter the plate and therefore should be prevented. The minimum angular distortion based on experimental research was 0.4 ° if the procedure parameters like gas flow rate, gun angle, plate length, and welding current were retained at 70 °, 15 lit/min, 90 amps and 150 mm respectively, and the welding speed at 100 mm/min was preserved. Max strength joints for whom fracture took place in Al alloys HAZs i.e. heat-affected zones at 89 MPa have also been acquired up to 72 per cent of Al alloy tensile strength with such a desired target of 0 and 1 mm for the torch. This can be reached in the conclusion that in the process-based parameters minimal angular distortion can be obtained using the value systems above. The percentage of error of angular distortion between both the observed and predicted value is 1.66 percent. Therefore, the developed model should be used precisely to anticipate angular distortion. The optimum processing parameters for angular distortion tried to give a value of 0.0305 ° that also illustrates the effectiveness and accuracy of the model established [26].

Monika K. et al. 2013 evaluated the mechanical properties of MIG Welded Dissimilar Joints. The determination of the heat input is done by the welding current, wire-speed, and voltage. The base material was used during the IS 2062, IS 45 C8, IS 103Cr1. Copper coated mild steel with a diameter of 1.2 mm has been used as a filler wire. Both joints (IS2062 & IS 103 Cr1) and (IS 2062 & IS 45 C8) increases the tensile strength when increased with heating rate, and also increased the surface hardness when reduced with heat input. Dissimilar metal joints were acquired among galvanized steel and aluminum alloy with excellent appearance; joints had three visible regions: the interfacial reaction layer, the fusion zone, zinc-rich zone depending on the phase attributes, a narrow discontinuous intermediate layer is now easily noticed at the welding interface, the hardness of which differed from about 5 m to 15 m depending on the energy input in the studies; the intermetallic compound within seam region near the welding site. [6].

Pradip D. Chaudhary et al. 2014 studied the impacts of the GMAW i.e. Gas Metal Arc Welding processing parameters mostly on tensile strength of the SS 3Cr12 steel material sample. Throughout this research, wire feed rate, welding voltage, gas flow rate, welding seed and were regarded to be an inflating input parameter. The study was conducted with a central composite design matrix and the study was applied using Minitab software. The assessment showed that the strength increased with an increase mostly in gas flow rate and welding speed, while the increase increased with a decline in the welding voltage and wire feed rate. Less coarsening is noted in the metal welding. The massive chunk of austenite is maintained in the austenite matrix including a tiny portion of ferrite. The transverse pattern, microstructure characteristics, and appearance of the joints have been evaluated. Significant study results could be summed up as follows: the aluminium coating would have a small impact on the wetability of aluminium filler metal; a large number of compounds were present on the aluminium steel surface, part of which has been melted, and a further part of the compounds entered the melting zone after fragmentation as a result of the welding heat input; there had been an existence of tempered martensit. [11].

Sahil Bharwal et al. 2014 studied the GTAW i.e. gas tungsten arc welding process for the AISI 202 SS grade weld metal. The GTAW process benefits the welded joint with better rate of deposition, and maximum strength. The obtained results after welding of AISI 202 are similar to the AISI 304 type which meets the requirements for the recommended characteristics including its welded joints. Therefore, 202 form SS should be used instead of 304 type SS the above-mentioned applications. In the current study, grade 202 stainless steel has been used to explore strength utilizing input processing parameters chosen from the welding test run. The tensile strength acquired is reasonable enough just to cover the service life of AISI 202 throughout the recommended applications. This can be mentioned that 202 SS could even be used instead of 304 SS. The values acquired from the microstructure exhibition that the structure is composed of austenite grains throughout the heat-affected zone and also the parent metal. Eventually, this can be concluded that AISI202 grade stainless steel has sufficient corrosion resistance to pitting and progressive grain growth in the heat affected area. Throughout the metal welding zone, there is a substantial part of austenite with a tiny portion of tempered martensite and ferrite. The microstructure seems to have a ferrite delta framework in the austenite matrix of the welded metal. This study proves prior findings by a few authors [7].

R. Sudhakaran et al. 2014 explored the role of GTAW parameters on pitting corrosion on AISI 202 chromium manganese stainless steel. An empiric mathematical model that correlates PREN i.e. pitting resistance equivalent number with welding parameters like welding speed, welding current, gas flow rate, and welding gun angle has been established. The central composite response surface methods, with five levels and four parameters, was used to test the study hypotheses. The suitability of the proposed model has been inspected utilising ANOVA. The significant effect of processing parameters on the PREN of its welded joints have been researched utilising contour and surface plots. The speed is 0.87 m / min. The melting current of the filler increases after the bypass current was applied. Whereas the current density was generally reduced and the constant heat centre offset was identified, the arc features in DSAW altered. Whenever the angle of the weld gun is retained at a reduced level of 50 °, the affected area by the heat gradually decreases because of less exposure of the welding metal to the arc. Gross grains are noted in the metal welding zone and the substantial part of austenite is maintained. The tempered martensite is widely spread during this zone. When the welding gun angle is retained at an elevated level of 90 °, there seems to be a rise in the affected area by the heat high levels of exposure of the welding metal to the arc. The presence of martensite increases the tensile strength of the welding metal. The existence of ferrite in the austenite matrix shows that the welding metal does have phase stability, adequate capacity and corrosion resistance [24].

Jong Young Lim et al. 2015 especially in comparison the productivity in enhancing material characteristics of rolled steel (SS400) with stainless steel (STS304) welded both by the MIG (metal inert gas) welding and CO 2 weld area method. Multi-tests were performed on the welded sample, such as X-ray irradiation, Vickers' hardness, tensile test, fatigue test, fatigue crack growth test. Predicated on the fatigue crack development procedure done by two techniques, the interaction between dN and da was analysed. And although hardness of the two techniques was comparable, the fatigue properties and tensile test of the MIG weld zone were higher than that of the CO2 welded one. In this research, the mechanical properties, fatigue and hardness properties of SS400 and STS304 welded materials utilizing different types of welding techniques were evaluated. From hardness test, the two CO2 welding specimens had comparable hardness, the hardness observed in the metallic weld zone and heat affected region and base metallic region, respectively, demonstrates that perhaps the metallic zone had the highest, welded CO2 TS of 463.4 MPa with deformation at 39.88 per cent. SS400-STS304 welded by MIG has a tensile strength of 623.4 MPa with elongation of 48.42 percent, which is really the greatest of all specimens, and STS304-STS304 welded by MIG does have a TS of 598.3 MPa with elongation of 26.02 percent. Because high current is quickly induced by a MIG weld area, both and SS400 and STS304 can be melted due to increased current induction, and that is why the MIG welded SS400-STS304 indicates the largest fatigue limit. From crack growth test, the heat affected MIG welding region and welded metallic region showed a slow crack rate of growth. However, CO2 welded SS400-SS304 and CO2 welded SS400-SS400 showed an opposite trend [14].

3. THE PROPOSED METHOD

3.1 Proposed Methodology

we will discuss the experimental procedure in detail. The step by step Flow Chart of the procedure of experiment is given below. All the steps are explained in details in this chapter ahead.

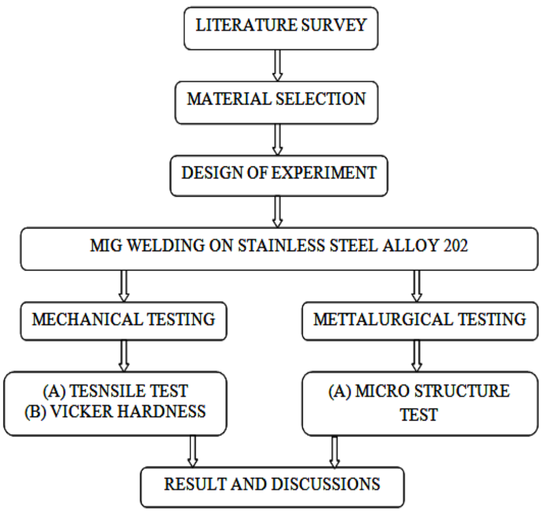

Fig. 2: Flow Chart for Planning of Work.

4.1 MIG WELDING SYSTEM

For appropriate welding and control on the parameters of welding, a welding setup was recognized and particulars have been considered in Chapter 1. The welding setup contains mostly the following parts:

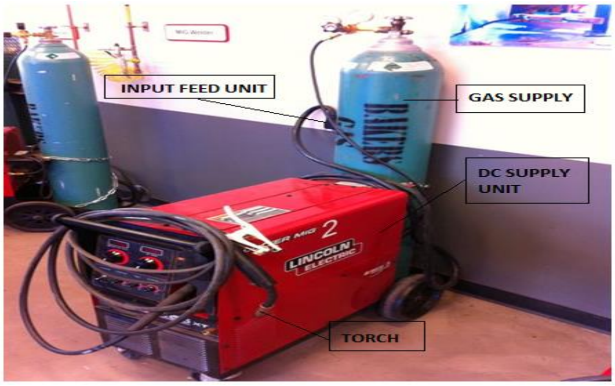

Fig. 3: Image of MIG Welding System Welding Setup

4.1.1 MIG Welding Machine Specifications

Table 4.1: MIG Welding Machine Specification.

ITEM	UNIT	RX600
Supply	V	415± 10%
Phase	Ph	3
Frequency	Hz	50
OCV (DC)	V	28-56
Load	KVA	26
Control Circuit	V	24
Torch	Model	X
Output (Min./Max.)	A	80/600
Output Steps	Nos	16
Torch Connector	Model	PM-3
Weight	Kg	280
Motor	Type	Permanent Magnet

4. RESULT ANALYSIS

Figure 4 shows variation of Hardness of specimens with welding current at gas flow rate 2 litres/min and welding speed 4 mm/min on heat affected zone (HAZ) and on weld pool. It can be seen that the hardness of weld pool is lower than that of base metal or HAZ which is due to the filler metal used has lower yield strength than the base metal and may be because of some welding defects. At weld pool the maximum hardness is achieved at 300 ampere current value which can be due to proper fusion at high heat input and combination of respective gas flow rate and welding speed.

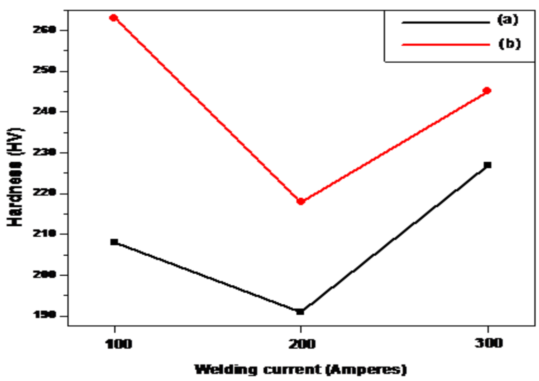

Fig. 4: Variation of Hardness of Specimens with welding Current at Gas Flow Rate 2 litres/min and Welding Speed 4 mm/min on (a) Weld Pool (b) HAZ

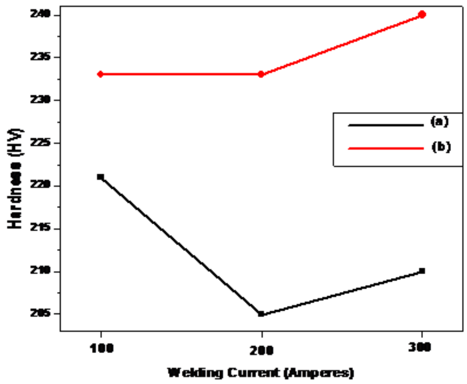

Fig. 5: Variation of Hardness of Specimens with Welding Current at Gas Flow Rate 1 litres/min and Welding Speed 3 mm/min on (a) Weld Pool (b) HAZ

Moreover, at heat affected zone maximum hardness is achieved at 100 ampere welding current which can be due to fast cooling rate and formation of small grains at low heat input. Figure 5 shows variation of hardness of specimens with welding current at gas flow rate 1 litres/min and welding speed 3 mm/min on weld pool and HAZ. The hardness in this case is somehow lower than that of previous case because at lower welding speed there is proper penetration and the weld pool is tougher and ductile which is why the hardness is low. However, same as above case the hardness of weld pool is lower than that of base metal or HAZ and maximum hardness at weld pool is achieved at 100 amperes current and at HAZ the maximum hardness is achieved at 300 amperes. At 200 ampere the hardness is lowest and thus it can be concluded that to achieve welded specimen with low hardness with these combinations of welding speed and gas flow rate, welding of this alloy should be done at 200 ampere welding current. Figure 6 shows variation of hardness of specimens with welding current at gas flow rate 1.5 litres/min and welding speed 5 mm/min on weld pool and HAZ. In this case the average

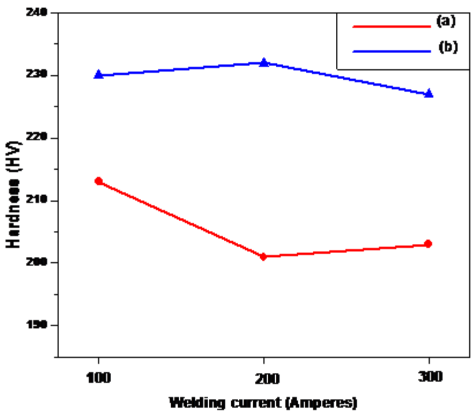

Fig. 6: Variation of Hardness of Specimens with Welding Current at Gas Flow Rate 1.5 litres/min and Welding Speed 5 mm/min on (a) Weld Pool (b) HAZ

value of hardness is lowest than previous cases which is due to welding of samples at high welding speed which leads to improper penetration, improper fusion and porosity which can be seen and discussed in microstructure analysis of samples.

5. CONCLUSION

The tensile strength or Welding force of the SS-202 welding joints relies on welding parameters such as welding current, gas flow rate, filler content, and welding speed.Welded specimens of SS-202 display low ductility and high tensile resistance at a low gas flow rate.Welding defects including Porosity may have a dramatic impact on the properties of SS-202 alloy welded specimens.At higher welding speed, there is indeed a high likelihood of welding defects and inadequate weld metal penetration occurs.Due to the change in microstructure particularly, grain size, the hardness value of the weld zone changes with the distance from the welding core.Hardness may raise two main reasons: one would be responsible for the formation of metal oxides at low gas flow rates, while the other is related to sufficient fusion of metal filler with the metal matrix.

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