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Mechanical Behavior of ARC Welding using Different Flux Materials

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Abstract: ***To perform welding process on the material under varying conditions with different flux materials, different welding parameters and further subjecting the material to various suitable tests such as tensile test, hardness test, optical tests and study the characteristics of the material under testing. The tests conducted on the welded work piece it is proposed the suitable parameters under which welding of greater precision can be performed. it is also analyzed the working conditions under which the selected work piece material of stainless steel grade 304 would deviate from its desired characteristics. From the results of the tests it is able to determine the conditions that would reduce the characteristics of the welded work piece. Thus it can be further used for reference when the welding process is done on the same material of stainless steel of grade 304. The electrodes that were chosen for this project were selected by the criteria of widely used and chief material in the welding of various grades of stainless steel. The composition of the chemicals that constitute the electrodes were tribiologically analyzed and studied. The need for high precision welding in large scale as well as small scale industries is relatively high as the threshold for errors in such areas are greatly undesirable. The results of this study would greatly contribute to the reduction of errors and defects in the welding operation.***

Key words: ***Core flux, microstructure, Tribiological ,Rutile flux, cobalt flux***

I. INTRODUCTION

Welding is a very important physical process that is carried out in the fabrication numerous numbers of products and components. It is a fabrication or sculptural process that joins materials usually metals or thermoplastics, by causing coalescence. Depending upon the process, the electrode is either consumable, in the case of gas metal arc welding or shielded metal arc welding, or non-consumable, such as in gas tungsten arc welding. In a DC system the welding stick is a cathode for a filling type of welding or an anode for other welding processes but in case of AC arc welder the welding rod would not be considered an anode or cathode.There are over 150 grades of stainless steel, of which fifteen are most commonly used. There are various welding processes that is in use now but the type that is most relevant to this study is the flux cored arc welding. In arc welding processes a number of welding parameters exist that can affect the size, shape, quality and consistency of the weld.

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The major parameters that affect the weld include weld amperage, arc voltage, and travel speed. The weld amperage that has been used are 127 Ampere, and 136 Ampere.
The workpiece stainless steel of grade 304 that has been used cannot be welded by currents below 100 amps as it would provide the required penetration for a sustainable weld. Hence these currents were chosen. The selected current provides greater penetration and hence gives more stabilized welds.

A. Literature review

In this study, influence of the welding process parameters on the weld ability of material, low carbon alloy steel (0.14% C) specification having the dimensions 75 mm x 50 mm x 6mm welded by metal arc welding were investigated. The intensity of welding current, arc voltage, rate of welding and heat supplied for welding are chosen as major welding parameters. The objective of this study is to obtain the fundamental information about the effect of electrode coating composition on the undercut defective of welding observed in Manual Metal Arc Welding (MMAW) process. Undercut in welding is one of the prime defects which are given special care as its severity increases manifolds due to, firstly the stress concentration caused by it in the parent material and secondly further weakening of HAZ where it is formed.

B. Aim

To perform welding process on the material under varying conditions with different flux materials and subject the material to various tests and studies the Mechanical behavior of the material under testing**.**

II. EXPERIMENTATION

The more frequently used types of grades are the type 304 and 316. It was chosen 304 for this project as it can be subjected to more weld ability. The chemical composition of the material was subjected to testing and verified.The electrodes with flux that were selected for the study are stainless steel electrode of Rutile flux with grade E308L and cobalt flux. E308L electrodes are used to weld stainless steels such as Types 301, 302, 304, 305, and 308.E308electrodes provide better corrosion resistance and physical properties. They have an yield strength of 55000 PSI and tensile strength 84500 PSI. This electrode is made of flux material of rutile which is made in the form of a coating over the electrode. The nominal composition of this weld metals is 19% chromium and 10% nickel with .04% carbon to increase resistance to intergranular corrosion by reducing carbide precipitation. The dimensions of the electrode are 3 mm diameter and 30 mm length. Cobalt flux is mainly used in wear applications, fusion welding, and hard facing applications.

They are widely used wear resistant hard facing materials.Their unique combination of wear resistance, strength and corrosion resistance make them adaptable to harsh environments. Cobalt flux is preferred for their excellent resistance to wear types including adhesive wear, abrasion, erosion, thermal shock, corrosion and oxidation.

A. Specimen preparation

In arc welding processes a number of welding parameters exist that can affect the size, shape, quality and consistency of the weld. The major parameters that affect the weld include weld amperage, arc voltage, and travel speed. The weld amperage that has been used are 127 Ampere, and 136 Ampere. The workpiece stainless steel of grade 304 that has been used cannot be welded by currents below 100 amps as it would provide the required penetration for a sustainable weld. Hence these currents were chosen.

Fig .1 Welding under processing

Fig .2 Welded work piece

The selected current provides greater penetration and hence gives more stabilized welds.we choosen stainless steel with grade 304 as the most appropriate material that can be subjected to testing. In order to verify whether the selected material meets the standard requirements we subjected it to chemical analysis in an accredited testing facility. The results of the test approved that the chemical composition of the material meets the requirements of AISI SS 304. Then the workpiece materials were welded in a butt weld using the different fluxes under varying currents. The welding operation was carried out manually.The welding is carried out by arc welding technique. In that we have chosen flux core arc welding technique. For the welding of stainless steel of grade 304 weld currents below 100 amps would not give good penetration. The current chosen were 127 and 136 as these were deemed suitable for a highly penetrative weld. The stainless steel chosen were machined to a length of 80mm and width of 30mm. The thickness of stainless steel is machined till we attained 6mm thickness.

B. Hardness Test

The term hardness may also refer to resistance to bending, scratching, abrasion or cutting. Hardness is not an intrinsic material property dictated by precise definitions in terms of fundamental units of mass, length and time. A hardness property value is the result of a defined measurement procedure.

Fig.3 Specimen for Hardness Test

C. Vickers Hardness Test

The Vickers hardness test method, also referred to as a micro hardness test method is based on an optical measurement system. The Micro hardness test procedure, specifies a range of light loads using a diamond indenter to make an indentation which is measured and converted to a hardness value. Sample preparation is usually necessary with a micro hardness test. Additionally, the sample preparation will need to make the specimen's surface smooth to permit good measurement.

D. Tensile Test

A tensile test, also known as tension test, is probably the most fundamental type of mechanical test that can be perform on material.The most common type of test used to measure the mechanical properties of a material is the Tension Test.

Fig: 4Tensile specimen 1

Fig :5 Tensile specimen2

E. Microstructure Analysis:

In microstructure analysis or microscopic examination the structure of a material is studied under magnification. The properties of a material determine how it will perform and these properties are dependent on the material's structure.A carefully prepared specimen and magnification are needed for microscopic examination. It involves carefully selecting a small sample of the material with consideration given to location and orientation .

Fig.6 Micro structure Testing

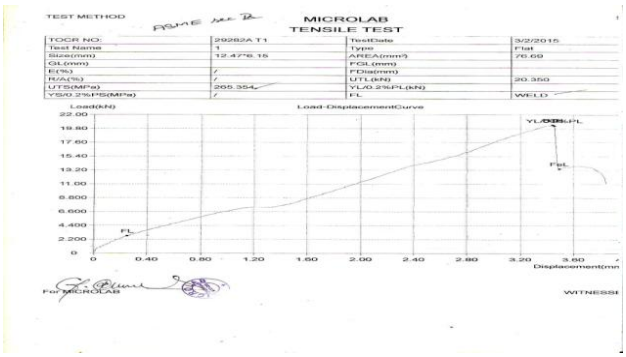
III. RESULT AND DISCUSSION

The results of the various test performed has concluded that rutile flux cored electrode provides stronger weld than the cobalt flux cored electrode. This has been analysed by the various tests performed. Although the use of cobalt flux cored flux in weld can be enhanced by preheating the workpiece, which in turn gives a stronger grain structure. This enhanced material when subjected to welding results in a reasonably strong weld. By this means cobalt flux can be used to obtain more cost effectiveness, which can be utilised for small magnitude welding. We have conducted the testing on welded work piece which is subjected to quenching. During quenching the martensite formation occurs in the stainless steel. This results in the decrease in the strength of the welded region. But we have done this to determine the maximum strength of the welded region after quenching. Since the practical application of ss304 is usually in building tanks, containers etc.The strength of the weld is not a credible one but the hardness of the material is considerably increased. So the required heat resistant properties of the material will have proportional effect on the hardness of the material. So we suggest that air cooling is best and suitable way of cooling but in some cases where only heat resistant property of the material is required quenching can be done.In short, Rutile gives more access to greater welded region in stainless steel rather than cobalt flux. Greater the amperage greater will be the penetration of the weld since the selected work piece is more heat resistant.The tests done also suggest that the high carbon or high alloy steel when subjected to welding must be preheated in order to reduce the martensite formation which will definitely increase the brittle nature of the weld and thereby decreasing the strength of the weld. So preheating is the compulsory criteria

A. Tensile Test

The ultimate tensile load is 8.8 KN when the test is conducted on specimen welded at 127 amp using cobalt flux. The ultimate tensile strength is 130.20 MPa.The ultimate tensile load is 18.85 KN when the test is conducted on specimen welded at 136 amp using cobalt flux. The ultimate tensile strength is 247.77 MPa.The ultimate tensile load is 20.70 KN when the test is conducted on specimen welded at 127 amp using rutile flux. The ultimate tensile strength is 271.01 MPa.The ultimate tensile load is 20.35 KN when the test is conducted on specimen welded at 136 amp using rutile flux. The ultimate tensile strength is 265.35 MPa

Table-I: Tensile Test Result summery



B. Hardness Test

The hardness is measured using Vickers method. Hardness carried out was on 127 amp cobalt flux. The observed value at 5 Kgf on parent metal is 299,304. On heat affected zone it is reduced to 282, 297. Hardness on weld is 438, 447. The hardness is measured using Vickers method. Hardness carried out was on 127 amp rutile flux. The observed value at 10 Kgf on parent metal is 254, 257. On heat affected zone it is reduced to 213, 221. Hardness on weld is 240, 238.The hardness is measured using Vickers method. Hardness carried out was on 136 amp cobalt flux. The observed value at 5 Kgf on parent metal is 306310. On heat affected zone it is reduced to 262268. Hardness on weld is 349 353.
The hardness is measured using Vickers method. Hardness carried out was on 136 amp rutile flux. The observed value at 10 Kgf on parent metal is 270274. On heat affected zone it is reduced to 209215. Hardness on weld is 246235.

Table-II: Hardness Test Result

TEST REPORT

Customer		
Mr.I. Kareem Nawaz Mr. A. Ahamed Tahsin Mr. Thahsin Mr. S. Althaf Mr. Nehal Ahamed Mr. S.M. Thasleem Aalim Muhammed Salegh College of Engineering, Avadi IAF, Chennai.	Report No / Date	ML/30416A/2/14-15 / Dt:14.03.2015
	Your ref./ Date	Letter / Dt: 11.03.2015
	Our ref./ Date	TOCR: 30416A/14-15 Dt: 11.03.2015
	Nature of test	Vickers Hardness Test
	Test Reference	ASTM E384-2011
	Date of Testing	13.02.2015
	Sample Drawn By	Customer
	Sample Description	Stainless Steel Weld Plate Grade SS 304 136 Amp Cobalt Flux Qty:1 No

Vickers Hardness Test:

Location	Observed Values (Hv5Kg)
Parent Metal	306, 310
HAZ	262, 268
Weld	349, 353

Page 1 of 1

TEST REPORT

Customer		
Mr.I. Kareem Nawaz Mr. A. Ahamed Tahsin Mr. Thahsin Mr. S. Althaf Mr. Nehal Ahamed Mr. S.M. Thasleem Aalim Muhammed Salegh College of Engineering, Avadi IAF, Chennai.	Report No / Date	ML/30651A/1/14-15 / Dt:14.03.2015
	Your ref./ Date	Letter / Dt: 13.03.2015
	Our ref./ Date	TOCR: 30651A/14-15 Dt: 13.03.2015
	Nature of test	Vickers Hardness Test
	Test Reference	ASTM E384-2011
	Date of Testing	13.02.2015
	Sample Drawn By	Customer
	Sample Description	Stainless Steel Weld Plate Grade SS 304 127 Amp Rutile Flux Qty:1 No

Vickers Hardness Test:

Location	Observed Values (Hv10Kg)
Parent Metal	254, 257
HAZ	213, 221
Weld	240, 238

TEST REPORT

Customer Mr.I. Kareem Nawaz Mr. A. Ahamed Tahsin Mr. Thahsin Mr. S. Althaf Mr. Nehal Ahamed Mr. S.M. Thasleem Aalim Muhammed Salegh College of Engineering, Avadi IAF, Chennai.	Report No / Date	ML/30651A/2/14-15 / Dt:14.03.2015
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	Date of Testing	13.02.2015
	Sample Drawn By	Customer
	Sample Description	Stainless Steel Weld Plate Grade SS 304 136 Amp Rutile Flux Qty:1 No

Vickers Hardness Test:

Location	Observed Values (Hv10Kg)
Parent Metal	270, 274
HAZ	209, 215
Weld	246, 235

TEST REPORT

Customer Mr.I. Kareem Nawaz Mr. A. Ahamed Tahsin Mr. Thahsin Mr. S. Althaf Mr. Nehal Ahamed Mr. S.M. Thasleem Aalim Muhammed Salegh College of Engineering, Avadi IAF, Chennai.	Report No / Date	ML/30416A/1/14-15 / Dt:14.03.2015
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	Test Reference	ASTM E384-2011
	Date of Testing	13.02.2015
	Sample Drawn By	Customer
	Sample Description	Stainless Steel Weld Plate Grade SS 304 127 Amp Cobalt Flux Qty:1 No

Vickers Hardness Test:

Location	Observed Values (Hv5Kg)
Parent Metal	299, 304
HAZ	282, 297
Weld	438, 447

Fig.7 Microstructure Results(sample1)

C. Microstructure Analysis

The optical images obtained by microstructure analysis of material welded using cobalt flux had shown a greater degree of martensite formation. This indicates the greater brittleness of the welded material. While the magnified images of the material welded using rutile flux had shown considerably lesser amount of martensite formation when compared to the cobalt flux. This indicates that it is considerably less brittle than when cobalt flux is used and hence gives good characteristics.

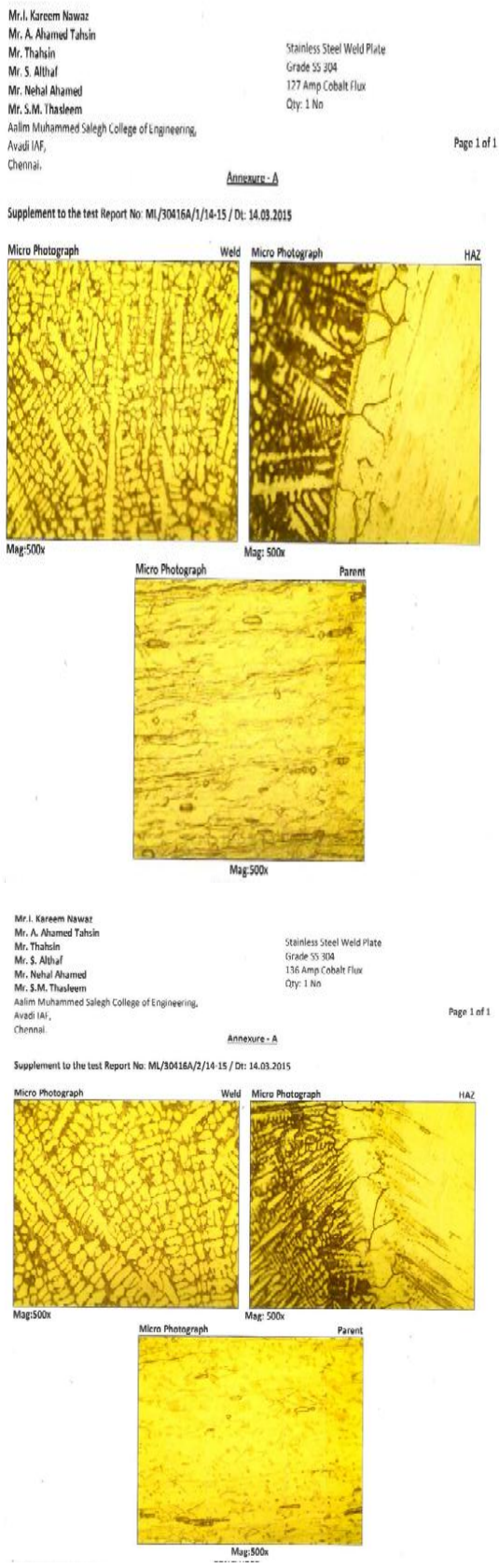

Fig.8 Microstructure Results(sample2)

IV.CONCLUSION

The results of the various test performed has concluded that retile flux cored electrode provides stronger weld than the cobalt flux cored electrode. This has been analysed by the various tests performed. Although the use of cobalt flux cored flux in weld can be enhanced by preheating the work piece, which in turn gives a stronger grain structure. This enhanced material when subjected to welding results in a reasonably strong weld. By this means cobalt flux can be used to obtain more cost effectiveness, which can be utilized for small magnitude welding. It is conducted the testing on welded work piece which is subjected to quenching. During quenching the martensite formation occurs in the stainless steel. This results in the decrease in the strength of the welded region. But it is done this to determine the maximum strength of the welded region after quenching. Since the practical application of SS304 is usually in building tanks, containers etc.The strength of the weld is not a credible one but the hardness of the material is considerably increased. So the required heat resistant properties of the material will have proportional effect on the hardness of the material. So we suggest that air cooling is best and suitable way of cooling but in some cases where only heat resistant property of the material is required quenching can be done. In short, Rutile gives more access to greater welded region in stainless steel rather than cobalt flux. Greater the amperage greater will be the penetration of the weld since the selected work piece is more heat resistant.The tests done also suggest that the high carbon or high alloy steel when subjected to welding must be preheated in order to reduce the martensite formation which will definitely increase the brittle nature of the weld and thereby decreasing the strength of the weld. So preheating is the compulsory criteria .

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Prof.Nehal Ahmad has completed B.E.Mechanical in 2006 and M.E CAD in 2009 from Anna University. He had worked in industry for 2 years as well as Asst.Professor for more than 10 years in various Engineering college. Presently he is working as Asst.Professor in HKBK College of Engineering.,Banglore.He is a member of SAE as well as Technician member of the IEI. His current research interest area includes composite materials, welding Design and structural stress analysis. He has authored more than 10 papers in international journals and conferences.

Mahboob Tabriz.B, presently working as the Professor and Head.in the Department of Mechanical Engineering in HKBK college of Engineering. He hold B.E in Mechanical Engineering and M.Tech in Machine design. He has more than 13 years of experience. He have been widely involved in innumerable of innovative projects and his area of research include in Design, Analysis on Aerospace and Automotive components using Hypermesh, Nastran, Patran ,Ansys, Auto CAD.

Prof.Fathima Parveen, is the Associate Professor in the Dept. Mechanical Engineering, in HKBK college of Engineering,Benglorer. Prior to joining this organization ,she was a faculty and Head in Mechanical Engineering, Dept in GOPALAN Engineering college Banglore, between 2010 to 2018.she is having more than 20 years of teaching experience. She is persuing her from VIT .Tmil Nadu,, . She has authored more than 15 papers in international journals and conferences.