Experimental Evaluation of Weld Joint Used in Automobile Chassis

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Abstract: FE410 is stainless steel which is normally used in chassis body frame. In this paper we are going to evaluate the weld joint of FE 410 material. This test includes tensile test, bending test, micro structure analysis and macro structural analysis of welded joint with parent material

Keywords: FE410, stainless steel, tensile test, bending test, micro structure, macro structural

I. Introduction

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond between the materials.

The mechanical properties in heat affected zone significantly distinguished from the heat affected zone on base metal depending on the heating and cooling conditions imposed by the welding process on the base plate. Bending test, tensile test, impact test are important standard engineering procedures to characterize properties related to mechanical behavior of materials. To consider actual loading conditions various specimen were drawn at different weld line from plate end, to signify the response of material. Although the behavior of the material in elastic limit is important but the information beyond elastic limit is also relevant since plastic effects with large deformation takes place in number of processes. Full range stress strain curve of welded joint differs from alloy stress strain curve. Deviation of stress strain curve is significant in post yield region.

The method used for welding the material is GMAW which stands for Gas Metal Arc Welding, in it we have used MIG (Metal inert gas) welding.

The objective of the current work is to carry out an investigation of effect of stresses on welded joint compared to parent material under tensile and three-point bending. The specimen model is then subjected to loading condition using theory of plasticity and the result are verified with experimental findings.

The mechanical and chemical properties of the material used for chassis i.e. FE 410

TABLE I PROPERTIES OF FE 410

Materials	C%	Mn%	S%	P%	Tensile strength	Yield strength
FE-410	0.25	1.5	0.040	0.040	540-660	410

II. Literature Review

Puspendu Chandra Chandra [8] has studied the effect of parameters such as welding current, welding voltage and filler wire on microstructure development of AISI 1018 mild steel processed by metal active gas (MAG) welding. The main results obtained from this study are as follow:

i. Macroscopic analysis demonstrated that the heat effected zone (HAZ) of MAG joints were composed of coarse grain zone near the weld zone, fine grain zone and incomplete recrystallization zone adjacent to the base metal. The coarse grain zone which was a typical weakness of joint as a result of its poor plasticity and impact toughness.

ii. Microstructural analysis also indicated that welding zone microstructure changes with cooling rate. A martensite structure is formed in the weldment due to very fast cooling. So, the weldments have higher hardness because the formation of martensite.

Radha Raman Mishra, Visnu Kumar Tiwari and Rajesha S [6] has investigated that Tungsten Inert Gas Welding is more suitable than Metal Inert Gas welding for dissimilar metal welding of mild steel and stainless steel, TIG welding process provides better strength. It may be because of less porosity in dissimilar metal welds during TIG welding and carbon precipitation which comes out due to welding is also less. The low percentage of free carbon allows the product (welded stainless steel with mild steel) better corrosion resistivity, ductility and strength.The main flaw which occurs in welding dissimilar material by MIG is the development of cracks during the welding, which needs more effort for achieving similar weld has by TIG welding.The percentage dilution in stainless steel is higher in MIG welded dissimilar joints which may be the reason of chromium loss due carbon precipitation in the joints and lower corrosion resistance.The dissimilar metal joint of SS 316 and mild steel has the best ductility for both TIG and MIG welding processes.

III. Process

The proposed work involves the following steps:

1. Collecting information of materials used for vehicle chassis frame.
2. Finding out mechanical and chemical properties of materials.
3. Finding standard size of test specimen by ASTM standards.
4. Deciding specific type of welding to be used for chassis.
5. Deciding welding material (third bonding material/filler material).
6. Finding welding parameters which affect the strength of welding joint.
7. Testing the sample specimen under various loading condition such as Bending test, tensile test, micro structure.
8. Comparing the results with parent material to find out the change in strength of chassis frame.

Gas Metal Arc Welding (GMAW), also metal inert gas (MIG), is a widely used welding method for carbon steel, high-strength, low-alloy steel, and stainless steel, aluminium, copper, titanium, and nickel alloys can be welded in all positions with this process by choosing the appropriate shielding gas, electrode, and welding variables and so on in industry for its high weld quality, good protection and relatively lower equipment investment. MIG welding involves a number of variables. Each variable has its effect on the weld and there is an interrelationship among variables that affects the weld characteristics. These welding variables are part of welding procedure. Depending on the thickness of the base material and type of weld joint extra filler material might be needed.

MIG WELDING PARAMETERS DETAILS

Electrode Material :ER 70S6 AWS A5.18
Diameter of Electrode :1.2 mm

TABLE II PARAMETERS OF WELDING

Input parameter	Unit	Level
Workpiece thickness (T)	mm	4
Welding current (I)	Amp	220
Welding voltage (V)	V	21
Wire feed rate (F)	lts/min	16

1.BENDING TEST AND RESULT

Bend test deforms the test material at the midpoint causing a concave surface or a bend to form without the occurrence of fracture and are typically performed to determine the ductility or mechanical behavior or resistance to fracture of that material. Unlike in a flexure test the goal is not to load the material until failure but rather to deform the sample into a specific shape. The test sample is loaded in a way that creates a concave surface at the midpoint with a specified radius of curvature according to the stand ard in relation to which the test is performed.

Bending tests are as popular as tensile test, compression test, and fatigue tests. A bending test produces tensile stress in the convex side of the specimen and compression stress in the concave side. This creates an area of shear stress along the midline. To ensure the primary failure comes from tensile or compression stress and the shear stress must be minimized. This is done by controlling the span to depth ratio; the length of the outer span divided by the height (depth) of the specimen. The bend test method measures behavior of materials subjected to simple loading. It is also called a transverse beam test with some material. Maximum stress and maximum strain are calculated for increments of load.

The dimensions of Specimens of weldments for bending tests were selected from study of literature papers and bend test parameter. In Bend testing, two specimens were selected of FE410. This specimen were cut by laser cutting. In this work, dimensions of specimen were selected as 130*30*4 mm (L* W *T). Specimens for tests were taken as perpendicular to weld direction.

Bending test was carried out on both the welded and parent specimen on FE 410. Bending test was conducted using 9800 N computer controlled universal testing machine. Before testing, cross-sectional area and gauge length were measured for each sample. The specimen was then loaded into a machine set up for bending loads as per specification and placed on roller fixture of a universal testing machine. Speed of transverse loading was 5 mm/ min. Details of test preparation, conducting, and conduct affect the test results:

Three point bending test: -Angle of bend: 90^0, Support span: 80mm

TABLE III OBSERVATION OF BENDING TEST

Sr. No.	Welded Specimen	Parent Material specimen
1.	No crack observed at 90^0 bend	No crack observed at 90^0 bend

Fig.1 Bending test

2.TENSILE TESTING AND RESULT

Tensile test was utilized to decide the mechanical conduct of material under statics, extend loading. In this the tensile testing was conducted on two samples of FE 410 welded by MIG process and parent FE 410 without welded. The elastic examples were set up according to ASTM E8.

The dimensions of specimens of weldments for tensile tests were selected from study of literature papers and bend test parameter. In tension testing, two specimens were selected of FE 410. These specimens were cut by laser cutting. In this work, dimensions of specimen were selected as 130*30*4 mm (L* W *T). Specimens for tests were taken as perpendicular to weld direction.

Tensile tests are directed utilizing 98000N computer controlled all-inclusive testing machine. Before testing, cross-sectional zone and gauge length was measured for each specimen. The example was then stacked into a machine set up for ductile loads according to the ASME determination and put in the correct grippers so that the tractable examples experience disfigurement. Once stacked, the machine can then be utilized to apply a consistent, proceeds malleable load. With use of tensile load, examples experiences miss happening and bendable break happens at specific load and this esteem is recorded to compute extreme rigidity of segment load.

TABLE IV OBSERVATION OF TENSILE STRENGTH

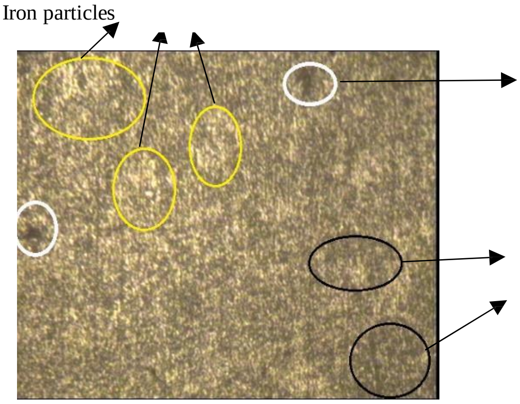
Sr. No.	Tensile Strength of welded specimen (MPa)	Tensile test of parent material specimen (MPa)
1.	289.99	564.29

Fig 2. Tensile test

3.MICROSCOPIC EXAMINATION

Microstructural images were captured using electron microscope at magnification 200X. The weld zone cross section was prepared for microstructural analysis using different grade of emery papers and then lapped over lapping machine then to observe microstructure the samples were dipped into 2% nital solution. from the observations it was inferred that tempered martensite, non-uniform distribution of iron particles, carbide particles which is shown in fig 3. The microscopic view showed weld pool region were as uniform distribution is observed in parent material, this is due to heating and rapid cooling of weld zone and change in chemical composition.

Iron particles



Martensite

Carbide particles

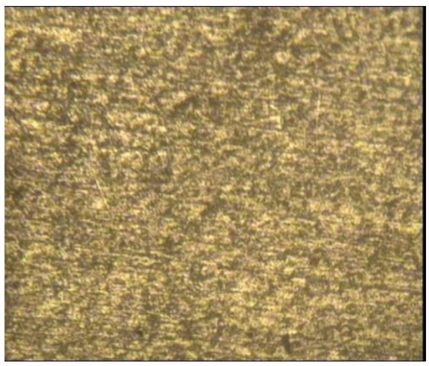


Fig. 3 microstructure of welded nugget

Fig. 4 microstructure of parent material

4.MACROSCOPIC EXAMINATION

Macrostructural images were captured using electron microscope at magnification 15X. The weld zone cross section was prepared for macrostructural analysis using different grade of emery papers and then lapped over lapping machine and then to observe macrostructure, the sample were dipped into a solution of methanol (40%) and nitric acid (60%). From the test, porosity was observed in welded region due to the absorption of oxygen and nitrogen from the atmosphere in molten weld pool which gets trapped in weld metal, shown in fig 5. And Fe_2O_3 was also observed in the weld joint which was formed because of reaction between oxygen and iron at high temperature.

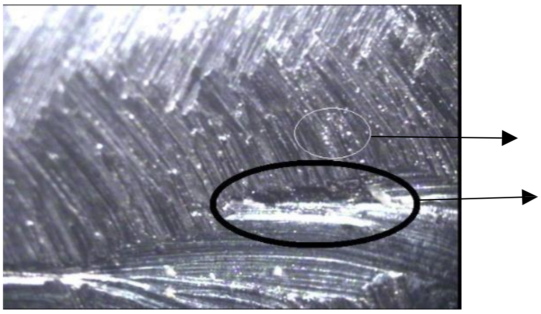


Fig.5 macroscopic view of welded specimen

IV. CONCLUSIONS

During the study, FE410 Grade of stainless steel was joined using MIG welding process. The tensile strength and Bending strength of welded joints were investigated. The selection of different grades of stainless steel used for welding play an important role in deciding the properties of the weld. From the study, following conclusions can be drawn –

- Tensile strength of welded specimen is less than the tensile strength of parent material, no cracks were observed at 90^0 bend of welded and parent material in bending test
- In microscopic test, tempered martensitic structure, carbide particles were observed along with non-uniform distribution of iron particles in welded joint. In macroscopic test porosity as well as iron oxide were observed in welded region.
- It is concluded that tensile strength of welded material is less than parent material due to formation of porosity, martensitic structure and carbide particles.

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REFERENCES

1. A.R. Bahman and E. Alialhosseini, change in hardness, yield strength and UTS of welded joints produced in St37 grade steel Indian Journal of Science and Technology Vol. 3 No. 12 (Dec 2010) ISSN: 0974- 6846.
2. Bhagwan F. Jogi, A. S. Awale, S. R. Nirantar, H. S. Bhusare, Metal Inert Gas (MIG) Welding Process Optimization using Teaching-Learning Based Optimization (TLBO) Algorithm 2214-7853 © 2017
3. Mohit Singhmar, NishantVerma, Experimental study for welding aspects of austenitic stainless steel (AISI 304) on hardness by Taguchi technique, Volume 2, Issue 1, January -2015
4. Pappu Kumar, Prof. Prakash Kumar, Optimization of Welding Parameter (MIG Welding) Using Taguchi Method, Volume. 4 Issue.11 November-2016 Pages-6053-6058 ISSN(e):2321-754
5. A.Sivashankar, S.Shaghulhameeth, T.Siva, S.Sathishkumar, K.Sowndhar, Welding process parameters & optimization & analysis OF SS410 with mild steel by using Taguchi, Volume 1, Issue 2, March 2017, ISBN 978-1-63535-889-6
6. Radha Raman Mishra, Visnu Kumar Tiwari and Rajesha S, A study of tensile strength of MIG and TIG welded dissimilar joints of mild steel and stainless-steel Vol.3, No.2, April 2014 DOI:10.14810/ijamse.2014.320323
7. Gurpreet Singh Malhi1, Taljeet singh, Improving strength of welded joints with the help of MIG welding parameters, IJME, Volume 2, Issue 3 (November, 2015) e-ISSN: 1694-2302 p-ISSN: 1694-2418
8. Puspendu Chandra Chandra, Microstructural study of mag welded joint of AISI 1018 mild steel, DOI:10.5281/zenodo.1002630 (October 2017) ISSN: 2277-9655