Parametric Study Of GMAW (Gas Metl Arc Welding) carried on boiler quality steel material

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Abstract – Gas Metal Arc Welding are widely used in conventional Arc welding process due to their portability, cost effectiveness, high quality performance. The GMAW also known as the Gas Metal Arc welding is also used in many application to take advantage of excellent quality of weld made by GMAW. Though this reports, study of parameter of current, gas, nozzle to workpiece distance was put forward . The Welding with GMAW was done on 'V' groove configuration to carry out the study on effect of GMAW current, GMAW gases, GMAW nozzle to w/p distance in different combination on ST 53 boiler grade material. During experimentation it was found that GMAW current and nozzle to w/p distance has a great effect on tensile strength of the weld and the hardness of the weld is mostly influenced by the type of gas used during welding. The GMAW current and nozzle to w/p distance also has great influence on the impact strength of weld in GMAW welding

Key Words: GMAW, ST53 , current , gas , nozzle to w/p distance

1. INTRODUCTION

GMAW welding process in which the source of heat is an arc formed between a consumable metal electrode and the workpiece. Active/Inert gas protects the molten metal from reacting with atmospheric gases. MAG Welding is a welding process in which an electric arc is formed between a consumable wire electrode and workpiece metal which heats the workpiece metal causing them to melt and join. Along with the wire electrode a shielding gas feeds through the welding gun , which shields the process from atmosphere contamination As compared to MAG welding which uses active gas like co2 for welding process , the MIG uses inert gas or gas mixtures as shielding gas for welding. Typical inert gas used for MIG welding are ARGON and HELIUM. This gases are usually used for MIG welding of aluminium nd other non ferrous materials. The parameters which are used in GMAW welding i.e, welding current,voltage,gas flow rate,welding speed,electrode tip angle,wire feed rate ,etc are varied and this results in change in the properties of the weld .

Advantages -

1. Consumable electrodes are easy to feed.
2. No filler rod is needed
3. Welding is simple
4. Gas shield protects the weld automatically

Limitations-

1. Not suitable for heavy sections
2. Less working temperature of gas flame
3. Slow rate of heating
4. Larger heat affected area

2. LITERATURE REVIEW

During the experimentation from different literatures it was observed that parameter such as welding polarity, welding current, speed of welding , welding voltage,nozzle to workpiece distance regulates the weld properties of GMAW welding.

N.R. Mandal [1] concluded that weld quality & weld metal deposition are both influenced by the various welding parameters These parameters are welding current , arc voltage, electrode, shielding gases. Each parameter has influence to a varying degree of deposition rate ,depth of penetration.

Yu Shen Guohong Ma. Peng Chen'. [2] Concluded the effect of the process parameters on welding process and weld was analyzed to provide a theoretical basis for further improving obtaining the weld which was in high quality and good forming.

HL.Wei H.Li.Y. Gao.X P Ding LJ. Yang [3] – Studied that there is the increase in welding current in order to enhance welding productivity.

The bypass filler wire can decrease the Critical current to obtain the desired spary metal transfer model, increase the transfer rate and speed of the droplet.

Belinga Maula. Paul kah.[4] For any welding process using a shielding gas such as hydrogen(h2) , oxygen (o2), Carbon dioxide(co2), Argon (Ar) .

Concluded that the shielding gas is ues not only to protect the molten deep and bead but also to mdify metal transfer penetration and mechanical properties.

The ideal estimation of shielding gas cost is 5-7% of the total welding cost.If gas waste is considered the cost of shielding gas could reach 25% of the total welding cost.

A.G. kamble R. Venkata Rao [5] GMW develops an arc by controlling the metal from the wire rod and te input process parameters. Proper control of the process parameters which affect the bead geometry, the mechanical properties like hardness is necessary.

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Concluded that, The arc length decreases and the arc width expands with the increase of carbon dioxide content in shielding gas. With the increase of CO2 content, the welding current deceases.

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Concluded that significant factors in melted area & bead width due to welding speed, ac voltage and wire feed speed that were determined. The melting efficiency Shows direct relationship with heat flow extraction in the welded joint.

3.RESEARCH GOAL

From literature survey it is evident that GMAW welding has its own advantages and disadvantages. The carbon dioxide gas used in MAG welding has good cleaning properties as well as low in cost hence mostly in industries carbondioxide welding is preffered. Also Argon on the other hand is slightly expensive as compared to c02 and also higly efficient in protecting molten metal from impurities. We are woking on industrial project and the industry uses boiler quality ST 53 grade material to weld thier crane cabins which is their actual component.

Hence this Experiment focues on study of parametric effect of MIG and MAG welding on mechanical properties i.e Tensil strength , Impact strength , Hardness for particular welds.

3. EXPERIMENTATION

Experimentation phase was divided into three distinctive parts ie procurement of material , welding with the help of skilled worker and fitter , testing to determine mechanicall properties of weldment. Each of this phases are discussed separately throughout this chapter.

- Procurement of material

A ST 53 grade material was selected as it is the most used boiler quality plate material in JEMCON Industry , MIDC , Ratnagiri. Material was procured from JEMCON Industries itself as the authorities sponsored the material for our project work. The material was in form of 6mm thick plate and had following chemical composition.

Mechanical properties of the plate as per material test certificate supplied by vendor are tabulated below

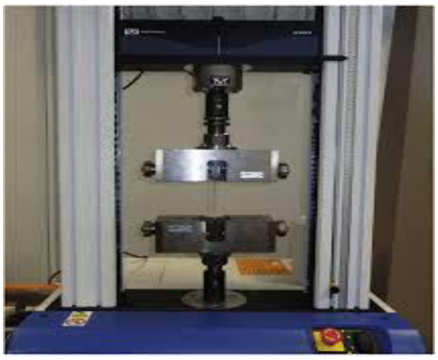
Mechanical properties of base plate

Hardness in HRB	77 HRB
Ultimate tensile strength	467 MPA

Table indicating different levels of parameters selected

PARAMETER	LEVEL 1	LEVEL 2
Welding current	150	170
Welding Gas	Carbon dioxide (co2)	Argon (Ar)
Torch nozzle to w/p distance	16mm	22mm

4.1 Test resuts



TENSILE TESTING MACHINE

IMPACT TESTING MACHINE

HARDNESS TESTING MACHINE

Table indicating tensile strength of specimen

Experiment No	Welding current	Gas	Torch nozzle to w/p distance	Yield stress (N/m m2)
1	150	Co2	16	480.9
2	150	Ar	22	472.5
3	170	Co2	22	495.6
4	170	Ar	16	510.9

Table indicating Impact strength of specimen

Experiment No	Welding current	Gas	Torch nozzle to w/p distance	Impact strength (J)
1	150	Co2	16	28.2
2	150	Ar	22	29
3	170	Co2	22	27.6
4	170	Ar	16	25.9

Table indicating Hardness of specimen

Experiment No	Welding current	Gas	Torch nozzle to w/p distance	hardness
1	150	Co2	16	182.5
2	150	Ar	22	210
3	170	Co2	22	175.5
4	170	Ar	16	212.5

4.2 Implementation of result by taguchi method

- Optimized levels of parameters obtained from all S-N ratio plots

RESPONSE	YIELD STRENGTH	HARDNESS AT WELD	IMPACT STRENGTH
PARAMETERS			
GMAW CURRENT (AMP)	170	150	150
WELDING GASES	Argon	Argon	Carbon dioxide
TORCH NOZZLE TO W/P DISTANCE	16	16	22

4.3 Response tables obtained from S-N ratios of all results.

RESPONSE TABLE FOR S-N RATIO OF YIELD STRENGTH RESULTS

LEVEL	GMAW CURRENT	WELDING GAS	NOZZLE TO W/P DISTANCE
LEVEL 1	53.56	53.77	53.90
LEVEL2	54.03	53.82	53.70
DELTA	0.46	0.05	0.20
RANK	1	3	2

RESPONSE TABLE FOR S-N RATIO OF HARDNESS AT WELD RESULTS

LEVEL	GMAW CURRENT	WELDING GAS	NOZZLE TO W/P DISTANCE
LEVEL 1	45.83	45.06	45.89
LEVEL2	45.72	46.50	45.66
DELTA	0.12	1.44	0.22
RANK	3	1	2

RESPONSE TABLE FOR S-N RATIO OF IMPACT STRENGTH RESULTS

LEVEL	GMAW CURRENT	WELDING GAS	NOZZLE TO W/P DISTANCE
LEVEL 1	29.13	28.91	28.64
LEVEL2	28.54	28.76	29.03
DELTA	0.58	0.15	0.40
RANK	1	3	2

4.4 ANOVA

Results noted through above tables were also used to analyze the variances in obtained response values and to find out the parameter which affects most on a particular response . This exercise also known as ANOVA (Analysis Of Variance) was carried out not only to validate results of ranks obtained through tables but also to find out percentile contribution of each parameter in creating variance in respone data. For this reason individual parameter was considered and its percent contribution in total variance was calculated using one way ANOVA. Further the decision making tool “F test” was also used to provide a confidence level for percent distribution calculated.

ANOVA FOR TENSILE STRENGTH RESULTS

	VARIANCE-V	PERCENT CONTRIB-UTION	F - VALUE
GMAW CURRENT	681.2	83.05	9.80
WELDING GAS	9	1.10	0.02
NOZZLE TO W/P DISTANCE	130	15.8	0.38
TOTAL		100	

ANOVA FOR HARDNESS TAKEN AT WELD

	VARIANCE-V	PERCENT CONTRIB-UTION	F - VALUE
GMAW CURRENT	5	0.47	0.01
WELDING GAS	1040.1	97.37	75.30
NOZZLE TO W/P DISTANCE	23	2.15	0.04
TOTAL		100	

ANOVA FOR HARDNESS TAKEN AT WELD

	VARIANCE-V	PERCENT CONTRIB-UTION	F - VALUE
GMAW CURRENT	3.423	66.04	3.88
WELDING GAS	0.20	3.85	0.08
NOZZLE TO W/P DISTANCE	1.56	31	0.86
TOTAL		100	

POOLED ANOVA FOR HARDNESS RESULTS

	Variance -v	Percent contribution	f- value
Welding gas	1040.1	94.75	74.29
pooled	14	5.25	
total		100	

5.RESULTS and ANALYSIS

5.1.Confirmation expreriment

Design of experiment for validation.

RESPONSE	HARDNESS	IMPACT
EXPERIMENT NO	V	VI
PARAMETER	LEVELS	LEVELS
GMAW CURRENT	150	150
GAS	Ar	Co2
NOZZLE TO W/P DISTANCE	16	22

Response values for preferred combination of parameter levels.

RESOPONSE	RESPONSE VALUE
Yield strength (N/mm^2)	510.9 N/mm^2
Hardness (Vickers)	203.5 vickers
Impact strength (joules)	28.05 joules

5.2 Regression analysis

General Linear relation between dependent and independent variables is given by

R = A + BIP + B2Q + B3R + B4S ... (7.1)

Where R is response value, P, Q, R, S are the parameters and A,BI.B2, B3 and B4 are regression coefficients obtained through regression analysis.

Using Minitab 16 , equations were generated for all responses and are given below.

Following are the regression equation generated from minitab.

Yield Tensile Strength = 317+1.31 (GMAW current) – 1.90 (Nozzle to workpiece distance) …..(7.2)

Hardness = 228 - 0.11 (GMAW current) – 0.79 (Nozzle to workpiece distance)

... (7.3)

Impact Strength = 38.5 - 0.0925(GMAW current) + 0.208 (Nozzle to workpiece distance) ….(7.4)

Above equations can be used to predict values of responses at different treatments.

RESPONSE VALUES FOR PREFERRED COMBINATION OF PARAMETER LEVELS THROUGH REGRESSION ANALYSIS

RESPONSE	RESPONSE VALUE
Yield strength (N/mm^2)	509.8 N/mm^2
Hardness (Vickers)	200.86 vickers
Impact strength (joules)	29.20 joules

6.Validation of results

- Confidence interval

formula - **CI=** $\sqrt{FX(Vep)X\frac{1}{n}X\frac{1}{r}}$

CI = Confidence interval

$F_{\alpha:1:v2}$ = F value required for

A = RisK

v2 = Degree of freedom for pooled error

Vep = Pooled error variance

r =Sample size for the confirmation experiment

n =Effective sample size

N = Total number of experiments conducted)

VALIDATION OF RESULTS

Response	µ (mean)	USL-LSL	Response value through confirmation experiment	Response value through regression analysis
Tensile strength	509.175	476.215-542.135	510.9 N/mm^2	509.8 N/mm^2
Hardness	211.25	199.88-222.62	203.5 vickers	200.86 vickers
Impact strength	29.225	24.3107-34.1393	28.05 joules	29.20 joules

Response values obtained from confirmation experiment and regression analysis falls under confidence interval. This confirms the optimum levels of parameters selected for responses

7.CONCUSION

GMAW welding has potential use in various large sacle as well as small scale manufacturing industries where mostly steel to steel welding is preferred. GMAW welding sound quality welds and mechanical properties ar a very low cost as compared to other welding processes.statistically design experiments based on taguchi method were performed using design experiments to analyze the mechanical properties of weld i.e tensile strength , Hardness , Impact strength. After performing experiment tests on test coupons and analyzing results using signal to noise ratio and analysis of variance(ANOVA) ; the influence of GMAW current , welding gas , nozzle to w/p distance on mechanical properties of weldment were established. S-N ratio results were confirmed by anova and confirmation experiments. GMAW current and nozzle to workpiece distance affected the tensile strength of the weld. Whereas the welding gas does not have much influence on the tensile strength of the of the material. The welding gas has a great influence on hardness of the weld and affected the hardness more as compared to the welding current and nozzle to workpiece distance. Considering Impact strength , the GMAW current and the nozzle to workpiece distance affected the impact strength of the weld the most and the welding gas does not have much effect on the impact strength of the weld. Optimization of parameter levels were also carried throughout the experimentation. 170 amps of GMAW current , Argon gas , and 16mm of nozzle to workpiece distance gave the highest value for tensile strength. 150 amps of GMAW current , Argon gas , and 16mm of nozzle to workpiece distance gave the highest value for Hardness of the weld. 150 amps of GMAW current , Carbon dioxide gas , and 22mm of nozzle to workpiece distance gave the highest value for Impact strength.

8.FUTURE SCOPE

During this project work , the effect of GMAW current , welding gas , nozzle to workpiece distance were studied by performing design experiments.
During the study it was observed that the welding gas plays a major role in hardness of the weld and hence using combination of welding gases ie argon + carbondioxide or in some case helium can be given attention.

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