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Study and Comparison of Shielded Metal Arc Welding, Metal Inert Gas Welding and Submerge Arc Welding Processes

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Abstract— In this review paper we mainly focus on study the methodology of SMAW,MIG and Submerge arc welding and there Advantages, disadvantages and Application. Then comparison on the various basis like deposition rate.
Key words: MIG, SMAW, SAW, C45, Welding

I. INTRODUCTION

The project is to study variation in properties of material of grade C-45.We going to perform SMAW,MIG and SAW welding on C-45.It is very difficult to weld the medium carbon steel and high carbon steel. The samples are being prepared according to ASME codes. All samples of welding is to test under tensile ,hardness, micro structural changes, chemical composition, ultrasonic testing And DPT for crack identification going to done. In this review paper our main focus is on study of welding technologies. We are studying which kind of welding rods, filler material, shielding gas and flux are been used. We are studying factor affecting the selection of welding procedure.

Welding is the permanent joining process of similar or dissimilar metals with or without the application of heat and pressure. Welding widely used in many industries for joining of metals.

The various factors affecting the selection of welding process are listed below,

- Metal: Thickness, melting point, thermal expansion
- Availability of consumables
- Service condition
- Precision required
- Economy

II. INTRODUCTION TO MIG WELDING

This process is based on the principle of developing weld by melting faying surfaces of the base metal using heat produced by a welding arc established between base metal and a consumable electrode. Welding arc and weld pool are well protected by a jet of shielding inactive gas coming out of the nozzle and forming a shroud around the arc and weld. MIG weld is not considered as clean as TIG weld. Difference in cleanliness of the weld produced by MIG and TIG welding is primarily attributed to the variation in effectiveness of shielding gas to protect the weld pool in case of above two processes. Effectiveness of shielding in two processes is mainly determined by two characteristics of the welding arc namely stability of the welding arc and length of arc besides other welding related parameters such as type of shielding gas, flow rate of shielding gas, distance between nozzle and work-price. The MIG arc is relatively longer and less stable than TIG arc. Difference in stability of two welding arcs is primarily due to the fact that in MIG arc is established between base metal and consumable electrode (which is consumed continuously during welding) while TIG welding arc is established between base metal and non- consumable tungsten electrode. Consumption of the electrode during welding slightly decreases the stability of the arc. Therefore, shielding of the weld pool in MIG is not as effective as in TIG [1].

Important elements of MIG welding are,

1) Welding spool
2) Shielding gas cylinder
3) Welding torch
4) Base plate
5) Welding power source
6) Consumable electrode.

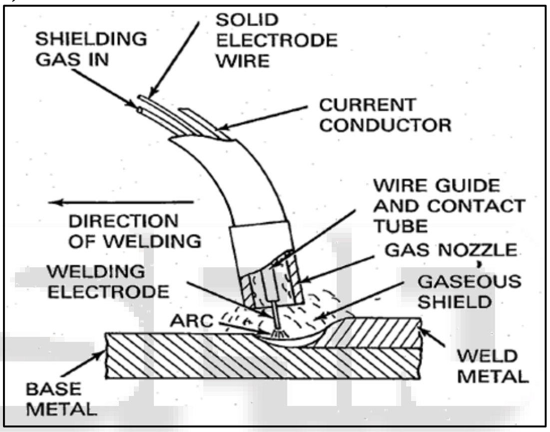

Fig. 1: Gas Metal Arc Welding Process [2]

A. Application

Some of application of MIG welding are as below,

- Used for welding of stainless steels, Aluminium, Mg, Cu and Ni alloys in aircraft and automobile industries.
- By increasing current we can increase the depth of penetration and we can weld high thickness material also.

B. Advantages

- The only consumable electrode process that can be use to weld most commercial metals and alloys.
- Deposition rate is higher than obtained in SMAW.
- Minimum postweld cleaning is required due to absence of slag.

C. Limitation

Some of limitations of MIG welding are as below,

- DCSP will cause unstable arc that result into large spatter.
- Welding equipment is more complex, more costly and less portable than SMAW.
- The welding arc must be protected from air drafts that will disperse the shielding gas.

III. EFFECT OF WELDING CURRENT ON ELECTRODE EXTENTION

Stick out of electrode affect the weld bead penetration and metal deposition rate because it changes the electrode heating due to electric resistance. If arc length increases the penetration decreases and if we increases the current the electrode extension is decreases and if decreases the welding current the electrode extension needed to be increased. It is describe in fig,.

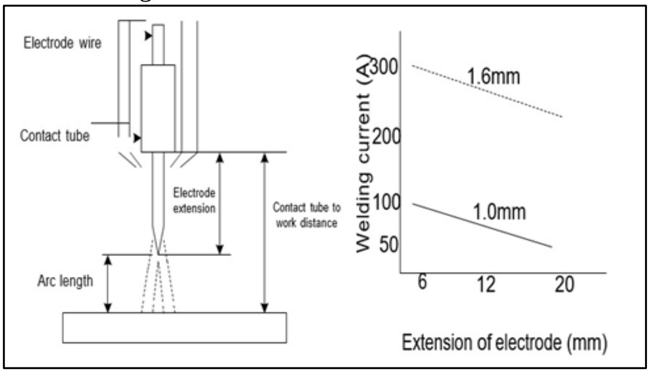

Fig. 2: Schematic diagram showing a) electrode extension and b) effect of electrode extension on welding current for different electrode diameters

IV. INTRODUCTION OF SUBMERGE ARC WELDING

Submerged arc welding (SAW) process uses heat generated by an electric arc established between a bare consumable electrode wire and the work piece. Since in this process, welding arc and the weld pool are completely submerged under cover of granular fusible and molten flux therefore it is called so. During welding, granular flux is melted using heat generated by arc and forms cover of molten flux layer which in turn avoids spatter tendency and prevents accessibility of atmospheric gases to the arc zone and the weld pool. The molten flux reacts with the impurities in the molten weld metal to form slag which floats over the surface of the weld metal. Layer of slag over the molten weld metal results:

- Increased protection of weld metal from atmospheric gas contamination and so improved properties of weld joint.
- Reduced cooling rate of weld metal and HAZ owing to shielding of the weld pool by molten flux and solidified slag in turn leads to a) smoother weld bead and b) reduced the cracking tendency of hardenable steel.

The fused and agglomerated types of fluxes usually consist of different types of halides and oxides such as MnO, SiO_2, CaO, MgO, Al_2O_3 TiO_2, FeO, and CaF_2 and sodium/potassium silicate. Halide fluxes are used for high quality weld joints of high strength steel to be used for critical applications while oxide fluxes are used for developing weld joints of non-critical applications. Some of oxides such as CaO, MgO, BaO, CaF_2, Na2,O K2,O MnO etc. are basic in nature (donors of oxygen) and few others such as SiO2, TiO2, Al2O3 are acidic (acceptors of oxygen). Depending upon relative amount of these acidic and basic fluxes, the basicity index of flux is decided. The basicity index of flux is ratio of sum of (wt. %) all basic oxides to all non-basic oxides. Basicity of flux affects the slag detachability, bead geometry, mechanical properties and current carrying capacity as welding with low basicity fluxes results in high current carrying capacity, good slag detachability, good bead appearance and poor mechanical properties and poor crack resistance of the weld metal while high basicity fluxes produce opposite effects on above characteristics of the weld[4].

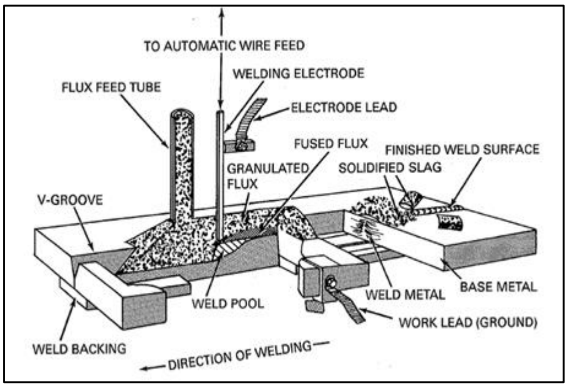

Fig. 3: Submerge Arc Welding Process

A. Advantages

1) High productivity due to high deposition rate of the welding metal.
2) Capability to weld continuously without interruptions as electrode is fed from spool, and the process works under 100% duty cycle.
3) High depth of penetration allows welding of thick sections.
4) Smooth weld bead is produced without stresses raisers as SAW is carried out without sparks, smoke and spatter.
5) Produce repeatable high quality welds for large weldments and repetitive short weldments.

B. Limitations

1) Invisibility of welding arc during welding.
2) Difficulty in maintaining mound of the flux cover around the arc in odd positions of welding and cylindrical components of small diameter.
3) Increased tendency of melt through when welding thin sheet.
4) A power supply capable of providing high amperage at 100% duty cycle is recommended.
5) Equipment required is more costly and extensive, and less portable.
6) Process is limited to shop application and flat position.

C. Applications

1) Submerged arc welding is used for welding of different grades of steels in many sectors such as shipbuilding, offshore.
2) Structural and pressure vessel industries fabrication of pipes, penstocks, LPG cylinders, and bridge girders.
3) SAW is also used for surfacing of worn out parts of large surface area for different purposes such as reclamation, hard facing and cladding.
4) The typical application of submerged arc welding for weld surfacing includes surfacing of roller barrels and wear plates.

5) Submerged arc welding is widely used for cladding carbon and alloy steels with stainless steel and nickel alloy deposits.

V. INTRODUCTION TO SHILDED METAL ARC WELDING

In this process, the heat is generated by an electric arc between base metal and a consumable electrode. In this process electrode movement is manually controlled hence it is termed as manual metal arc welding. This process is extensively used for depositing weld metal because it is easy to deposit the molten weld metal at right place where it is required and it doesn't need separate shielding. This process is commonly used for welding of the metals, which are comparatively less sensitive to the atmospheric gases.

This process can be use both AC and DC. The constant current DC power source is invariably used with all types of electrode (basic, rutile and cellulosic) irrespective of base metal (ferrous and non-ferrous). However, AC can be unsuitable for certain types of electrodes and base materials. Therefore, AC should be used in light of manufacturer's recommendations for the electrode application. In case of DC welding, heat liberated at anode is generally greater than the arc column and cathode side. The amount heat generated at the anode and cathode may differ appreciably depending upon the flux composition of coating, base metal, polarity and the nature of arc plasma. In case of DC welding, polarity determines the distribution of the heat generated at the cathode and anode and accordingly the melting rate of electrode and penetration into the base metal are affected.

Heat generated by welding arc is denoted by H and is given by,

$$H = I \times V \times 60/S \text{ in Joule per inches}$$

Where,

I-Welding current,

V-Welding voltage,

S-Welding speed in Inches per Minute

To avoid contamination of the molten weld metal from atmospheric gases present in and around the welding arc, protective environment must be provided. In different arc welding processes, this protection is provided using different approaches. In case of shielded metal arc welding, the protection to the weld pool is provided by covering of a) slag formed over the surface of weld pool/metal and b) inactive gases generated through thermal decomposition of flux/coating materials on the electrode. However, relative effect of above two on the protection of the weld metal depends on type of flux coating. Few fluxes (like cellulosic coating) provide large amount of inactive gases for shielding of weld while other fluxes form slag in ample amount to cover the weld pool. Shielding of the weld pool by inactive gases in SMAW is not found very effective due to two reasons a) gases generated by thermal decomposition of coating materials don't necessarily form proper cover around the arc and welding pool and b) continuous movement of arc and varying arc gap during welding further decreases the effectiveness of shielding gas . Therefore, SMAW weld joints are often contaminated and are not very clean for their possible application to develop critical joints. Hence, it is not usually recommended for developing weld joints of reactive metals like Al, Mg, Ti, Cr and stainless steel. These reactive metal systems are therefore commonly welded using welding processes like GTAW,GMAW etc. that provide more effective shielding to the weld pool from atmospheric contamination[5].

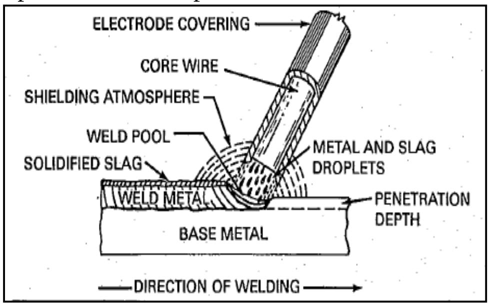

Fig. 4: Shielded Metal Arc Welding Process [6]

Constituent in flux	Role on welding arc features
Quartz (SiO_2)	Increases current-carrying capacity
Rutile (TiO_2)	Increases slag viscosity, good re-striking
Magnetite (Fe_3O_4)	Refines transfer of droplets through the arc
Calcareous spar ($CaCO_3$)	Reduce arc voltage, slag formation
Fluorspar (CaF_2)	viscosity of basic electrodes, decreases ionization ionization
Calcareous-fluorspar (K_2O Al_2O_3 SiO_2)	Improves arc stability by easy ionization
Ferro-manganese & Ferro-silicon	Acts as deoxidant
Cellulose	Produces inactive shielding gas
Potassium Sodium Silicate (K_2SiO_3 / Na_2SiO_3)	Acts as a bonding agent

Table 1:

The below table shows the role of common constituent in flux of electrode,

A. Advantages

1) Equipment is relatively simple, inexpensive and portable.
2) Process can be use in area of limited access.
3) Process is less sensitive to wind w.r.t other process.
4) Process is suitable for most of the commonly used metal and alloys [7].

B. Limitations

1) Deposition rate are lower than other processes.
2) Slag usually must be removed from every deposited weld pass, at stops and starts, and before depositing a weld bead adjacent to or onto a previously deposited weld bead [7].

VI. COMPARISON OF SMAW, GMAW AND SAW

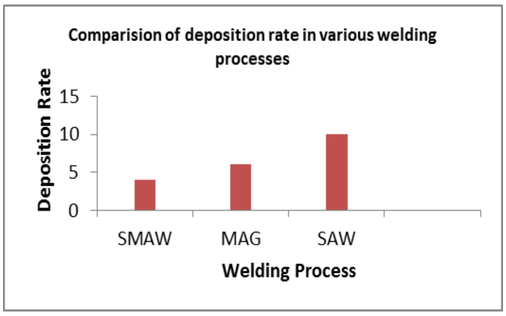

Fig. 4: From above chart it is clear that the deposition rate is good in SMAW, Better in MAG and Best in SAW Process.

Welding process	Welding position			
	F	V	OH	H
SMAW	X	X	X	X
MAG	X	X	X	X
SAW	X			

Table 2: we get to know that SMAW and MAG is applicable in all welding position.

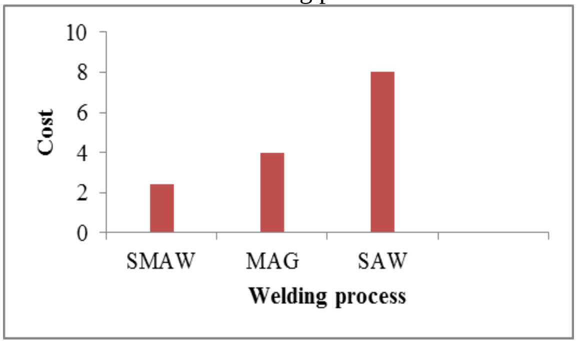

Fig. 5: From above chart, we get to know that cost of machines of different welding processes.

VII. Conclusion

We study the various welding process like SMAW, MAG and SAW. We compare the three processes on different parameters.

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