LESSON PLAN

Date_______________ Trade:- Welder

Name_____________ Week No:- Twenty one

Subject :- Aluminum and its alloy, properties and weld ability, welding methods. Arc cutting and gauging.

Motivations:- in previous week we learned about Brass-types-properties and welding methods. Copper-types-properties and welding methods.

PREPARATION: - Teaching Aids:-Chalk, Charts,

INTRODUCTION: - Aluminium or **aluminum** (in North American English) is a chemical element in the boron group with symbol **Al** and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal. Aluminium is the third most abundant element in the Earth's crust (after oxygen and silicon) and its most abundant metal. Aluminium makes up about 8% of the crust by mass, though it is less common in the mantle below.

PRESENTATION:-

Topic	Information Point	Spot Hint

Aluminium metal is so chemically reactive that native specimens are rare and limited to extreme reducing environments. Instead, it is found combined in over 270 different minerals.[7] The chief ore of aluminium is bauxite.

Aluminium is remarkable for the metal's low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in transportation and structures, such as building facades and window framesThe oxides and sulfates are the most useful compounds of aluminium.

The weldability of aluminium alloys varies significantly, depending on the chemical composition of the alloy used. Aluminium alloys are susceptible to hot cracking, and to combat the problem, welders increase the welding speed to lower the heat input. Preheating reduces the temperature gradient across the weld zone and thus helps reduce hot cracking, but it can reduce the mechanical properties of the base material and should not be used when the base material is restrained. The design of the joint can be changed as well, and a more compatible filler alloy can be selected to decrease the likelihood of hot cracking. Aluminium alloys should also be cleaned prior to welding, with the goal of removing all oxides, oils, and loose particles from the surface to be welded. This is especially important because of an aluminium weld's susceptibility to porosity due to hydrogen and dross due to oxygen.

Aluminium alloys (or **aluminum alloys**; see spelling differences) are alloys in which aluminium (Al) is the predominant metal. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc. There are two principal classifications, namely casting alloys and wrought alloys, both of which are further subdivided into the categories heat-treatable and non-heat-treatable. About 85% of aluminium is used for wrought products, for example rolled plate, foils and extrusions. Cast aluminium alloys yield cost-effective products due to the low melting point, although they generally have lower tensile strengths than wrought alloys. The most important cast aluminium alloy system is Al–Si, where the high levels of silicon (4.0–13%) contribute to give good casting characteristics. Aluminium alloys are widely used in engineering structures and components where light weight or corrosion resistance is required.[1]

Alloys composed mostly of aluminium have been very important in aerospace manufacturing since the introduction of metal-skinned aircraft. Aluminium-magnesium alloys are both lighter than other aluminium alloys and much less flammable than alloys that contain a very high percentage of magnesium.[2]

Aluminium alloy surfaces will develop a white, protective layer of aluminium oxide if left unprotected by anodizing and/or correct painting procedures. In a wet environment, galvanic corrosion can occur when an aluminium alloy is placed in electrical contact with other metals with more positive corrosion potentials than aluminium, and an electrolyte is present that allows ion exchange. Referred to as dissimilar-metal corrosion, this process can occur as exfoliation or as intergranular corrosion. Aluminium alloys can be improperly heat treated. This causes internal element separation, and the metal then corrodes from the inside out.[citation needed]

Aluminium alloy compositions are registered with The Aluminum Association. Many organizations publish more specific standards for the manufacture of aluminium alloy, including the Society of Automotive Engineers standards organization, specifically its aerospace standards subgroups,

Aluminium alloys with a wide range of properties are used in engineering structures. Alloy systems are classified by a number system (ANSI) or by names indicating their main alloying constituents (DIN and ISO). Selecting the right alloy for a given application entails considerations of its tensile strength, density, ductility, formability, workability, weldability, and corrosion resistance, to name a few. A brief historical overview of alloys and manufacturing technologies is given in Ref.[4]Aluminium alloys are used extensively in aircraft due to their high strength-to-weight ratio. On the other hand, pure aluminium metal is much too soft for such uses, and it does not have the high tensile strength that is needed for airplanes and helicopters.

Often, the metal's sensitivity to heat must also be considered. Even a relatively routine workshop procedure involving heating is complicated by the fact that aluminium, unlike steel, will melt without first glowing red. Forming operations where a blow torch is used can reverse or remove heat treating, therefore is not advised whatsoever. No visual signs reveal how the material is internally damaged. Much like welding heat treated, high strength link chain, all strength is now lost by heat of the torch. The chain is dangerous and must be discarded.

Aluminium is subject to internal stresses and strains. Sometimes years later, as is the tendency of improperly welded aluminium bicycle frames to gradually twist out of alignment from the stresses of the welding process. Thus, the aerospace industry avoids heat altogether by joining parts with rivets of like metal composition, other fasteners, or adhesives.

Stresses in overheated aluminium can be relieved by heat-treating the parts in an oven and gradually cooling it—in effect annealing the stresses. Yet these parts may still become distorted, so that heat-treating of welded bicycle frames, for instance, can result in a significant fraction becoming misaligned. If the misalignment is not too severe, the cooled parts may be bent into alignment. Of course, if the frame is properly designed for rigidity (see above), that bending will require enormous force.

Aluminium's intolerance to high temperatures has not precluded its use in rocketry; even for use in constructing combustion chambers where gases can reach 3500 K. The Agena upper stage engine used a regeneratively cooled aluminium design for some parts of the nozzle, including the thermally critical throat region; in fact the extremely high thermal conductivity of aluminium prevented the throat from reaching the melting point even under massive heat flux, resulting in a reliable, lightweight component.

The Aluminum Association (AA) has adopted a nomenclature similar to that of wrought alloys. British Standard and DIN have different designations. In the AA system, the second two digits reveal the minimum percentage of aluminium, e.g. 150.x correspond to a minimum of 99.50% aluminium. The digit after the decimal point takes a value of 0 or 1, denoting casting and ingot respectively.[1] The main alloying elements in the AA system are as follows

- 1xx.x series are minimum 99% aluminium
- 2xx.x series copper
- 3xx.x series silicon, copper and/or magnesium
- 4xx.x series silicon
- 5xx.x series magnesium
- 7xx.x series zinc
- 8xx.x series tin
- 9xx.x other elements

Wrought aluminium alloy composition limits (% weight)																
Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	V	Ti	Bi	Ga	Pb	Zr	Limits††		Al
														Eac	Tot	
1050[9	0.25	0.40	0.05	0.05	0.05			0.05						0.03		99.5 min
1060	0.25	0.35	0.05	0.03	0.03	0.03	0.05	0.05	0.03	0.03	0.03	0.03	0.03	0.03		99.6 min
1100	0.95 Si+Fe		0.05	0.05			0.10							0.05	0.15	99.0 min
1199[9	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00		0.00			0.00		99.99
2014	0.50	0.7	3.9–	0.40	0.20	0.10	0.25		0.15					0.05	0.15	remaind
2024	0.50	0.50	3.8–	0.30	1.2–	0.10	0.25		0.15					0.05	0.15	remaind
2219	0.2	0.30	5.8–	0.20	0.02		0.10	0.05	0.02				0.10	0.05	0.15	remaind
3003	0.6	0.7	0.05	1.0–			0.10							0.05	0.15	remaind
3004	0.30	0.7	0.25	1.0–	0.8–		0.25							0.05	0.15	remaind
3102	0.40	0.7	0.10	0.05			0.30		0.10					0.05	0.15	remaind
4041	4.5–	0.80	0.30	0.05	0.05		0.10		0.20					0.05	0.15	remaind
5005	0.3	0.7	0.2	0.2	0.5-	0.1	0.25							0.05	0.15	remaind
5052	0.25	0.40	0.10	0.10	2.2–	0.15	0.10							0.05	0.15	remaind
5083	0.40	0.40	0.10	0.40	4.0–	0.05	0.25		0.15					0.05	0.15	remaind
5086	0.40	0.50	0.10	0.20	3.5–	0.05	0.25		0.15					0.05	0.15	remaind
5154	0.25	0.40	0.10	0.10	3.10	0.15	0.20		0.20					0.05	0.15	remaind
5356	0.25	0.40	0.10	0.10	4.50	0.05	0.10		0.06					0.05	0.15	remaind
5454	0.25	0.40	0.10	0.50	2.4–	0.05	0.25		0.20					0.05	0.15	remaind
5456	0.25	0.40	0.10	0.50	4.7–	0.05	0.25		0.20					0.05	0.15	remaind
5754	0.40	0.40	0.10	0.50	2.6–	0.30	0.20		0.15					0.05	0.15	remaind
6005	0.6–	0.35	0.10	0.10	0.40	0.10	0.10		0.10					0.05	0.15	remaind
6005	0.50	0.35	0.30	0.50	0.40	0.30	0.20		0.10					0.05	0.15	remaind
6060	0.30	0.10	0.10	0.10	0.35	0.05	0.15		0.10					0.05	0.15	remaind

6061	0.40	0.7	0.15	0.15	0.8–	0.04	0.25		0.15					0.05	0.15	remaind
6063	0.20	0.35	0.10	0.10	0.45	0.10	0.10		0.10					0.05	0.15	remaind
6066	0.9–	0.50	0.7–	0.6–	0.8–	0.40	0.25		0.20					0.05	0.15	remaind
6070	1.0–	0.50	0.15	0.40	0.50	0.10	0.25		0.15					0.05	0.15	remaind
6082	0.7–	0.50	0.10	0.40	0.60	0.25	0.20		0.10					0.05	0.15	remaind
6105	0.6–	0.35	0.10	0.10	0.45	0.10	0.10		0.10					0.05	0.15	remaind
6162	0.40	0.50	0.20	0.10	0.7–	0.10	0.25		0.10					0.05	0.15	remaind
6262	0.40	0.7	0.15	0.15	0.8–	0.04	0.25		0.15	0.40		0.40		0.05	0.15	remaind
6351	0.7–	0.50	0.10	0.40	0.40		0.20		0.20					0.05	0.15	remaind
6463	0.20	0.15	0.20	0.05	0.45		0.05							0.05	0.15	remaind
7005	0.35	0.40	0.10	0.20	1.0–	0.06	4.0–		0.01				0.08	0.05	0.15	remaind
7022	0.50	0.50	0.50	0.10	2.60	0.10	4.30		0.20					0.05	0.15	remaind
7068	0.12	0.15	1.60	0.10	2.20	0.05	7.30		0.01				0.05	0.05	0.15	remaind
7072	0.7 Si+Fe		0.10	0.10	0.10		0.8–							0.05	0.15	remaind
7075	0.40	0.50	1.2–	0.30	2.1–	0.18	5.1–		0.20					0.05	0.15	remaind
7079	0.3	0.40	0.40	0.10	2.9–	0.10	3.8–		0.10					0.05	0.15	remaind
7116	0.15	0.30	0.50	0.05	0.8–		4.2–	0.05	0.05		0.03			0.05	0.15	remaind
7129	0.15	0.30	0.50	0.10	1.3–	0.10	4.2–	0.05	0.05		0.03			0.05	0.15	remaind
7178	0.40	0.50	1.6–	0.30	2.4–	0.18	6.3–		0.20					0.05	0.15	remaind

Physical Properties (1)

	Aluminum	Steel	Stainless
Density (kg/m³)	2700	7800	7880
Modulus of elasticity (10³ MPa)	69	200	200
Melting point (°C)	660	1350	1426
Specific heat (J/kg.°C)	940	496	490
Electrical conductivity (% IACS)	62	10	2
Thermal conductivity (W/m.°C)	222	46	21
Coefficient of linear expansion (10^{-6} °C^{-1})	23.6	12.6	16.2

Arc Gouging

The main advantage of manual metal arc (MMA) gouging is that the same power source can be used for welding, gouging, or cutting, simply by changing the type of electrode.

As in conventional MMA welding, the arc is formed between the tip of the electrode and the workpiece. MMA gouging differs because it requires special purpose electrodes with thick flux coatings to generate a strong arc force and gas stream. Unlike MMA welding where a stable weld pool must be maintained, this process forces the molten metal away from the arc zone to leave a clean cut surface.

The gouging process is characterised by the large amount of gas which is generated to eject the molten metal. However, because the arc/gas stream is not as powerful as a gas or a separate air jet, the surface of the gouge is not as smooth as an oxyfuel gouge or air carbon arc gouge.

MMA gouging is used for localised gouging operations, removal of defects for example, and where it is more convenient to switch from a welding electrode to a gouging electrode rather than use specialised equipment. Compared with alternative gouging processes, metal removal rates are low and the quality of the gouged surface is inferior.

When correctly applied, MMA gouging can produce relatively clean gouged surfaces. For general applications, welding can be carried out without the need to dress by grinding. However, when gouging stainless steel, a thin layer of higher carbon content material will be produced; this should be removed by grinding.

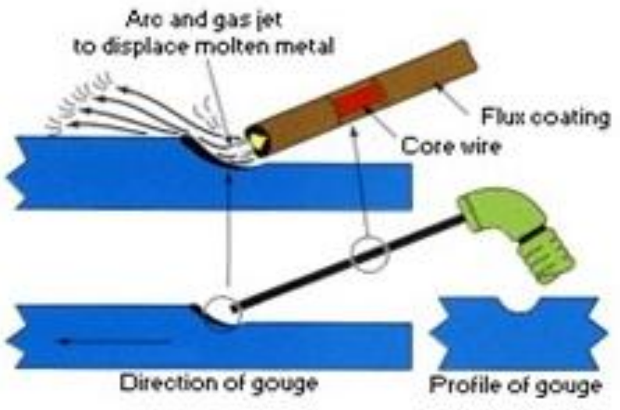
According to the size of gouge specified, there is a wide range of electrode diameters available. These grooving electrodes are also not just restricted to steels, the same electrode composition may be used for gouging stainless steel and non-ferrous alloys.

TWI can provide you with technical support, including:

- Welding Engineering Helpdesk: call our qualified welding engineers or metallurgists free of charge
- Consultancy on fabrication problems
- Technology audit: TWI can review your welding procedures impartially; can assess your workshop layout and quality management system and can improve your quality and reduce your costs
- Visit TWI to take advantage of the latest technical developments and discuss your business needs
- Re-appraise your products and be offered recommendations on alternative designs, materials and innovative joining processes

TWI is noted for its experience on Health and Safety about fume (and hazards) emanating from cutting processes.

TWI can help your company developing, supervising/implementing and providing guidance on specialist cutting procedures for a wide range of applications across all industry sectors.



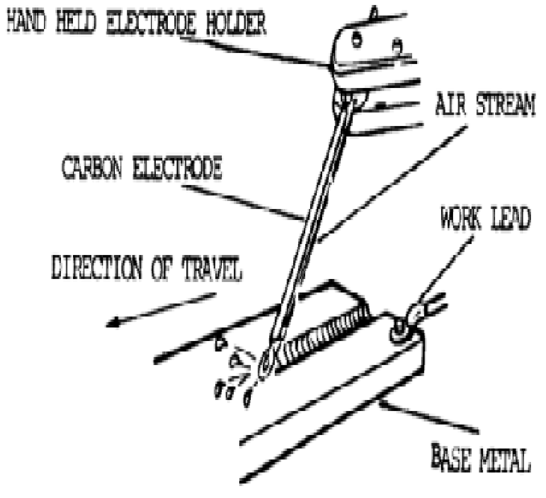


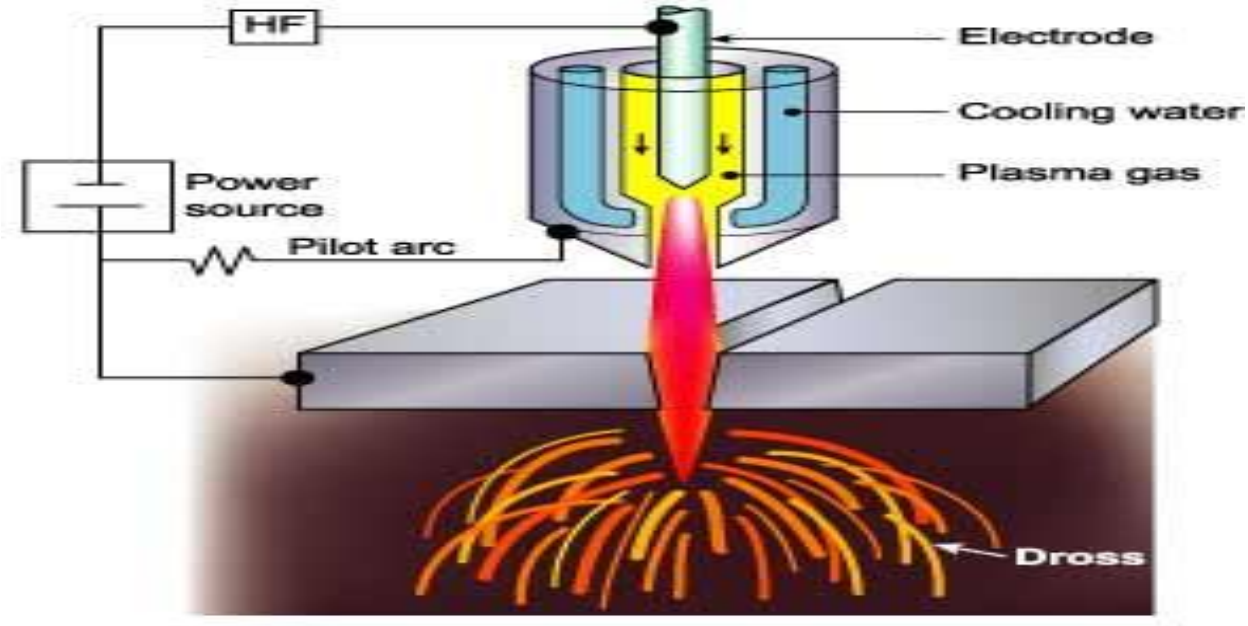
Figure 2-6. Process diagram for air carbon arc cutting.

Air carbon arc cutting previously known as **air arc cutting**,[1] is an arc cutting process where metal is cut and melted by the heat of a carbon arc. Molten metal is then removed by a blast of air. It employs a consumable carbon or graphite electrode to melt the material, which is then blown away by an air jet.

This process is useful for cutting a variety of materials, but it is most often used for cutting, and gouging aluminum, copper, iron, magnesium, and carbon and stainless steels. Because the metal is blown away by the air jet, it does not need to be oxidized. This process differs from plasma cutting operations because in air carbon cutting, an open, or un-constricted, arc is used, and the arc operates separately from the air jet.[2]

Air pressures for the jet usually vary from 60 to 100 psig. The carbon electrode can be worn away by oxidation from heat buildup. This can be reduced by coating the carbon electrodes with copper.

The sharpened carbon electrode is drawn along the metal, an arc forms and melts the metal. The air jet is then used to blow away molten material. This can be dangerous as the molten material can be blown substantial distances.[3] The process is also very noisy.



Questions:-

1. What is aluminum?
2. Right aluminum welding process.
3. Write three aluminum alloys.

Next Lesson:- Cast iron –its properties and types.welding methods of cast iron.

Assignment:- Aluminum and its alloy, properties and weld ability, welding methods. Arc cutting and gauging.

Checked by………………………….. Instructor……………..