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Aluminum Preparation, its Uses and Practical Applications

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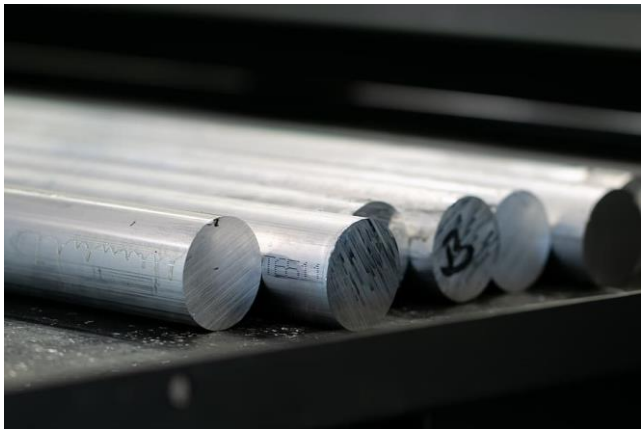
***Abstract*—** Aluminum is a lightweight, silvery metal that can be easily shaped into any shape. It can be rolled or hammered into thick slabs for use in armored tanks, or into thin wafers used to wrap some types of sweets. It can be drawn into wires or made into boxes. Aluminum does not rust, and resists corrosion by weather conditions or chemicals. Pure aluminum is soft and has limited hardness. For this reason, aluminum producers usually form aluminum ingots, which consist of aluminum with small amounts of copper, magnesium, zinc and other elements added. These elements add strength and other qualities to aluminum to make it a very useful metal. In fact, the world uses more aluminum than any other metal, except iron and steel. The bulk of aluminum alloys are used in the manufacture of packaging materials for various products such as beverage cans, glassware lids, bags and foil, and in food canning.

***Keywords*—** Aluminum – Products – Industry – thin wafers

I. INTRODUCTION

The architectural construction industry uses aluminum alloys for the manufacture of domestic sewer pipes, various sectors in housing, ceilings and walls of buildings, as well as electrical wiring pipes and external frames for windows. Large amounts of aluminum are used in the manufacture of transportation, such as airplanes, cars, ships, and railroad cars. Aluminum is also used in many electrical products, and in telephone wires. Many other products contain aluminum. These include kitchen utensils, golf clubs, sewing needles, paint cans, electric refrigerators, rocket fuel, and clothes zippers. Aluminum is the most abundant metallic element in the Earth's crust, and the third most abundant element in general, after oxygen and silicon. Aluminum makes up about 8% of the Earth's crust. Unlike some other metals such as gold and silver, it is never found in a pure (non-combining) state in nature, but it is always found in union with other elements. It was not until the nineteenth century that man had a means to separate aluminum from the

elements combined with it. At this time, scientists developed methods for separating aluminum and producing it in a pure state. Since then these methods have been used to produce aluminum. Aluminum or aluminum is an element in the periodic table and a light metal with the symbol Al. It is used in the aircraft industry due to its lightness. It is one of the most abundant minerals on the surface of the globe in air, water and soil.



Its properties are light weight, non-magnetic, silver-like in color, and a good conductor of heat and electricity. It is not used alone, but other minerals are added to it to improve its properties. It is widely used in many products in our daily life in kitchen utensils, furniture, toys, deodorants, indigestion medicine, parts in airplanes and missiles, the famous aluminum foil used in the kitchen to wrap foods.

II. ALUMINUM PREPARATION

Aluminum is obtained from bauxite, which is a hydrated aluminum oxide. Bauxite consists of alumine (50-60%) Al2O3 and silica (3-5%), titan oxide (2-4%) and iron oxide (20-30%). In the case of aluminum, it is difficult to apply the traditional methods used to extract metals, in which the metal (or a solution of it) is prepared initially and then purified from its impurities, because aluminum is highly susceptible to oxidation. Therefore, its preparation methods depend on obtaining alumina with a high degree of purity and then electrolyzing it.

Aluminum purification by Bayer method

To purify alumina according to the most common Bayer method, bauxite ore is treated under high pressure with a hot concentrated caustic soda solution (NaOH), so that the silica melts, turning into silicates, and titan oxide dissolves into titanate, and aluminum oxides dissolve into Na3Al2O3 or NaAlO3 aluminates.

Al2O3+6NaOH Š 2Na3AlO3+3H2O

As for iron oxide Fe2O3, it is precipitated in the form of a red sludge.

The sodium aluminate solution is separated from the sediment by the compressor filter and the alumina is precipitated from the filter by cooling, diluting with water and passing carbon dioxide, which reacts with aluminum hydroxide and thus accelerates the separation of aluminum hydroxide:

Na3AlO lowercase text3+3H2OŠAl(OH)3+3NaOH

The aluminum hydroxide is separated from the solution by filtration, washed well with water, and then calcined in rotary kilns at a temperature of about 1000 °C to obtain the dry alumina:

2Al(OH)3 D Al2O3+3H2O

The resulting anhydrous alumine is shipped to the Hall-Hero process units (Fig. 1) where it is electrolyzed into a typical (bath) cell consisting of a rectangular steel tub lined with

insulating brick and carbon containing an electrolyte of alumina and molten cryolite (cryolite is a double salt of fluoride). Aluminum and sodium fluoride in a ratio of one molecule of the first to three molecules of the second 3NaF, AlF3). The carbon bottom is covered by a molten aluminum mattress that functions as a cathode. In the electrolyte, lumps of carbon that have already been calcined are suspended, and carbon is used as an anode because no alternative material has yet been known to resist the corrosive effect of molten fluoride and because it is an electrolytic (electrolytic) reference suitable for alumina. The cathodic current passes through the carbon bottom through steel rods attached to the cathode.

The mechanism of the reactions that occur inside the cell is not known precisely, and the simplest theory assumes the ionization (displacement) of alumina at high temperatures. During electrolysis, aluminum is deposited on the metal bed, i.e. the cathode, and oxygen is released at the anode to react with carbon, giving CO2, and carbon returns a portion of CO2 to carbon monoxide CO in secondary reactions. After 24-48 hour intervals, molten aluminum is allowed to drain from a siphon from a W-tube attached to the cell.

The Hall procedure requires large amounts of electrical energy (about 14,000 kilowatt-hours per ton) and is plagued by the problem of toxic fluoride pollution.

III. MODERN METHODS OF PREPARING ALUMINUM

The Aluminum Company of America method: It is a more effective method for producing aluminum from bauxite, in which aluminum oxide reacts with chlorine to give aluminum chloride, and by electrolysis of the latter produces the metal and chlorine. The advantage of this company's plan is to not use fluoride and to consume a third of the electrical energy required by the Hall-Hero method.

Toth method: In this method, aluminum metal is produced from kaolin and other types of clay rich in aluminum oxide, in which the clay is calcined and chlorinated. The reaction takes place at a relatively low temperature (260° C) and manganese metal and chlorine gas are recovered from manganese chloride by electrolysis of its molten, and are reused in the process. The Toth method is more effective and less expensive than the Hall method, as it is less energy consuming and does not use imported bauxite.

The non-electric method: It is a method in which electricity is not used, but the mixture of aluminum ores with fuel derived from coal is heated in a closed furnace, producing alloys of aluminum and Al-Si that can be purified into pure aluminum.

One of the purification methods to obtain ultra-pure aluminum is the zone refining method, which includes repeated melting and crystallization, by placing the sample to be purified in a relatively long narrow tube and slowly passing it through a furnace with short alternating hot and

cold zones, so melting occurs in the hot regions and crystallization occurs in the regions cold. When the rod moves through the furnace, it passes successively through all the areas, leaving the impurities in the molten areas moving to one end of the rod.

Often resorting to this method to obtain very pure materials, when the quantities are small and high costs, as it can reach a degree of purity in which only 2.0 parts per million of impurities remain.

Aluminum metal

Aluminum body, silvery-white crystalline solid; Its tensile strength when annealed is 463 kg/cm², and when it is cold laminated 1089 kg/cm². It is non-toxic and very light, its relative density is 2.708, melts at 660° C, and boils at 2450° C. It is a soft and highly elongated metal, and it can be elongated by stretching. to 50% of its length. It is a good conductor of heat and electricity, as its conductivity is two-thirds of that of copper, and it is an excellent reflector of ultraviolet, visible and infrared rays, and the degree of its reflection of infrared rays can reach 97%. On its surface, in its natural state, a protective film of aluminum oxide Al2O3 of 50 angstroms (A = 10-10 metres) is formed which protects it from normal wear.

IV. ALUMINUM APPLICATIONS AND USES

General Usage

They are alloys that contain metals such as copper, silicon, magnesium and zinc. There are many types of them that are used in casting molds and forming products by welding, forging, plating and drawing. Some of them can be heat treated, especially hardening and aging. Duralumin is a lightweight, highly resistant alloy. It is composed of 95% aluminum, 4% copper, 0.5% manganese and 0.5% silicon. It is resistant to abrasion in acids and sea water, malleable and acquires important mechanical advantages after hardening. It is used as parts for airplanes, railroad cars, ships and various machinery.

Alloys “aluminum-magnesium” contain 4-8% of magnesium and 0.5-1% of manganese (including alumag, duralinox and magnalium), and they are used, due to their resistance to corrosion by water and alkaline products, in the manufacture of ships, buses and gas bottles. With the addition of 5-9% of zinc, alloys used in the aircraft industry are obtained. The alloy-alloy of 3% magnesium and 0.3% manganese has good malleability and is therefore used in making structural elements of vehicles.

Aluminium-silicium alloys are used in casting because alloys containing 13% silicon are eutectic, have a low melting point and have good sildenability. Mixtures containing 10-13% silicon, max 1.5% copper, 0.2-1.5% magnesium, and 0.3% alpax manganese were commonly used in the manufacture of automobiles (engine blocks, instrument enclosures or pans). and compressors), and in the manufacture of electrical equipment, and in the molding of parts, whether complex or huge.

Aluminum Castings Aluminum is used in building and construction, in corrosion-resistant chemical equipment (desalting plants), in die-cast automobile parts, in the electrical industry (power transmission lines), in the manufacture of photo-etching plates and permanent

magnets, in cryogenic technology, and in Manufacture of machines and their ancillary equipment, and in various food procedures equipment, tubes of ointments, toothpastes, shaving and others. Aluminum is used as a powder in paints and coatings, as a fuel for rockets, as a component of incendiary mixtures (thermite) for welding metals, and as an intermediate; and in foam concrete, metallized in space, and as coating and foil in packing, cooking and decorative printing; and flakes in the insulation of liquid fuels.

V. ALUMINUM PROPERTIES

The properties of pure aluminum

Only small amounts of aluminum are used to make some materials such as electrical conductors, jewelry, and accessories for equipment and automobiles.

Most aluminum is produced as alloys containing 15% of one or more of the other elements. The most common elements used to form aluminum alloys are copper, magnesium, manganese, silicon, tin, and zinc. Copper and magnesium increase the hardness and strength of aluminum. Magnesium also makes it easier to use aluminum as a solder. Manganese helps aluminum resist corrosion and provides strength. Silicon lowers the melting point of aluminum and makes it easier to cast or mold into moulds.

Tin increases the ease of forming aluminum with forming machines. As for zinc, especially when mixed with magnesium, it gives additional strength to aluminum. It is possible to work alloys of aluminum and other elements to produce alloys that have special uses. These elements include bismuth, boron, cadmium, chromium, cobalt, iron, lead, lithium, nickel, sodium, titanium, vanadium, and zirconium.

Aluminum and its alloys have many special, important and useful properties, which make it a very important metal. These attributes include:

- light weight
- strength
- Rust resistance
- Connecting the electric current
- Heat conduction
- Reversing light and heat.

Light weight

Aluminum is one of the lightest metals, so aluminum is being replaced by steel in many uses. For example, some parts for airplanes and cars are now made of aluminum instead of steel; Because lightweight vehicles consume less fuel. Also, products that are packaged in aluminum containers have lower shipping costs than others; Because containers made of this metal are lighter in weight than containers made of other metals. Lightweight lithium metal is added to aluminum to make aluminum alloys lighter than others.

Power

Although pure aluminum is weak, some aluminum alloys have the strength of steel. These alloys are used in the manufacture of aircraft bodies and transport vehicles, in road safety barriers, and in some other products that require significant strength. Aluminum alloys lose part of their strength under the influence of high temperatures, but unlike

many other metals, their strength increases under the pressure of very low temperatures. Aluminum alloys are widely used in liquid natural gas processing, transporting and storing liquid natural gas whose temperature reaches -162°C.

Rust Resistance

Some metals corrode if they are exposed to oxygen, water, and some chemicals. In this case, a chemical reaction occurs that causes the metal to rust or change its color. But when aluminum reacts with oxygen, the metal forms an invisible layer of a chemical compound called aluminum oxide (Al2 O3). This layer protects aluminum from corrosion by oxygen, water, and many chemicals. This characteristic makes aluminum an important and valuable material for use outside homes, because the metal resists the action of wind, rust and pollution.

Electrical connection

Aluminum and copper are the only metals commonly used as electrical conductors. Aluminum is more ductile than copper, which means it is easier to draw into thin wires. As a result, steel-reinforced aluminum wires are used in all electrical cables found in high-voltage power stations.

Heat conduction

The first commercial use of aluminum was to make kitchen utensils. Aluminum kitchen utensils heat up quickly and evenly. It also cools quickly, making it popular in some units such as beverage cans and ice makers.

Reversing light and heat

Aluminum reflects about 80% of the light falling on it, and is widely used in lighting units. Aluminum also reflects heat. Buildings that are manufactured with aluminum roofs reflect a large part of the sun's heat falling on them, so these buildings are somewhat cool in hot weather. When firefighters have to enter and pass through a fire, they wear special clothing, covered with aluminum paint to reflect the heat.

Other attributes

Aluminum is a nonmagnetic metal, which makes it important and useful for protecting electrical appliances from magnetic interference. Aluminum hitting another metal does not produce any spark, so it can be used near flammable materials or explosives. Aluminum is a non-toxic metal, so non-acidic foods can be wrapped in aluminum containers. But food contamination with aluminum compounds should be avoided, because scientists have some doubts about the existence of a relationship between the development of Alzheimer's disease and the amount of aluminum in the human body. Aluminum can be formed in any way of forming metals, and aluminum can be joined with nails, riveted, welded, or bonded in any way used with other metals. Finally, aluminum can be reused again.

VI. THE MAIN ALUMINUM DERIVATIVES

Among these derivatives are the following:

Aluminum or alumina oxide

Alumina is crystallized in nature and is known as sapphire or corundum, and it turns red when it is impregnated with chromium oxide, so it is called ruby. It is also made from its powder, a very hard emery stone used in abrasive and smoothing, and it is hydrated in bauxite.

Aluminum oxide can be prepared as a white powder, balls or lumps, and its properties change according to the method of its preparation. Its relative density ranges between 3.4 and 4, and it melts at 2030 °C. It is insoluble in water, poorly soluble in mineral acids and strong alkalis, incombustible and non-toxic.

It is obtained by treating bauxite with caustic soda, and then hydrolysing the product, precipitating hydrated aluminum oxide or alumina hydrate, which gives anhydrous aluminum oxide by filtering and dehydrating calcination. It is also prepared from coal mine waste water that gives aluminum sulfate, which is then returned to alumine.

Alumine is presented on the market in different degrees of purity, including technical, chemically pure, fibres, high purity, molten, calcined, and packed in multi-coated paper bags, as well as in drums.

Among its dangers is the toxicity of its dust by inhalation, and it is dangerous to breathe air in which aluminum oxide dust exceeds 10 mg/m3.

It is used in the production of aluminium, in the manufacture of abrasive stones, heat-resistant bricks, ceramics, electrical insulators, media holders, paper, eyelids, and laboratory instruments, in the adsorption (sorption) of gases and water vapor, and in chromatography, artificial jewelry, and heat-resistant fibres.

Aluminum hydroxide

Aluminum hydroxide Al2O3 ,3H2O or Al(OH)3 is white crystalline powder, balls or granules, relative density 42,2, insoluble in water and soluble in mineral acids and caustic soda; It is not flammable.

It is prepared from bauxite by dissolving the ore in caustic soda, then by modifying the resulting sodium aluminate solution, so aluminum hydroxide is precipitated.

Aluminum hydroxide is marketed in two grades of purity: technical and chemically pure, in bags or drums or without packaging.

Aluminum hydroxide is used in the manufacture of glass, ceramics, ferrous aluminium, and aluminum salts, and in the manufacture of activated alumin, mainly for organic lacquers, and, more recently, for flames; Its extra fine powder (0.1-0.6 micron) is also used as a reinforcing agent for rubber, as a paper coating, as a filler, and in cosmetics.

aluminum hydroxide gel

or alumina gel, Al2O3,xH2O, which is a white gelatinous precipitate whose constants change according to its composition; It has a relative density of about 2.4, is insoluble in acids or alkalis, is non-toxic, and is non-flammable.

Prepared by treating a solution of aluminum sulfate or aluminum chloride with caustic soda, sodium carbonate or ammonia; It is precipitated from a solution of sodium aluminate, usually by acidification with carbon dioxide or by seeding.

Alumina gel is put on the market in different degrees of purity, including technical and chemically pure.

It is used as a mordant in dyeing, as well as in water purification, in the manufacture of impermeable fabrics, in the manufacture of lacquers, a filter medium, in the manufacture of chemicals (aluminum salts), in lubricating compounds, in the manufacture of glass, adhesive paper, in porcelain polishing, and as an anti-acid.

Potash alum or double crystallized potassium aluminum sulfate

Its formula is Al2(SO4)3,K2SO4, 24H2O and writes AlK(SO4)2,12H2O. It is odorless white crystals with astringent taste, its relative density is 1.75, it melts at degree 92°C, and it loses at degree 64.5°C 18H2O, and it becomes anhydrous at degree 200°C. It is soluble in water and insoluble in ghoul, and its aqueous solutions are acidic, non-flammable and non-toxic.

Potash alum is prepared from alunite or leucite, or by crystallizing a solution of aluminum sulfate and potassium sulfate.

It is presented in the market in different degrees of purity, including technical, agglomerated, crushed and powdered.

It is used as a mordant in dyeing, as well as in making paper, matches and paints, as a medium in tanning, as a medium to prevent water penetration, in water purification, and in the manufacture of aluminum salts, food additive, dough powder (yeast), astringent, and cement hardener.

Anhydrous aluminum chloride

Formula AlCl3, is white or yellowish crystals that dissolve in water, its relative density is 2.44 at 25°C. It melts at 190 °C (at 5.2 atm), ascends easily at 178 °C, and its vapor is composed of double molecules of Al2Cl6.

It is prepared by the reaction of purified gaseous chlorine with molten aluminum, or by the reaction of bauxite with coke and chlorine at about 875 °C, and it is tainted by free iron and aluminum chloride and other insoluble substances.

It is toxic if taken orally or through the respiratory system. It is also a severe irritant to tissues, and it reacts violently with water, releasing HCl gas.

It is used as an intermediate in the alkylation of benzene, ethyl chloride, organic pharmaceuticals (Friedel-Crafts intermediate), butyl rubber, in petroleum refining, and in the preparation of hydrogen carbonate resins.

Its containers, when shipped in the air, must bear labels with the word "corrosive".

Aluminum chloride hydrate

With formula AlCl3,6H2O, it is a white or yellowish-white liquefied crystalline powder that is almost odorless, sweet in taste, and has astringent taste. It has a relative density of 2.4, decomposes on heating, and dissolves in water and ghouls.

It is prepared by crystallizing the anhydrous form from its solution in hydrochloric acid.

It is put on the market in one of two forms, technical and chemically pure.

It is used in the manufacture of pharmaceutical and cosmetic materials, dyes and granules for covering ceilings, special papers and photography, and textiles (wool).

VII. CONCLUSION

The fine powder of aluminum forms flammable and explosive mixtures in the air. Therefore, it is not allowed in the air to contain more than 10 mg of powder per cubic meter, nor is it allowed to contain more than 2 mg of dissolved aluminum salts in the air.

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