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Mg Alloy Surface Treatment

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Abstract

Before the surface treatment of magnesium alloy, it is necessary to consider the degree of electrical resistance, the apparent surface condition, and the degree of corrosion resistance, so that the most appropriate method could be used for the surface to be treated. Magnesium alloy also follows the basic rule of metal, and the best method is to process after mechanical and chemical cleaning.

Keywords: Mg alloy, surface treatment, plasma electrolytic oxidation, AZ31, AZ91, Aluminum, hard coating, porous

1. Introduction

The application of Mg alloy is expected, in particular involving motion or portability of a component, to increase in the future because of its high strength-to-weight ratio and a relatively high stiffness. Magnesium and its alloys are increasingly used in a number of components where weight reduction is of great concern. However, the poor corrosion resistance of Mg and its alloys has limited their applications in corrosive environments. Recently, the creep behavior of Mg-alloy has attracted much attention due to its useful value in practice. However, the conventional magnesium alloy has a relatively low resistance to creep at elevated temperatures in contrast to Al alloy, which has restricted the development of Mg alloy. In addition, magnesium alloys possess many good properties that make them ideal materials for a large number of applications. However, poor corrosion resistance and high chemical reactivity have hindered the wide applications of magnesium alloys. This chapter describes the process of surface treatment of the magnesium alloy.

2. Mechanical cleaning

First, this process is performed after removing oil from the surface. The processes of mechanical cleaning are as follows:

1. Grinding and rough polishing

This process uses a belt and a grinding surface. It is used for surface treatment of the product by low-pressure casting.

2. Dry-abrasive blast cleaning

This method falls in the sandblasting category and uses 25 or 35 AFS silica sand method.

3. Wet-abrasive blast cleaning

This method is used prior to metal coating.

4. Barrel or bowl abrading

This process is required for the manufacture of pressure casting.

3. Chemical cleaning

Different types of chemical cleaning methods are as follows:

1. Solvent cleaning and vapor degreasing.

2. Emulsion cleaning.

3. Alkaline cleaning.

4. Acid picking.

5. Fluoride anodizing.

4. Mechanical finishing operations

This method is performed as the last step after the chemical treatment or coating. The different types of mechanical finishing operations are as follows:

1. Mass (barrel) finishing.

2. Vibratory finishing.

3. Polishing and buffing.

5. Chemical conversion treatment

This method is used for improving the conversion of the magnesium surface of the neutral state to the state of an alkali. The primary reason is that takes place between the well is combined with other coating materials. It is used in the current processing methods, except in the light range of chromium. If the corrosion resistance is of excellent quality, the method based on the chromate-treated surface comes to mind as the first method.

1. Chrome-pickle treatment

This method is used to remove the oxide formed on the surface of the total chromium and magnesium, and it can be expressed in gray and gold colors.

2. Dichromate treatment

This method forms an oxide layer (2 μm) thicker than that formed after chrome-pickle treatment and this thick oxide layer is formed due to the characteristic high electrical resistance.

3. Chrome-manganese treatment

- The processing method, including chrome-manganese developed by Magnesium Electron Company, is carried out at a temperature of 93°C.
- It has good coating efficiency, as in chromate treatment.
- In addition, this method is conducted in low temperature.

4. Ferritic nitrate picking

- This method is used for cleaning the magnesium alloy surface before the organic coating process. And the method is used for etching.

5. Phosphate treatments

- This method uses indium treatment of magnesium alloys.

6. Anodic treatments

Anodic treatment uses the battery or other direct current power source, but corresponds to the negative terminal, while the passive load corresponds to a positive electrode terminal. Electronic tube proceeds from the anode along the tube out of the cathode, and anions in electroplating cell are accumulated on the cathode, the places where the anodes accumulate in the electrochemical oxidation.

1. Chemical treatment nr. 9

- Applying a low DC voltage to the thin film growth.

- It can make a black or dark brown coat color.
- 2. Chemical treatment nr. 17
 - Used for all types of magnesium alloy.
 - Low DC voltage is applied → 5 μm degree of the oxide film layer is formed.
 - And dark green colors used in the amorphous structure are implemented.
- 3. HAE treatment
 - When you use a two-phase coating on the surface of magnesium alloy.
- 4. Keronite
 - This is a familiar method of forming a coating layer of electrically oxidized magnesium alloy.
 - The method to form the oxide film layer of the 10–60 μm degree.

The amount of the metal in accordance with industrial requirements has been increasing. However, raw material prices have been rising rapidly due to the limited available resources useful to secure stable resources of these metals and it is recognized as a key element of national competitiveness and sustainable economic growth. In particular, recent increase in the social and industrial requirements for the development and commercialization of resource recycling technology for reuse by recovery of metal from the waste that occurs during the life cycle of the metal resources is strengthening the resource weaponization policy of resource-rich countries, including China and Russia [1–7]. Mg is said to be of the lightest weight among structural metal products and possesses characteristics such as nasal degrees, nonrigid, castability, machinability, impact properties, vibration absorption capability, etc. Weight reduction is required in transport equipment, electronic appliances, sports leisure, medical equipment, military products, industrial equipment, and robotics. Mg is added to the second and third element in order to reduce weight and improve performance during practical use. If you want to increase the strength of the alloy heat resistance, and creep resistance (resistance-creep) is improved. In the case of aluminum, zinc (AZ) series alloy addition of the zinc improves the strength, castability, workability, corrosion resistance, weldability, etc., depending on the addition amount of zinc [8–17]. In particular, the addition of rare earth elements such as Ce and Nd has high strength at 200–250°C. The creep (creep-resistance) characteristics are excellent for heat-resistant alloy.

7. The nonferrous metals (Al, Mg) surface treatment characteristics

7.1. Al anodizing

Al in the air combines with oxygen to produce oxidized layer (Al_2O_3) with naturally irregular arrays. This oxide layer is created artificially by anodic oxidation method than the natural oxide layer made with a regular array. This artificially made oxide layer is called anodic aluminum

oxide (AAO), generally called aluminum country [18–21]. AAO barrier-type oxide produced according to the conditions (barrier type film; BTF) and the porous oxide type (porous type film; PTF) is divided into two types. BTF is made to proceed if the anodizing electrolyte is at pH 5 or more, and PTF is created when the anodizing proceeds in an electrolyte pH of less than 5. **Figure 1(a)** shows a passivation oxide layer having a uniform thickness of the same structure. At this time the minimum value decreases in the form of look and measure the current density exponential. This is because the thickness of the oxide layer thickened the ion moving rate of the reduction and reduces the electric field strength. This relationship is shown in Eq. (1):

$$i = A \exp\left(\frac{BE_f}{d}\right) \quad (1)$$

where i (A/cm²) is the current density, E_f is the voltage difference between the aluminum and the electrolyte, d represents the thickness of the oxide layer, and A and B are the coefficients. The current density (i) and electric field (E_f) are the exponential functions that take place from a high electric field in the process of moving ions in the aluminum oxide layer and the boundary surface. PTF is created in the electrolyte, including sulfuric acid, phosphoric acid, and oxalic acid. PAA is formed to a structure (**Figure 1(b)**). For PAA, the thickness of the oxide layers, unlike the BTF, as well as the anodizing voltage, anodizing time, and current density, is known to be affected by the kind of electrolyte. PTF is not to have a minimum value, continuously decreasing as the current density in the form of exponential function when the predetermined time when the BTF is stabilized after the increase (**Figure 2**).

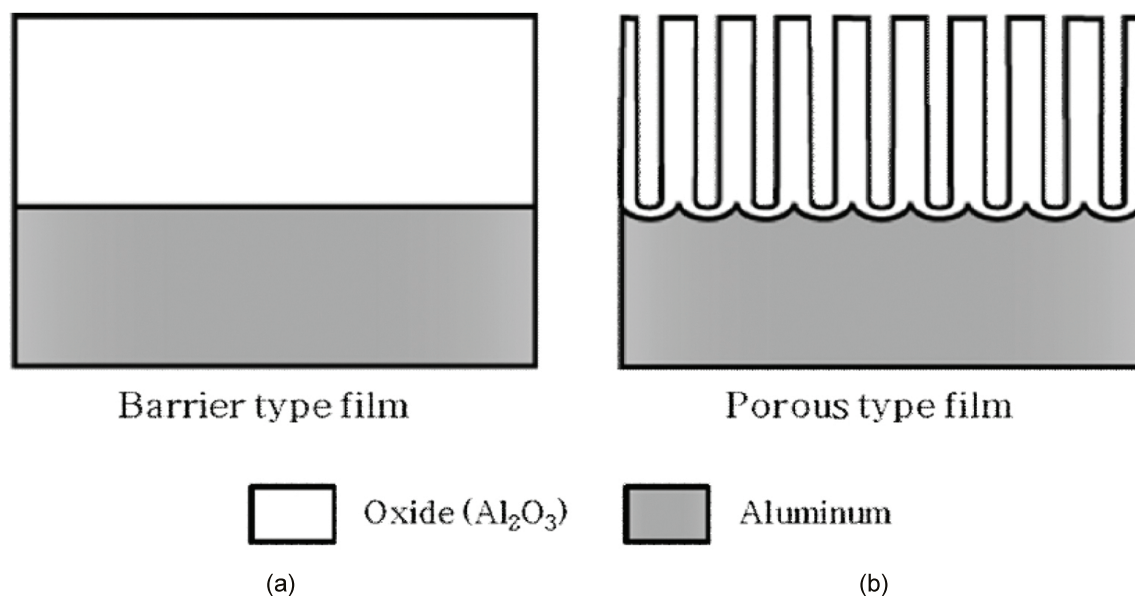


Figure 1. The image of barrier type film and porous type film. (a) Barrier type film; (b) porous type film.

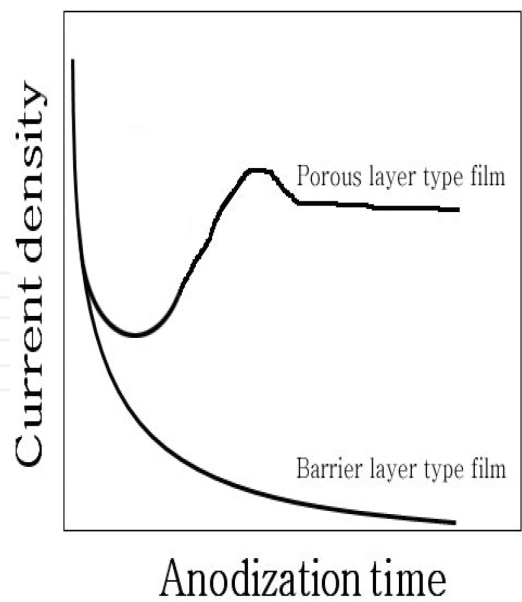


Figure 2. The anodic oxidation current density images. During BTF and PTF are formed over time.

The structure of the PAA was first discovered by F. Keller in 1953, since then many studies have been published. PAA is typically well aligned with a regular hexagonal dense structure (**Figure 3(a)**). Looking at the state of alumina grow in a perpendicular direction on the aluminum surface, there is a cell in a hexagonal shape as shown in **Figure 3(b)** and has a pore in the center of the cell. Pore size of the cells is determined by the temperature and the kind of voltage applied to the electrolyte during the anodic oxidation process, and the size of the pores can be controlled in several tens of nanometers to several hundred nanometers. Observing the cross-section PAA, one end of the structure is blocked in a cylindrical way. A porous oxide layer with a pore layer referred to as a barrier layer of an oxide layer of aluminum is in contact with the hemispherical surface.

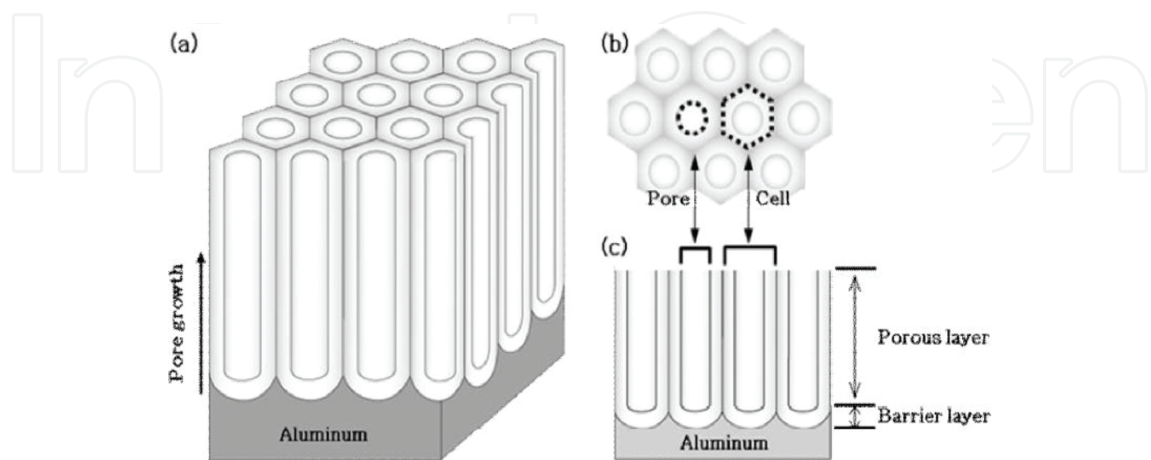


Figure 3. Schematic of Porous Anodic Alumina (PAA). (a) PAA overall appearance, (b) PAA surface appearance, and (c) PAA sided appearance.

Figure 4 shows the surface of the cross-sectional image of the observed PAA.

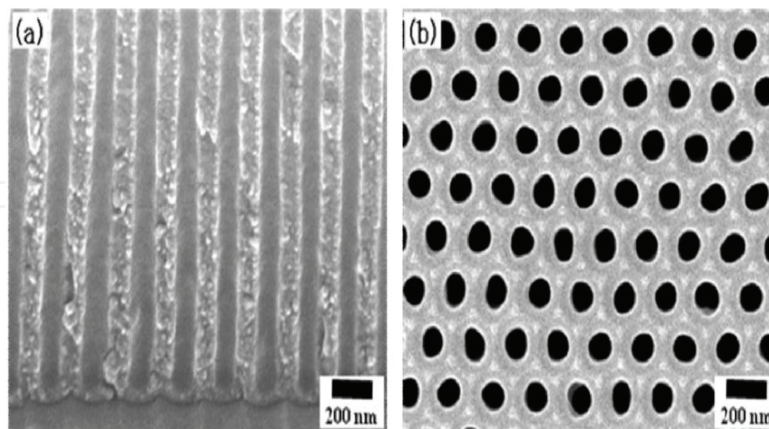


Figure 4. PAA of FESEM image of (a) cross section and (b) surface.

PAA is shown in **Figure 5**. First, as shown in **Figure 5(a)** PAA is made up of pores with irregular arrangement and size. The PAA is thus anodized over time. The size, as shown in **Figure 5(b)**, is constant and the changes in appearance are well aligned. This process is called self-alignment of the information on the magnetic alignment of PAA. During the forming of PAA in the anodizing process, self-alignment, voltage, and the type of electrolyte are known to be affected by the temperature of the electrolyte [22, 23]. In the case of the anodizing voltage expressions (2) and (3) and it is known that as determining the distance between the pore size of the PAA and the pores with the pore, where D_{pore} , D_{int} , D_{cell} the size of each pore, the pore, denotes the size of the cells, U is Empty indicate the anodizing voltage:

$$D_{\text{pore}} = 1.29 \times U \quad (2)$$

$$D_{\text{f}} = D_{\text{cell}} = 2.5 \times \tau \quad (3)$$

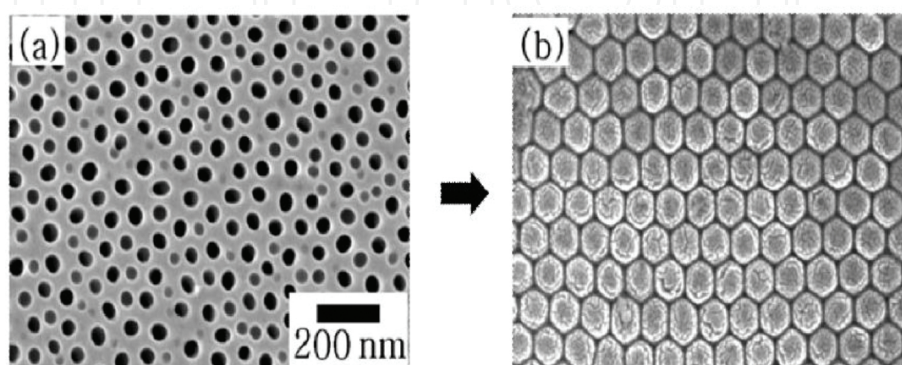


Figure 5. FESEM images of (a) the initial PAA anodized surface and (b) after anodic oxidation under PAA surfaces.

7.2. Mg plasma electrolytic oxidation

The areas that are focused on research and development in each country are different. In Japan, it is used in the development of automation technology, plating equipment, developing speed and partial screen technology, plating, and developing precision and advanced technology in plating bath. In the United States, it is used in purity control, alloy and composite technology development and evaluation, and coating technology, such as high heat-resistant special coating technology, additives development technology, and environmental protection coating technology. There has been rapid progress in the dry surface treatment sector of the developed countries, vacuum plasma technology-based industries, and related high-tech industries. Therefore, the development of surface treatment technology has been applied in the mechanical industry, automobile industry, and electrical electronic industry [24–27]. It is extensively applied to the functional surface treatment for various sectors ranging from the aviation industry to large industrial type. Especially in developed countries, vigorous research has been done in developing highly functional products of high-added value of the industrial upgrading progresses interested in the industry for dry surface treatment technology. Also, dry coating surface treatment process has been applied in LCD, sensor, electronic components, plasma, ion beam, etc. using metal, ceramics, and synthetic resins. High-performance surface treatment technology is also actively applied in the glass and electronics industry. Plasma electrolytic oxidation surface treatment of magnesium alloys are currently only four UK Kero night and henkelsa Germany has a unique blend of solutions. **Figure 6** shows an electrolytic oxidation process diagram of typical magnesium alloys.

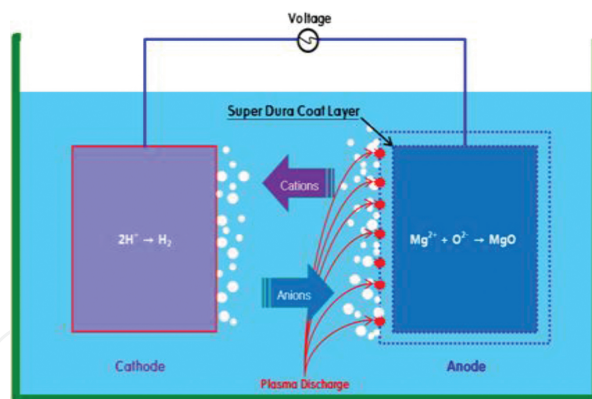


Figure 6. The schematic of PEO device.

8. Surface treatment types

8.1. Chemical treatment (chemical conversion)

Cr(VI)(CrO₃) is generated by the ions in the Cr₂O₇ (DOW1, 7, 20, 21 chromate method). This is a practical solution to many of the chemical conversion treatment method using a magnesium croissant mating. Dow Chemical developed a chromic acid solution for surface coating using

Cr-free chemical conversion solution and its use thereof is restricted. In a typical example using the chemical conversion treatment solution containing KMnO_4 amorphous Mg oxide (or hydroxide) and Mn oxide (or hydroxide) it is formed in the surface coating. This reported to also have little in the KMnO_4 solution containing HCl $\text{Na}_2\text{B}_4\text{O}_7$ and boron oxide in the coating film produced having a corrosion resistance comparable to the chrome mating method, a change in pH significantly influences the quality of the surface coating. Corrosion resistance for NH_4^+ ions and PO_4^{3-} ions in the Cr^{6+} instead harmless Cr^{3+} treatment using the ion solution purpose utilized for automobile parts of 1 g/L, by 10 g/L, respectively, a (NH_4) been reported $2\text{SO}_4 + \text{H}_3\text{PO}_4$ solution have. Metal phosphate is insoluble and chemically stable, and heat resistance promises a chemical treatment method; however, a drawback is that the corrosion resistance is lower than the croissants mating in the water. As a way to improve this method, forming a composite film by a complex process that combines steam treatment and phosphate treatment of magnesium hydroxide ($\text{Mg}(\text{OH})_2$) and phosphate ($\text{NH}_4\text{Mg}(\text{PO}_4) \cdots \text{H}_2\text{O}$) has been developed [28–31].

The pure Mg, AZ31 and AZ91D alloy is happening initial general corrosion then dipped in molten salt corrosion occurs Phil Reform (filiform corrosion) of the fiber with the generation of hydrogen bubbles caused by the corrosion reaction. As a technique to prevent this corrosion, after treatment in solution 1–10% NaCl + 10% NaOH (pH 12) is performed. If the heat treatment (corrosion-oxidation) in air at 673–773 K generated in the alkali solution $\text{Mg}(\text{OH})_2$ in the oxide film is heat-treated, Phil reform corrosion is prevented by changes to MgO .

8.2. Anodizing

It has been switched from a conventional chromium-/fluoride-based electrolyte in terms of environmentally friendly even anodizing with phosphoric acid (H_3PO_4), sodium silicate-based (NaSi), and potassium permanganate-based (KMnO_4) electrolyte. In the plasma electrolyte oxidation surface treatment of ammonium phosphate was added, contributing to $\text{Mg}_3(\text{PO}_4)_2$ improved corrosion resistance that is detected in the positive electrode film and ammonia, alcohols, and amines, and contributes to the densification of the film and flattening by the discharge spark. In addition, because the case of phosphate electrolyte contains magnesium alloy containing Al MgO , MgAl_2O_4 , is formed $\text{Mg}_3(\text{PO}_4)_2$ coating the low melting point composite compounds of two gas discharge easily in the coagulation process. The higher the Al content, a dense coating with low porosity is formed. The phosphate solution containing aluminate ions to form a coating layer similar to the anodized aluminum film shown in the anodic oxidation of aluminum, the corrosion resistance is greatly improved by the addition of small amount of silicates. In addition, the corrosion resistance is greatly improved even when repeated with $\text{KOH} + \text{Al}(\text{OH})_3$ and then using a mixed electrolytic solution for 5 min, the waveform of a minute unit cell lower voltages. After chemical conversion surface treatment with a phosphoric acid solution as a method of improving the corrosion resistance and coating adhesion at the same time in addition to ($\text{K}_2\text{SiO}_3 + \text{KOH} + \text{KF}$) after anodizing by electrolyte, to form a forsterite (Mg_2SiO_4) as a multistage process for performing 100°C H_2O sealing treatment method by which method, using a mixed solution of phosphoric acid anodizing solution and an aqueous ammonia solution for antistatic and electromagnetic shielding of the

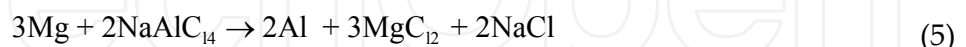
electronic circuit of the electronic equipment to obtain a conductive film of 0.4Ω or less has been developed. Recent use of discontinuous oxidation reaction accompanying the spark discharge at a high voltage of several hundred volts beyond the area of the anodizing electrolytic plasma oxidation method [plasma electrolytic oxidation (PEO)] has been noted. In Applying a high voltage between the electrodes reaches the micro-arc oxidation (MAO) area occurs in the vibration of the breakdown by slight discharge from a material immersed in the electrolyte after the voltage is increased linearly from the anodizing area. The MAO region is formed with a relatively thick porous film and is expected to use as a surface treatment for wear resistance, corrosion resistance, heat resistance, and the like. AZ91D alloy K_2ZrF_6 (10 g/L)- Na_2SiO_3 (10 g/L)-KOH (4 g/L), an electrolytic solution (pH 12.86) at 300 V of voltage for 5 min, was added to form that coating of the surface and cross-section image in the PEO peculiar typical porous as shown in the film. And the oxide layer is grown on only $12.9 \mu m$ in only 5 min to form a pore in the vicinity of the surface layer (outer layer) and a dense inner coating layer (inner layer), Mg_2SiO_4 , ZrO_2 , MgF_2 , and SiO_2 composite film consisting of a corrosion resistant component at $60^\circ C$ or more. PEO dispersing the porous polytetrafluoroethylene (PTFE) nanoparticles in an alkaline electrolyte solution, the addition of a phosphate surfactant in a method of charging a food material within the pores of the film are reported statutes PEO to form a film on the pulsed supply. In addition to the hydrophobic effect and lubricating effect of the PTFE component, improvement in wear resistance is effective in improving the corrosion resistance of magnesium vulnerable to moisture. In a similar way to the method CeO_2 particle-containing coating using the PEO-based electrolyte Na_2SiO_3 , self-assembled nanophase particle (SNAP). The PEO + SNAP coating method using a solution has been reported. In This Recent study, on the PEO process various additives on the corrosion resistance of PEO coating in KOH containing alkali silicate electrolyte ($NaAlO_2$, $Na_2B_4O_7$, Na_3PO_4 , K_2TiF_6 , $CO(NH_2)_2$, etc.), PEO coatings + polymer film composite layer the corrosion resistance, the effect of the current mode and the discharge form on the corrosion resistance of PEO coating, monocrySTALLINE sol gel-forming effect for sealing (pore filling) of the PEO film, the microstructure and corrosion resistance to a wide variety of ideas of preprocessing PEO film by laser the results are presented to verify [32–34].

8.3. Diffusion coating (diffusion coating) and Sol-gel coating method

The Diffusion coating is a process of diffuse coating component and the material component and the excellent adhesive force with a strong metallic bond and thermal resistance between the thermal chemical reaction substrate and the film to a surface treatment method for forming a coating material, while it is in contact with another phase (phase), abrasion resistance, it is possible to control properties such as electrical conductivity, electromagnetic wave shielding ability, and heat conductivity. The Mg diffusion coating of Al is used a lot. Al is used due to its easy generation of the Mg and the corrosion resistance and excellent abrasion resistance between the metal compounds ($Mg_{17}Al_{12}$, Mg_2Al_3 , etc.), AZ91 and AZ30, including excellent recycling of large magnesium alloys containing 3–10% of Al. Formation of the intermetallic compound film by diffusion of Al is by processing at temperature $437^\circ C$ or less. The compound being the diffused surface of Al forms Mg-Al solid solutions, between γ - $Mg_{17}Al_{12}$ metal, and depending on the Al concentration increases the surface of the Mg-Al that has been created.

The β - Mg_2Al_3 is generated when Al is increased above the equilibrium concentration. At 437°C , a two-phase structure of the $\text{Mg} + \text{Mg}_{17}\text{Al}_{12}$ is distributed in a fair response to the $\text{Mg}_{17}\text{Al}_{12}$ discontinuous phase. Diffusion coating method is an example of magnesium pack cementation (PC) method, a melting of two-stage process has been reported. PC as heated metal powder is provided in the device to perform the simple method of forming a film by spreading the powder onto the substrate surface element and fewer process ratios are easy to apply to the parts of complex shapes. In the diffusion coating of the AZ91D alloy using the Al powder, a $750\mu\text{m}$ ($\gamma + \delta$ - Mg - $\text{Mg}_{17}\text{Al}_{12}$) thick film is formed in 1 hour at 450°C , which improves the hardness remarkably. The diameter of the AZ91D alloy capacitive loop (loop capacitive) indicates the size of the polarization resistance as a plot obtained by treatment of 1.5 hours at 420°C ; corrosion resistance of the film improves remarkably than the Al diffusion treatment. Using Al + Zn powder mixture as a method for lowering the diffusion temperature is effective to form a film when Al-Zn solid solution is formed with low melting point in the creation of Mg-Al-Zn three alloy in surface Al/Zn powder layer and in the Mg base the concentration gradient between the spread is facilitated. The result is a surface vicinity of excellent corrosion resistance, Al/Zn-rich τ differently, creating different Mg-rich β side of the substrate. The addition of Zn has an effect of preventing sintering of the Al powder and the addition of ethylene glycol in Al powder promotes the adhesion between the base materials.

In halide activators (activator) such as NH_4Cl or ZnCl_2 in Al powder to precipitate the activated Al halide activation method for forming a composite film of $\text{Mg}_{17}\text{Al}_{12}$, MgZn_2 , Zn_3Mg_7 (Hal-aide pack cementation; HAPC), by treatment in a vacuum alumina vacuum to lower the diffusion temperature to 400°C , a film containing as a main component a β - $\text{Mg}_{17}\text{Al}_{12}$ easing laws have been proposed. Melting is a method for forming a corrosion-resistant coating film by immersing the material in the molten salt bath of the halide. When using a low melting point mixed with salt $\text{AlCl}_3 + \text{NaCl}$, formulas (1) and (2) between the coating compound Mg-Al-based metal is formed by the precipitation and diffusion of the Al produced by the reaction. Eq. (5) presents the spread of Al 523–673 K thermal conductivity differences in the $\Delta G \ll 0$ and it occurs at about 100°C or lower temperature than the pack cementation, where G is the thermal conductivity:



Pack cementation activates Al from the Al powder in a low-temperature. It is difficult to produce the film by a high-temperature process since it is a discontinuous process (α -Mg + γ - $\text{Mg}_{17}\text{Al}_{12}$) and the melt activates even at low temperatures as the Al is generated by interdiffusion occurring and continuing as intermetallic compound of Mg. Two-step method for surface mechanical attrition treatment of the surface by mechanical abrasion is used. After the formation of the nano-crystalline layer on the surface, PC SMAT treatment method has been reported. Plastic deformation is repeated by SMAT processing surface and is formed by deformed layer of about $1500\mu\text{m}$ thick. Surface of about $100\mu\text{m}$ thickness have been used to produce ultrafine nano-crystalline layer having an average of $30 \pm 5\text{ nm}$ hardness and reaches

about two times of the bulk. Diffusion coating of AZ91D alloy of the temperature is lowered to 380°C. Microstructure with the A and B regions of the film results from diffusion coating at 400°C and a γ -solid solution of Mg and $\text{Mg}_{17}\text{Al}_{12}$ coexist, C region is a Mg solid solution phase. The concentration of γ - $\text{Mg}_{17}\text{Al}_{12}$ nano-crystalline layer area A is higher than B zone, B zone, the γ - $\text{Mg}_{17}\text{Al}_{12}$ and Mg solid solution is in lamellar structure, such as perlite to increase wear resistance. In addition to two-stage process, it has been proposed to improve the bonding strength and corrosion resistance of a resistance component and a coating component into the substrate due to interdiffusion after forming the coating layer by spraying heat treatment. These two processes are the same as the development of practical skills is expected to increase in the effective removal of defects, adhesion strength, and corrosion resistance. Sol-gel coating method is a method to form a film by simple operation of heating and drying after dipping the coating in the sol-gel solution. There is no evaporation or decomposition of organic matter of a liquid precursor to form a thin film, even a complicated shape has been used as a coating of the oxide. Magnesium has the effect of various oxide; sol-gel coating the ZrO_2 , SiO_2 has been reported. ZrO_2 sol $\text{Zr}(\text{NO}_3)_4 \cdots 5\text{H}_2\text{O}$ precursor, improving agent (acetyl acetone), methanol 1:4; which is a method for producing blended in a molar ratio of 8 to see, in the ZrO_2 coating applied to the AZ91D alloy after the sol-gel treatment the annealing temperature the higher the greater the corrosion resistance is to form a dense film. For a SiO_2 coating, the tetraethyl Ortho-silicate (TEOS) as the precursor is used, in combination with ethanol, water, acetic acid, etc., herein to prepare a sol [35, 36].

A silane coupling agent (triethoxy-vinylsilane; VTEO) is added to ethylene to prevent the aggregation of SiO_2 sol ($\text{CH}_2\text{-CH-}$) and it has been reported to be effective in improving the corrosion resistance.

8.4. Surface treatment techniques for metallic luster and coloring

The above-mentioned chemical treatment, anodic oxidation, diffusion coating, etc. are used for surface treatment of corrosion resistance of magnesium for products with an emphasis on aesthetics, such as cameras used in moderate environments gloss or color in the castle design. Magnesium metal gloss surface also has a close relationship with the surface roughness (roughness).

Expression (6) shown below

$$R / R_o = f(\sigma / \lambda, \psi, \Delta\theta, m) \quad (6)$$

measures the angular width of the formula incident angle (R), a light receiver from the σ / λ , and theoretically mirror measurement results of the gloss square average square also (δ) to quantify gloss, root mean square slope (m) by analysis with respect to the control of the surface roughness and thickness it has been developed acidic solution treatment expressing metallic luster. Here, R is the mirror reflectivity of the sample, R_o is the specular reflectance of a complete smooth surface, λ represents the wavelength of incident light.

Eq. (6) controls the thickness of the colored film or microstructure of the surface without the use of a film formation is possible by the addition of a dye in the various color dyes in the anodizing solution to get the desired color.

8.5. Mg alloy properties

8.5.1. The main composition

Mg alloys have liquidity compared with Al alloy, and it also has small and easy to micro-shrinkage riser effect to occur. Therefore, pressure resistance of small pinhole is not generated. Thus, the factors equipped with cast Al alloy is more difficult. The occurrence of pinhole being the most problematic in the Al alloy castings is the only feature that is not a problem for Mg alloys [37].

Mg alloy is not permission the flow of the molten metal also not so easy to good thermal capacity to cool a molten metal is decreased to a high temperature. Therefore, there is a problem with the minimum thickness of the casting, the minimum thickness must be 4 mm, and the optimal thickness must be 8 mm.

8.5.2. Dimensional accuracy

Mg alloy die-castings and the addition of antioxidants, and the like for molding the molding sand, if the CO₂ detective obtains a desired dimensional accuracy of the casting because it uses a relatively coarse sand or increase applied to the mold can be improved relatively in dimensional accuracy. The degree of finish applied to the casting is shown in **Table 1**.

| Casting size | 150 mm | | | 150–600 mm | | | 600 mm | | |
|------------------------------|--------|---------|-----|------------|---------|---------|---------|-----------|-----|
| Degree of roughness | ▽ | ▽▽ | ▽▽▽ | ▽ | ▽▽ | ▽▽▽ | ▽ | ▽▽ | ▽▽▽ |
| Separate values of roughness | 2.0 | 2.5–3.5 | | 2.5–3.5 | 3.0–4.0 | 3.0–4.0 | 3.0–4.0 | 5.0 below | |

Table 1. Surface roughness values in casting.

Table 2 displays the tolerance to be considered in the casting. However, the tolerance may be improved by examining the methods of casting required.

8.5.3. Good appearance

According to the foregoing, the molding sand is rough, the strength of a molding sand of the casting surface is lower than the casting for use, and Al is not necessarily satisfactory in the kitchen state. Also, because often use the fill, and also in many cases establishing the riser directly on top of the product, the casting surface is often the finishing touches according to the degree required. After finishing because irradiation of the surface with sand blast, short blast, may generally be obtained a surface roughness of 50–30 μm.

| Dimensional space | Parallel in spilt plane | Right angel in spilt plane |
|-------------------------|-------------------------|----------------------------|
| 50 below | ±0.8 | ±1.3 |
| 50–100 | ±1.0 | ±1.8 |
| 100–200 | ±1.5 | ±2.5 |
| 200–300 | ±2.0 | ±3.3 |
| 300–500 | ±2.5 | ±4.0 |
| 500 below | ±3.5 | - |
| Difference in thickness | | |
| 5 below | ±0.5 | |
| 5–10 | ±1.0 | |
| 10–20 | ±1.5 | |
| Slope | 2°C | |

Table 2. Dimensional tolerances of the Mg alloy die-castings (unit: mm).

9. Conclusion

Magnesium is a metal element belonging to the second tribe, the alkaline earth metal of the periodic table and is the lightest structural metal. Magnesium is known originally by the compound, such as magnesium sulfate, magnesia, magnesium carbonate alkali, etc. The application of Mg alloy is expected, in particular involving motion or portability of the component, to increase in the future because of the material's high strength-to-weight ratio and a relatively high stiffness. Magnesium and its alloys are increasingly implemented into a number of components where weight reduction is of great concern. However, the poor corrosion resistance of Mg and its alloys has limited their applications in corrosive environments. Recently, the creep behavior of Mg alloy has attracted much attention due to its useful value in practice. However, the conventional magnesium alloy has a relatively low resistance to creep at elevated temperatures in contrast to Al alloy, which has restricted the development of Mg alloy. Also, magnesium alloys have many good properties which make them ideal materials in a number of applications. However, poor corrosion resistance and high chemical reactivity have hindered the wide applications of magnesium alloys.

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