Flame-resistant Magnesium Alloys with High Strength

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1. Introduction

Magnesium alloys are very attractive in such applications as automotive, railway and aerospace technologies. However, their low ignition temperatures (470~550 deg C) and low mechanical strength have restricted their use. The ignition temperature has been improved to approximately 620~810 deg C by developing Ca-added, CaO-added and (Ca and Y)-added alloys; however, their mechanical properties are inferior to those of aluminum alloys. Recently, we have developed two types of flame-resistant magnesium alloys with high strength.

2. New Flame-resistant Magnesium Alloys

(1) LPSO-type Mg Alloys (*KUMADAI* Heat-resistant Mg Alloys)

LPSO-type Mg alloys are duplexes of α-Mg phase and a novel phase with a long period stacking ordered (LPSO) structure. The LPSO structure is formed in Mg-M-RE alloys, in which the M element is Co, Ni, Cu, Zn or Al, and the RE (rare earth) element is limited to Y, Gd, Tb, Dy, Ho, Er or Tm. The LPSO-type Mg alloys are called "*KUMADAI* heat-resistant Mg alloys", in which "*KUMADAI*" means Kumamoto University in Japanese. The LPSO-type Mg alloys produced by extrusion of cast ingots have high yield strength (350-520 MPa for 0.2% proof strength) and reasonable elongation (5-15 %) at room temperature, and high elevated-temperature yield strength (250-350 MPa at 473 K). These mechanical properties are superior to those of ordinal magnesium alloys such as AZ91, and high strength aluminum alloys such as super duralumin and extra-super duralumin. The LPSO-type Mg alloys produced by rapidly solidified powder metallurgy (RS P/M) processing exhibit higher mechanical properties and corrosion resistance than the LPSO-type Mg alloys produced by ingot metallurgy (I/M) processing. A RS P/M $Mg_{96.75}Zn_{0.75}Y_2Al_{0.5}$ alloy has tensile yield strength of 533 MPa, tensile elongation of 10.6 %, and fatigue strength (10^7 cycles) of 325 MPa. Its specific yield strength and specific fatigue strength and corrosion resistance are 1.6, 1.7

and 2.8 times as high as those of extra-super-duralumin (7075-T6). The ignition temperature of the LPSO-type Mg alloys is ranging from 780 to 940 deg C, which is much higher than that of ordinary magnesium alloys.

(2) C36-type Mg Alloys (*KUMADAI* Non-flammable Mg Alloys)

C36-type Mg alloys, which contains no rare metals, are called "*KUMADAI* non-flammable Mg alloys". These alloys are consisted with α-Mg phase and C36-type intermetallic compounds. The C36-type intermetallic compound is easily dispersed in α-Mg matrix by extrusion, resulting in good ductility. The C36-type Mg alloys produced by extrusion of cast ingots have high yield strength (410~460 MPa for 0.2% proof strength) and reasonable elongation of 3.5% at room temperature. Their ignition temperature exceeds the boiling point of pure magnesium (1,091 deg C).

(3) FAA Flammability Test

FAA Technical Center has carried out the flammability tests on *KUMADAI* heat-resistant Mg alloy and *KUMADAI* non-flammable Mg alloy. The rectangular bar samples with a 0.25 inch thickness, a 1.5 inch height and 20 inch length were used for the flammability tests. The bar sample was exposed to oil fired burner flame for 4 minutes. The flammability test was carried out 6 times for each alloy. All samples passed the test very easily, with essentially no burning at all.

3. Conclusions

We have developed two types of new magnesium alloys with high strength and high ignition temperature. These alloys passed the FAA flammability test easily, with essentially no burning at all. These alloys enable us to expand the application field, to reduce the production costs, and to improve the safety of materials production and working.