



# The influence of casting temperature on castability and structure of AJ62 alloy

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## ABSTRACT

**Purpose:** The AJ62 magnesium alloy exhibit good elevated-temperature tensile properties, excellent creep resistance and good castability. This alloy contains approximately 6% aluminum and about 2.5% strontium. Typically, it is used in automotive industry for the engine crankcase and power-train components. The aim of this paper is to present the results of the influence of pouring temperature on the fluidity and microstructure of the AJ62 magnesium alloy.

**Design/methodology/approach:** The study was conducted on AJ62 magnesium alloys. Sand casting was performed at 695-755°C temperatures. The spiral test of fluidity was used. The microstructure was characterized by optical microscopy (Olympus GX-70) and a scanning electron microscopy (Hitachi S3400) equipped with an X-radiation detector EDS (VOYAGER of NORAN INSTRUMENTS). The phase identification of these alloys was identified by X-ray diffraction (JDX-75). Quantitative examination was conducted using the "MET-ILO" automatic image analysis programme.

**Findings:** In as cast condition AJ62 alloy consisted of  $\alpha$ -Mg grains with some types of intermetallic phases: (Al,Mg)<sub>4</sub>Sr, Al<sub>8</sub>Mn<sub>5</sub> and Al<sub>3</sub>Mg<sub>13</sub>Sr. The flow length and the intermetallicphases area fraction increase with increase the pouring temperature.

**Research limitations/implications:** Future researches should contain investigations of the influence of casting temperature and heat treatment parameters on mechanical properties of AJ62 magnesium alloy.

**Practical implications:** The established casting parameters (mainly temperature) can be useful for preparing sand and die casting technology of the AJ62 magnesium alloy.

**Originality/value:** The relationship between the initial structure, casting temperature, castability and phase composition in AJ62 magnesium alloy was specified.

**Keywords:** Metallic alloys; Manufacturing and processing; Casting; AJ62 magnesium alloy

## MATERIALS

### 1. Introduction

Magnesium alloys with aluminum characterize a good mechanical properties, corrosion resistance and castability after sand and die casting. However, they have poor creep properties at elevated temperature, higher than ~125°C [1-3]. Mg-Al alloys are characterized by solid solution  $\alpha$ -Mg with precipitates of Mg<sub>17</sub>Al<sub>12</sub> intermetallic phase [4-6]. The poor elevated temperature

properties of Mg-Al based alloys is due to precipitation of Mg<sub>17</sub>Al<sub>12</sub> from the supersaturated solid solution and coarsening of this phase in the interdendritic regions at high temperatures. The service temperatures of automotive powertrain components are mostly above 150°C, therefore, creep resistance is a major requirement for use of magnesium in critical automotive components [7, 8].

Possible approaches to improving creep resistance of Mg-Al alloys include introducing [1]:

- alloying elements with higher affinity to aluminum;
- secondary phase particles at grain boundaries to pin the sliding phenomenon;
- a fine dispersion of stable precipitates.

Many magnesium alloys with addition of Sr have emerged in the 1990s and 2000 [9]. The magnesium alloys with strontium exhibit good elevated-temperature tensile properties, excellent creep resistance and good castability [1]. Strontium is added for creep resistance in die casting and gravity casting alloys or to reduced shrinkage porosity. Sr level may range from 0,02% to 3%. The preferred alloying temperature is around 675-700°C [9]. These alloys were targeted for automotive applications such as oil pans, cylinder blocks (~ 200°C) or engine pistons housings (~ 250°C) [9, 10].

Fluidity is defined as the ability for a molten metal to flow through and to fill a mould cavity before solidification occurs [11]. It gives the ability to determine if an alloy is suitable to cast into a certain product with good quality. It will depend on the die design, pouring system, mould materials, casting parameters and chemical composition of alloy [12]. It is obvious that aluminium, zinc, silicon and rare earths increase castability [12, 13], while calcium decreases it (some authors report that RE decreases castability of magnesium alloys) [14]. The increasing of the fluidity length with increasing rare earths and strontium content has been attributed to the reduction in the freezing range of the alloys and the high latent heat of RE and Sr containing precipitates, which may act to slow the solidification [15]. In general terms, short freezing range alloys have higher fluidity than long freezing range alloys [12].

## 2. Description of the work methodology and material for research

### 2.1. Material for research

The material for the research was AJ62 magnesium alloy. The chemical composition of this alloy is provided in Table 1.

Table 1.  
Chemical composition of the AJ62 alloy

Alloy	Mg	Al	Mn	Sr
AJ62	balance	6.1	0.34	2.1

### 2.2. Research methodology

Fluidity has been investigated by determining the flow length with a mould featuring a spiral shaped cavity. The shape of fluidity spiral is shown in Fig.1. Casting in sand moulds has been done at different melt temperature from 695°C up to 755 °C.

For the microstructural observation, a OLYMPUS GX 71 metallographic microscope and a HITACHI S-3400N scanning electron microscope with a Thermo Noran EDS spectrometer equipped with SYSTEM SIX were used. To measure the stereological parameters, a program for image analysis "MET-ILLO" was used. A set of grey image transformations until obtaining a binary image are shown in Fig. 2.

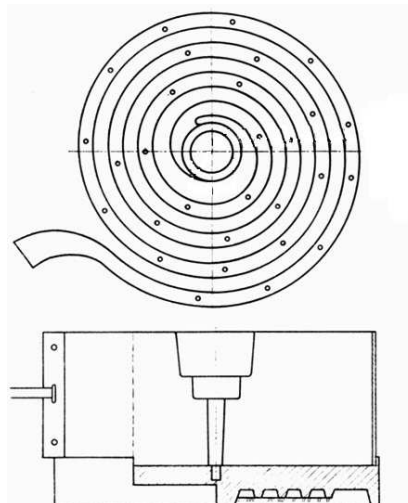


Fig. 1. Diagram of spiral sample to investigations of fluidity

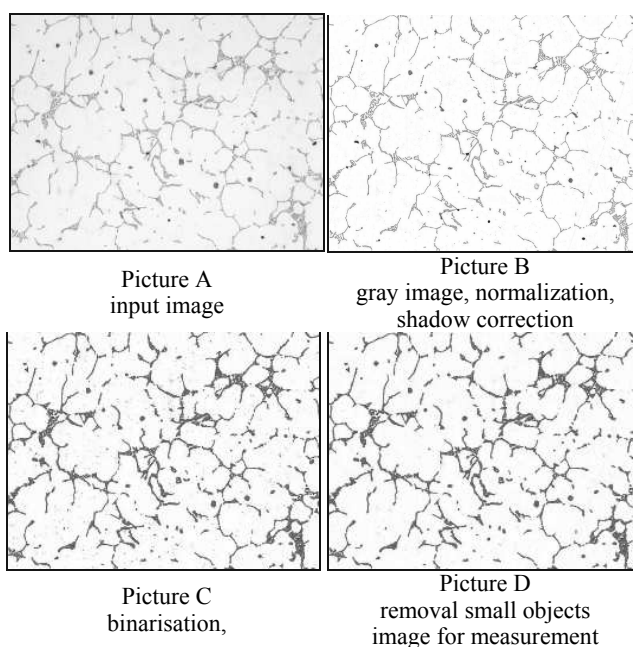


Fig. 2. The procedure of intermetallic phases detection, LM

## 3. Description of achieved results of own researches

### 3.1. Microstructure of the AJ62 alloy

The AJ62 magnesium alloy after sand casting is characterized by the solid solution  $\alpha$  with the lamellar eutectic  $(Al,Mg)_4Sr$  + solid solution  $\alpha$  and the globular precipitates of the  $Mn_5Al_8$  phase. Moreover the occurrence of not numerous precipitates of the massive  $Al_3Mg_{13}Sr$  phase have been provided (Fig.3).

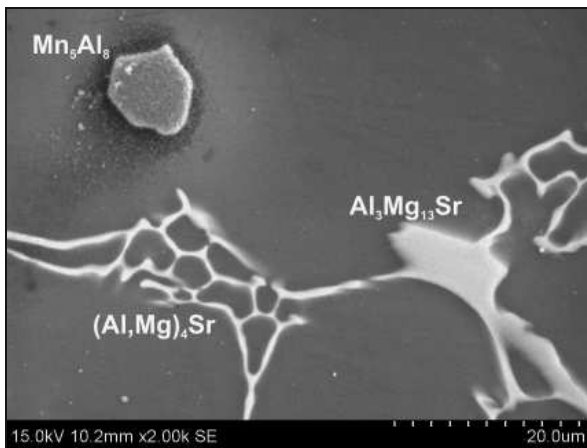


Fig. 3. The precipitates of  $(Al,Mg)_4Sr$ ,  $Mn_5Al_8$  and  $Al_3Mg_{13}Sr$  phases in AJ62 alloy after sand casting

### 3.2. Influence of pouring temperature on fluidity

Spiral casts after pouring from temperature 695°C and 755 °C were showed on figures 4 and 5, respectively. Table 2 shows the influence of pouring temperature on filling lengths. Within a temperature interval of about 60 °C the passes distance increase up to a value 1,5 times above the original flow length of 38 cm. The detected correlation can be explained by the extended interval from pouring to freezing temperature.

Table 2. Influence of pouring temperature on fluidity of AJ62 alloy

Pouring temperature [°C]	695	715	735	755
Filling length [m]	0.38	0.48	0.53	0.57



Fig. 4. Spiral cast of AJ62 alloy after pouring from temperature 695°C. Fluidity length is equal 38 cm



Fig. 5. Spiral cast of AJ62 alloy after pouring from temperature 755°C. Fluidity length is equal 57 cm

### 3.3. Influence of pouring temperature on volume fraction of intermetallic phases

The area fraction of intermetallic phases (mainly eutectic  $(Al,Mg_4Sr+\alpha)$ ) after sand casting from temperature 695°C was equal  $A_A=5.6\%$  (Fig. 6).

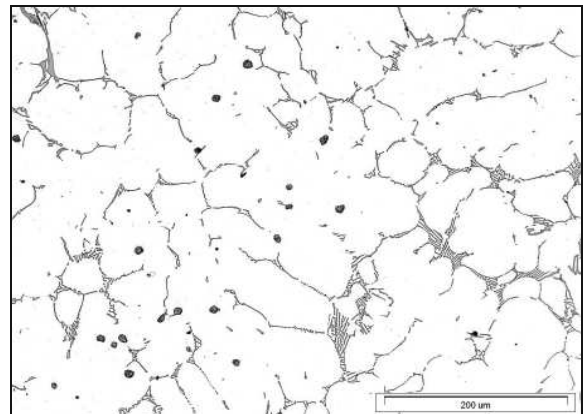


Fig. 6. Microstructure of AJ62 alloy after pouring from temperature 695°C. The area fraction of intermetallic phases is equal  $A_A=5.6\%$

Table 3. Influence of pouring temperature on area fraction of the intermetallic phases

Pouring temperature [°C]	695	715	735	755
Area fraction $A_A$ [%]	5.6	5.8	6.6	7.0

The area fraction of intermetallic phases increases with increase of pouring temperature (table 3). After casting from temperature 755°C area fraction of intermetallic phases was equal  $A_A=7.0\%$  (Fig. 7).

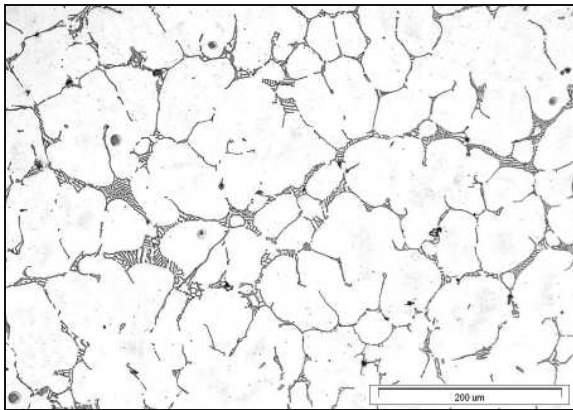


Fig. 7. Microstructure of AJ62 alloy after pouring from temperature 755°C. The area fraction of intermetallic phases is equal  $A_A=7.0\%$

#### 4. Summary

The AJ62 magnesium alloy structure after sand casting is characterized by a solid solution structure  $\alpha$  with the lamellar eutectic  $(Al,Mg)_4Sr$  + solid solution  $\alpha$ , globular precipitates of the  $Mn_5Al_8$  phase and not numerous precipitates of the massive  $Al_3Mg_{13}Sr$  phase. The area fraction of intermetallic phases (mainly eutectic  $(Al,Mg_4Sr+\alpha)$ ) increase with increase of pouring temperature. Fluidity of AJ62 alloy linearly increases with increase of pouring temperature and are fraction of intermetallic phases (Fig. 8).

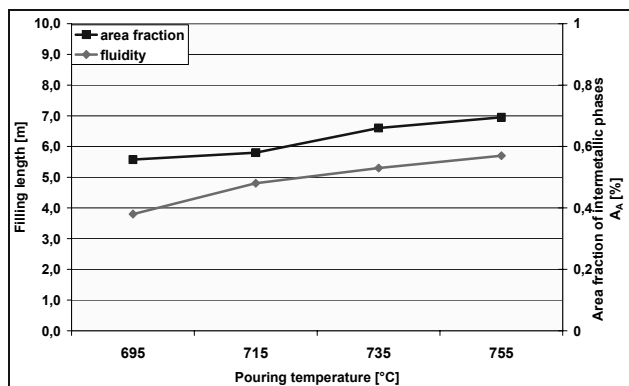


Fig. 8. The influence of pouring temperature on fluidity of AJ62 magnesium alloy

The detected correlation can be explained by:

- the extended interval from pouring to freezing temperature,
- the increase of area fraction of intermetallic phases.

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