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The new foundry line for magnesium alloys high-pressure die-casting

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Abstract

The new foundry line for high-pressure die-casting of magnesium alloys constructed in the "SILUM" Foundry (Opojowice, Poland) is described. In the process cold chamber die-casting machines are used. The experimental casts and the radiators fabricated using the new cold chamber die-casting line are presented as the final results. The new production line allows to obtain good quality magnesium casts.

Keywords: Magnesium alloys, High-pressure die-casting

1. Introduction

Magnesium alloys are light metallic structural materials which have unique combination of properties. They are very attractive in such applications as automobile, aerospace and electric industries. Magnesium alloys become significant due to their relatively lower density (three times), improved damping ability, a higher resistance to corrosion and better mechanical properties in comparison to aluminum. Commercial magnesium alloys are often based on Mg-Al system. The most commonly used magnesium alloys are AZ91 and alloys of the AM series [1-5].

The development of high-pressure die-casting process should have a priority over other metal casting technologies because it ensures the production of thin walled cast details of complicated shapes with a high yield and high dimensional precision. The high-pressure die-cast magnesium components are being increasingly used because of the excellent castability and properties that magnesium offers. High-pressure die-casting of thin walled components is particularly suitable because of the excellent flow characteristics of molten magnesium alloys [6-10].

The die-casting technology for magnesium and aluminum alloys is basically similar. However, there are important differences like handing of the molten alloy. A melting of magnesium is also different from other metals because it requires protection against surface oxidation. It should be noted that magnesium and aluminum die-casting alloys also possess different chemical and physical properties, which require modifications in injection parameters and die design [2-4, 11].

In the present paper, the new foundry line constructed in the "SILUM" Foundry (Opojowice, Poland) for high-pressure die-casting of magnesium alloys is presented. Although, both cold chamber and hot chamber die-casting machines are used extensively for magnesium alloys die-casting [5-14], cold chamber machines are exploited in the presented line.

2. Description of the foundry line

Thanks to cooperation between Institute of Materials Engineering of Czestochowa University of Technology and the "SILUM" Foundry the new foundry line of high-pressure die-casting with cold chamber machines for magnesium alloys has been opened this year. The main technological problems taken into account during designing the technological line were: (i) gas protection in all casting cycle which required closed system for molten magnesium alloy, (ii) system metering molten metal from crucible to casting machine and also (iii) appropriate selection of materials which are in a contact with molten magnesium alloys.

Figure 1 illustrates the scheme of the cold chamber die-casting line for magnesium alloys. Main elements of the line are:

- Single chamber furnace,
- Two-chamber crucible,
- Special system for gas protection of molten metal,
- Metering system consisted of pump and tube transporting molten metal form the pump to the casting machine, and also
- Temperature control system.

Due to a strong tendency of molten magnesium to be oxidized, it was prerequisite to use a protective gas atmosphere over the molten metal in all casting cycle. For that purpose a special molten metal gas protection system was performed. In the system elaborated for to that purpose, protective gases were supplied to the furnace, the pump and also to the transporting tube. In the first stage a mixture of sulfur hexafluoride with nitrogen was used. It is also possible to change easily the protective gas mixture to another one (e.g. sulfur dioxide in dry air).

Thanks to applying the two-chamber crucible it was possible for obtain molten alloy free from slag, in spite of using the single chamber furnace. For metering molten metal to the shot sleeve the pump was constructed according to our project. Additionally, the molten metal metering system was equipped with steel tube transporting molten metal from the pump to the casting machine.

In our preliminary work, Polak cold chamber die-casting machines with locking force at 160 and 350 tones were used. Of course it is also possible to change machines as required.

In Figure 2 the photograph of the cold chamber die-casting line for magnesium alloys in the “SILUM” Foundry is presented.

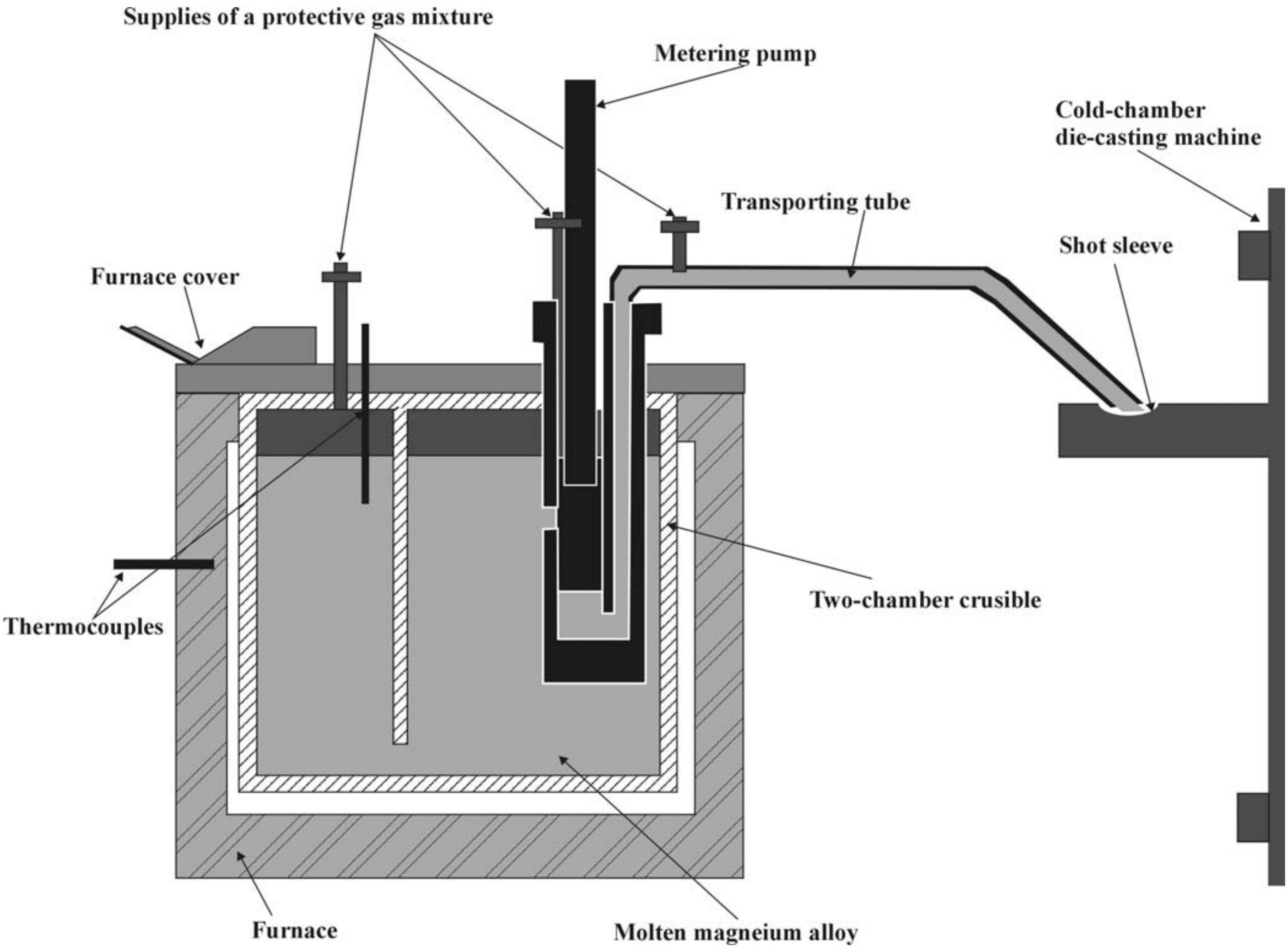

Fig. 1. Scheme of the cold-chamber die-casting line for magnesium alloys in the “SILUM” Foundry

Fig. 2. Photograph of the cold-chamber die-casting line for magnesium alloys in the "SILUM" Foundry:
1 – furnace with two-chamber crucible, 2 – metering pump,
3 – transporting tube, 4 – cold chamber die-casting machine

3. Results

Figures 3 and 4 show examples of macrographs of casts fabricated on the cold chamber die-casting machine in the "SILUM" foundry. They are the experimental casts and radiators, respectively. The commercial AZ91 magnesium alloy in the form of ingots (Hydro Magnesium Ltd.) with a chemical composition given in Table 1 was used.

Table 1.
Chemical composition of AZ91 alloy according to ASTM B93-94

Chemical composition [wt %] *								
Alloy	Al	Zn	Mn	Si max	Fe max	Cu max	Ni max	Others each max
AZ91	8,5-9,5	0,45-0,9	0,17-0,4	0,05	0,005	0,03	0,002	0,02
* Mg rest								

For safety reasons ingots were preheated prior to immersion in the molten metal. The casting temperature of the alloy was in the range 660-690^{O}C. There were other casting parameters selected experimentally, for example an injection rate, a plunger speeds in particular phase, a casting pressure, die temperature, etc.

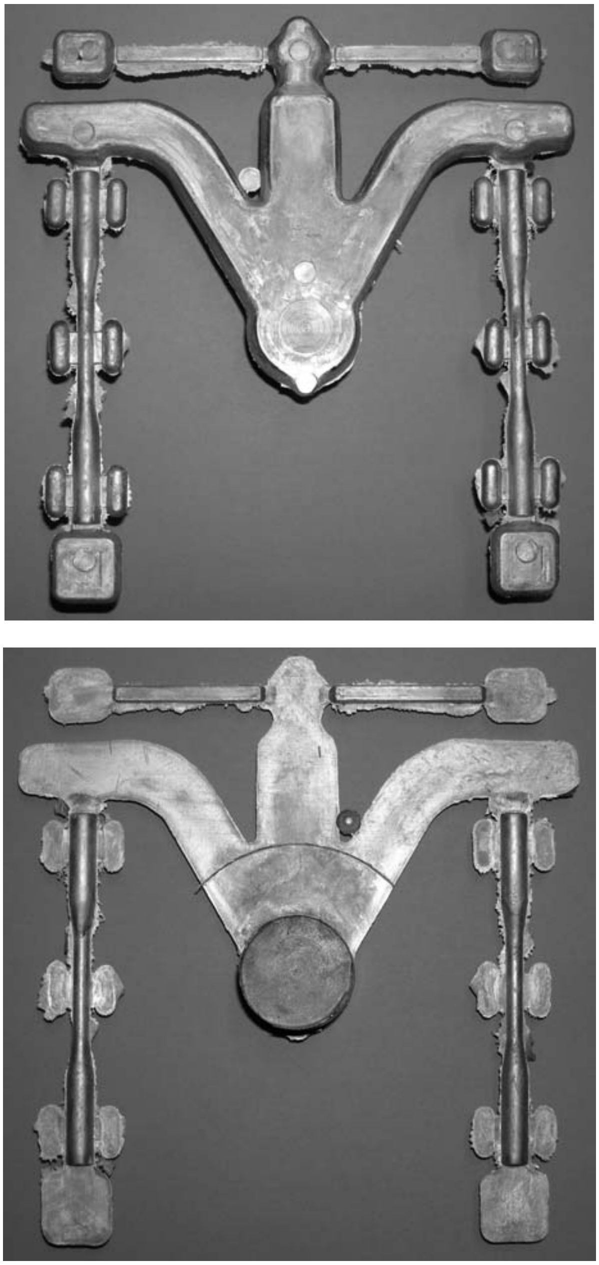

Fig. 3. Macrographs of AZ91 magnesium alloy experimental casts fabricated on the Polak cold-chamber die-casting machine with 160 tons locking force in the "SILUM" Foundry

Casts obtained at the new cold chamber die-casting line in the "SILUM" Foundry are characterised by correct representation of dies without visible casting defects (like incomplete filling of die cavity, cold flows or cold shuts, hot cracking, deformation, distortion or fracture, etc.) and also satisfactory quality of surfaces.

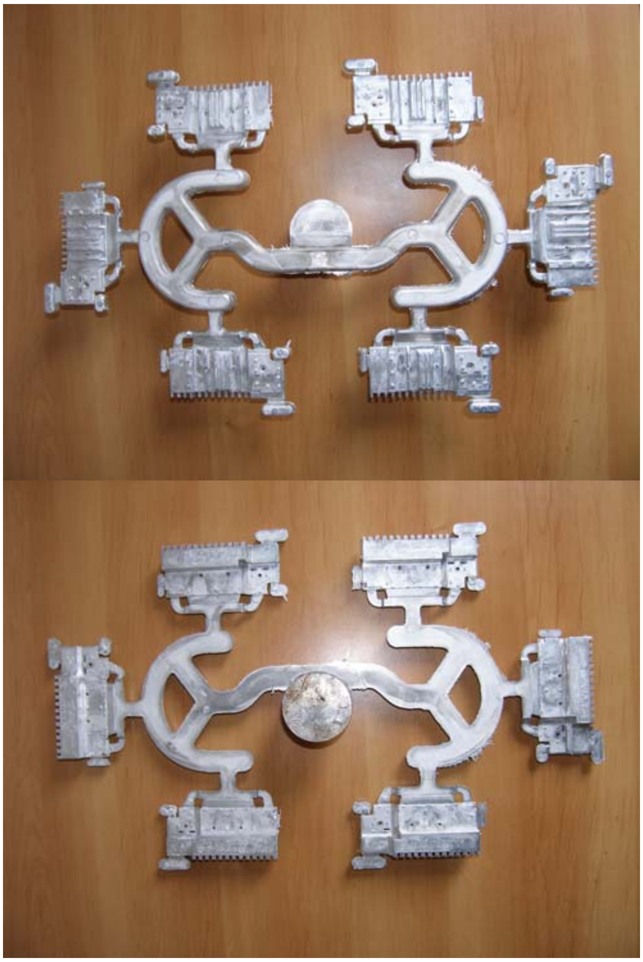

Fig. 4. Macrographs of AZ91 magnesium alloy radiators fabricated on the Polak cold-chamber die-casting machine with 250 tons locking force in the “SILUM” Foundry

4. Summary

The line, described in this paper, for high-pressure die-casting using cold chamber die-casting machines fully satisfies the condition of magnesium alloys casting. It allows to obtain good quality magnesium details. In this moment the volume of production in the “SILUM” Foundry is about 20 tons per year. Since magnesium is nowadays a low cost material that offers lightweight, environmental-friendly and safe solution, a production can be successively enlarged according to clients' needs.

Acknowledgments

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