

- 1 -

FILTRATION SYSTEM FOR RECYLCING AND PURIFICATION OF A MAGNESIUM MELT

FIELD OF THE INVENTION

- 5 The present invention relates to a filtration system for recycling and purification of magnesium melt. The invention also provides an assembly for die casting which includes such a filtration system and also a method for the recycling and purification of scrap magnesium and/or magnesium ingots including impurities.

10 BACKGROUND

- Molten magnesium alloys generally quite easily oxidize and react with impurities elements. As a result, contamination of molten magnesium alloys by non-metallic and metallic inclusions, such as oxides and intermetallic compounds, is a severe problem generally experienced during melting of magnesium alloys, especially when scrap parts are
- 15 involved. The presence of these inclusions, particularly when using the remelted magnesium from scraps or returned runner systems, will adversely affect the quality of the final castings. Indeed, it may result in "through-hole" defects in diecast thin-wall components. In order to secure the casting quality, the current practice of many magnesium dicasters is to send the magnesium scraps and return runner systems back to
- 20 the smelter for recycling. However, this is very costly.

- Separation of the liquid metal and solid particulate impurities may be achieved via several routes. One effective way is using a filtration technique. Filtration of molten aluminum alloys using ceramic filters has been used in aluminum casting. Indeed, it has been
- 25 reported that solid-phase inclusions could be removed by filtration thus improving castability, yield and productivity.

- For magnesium casting, furnaces generally used include those with two or three chambers. The chambers are separated by top and bottom impediment plates. Such methods, as used
- 30 in magnesium die casting at this time, facilitate separation of top and bottom sludge but are not effective for the removal of inclusions suspended in the melt.

The present invention advantageously provides a system which may be used in die casting and which facilitates filtration of magnesium melt, the system providing a means for reducing the amount of suspended inclusions or impurities in the melt.

5 SUMMARY OF THE INVENTION

A filtration system for recycling and purification of magnesium melt, the filtration system including:

- a first chamber for containing a magnesium melt which includes impurities; and
- a second chamber for receiving a purified magnesium melt;

10 wherein said first and second chambers have disposed therebetween a filter, said filter including a silicon-free filter medium.

As used herein the term "magnesium melt" includes a melt of magnesium or a magnesium alloy. Also, as used herein the term "magnesium" includes magnesium or a magnesium
15 alloy.

As used herein the term "purified magnesium melt" means a magnesium or magnesium alloy melt having a reduced amount of suspended impurities relative to that of the raw magnesium melt from which the purified magnesium melt has been obtained.

20

As used herein the term "silicon-free" includes a material which does not include any silicon or silicate which may be available for reaction with the magnesium melt as it is passed through the filter.

25 Although the filter medium may include any appropriate silicon-free filter medium, in a preferred embodiment, the filter medium includes a silicon-free material. Even more preferably, the filter medium is either a steel filter or ceramics which are made from or contain one or more of Al_2O_3 , MgO , $AlPO_4$ and $Mg_3(PO_4)_2$.

30 The filter medium reduces the number of suspended impurities in the magnesium melt as the magnesium melt passes from the first chamber to the second chamber. In this regard,

the filter medium preferably has a whole distribution of pores between 5 and 250 microns. Preferably, the whole distribution of the filter medium is such that the filter medium facilitates removal of substantially all impurities having a particle size of greater than about 30 microns, more preferably 10 microns, even more preferably 5 microns.

5

The filter may be disposed between the first and second chambers by any suitable means. In a preferred embodiment, however, the filter includes a filter plate which is removably positionable between the first and second chambers, the filter medium being disposed in the filter plate. Even more preferably, the filter plate includes a steel housing which

10 houses the filter medium.

The first and second chambers of the filtration system may take any suitable form. Preferably, the chambers are heated so as to maintain the magnesium melt at an appropriate temperature. In this regard, in a preferred embodiment one or both of the first and second chambers includes a thermocouple, preferably a set of thermocouples, for

15 controlling the temperature within the chambers. Preferably, both chambers include thermocouples. The thermocouples independently control the temperature within each chamber.

20 Preferably, the atmosphere within both of the first and second chambers is controlled so as to protect the magnesium melt from reaction with the atmosphere. As such, both of the first and second chambers preferably includes an inlet for introducing a protective gas into the chamber so as to maintain a protective atmosphere in the chamber.

25 The filtration system according to the invention is preferably incorporated into a die casting assembly. Accordingly, the present invention also provides a die casting assembly which includes a filtration system according to the invention, wherein the second chamber constitutes an injection chamber of the die casting assembly.

According to another aspect of the invention there is provided a method for the recycling and purification of scrap magnesium and/or magnesium ingots including impurities, said method including:

- introducing the scrap magnesium and/or magnesium ingots to a first chamber;
- 5 heating said scrap magnesium and/or magnesium ingots in said first chamber to form a magnesium melt;
- passing said magnesium melt through a silicon-free filter medium to provide a purified magnesium melt; and
- collecting said purified magnesium melt.

10

DETAILED DESCRIPTION OF THE INVENTION

The invention will now be described in detail with reference with the accompanying drawings in which:

- Figure 1A-1B illustrate a particular embodiment of the filtration system;
 - 15 Figure 2 illustrates a cross-sectional view of the filtration system according to one embodiment;
 - Figure 3 illustrates LOM micrographs of tensile specimens at low and high magnification;
 - Figure 4 illustrates LOM micrographs of hand-phone front case at low and high
 - 20 magnification;
 - Figure 5 illustrates graphically the tensile strength (ultimate tensile strength and yield strength) and elongation as a function of cross-head speed of samples cast from a magnesium melt which has been treated using the filtration system of the invention.
- 25 Normal filters used for the filtration of aluminum alloys can not be used for filtering molten magnesium as they are made of either SiC or ceramics containing silicate, which will react with magnesium and cause contamination. Therefore, according to the invention, silicon free filters are employed for filtration of molten magnesium. Figures 1 and 2 illustrate the basic set up of the filtration system according to the invention,
- 30 particularly as it applies to a die casting assembly.

Referring to Figures 1 and 2, the filtration system 10 includes a first chamber 11 and a second chamber 12. Disposed between the first and second chambers 11, 12 is a filter 13 which includes a filter medium 14. The thickness of the filter medium 14 is generally in the order of 25 mm. The filter 13 is preferably formed from a housing 15 which houses the
5 filter medium 14.

Magnesium in the form of scraps and/or ingots are introduced to the first chamber 11 to form a magnesium melt 16. The magnesium melt includes a number of inclusions or impurities which are illustrated as dotted regions in Figure 2.

10

The molten material is filtered by passing it through the filter medium 14 into the second chamber 12, thereby providing purified magnesium melt 17. Both chambers 11 and 12 are provided with thermocouple sets TC1, TC2. As represented in Figure 2, the second chamber 12 is an injection chamber.

15

EXAMPLES

Two types of parts, hand-phone case and tensile test specimens, were cast during tests. The alloy used in the tests was AZ91 HP: Al 8-9.5%, Zn 0.3-1%, Mn $\geq 0.17\%$, Si $\leq 0.05\%$, Fe $\leq 0.004\%$, Cu $\leq 0.015\%$, Ni $\leq 0.01\%$, others $\leq 0.01\%$, others $\leq 0.01\%$, Mg (remaining)
20 . For comparison the tests were conducted using 100% fresh ingot and ingot including 10% scraps material.

After casting, the microstructure and chemical properties of the specimens were analyzed. The microstructure analysis was conducted with light optical microscopy while mechanical
25 properties were determined using an Instron tensile testing machine. The cross-head speed was varied from 0.1 to 20 mm/min during tensile tests.

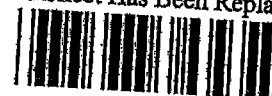
Typical microstructures for the tensile specimen (dia: 10 mm—thick walled part) and the handphone front case (wall thickness: 0.6 mm—thin walled part) are shown in Figure 3
30 and Figure 4. In both thick and thin walled parts, the microstructures consist mainly of ∇ -Mg, intermetallic- $\text{Al}_2\text{Mg}_{17}$, eutectic and some fine precipitation. However, thin walled

parts (Figure 4) showed much finer structure when compared to thick walled parts (Figure 3). The reduced V-Mg grain size is due to rapid solidification rate occurred in the thin walled part.

- 5 Mechanical properties of cast samples were determined after casting. Figure 5 whose the tensile strength (ultimate tensile strength and yield strength) and elongation as a function of the cross-head speed. As the cross-head speed is directly related to the strain rate of the testing, the results indicate that the strain rate has a very slight influence on the flow stress and strain of magnesium castings when tested at room temperature. The UTS and YS are
10 about 142 and 119 MPa respectively with an elongation of about 1%.

A comparison was done of mechanical properties between castings made with filtered magnesium (with about 10% scraps) and fresh magnesium (100% new ingot). The strength of castings is increased using filtered magnesium when compared to 100% new
15 magnesium ingot, but the ductility of the alloys is reduced. The decreased ductility is probably due to the presence of more intermetallic compounds and less magnesium in the alloy using scrap parts although the alloy has been filtered. Therefore, the composition of the alloy should be adjusted when using scrap parts.

- 20 Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications which fall within its spirit and scope. The invention also includes all the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and
25 any and all combinations of any two or more of said steps or features.



CLAIMS

1. A filtration system for recycling and purification of magnesium melt, the filtration system including:
 - 5 a first chamber for containing a magnesium melt which includes impurities; and
 - a second chamber for receiving a purified magnesium melt;wherein said first and second chambers have disposed therebetween a filter, said filter including a silicon-free filter medium.
- 10 2. A filtration system according to claim 1, wherein said filter medium includes a silicon-free ceramic material.
3. A filtration system according to claim 2, wherein said filter medium includes a steel filter or a ceramics filter including one or more of Al_2O_3 , MgO , AlPO_4 and $\text{Mg}_3(\text{PO}_4)_2$.
- 15 4. A filtration system according to claim 1, wherein said filter medium has a hole distribution of between 5-250 microns.
- 20 5. A filtration system according to claim 1, wherein said filter medium has a hole distribution which facilitates removal of substantially all impurities having a particle size of greater than about 5 microns.
- 25 6. A filtration system according to claim 1, wherein the filter includes a filter plate which is removably positionable between said first and second chambers, the filter medium being disposed in the filter plate.
7. A filtration system according to claim 6, wherein the filter plate includes a steel housing which houses the filter medium.
- 30



- 8 -

8. A filtration system according to claim 1, wherein one or both of said first and second chambers includes thermocouples for controlling the temperature within said chamber.
- 5 9. A filtration system according to claim 1, both of the first and second chambers includes an inlet for introducing a protective gas into said chambers so as to maintain a protective atmosphere in said chambers.
- 10 10. A die casting assembly which includes a filtration system according to claim 1, wherein said second chamber constitutes an injection chamber of the die casting assembly.
11. A method for the recycling and purification of scrap magnesium and/or magnesium ingots including impurities, said method including:
- 15 introducing the scrap magnesium and/or magnesium ingots to a first chamber;
- heating said scrap magnesium and/or magnesium ingots in said first chamber to form a magnesium melt;
- passing said magnesium melt through a silicon-free filter medium to
- 20 provide a purified magnesium melt; and
- collecting said purified magnesium melt.