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Recycling of Magnesium Alloy Die-Castings with Paint Finishing

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The recycling process for the thin-walled scraps of the professional video camera components with paint finishing was investigated through a simple remelting process. Firstly, the paint materials on the scraps were removed by shot blast, and then the scraps were melted. The generation of harmful gases resulting from the incomplete combustion of organic constituents in the paint materials on heating was depressed. Recovery ratio of the recycled ingots is remarkably improved due to depression of Mg oxidation caused by the paint combustion, and consequently is higher than 80%. Chemical compositions of the recycled specimens satisfy the values specified by ASTM, and only contain minor quantities of the impurities with a bad influence on corrosion resistance such as Fe, Ni and Cr. As a result, the recycled specimens exhibit the same level of corrosion resistance as a virgin ingot of AZ91D magnesium alloy, and have tensile properties satisfying the values specified by ASTM.

Keyword: AZ91D magnesium alloy, Recycling, Tensile properties, Corrosion resistance

1.INTRODUCTION

Recycling of relatively clean magnesium alloy scraps in as die-cast condition is actively being carried out, and its capacity is increasing[1]. However, not much has been done about recycling of thin walled AZ91D magnesium alloy die-castings with paint finishing.

The authors[2),3)] had earlier tried to obtain the recycled ingots, which satisfy ASTM specifications on AZ91D magnesium alloy ingot, from the scraps of the professional and non-professional video camera components. However, the contents of impurities such as Fe and Ni in the recycled ingot from the scraps of the professional ones exceeded the tolerance limit[4)] guaranteeing the corrosion resistance of AZ91D magnesium alloy. This is because the paint film of the professional ones was thick, and the heavy metallic impurities from the undercoat and paint materials contaminated the melt.

Therefore, as a second trial, Mn was added in the form of Al-Mn master alloy in order to create a coarse Al-Mn-Fe compound that sank to the bottom of the crucible, making it possible to remove the impurities[5)].

However, the recovery ratios of the above recycling processes were low because the paint materials burnt on the melt by radiation heat from the melt and oxidation loss of magnesium became consequently large. Therefore, in this study the paint materials on the professional video camera component scraps made of AZ91D magnesium alloy are first removed by shot blast method. After that the scraps were melted and poured into permanent mold. Chemical analysis, microstructural observation, and corrosion and tensile tests were carried out to evaluate quality of the recycled ingots.

2.EXPERIMENTAL PROCEDURE

In this experiment, used professional video camera components were employed as the scraps. They were paint-finished die-castings of less than 2mm-section thickness made of AZ91D magnesium alloy. Before melting, screw threads were taken off, and the paint materials were removed from the scraps by an air blast machine using spherical glass beads of particle diameter ranging from 250 to 350 μ m.

Table I shows the chemical compositions of the scraps of the professional video camera components and a virgin ingot of AZ91D magnesium alloy as a

Table I Chemical compositions of the scraps of professional video camera components and a virgin ingot of AZ91D magnesium alloy as a reference (mass%)

Alloy		Al	Zn	Mn	Si	Cu	Ni	Fe	Cr	Mg
AZ91D ingot	as-cast	9.10	0.70	0.23	0.03	0.001	<0.001	0.001	-	Bal.
Scrap	as-diecast	8.71	0.71	0.13	0.03	<0.005	<0.002	<0.005	-	Bal.
	paint-finished	9.38	0.78	0.08	-	0.0026	0.0007	0.0462	0.0058	Bal.
	paint-removed	10.96	0.83	0.20	0.01	0.0021	0.0004	0.0040	0.0029	Bal.

reference. The chemical compositions of the scraps are those from as-diecast, paint- finished and paint-removed samples. Composition analysis of the scraps was used except for the part of the screw threads, and performed using ICP atomic emission spectrometry. The scrap with paint finishing contains large quantities of impurities such as Fe and Cr. The impurities are contained in the undercoat and paint materials, and are predicted to contaminate the recycled ingot.

Fig.1 shows a schematic diagram of the melting process used in this study. The paint-removed scraps of about 1200g were cut to sizes that could be easily put into the crucible, which is made of steel, and were heated from room temperature. Melting was conducted in the presence of SF_6+CO_2 (40:200ml/min) mixed gas at 700℃. Since the paint materials were already removed by the shot blast before the melting the generation of harmful gases with the incomplete combustion of organic constituents in the paint materials on heating was depressed.

After the melting, flux corresponding to 2% of the total melt weight was added to the melt, and then the melt was stirred. The resulting slag was then removed from the bottom of the crucible and melt surface. After 20min killing, the melt was poured into boat type permanent mold.

The recovery ratio, Y (%) of the recycled ingots can be calculated from the following equation:

$$Y\,(\%) = 100W_T / W_S$$

W_T and W_S represent weights of the recycled ingot and the charged scrap, respectively. Composition analysis of the recycled ingots was performed using ICP atomic emission spectrometry.

Microstructural observation, EPMA analyses and EDS analyses were conducted in order to investigate the size, distribution, quantities and constituent elements of intermetallic compounds in recycled ingot. Tensile test was performed using round specimens of 6mm diameter and 30mm gauge length at an initial strain rate $5.56\times10^{-4}s^{-1}$. Corrosion resistance was evaluated by a spray test using 5%NaCl aqueous solution at 35℃ and an immersion test using 3%NaCl aqueous solution at room temperature.

3.RESULTS AND DISCUSSION

3.1 Recovery ratio of the recycled ingots

Fig.2 shows the recovery ratio of the ingots recycled from the paint-removed professional video camera components compared with that from the professional and non-professional ones with paint finishing. The recovery ratio of the ingots recycled from the professional and non-professional ones with paint finishing show the results of two times. The paint film of the professional ones is thicker than the non-professional ones. Recovery ratio of the paint-removed scraps is about 85% and is remarkably improved as compared with the ingots recycled from the scraps with paint finishing. This may be due to depression of Mg oxidation caused by the paint combustion of increased surface temperature.

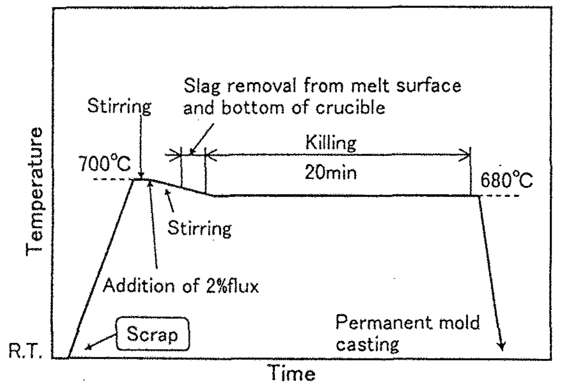

Fig.1 The schematic diagram of the melting process used in this study.

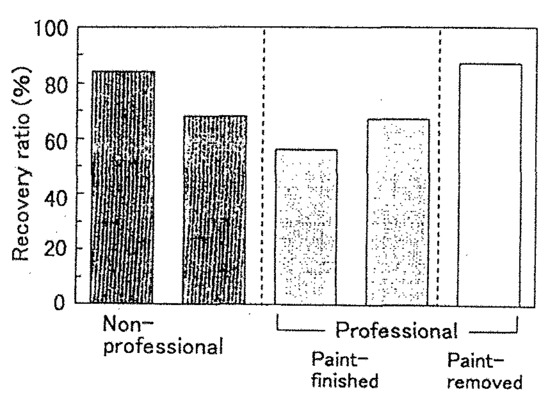

Fig.2 The recovery ratio of the ingots recycled from the paint-removed professional video camera components compared with that from the professional and non-professional ones with paint finishing.

Table II The chemical compositions of recycled ingots (mass%)

	Alloy	Al	Zn	Mn	Cu	Ni	Fe	Cr	Mg
ASTM standard specification	die castings	8.3-9.7	0.35-1.0	≧0.15	≦0.030	≦0.002	≦0.005	-	Bal.
	ingot	8.5-9.5	0.45-0.9	≧0.17	≦0.015	≦0.001	≦0.004	-	Bal.
Recycled AZ91D magnesium alloy	paint-finished	9.1	0.76	0.16	<0.005	0.008	0.017	-	Bal.
		8.9	0.74	0.15	0.0022	0.0064	0.0115	0.0020	Bal.
	paint-removed	9.6	0.73	0.18	0.0328	0.0007	0.0025	0.0004	Bal.
		9.7	0.77	0.17	0.0431	0.0007	0.0030	0.0010	Bal.

3.2 Chemical compositions of the recycled ingots

Table II shows the chemical compositions of the recycled ingots. The ingots recycled from the scraps with paint finishing contain large quantities of Fe, Ni and Cr, which are contaminated by the undercoat and paint materials. Whereas the chemical composition o the ingots recycled from the paint-removed scraps satisfy the values specified by ASTM except for Cu. Particularly the impurities having a bad influence on corrosion resistance such as Fe, Ni and Cr are remarkably reduced as compared with those of the ingots recycled from the paint-finished scraps. Cu may have entered into the recycled ingot from reinforced materials made of brass for a nut-fastened part.

3.3 Microstructures of the recycled ingots

Fig.3 shows the microstructures of the ingots recycled from the paint-removed professional video camera components. The microstructure of the recycled ingot is similar to that of normal sand or permanent mold castings. Grey granular phase seems to be Al-Mn system compound.

Fig.4 shows the results of EDS analyses of the compounds observed in the ingots recycled from the paint-removed professional video camera components. Fe, Ni and Cr could not be detected in both compounds. The X-ray images also show only the presence of Al and Mn in compound A and that of Al and Mg in compound B. From these results, the compounds A and B are presumed to be Al_xMn (x=6 or 4) and $Mg_{17}Al_{12}$, respectively.

3.4 Corrosion resistance of the recycled ingot

Fig.5 shows the relationship between test time and weight loss of the specimens recycled from the professional video camera components in comparison with that of AZ91D magnesium alloy virgin ingot and the specimens recycled from the non-professional ones. Weight loss of the specimens recycled from the professional ones with paint finishing is remarkably large due to contamination by impurities such as Fe, Ni and Cr from undercoat and paint materials. Whereas weight loss of the specimen recycled from the paint-removed professional ones is remarkably lowered by decreases in the contents of Fe, Ni and Cr through the

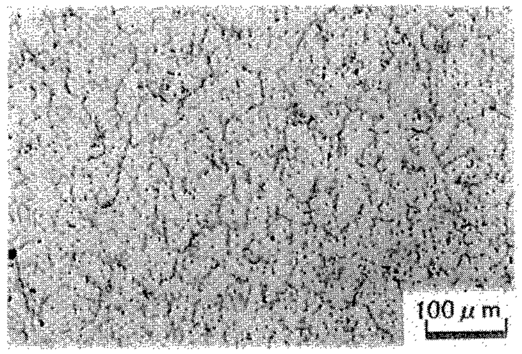

Fig.3 The microstructures of the ingots recycled from the paint-removed professional video camera components.

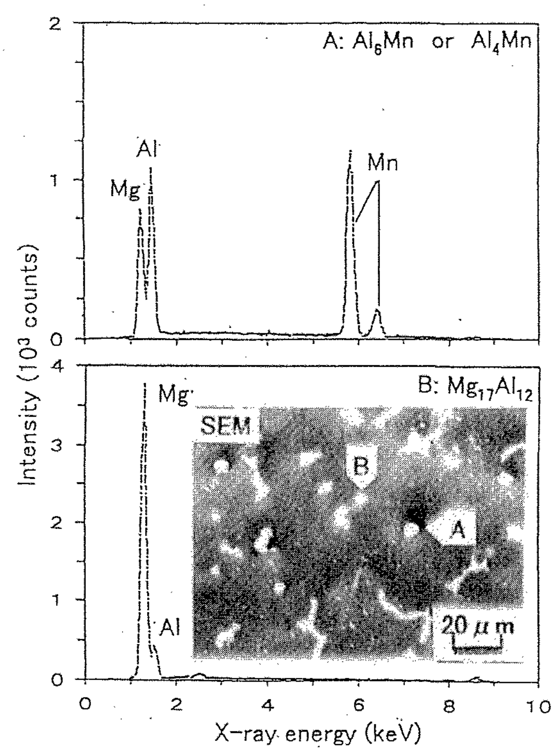

Fig.4 The results of EDS analyses of the compounds observed in the ingots recycled from the paint-removed professional video camera components.

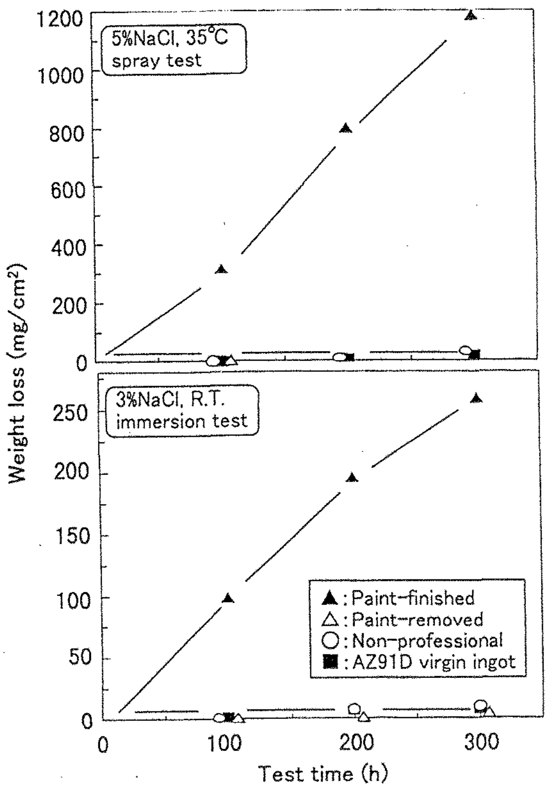

Fig.5 The relationships between test times and weight losses of the specimens recycled from the professional video camera components in comparison with that of AZ91D magnesium alloy virgin ingot and the specimen recycled from the non-professional ones.

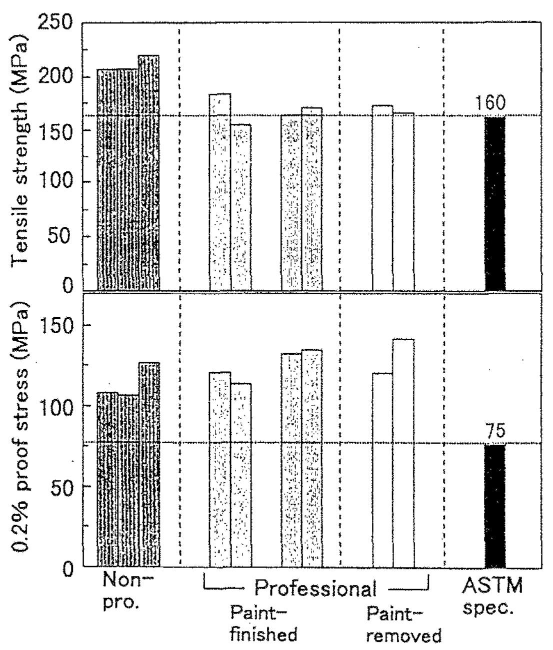

Fig.6 The tensile properties of the specimens recycled from the paint-removed professional video camera components compared with those from professional ones with paint finishing and the non-professional ones.

paint removal. Consequently, the specimen recycled from the paint-removed scraps exhibits almost the same level of corrosion resistance as the specimen recycled from the non-professional ones and virgin ingot of AZ91D magnesium alloy.

3.5 Tensile properties of the recycled ingot

Fig.6 shows the tensile properties of the specimens recycled from the paint-removed professional video camera components compared with those from the professional ones with paint finishing and the non-professional ones. ASTM standard specification is also shown. Tensile strength and 0.2% proof stress of the specimens recycled from the paint-removed professional video camera components satisfy the ASTM values, and especially, 0.2% proof stress is higher than that of the specimens recycled from the non-professional ones.

4.CONCLUSIONS

In this study, the paint materials on the scraps were first removed by shot blast, and then the scraps were melted. The generation of harmful gases with incomplete combustion of organic constituents in the paint materials on heating was, therefore, depressed. Recovery ratio of the recycled ingots is remarkably improved due to the depression of Mg oxidation caused by the paint combustion and is higher than 80%. The recycled specimen has chemical compositions satisfying the values specified by ASTM, and only contains little quantities of the impurities with a bad influence on corrosion resistance such as Fe, Ni and Cr. As a result, corrosion resistance of the recycled specimen exhibits the same level as a virgin ingot of AZ91D magnesium alloy. Tensile properties of the recycled specimens exceed the values specified by ASTM.

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