Swell-peeling method for aluminum can paints.

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ABSTRACT

The recycling of used aluminum beverage cans (UBCs) into can body material is the main recycling method for aluminum products. However, in the remelting of UBCs, "paints" remain as an unfavorable molten metal residue (primarily titanium) and lower molten metal yield.

This paper reports the application of a swell-peeling method in which paints are chemically removed. It also reports on a swell-peeling method that successfully improves molten metal yield and prevents the impurity element titanium from contaminating molten metal simultaneously.

KEY WORDS : *recycling/UBC/paint-peeling/swelling/metal yield/Ti impurity*

1. INTRODUCTION

The increased promotion of aluminum UBCs recycling is an important subject for the future aluminum industry.

As aluminum UBCs are coated with paints, however, the lowering of the molten metal yield of aluminum and the deterioration of the molten metal composition occur during recycling and the deterioration (titanium impurity) makes "Can to Can" recycling difficult.

For the removal of aluminum UBCs paints (hereinafter referred to as paints), the thermal method (roasting method[1]), the mechanical method (shot blasting method[2]), and the combination of these methods are in common practical use. However, in the thermal method, titanium which has a negative effect on material quality, is not removed, and remains in pigment form. The mechanical method also results in such problems as iron mixing, etc.

Accordingly, a new recycling system using a chemical method (the swell-peeling method) that utilizes the property of paints to absorb a solvent is reported in this paper.

2. EXPERIMENTAL

2.1 Raw material

2.1.1 UBC material

Aluminum UBCs are shredded for recycling. In this experiment a shredder (apparent bulk specific gravity : 0.12 Mg/m^3) was applied to the raw aluminum UBC material. Only one kind of UBC was cut into squares with a small cutter to produce a different surface area. In this case, the inner paints were removed with sand paper.

2.1.2 Swell-peeling solution

Table 1 shows the composition of three types of swelling peeling solution. A new solution (C) was made to improve the peeling action.

Table 1 The swell-peeling solution composition

	Solvent	Acid	Reference
A	Methylene chloride	None	
B	Ditto	Formic acid	Usual peeling solution
C	Ditto	Formic acid + Halogenated acetic acid etc.	New peeling solution

2.2 Swell-peeling test

2.2.1 Peeling test of UBCs with three types of solutions

In order to compare the performance of the peeling solutions, the relationship between the paint peeling rate and the peeling time was examined in a sealed container. The peeling rate of paints is defined in Equation 1.

Peeling rate of paint = {1-(UBC mass after the lapse of the chosen peeling time) / (UBC mass before peeling)} × 100% (1)

Where the peeling time is between 300 seconds and 7,200 seconds, and the mass ratio of shredded articles / peeling solution is 1/10 (shredded articles : 0.1kg). After the appointed peeling time elapsed, the aluminum UBCs were taken out, cleaned with methylene chloride, and dried. The resultant mass of aluminum was then weighed.

2.2.2 Peeling test of UBCs having different surface areas

UBCs having different surface areas were dipped in the above liquid and the relationship between the surface area of sample and peeling time was investigated. Peeling time means the time to peel and separate the paint completely from the UBCs.

2.3 Melting test

Aluminum UBCs were obtained in as used form and cut by shredder. Then, the paints were removed using the rotational peeling method with a small-sized concrete mixer. In this test, the aluminum UBCs compounding ratio in the melted material was made to be 50 mass% aluminum UBCs and 50 mass% aluminum metal (99.7 mass%) in consideration of actual industrial conditions. In addition, shredded material from aluminum UBCs (without removing paints, as received), roasted material from aluminum UBCs (roasting temperature : 798k), and plate aluminum (JIS 3004 ; thickness : 0.3 mm) were used as comparison materials.

The 100 kg/charge materials were air-melted at 993K using a graphite crucible type induction furnace (1 kHz). The entire quantity of aluminum metal was melted first, and then aluminum UBCs were added to the molten material and melted together. And then, as the dross was skimmed using a rake. The aluminum component was recovered from the skimmed dross using a rotary vane type ash wringer.

The samples obtained from the molten metal were analyzed using an ICPA to clearly determine chemical composition.

The metal loss rate of the 99.7 mass% aluminum metal which was applied to the base melt was observed to be below 0.1 mass% as a result of actual measurement. Thus, the melting yield of the aluminum metal was presumed to be 100%. In the case where the compounding rate of aluminum UBCs was 50%, the results were converted into a comparative value (Such that the compounding rate of aluminum UBCs was 100%) by proportional calculation.

3. RESULTS

3.1 Swell-peeling test

3.1.1 Peeling test of UBCs with three types of solutions

The influence of peeling time on the peeling rate of paints is shown in **Fig. 1**. In the usual peeling solution, which only contains formic acid, the peeling rate of paints showed a fixed value after a peeling time of 800 seconds. This fixed rate was extremely low, although some paint peeling did occur in the first period. On the other hand, for the new peeling solution, which contained both formic acid and halogenated acetic acid, etc., a remarkable peeling effect was observed even after a peeling time of 300 seconds, and the observed peeling rate was 1.8%.

3.1.2 Peeling test of UBCs having various surface areas

Fig. 2 shows the relationship between the specimen surface area and peeling time. When

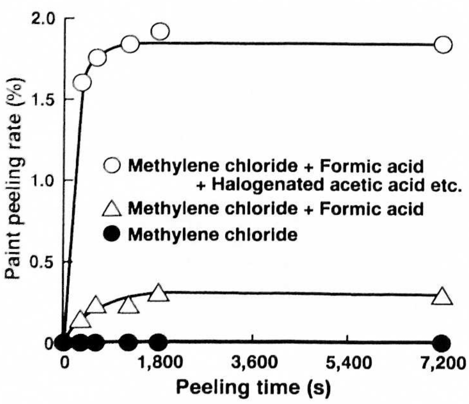

Fig.1 Effects of time on peeling rate.

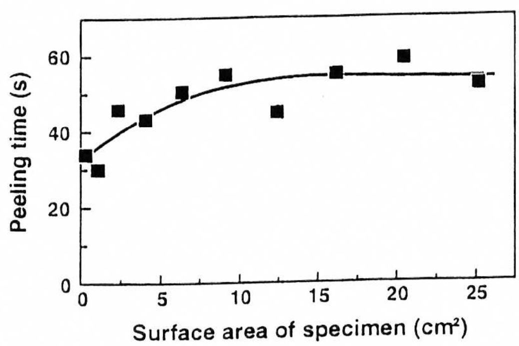

Fig.2 Effect of surface area on peeling time.

the surface area is 10 cm^2 or over, peeling time is independent of the surface area.

3.2 Melting test

The effect of paint removal upon the concentration of titanium as an impurity element in the molten obtained is shown in **Fig. 3**. The titanium concentration in the molten metal was 0.04 mass% in the case where the material was melted without paint removal (as received). On the other hand, titanium concentration decreased to about 0.02 mass% through paint removal, nearly equivalent to the titanium level found in JIS 3004 on the market.

The effect of paint removal upon melting yield and operation yield is shown in **Fig. 4**. In the case where paints were not removed, the operation yield was roughly 83%. On the other hand, in the case where pains were removed first, the operation yield increased to roughly 91%.

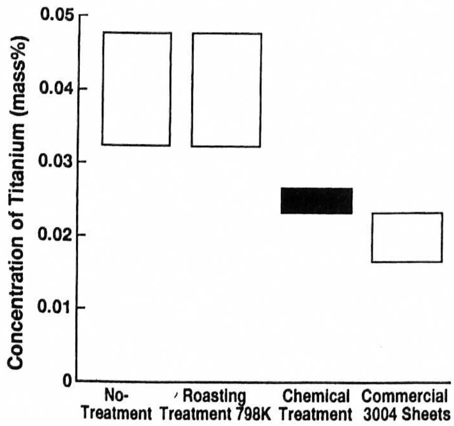

Fig.3 Positive effects of pretreatments of aluminum UBC on titanium concentration in the molten metal.

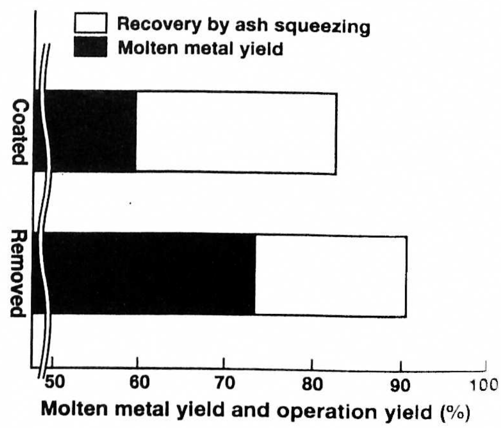

Fig.4 Positive effects of removal of UBC paints on molten metal yield and operation yield.

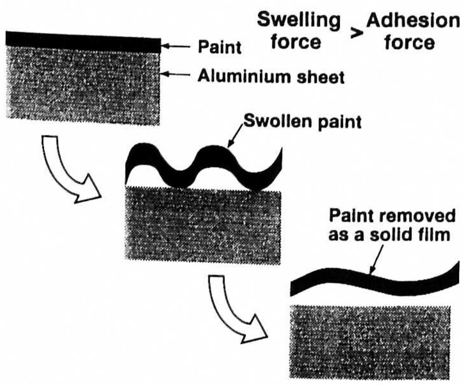

Fig.5 Schematic presentation of swell-peeling method paints on aluminum beverage cans.

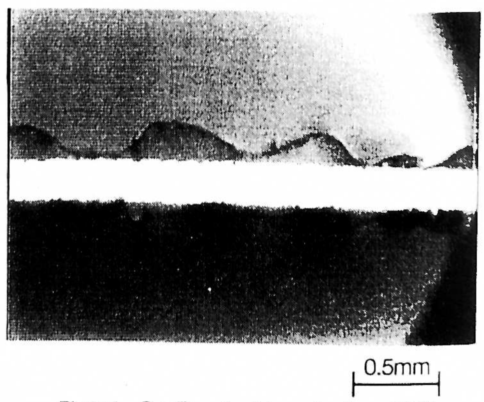

Photo.1 Swelling of paint on aluminum UBC (side view).

4. DISCUSSION

4.1 Swell-peeling of paint

It is well known that bridged three-dimensional macromolecules swell in a solvent, and this phenomenon has been utilized to peel off paints [4]. When the swelling force on the paint macromolecules exceeds the adhesion force to the material, peeling is possible. The swell-peeling state is shown schematically in **Fig. 5**.

On the other hand, **Photo. 1** shows swelling of UBC paint (side view) observed with a optical microscope. The peeling solution (c) was diluted with 30 mass% methnol for easier microscopic observation. This photograph corresponds to the above schematical figure.

For the case where the new peeling solution was used, **Fig. 6** schematically shows the mechanism of the paint swelling. The new peeling solution contains not only formic acid but also halogenated acetic acid, etc. and thus the bridge density is reduced by the promotion of hydrolysis. Consequently, it was concluded that methylene chloride more easily penetrates the paint, thereby enhancing the paint peeling from the surface of the aluminum.

4.2 Structure and paint peeling rate

It was shown in Fig. 2 that when the surface area of the sample was over 10 cm^2, peeling time was constant. This phenomenon indicates that the peeling liquid does not penetrate only from the UBC edge, which was also supported by the optical microphotographs of the paint surface (**Photo. 2**) before swelling. Namely, there are many fine pits on the paint surface and the peeling liquid is supposed to penetrate through these pits as well as from the edge to contribute to swell-peeling of the paint. The fact that the peeling time is independent of the surface area is likely because the peeling rate is determined by the liquid penetration through the surface pits.

4.3 A proposal for peeling equipment based upon these investigations

As to the constitution of peeling equipment, an example devised upon the above results is

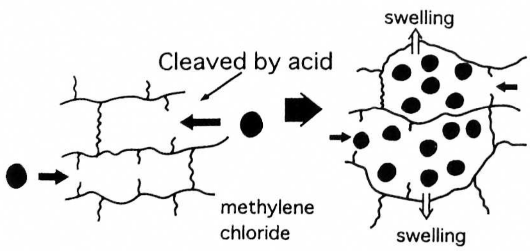

Fig.6 Schematic presentation of swelling and peeling mechanism of aluminum beverage can paints by the proposed peeling liquid.

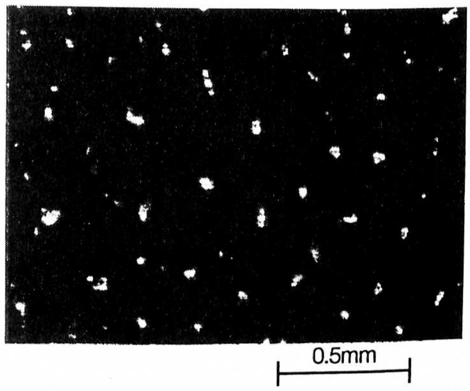

Photo.2 Surface of aluminum UBC paint.

shown in **Fig. 7**. Aluminum UBCs are shredded, and then the foreign matter is separated out. Then the leftover material is put into mash baskets, built into the peeling equipment, and peeling is promoted by rotation in the peeling solution.

In this system, the peeling solution is extracted from the bath, and paint films are separated from it through filtration. The solution is then re-circulated to the bath, since paint films are peeled off in a solid state without dissolving in the solution. The aluminum UBCs material is cleaned using a vapor with a composition equivalent to the peeling solution. Aluminum UBCs after peeling are thus made into briquettes with a press machine and carried to the melting process.

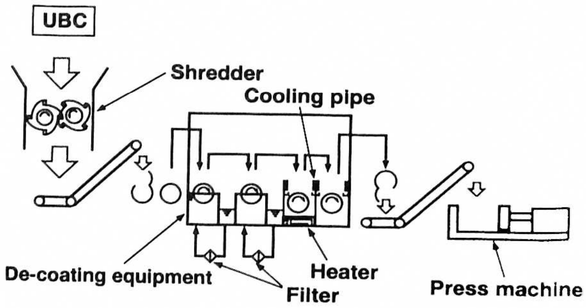

Fig.7 A proposed block diagram of the de-coating paint.

5. CONCLUSION

(1) Peeling takes place when the swelling force generated by methylene chloride exceeds the adhesion force between the paint and the surface of aluminum, that is weakened by the coexisting acid.

(2) When the surface area of UBC is more than 10 cm^2, peeling time is independent of the surface area because swelling phenomenon is controlled by the penetration of the liquid through the fine pits on the surface of the paint.

(3) The swell-peeling method improves the molten metal yield and prevents the impurity element titanium from contaminating the molten metal. Therefore, it becomes possible to promote aluminum UBCs recycling with this method.

6. REFERENCE

1. J.H.L.van Linden : Science & Engineering of Light Metals,(1991), p. 1121
2. Japanese Patent : Patent No. Heisei 7-61611
3. Japanese Patent : Patent opened at No. Heisei 3-290475
4. Edition by Macromolecular Society : Lecturers on Macromolecular Physics and Macro molecular Engineering, vol.2(1967), p. 391