ROLES OF FLUX IN MELTING AND REFINING OF ALUMINUM

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In melting process of aluminum alloy, removal of hydrogen and inclusion are required in order to keep metal quality.

Recently halide flux has been major reflection replaced to chlorine gas, since safety and environmental problems were closed up.

Flux conditions which bring refining ability to the same extent as chlorine were studied. New flux ($KCl-AlF_3-K_3AlF_6-K_2SO_4$) with low moisture was developed successfully.

Key word : aluminum, flux, refining, metal loss.

1. Introduction

Recent aluminum products have required extremely high quality. For example inclusion must be controlled less than ppm order.

To keep this quality, generally, refining treatment is done not only in the furnace but also out of the furnace.[1)]

In the furnace, chlorine is injected into molten aluminum to remove hydrogen and inclusion roughly. Then on the following continuous refining out of the furnace, argon is injected to remove hydrogen and the metal is filtrated with porous refractory to remove inclusion, so that metal quality might be guaranteed (ex. size of inclusion less than 20 μm, hydrogen in the metal less than 0.1 ppm).

However in case of flux refining, it is considered to be more difficult to improve metal quality than chlorine.

In order to develop the flux, roles and refining ability of flux were compared with chlorine.

2.Experimental Method

Experimental conditions are listed in Table 1.

•Decomposition : behavior of flux was tested by holding 3000sec under nitrogen atmosphere at the temperature of 625~1325K.

Refining of molten metal was evaluated by the changes in inclusion quantity and hydrogen content.

• Inclusion quantity : using pressed type inclusion sampler, the metal which went through filtering media was weighed at constant time.

• Hydrogen content in the metal : direct measurement by using the partial pressure equilibrium method.

Also metal loss was calculated from equation (1) :

Table 1 Experimental method

Items	Conditions
Alloy	JIS 6063
Melting •Furnace •Temperature	20 metric tons capacity, heavy oil burner 993K
Refining •Flux •Addition •Temperature	$KCl-CaF_2-AlF_3$ System Injection (chlorine, nitrogen) 993K

$$\frac{\text{dross weight}}{\text{charging material weight}} \times 100\ (\%) \qquad (1)$$

3. Results and Discussion

3.1. Decomposition behavior of flux during heating

Due to difficulty to observe flux decomposition in molten aluminum directly, we examined the decomposition behavior by heating fluxes under nitrogen.

Condition of various gases generated from flux and flux decomposition ratio are shown in Fig.1. It is found that chloride generates chlorine gas and fluoride generates fluorine

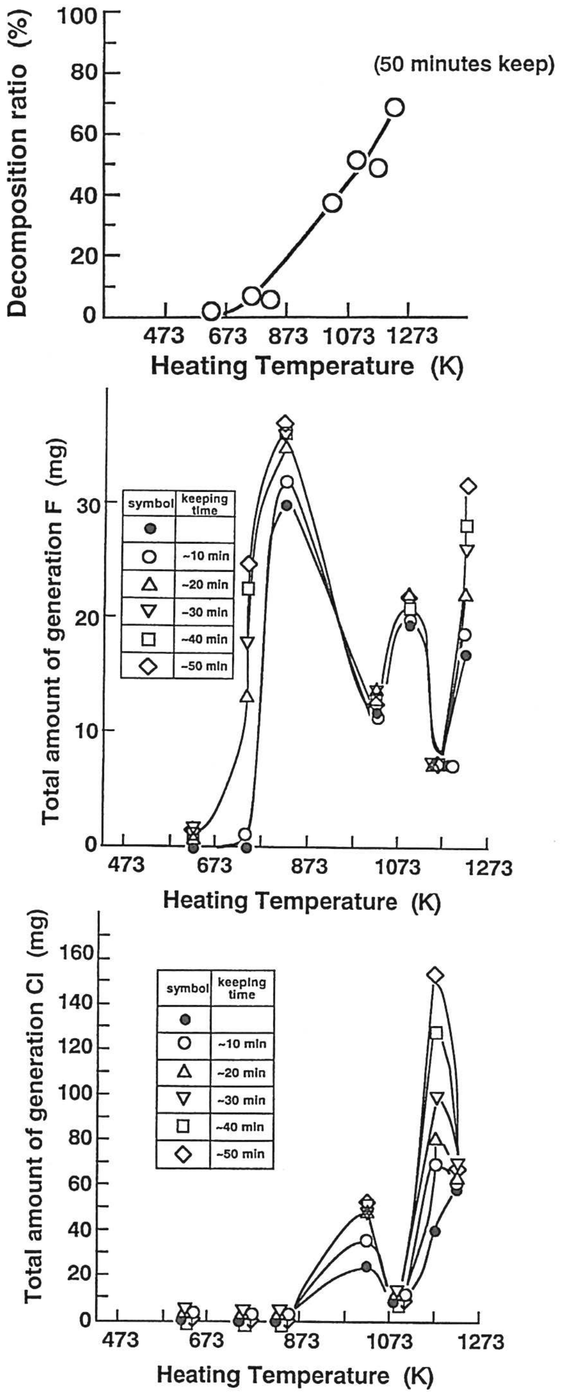

Fig.1 Condition of decomposition of flux (KCl-Fluoride system)

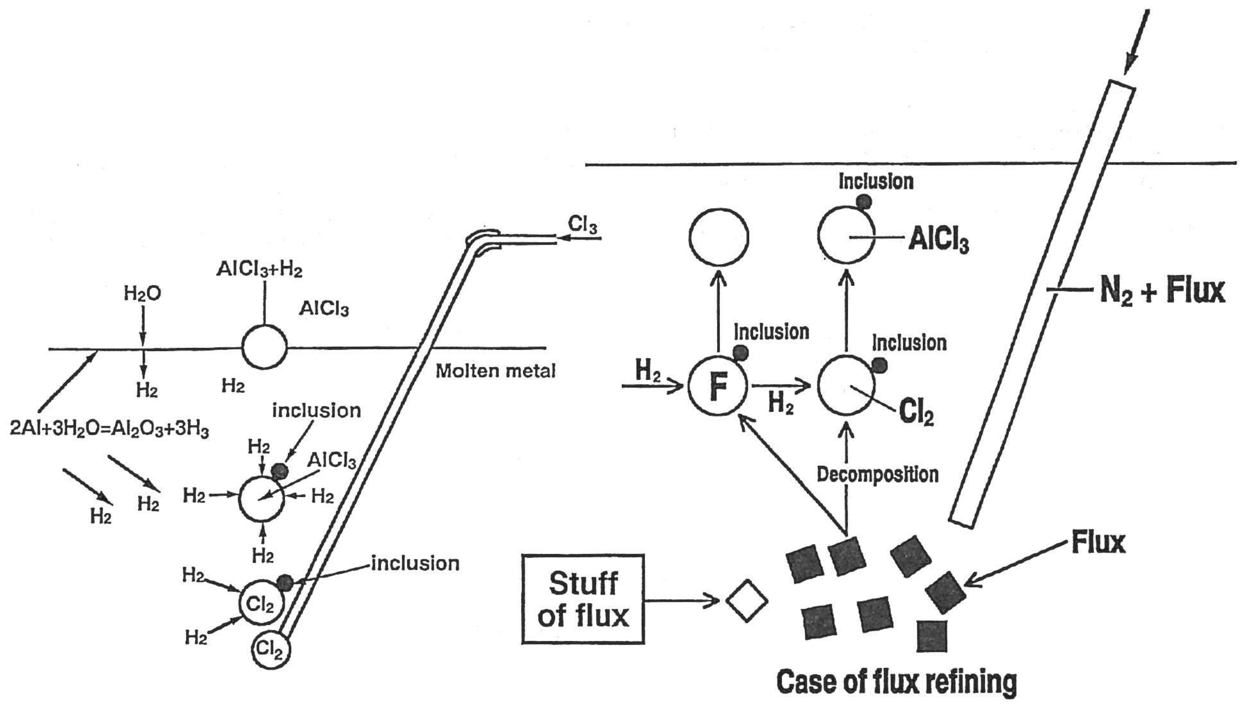

Fig.2 Comparison of reaction between chlorine gas and flux injection

gas.

Decomposition ratio of flux is less than 30 % at 973K. This means that flux does not decompose violently with very low rate.

Decomposition reaction in molten aluminum is schematically shown in Fig.2.

In case of chlorine injection, chlorine react with aluminum and generated gaseous $AlCl_3$. Inclusion is trapped by $AlCl_3$ and hydrogen diffuses into $AlCl_3$. On the other hand, in case of flux injection, a part of flux decomposes and generates halogen gas . This halogen has a role similar to chlorine . Also undecomposited stuffs are existed in the molten aluminum.

3. 2. Quality of molten aluminum.

(1) Removal of inclusion.

Removal behavior of inclusions by chlorine and flux injections were shown in Fig.3.

There is no significant difference between chlorine and flux refining on inclusion removability. In aspect of microscopic view, however, generally flux refining bring about more defect than chlorine injection. Typical defect

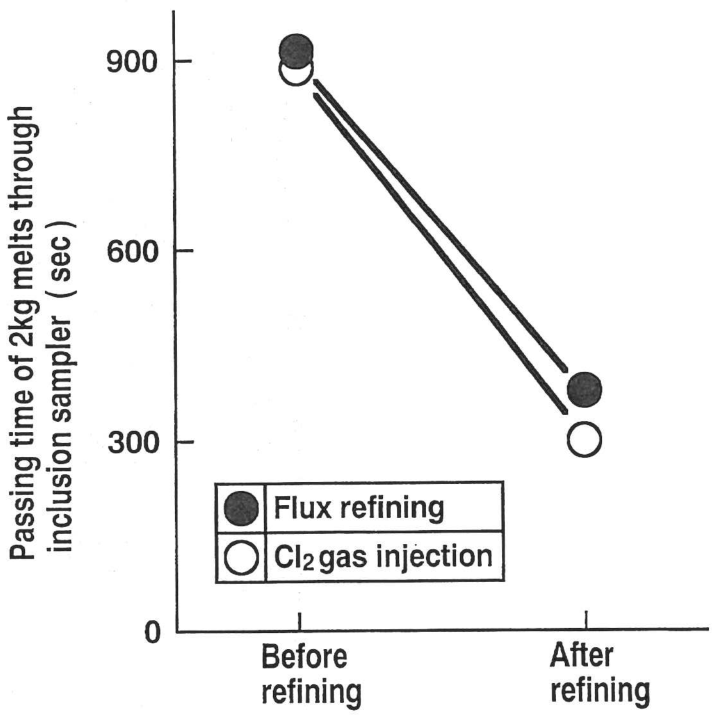

Fig.3 Comparison of inclusion removal behavior by flux and chlorine gas injection.

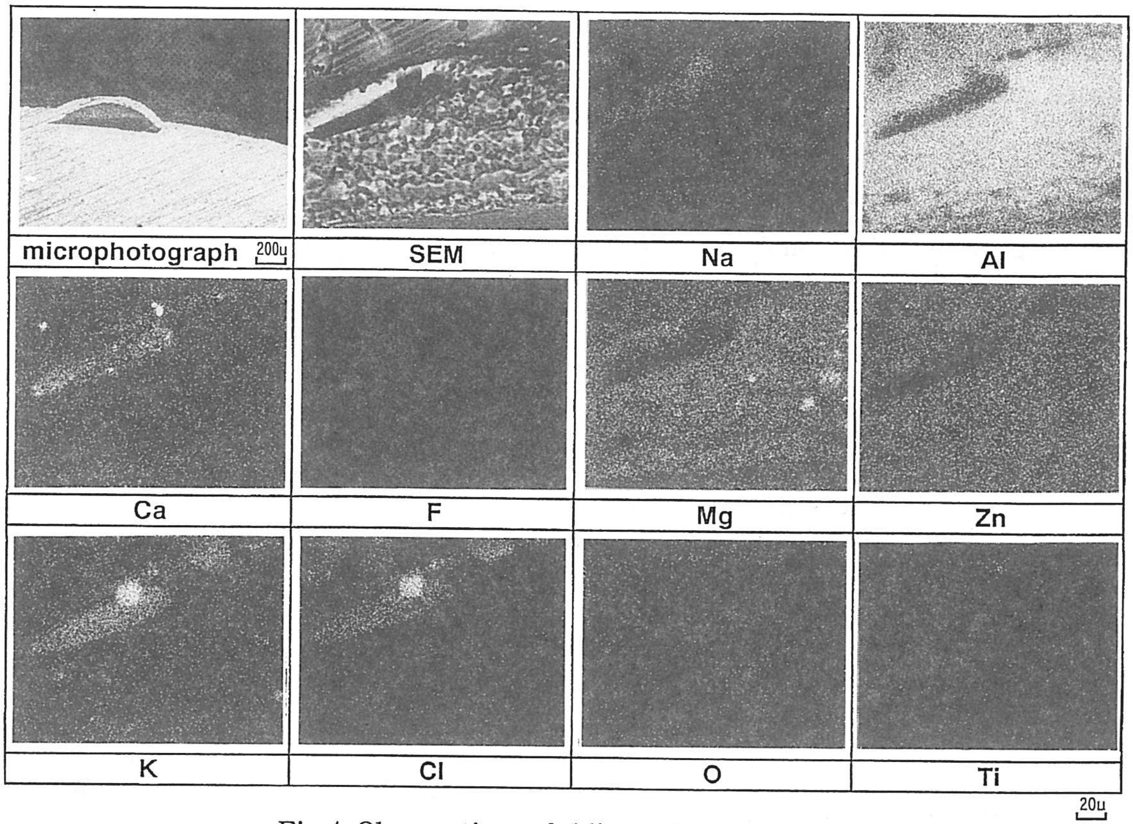

Fig.4 Observation of blister by EPMA

occurred by flux refining is shown in Fig.4.

At the defect site, elements of flux (KCl, CaF_2 etc) K, Cl, Ca etc were detected. It is supposed to be caused by remained flux. It means that flux generates halogen gas having ability of removal of inclusions, but remained flux might be new inclusion.

(2) Degassing

Degassing behaviors of flux and chlorine injection are shown in Fig.5. It is easy to remove hydrogen in molten aluminum down to 0.1ppm by chlorine injection. When using dried flux, hydrogen content in molten metal is extremely reduced as show in Fig.6. This hydrogen level is same as chroline injection in Fig.5. It is significant to dry prior to inject, because fluxes can work for degassing and also become source of hydrogen.

(3) Metal loss

In the refining process of aluminum, heat generated by creating $AlCl_3$ grows up molten aluminum and oxidized molten metal. This causes metal loss.

However in the process of chlorine gas injection, this heat generation occured in short term and continued. It is impossible to control the heat

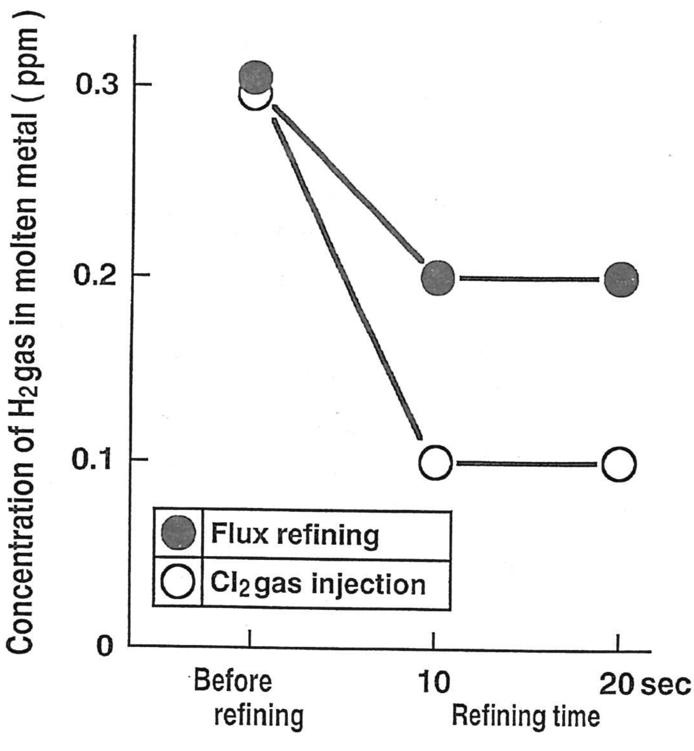

Fig.5 Comparison of degassing behavior by flux and chlorine gas injection.

generation. And metal loss is facilitated much greater. In order to prevent oxidation of molten aluminum the gas which generated by flux decomposition and whose density is larger than air, cover the surface of molten metal. It prevents that molten aluminum touches to air. Eventually the metal loss decreases as shown in Fig.7. In this case, SO_2 gas decomposed from K_2SO_4 has such a role.

(4) Flux composition

We developed the flux which consists of some compound having low decomposition temperature. From the results above mentioned, roles of each flux component are considered as follws :

- KCl → source of generated chlorine gas
- AlF_3, K_3AlF_6 → source of heat which favors high dross removability by reaction with oxide.
- K_2SO_4 → promotion of heat and covering on the surface of molten aluminum.

As the flux composition, KCl-AlF_3-K_3AlF_6-K_2SO_4 system is selected.

In this choice, we use K_3AlF_6 which has low decomposition temperature instead of CaF_2 which is generally used, because it causes some defects in final products.

It is found that ability of flux refining is same as that of chlorine injection by development of flux composition and drying flux.

4. Conclusions

Developing the flux which has ability of making high quality of molten aluminum and good dross removability, we could attain low metal loss in melting aluminum without chlorine injection.

5. Reference

1) Y. Tsumura : Aluminum Alloys, Kinzoku - Tsushin - sha (1976), p.130.

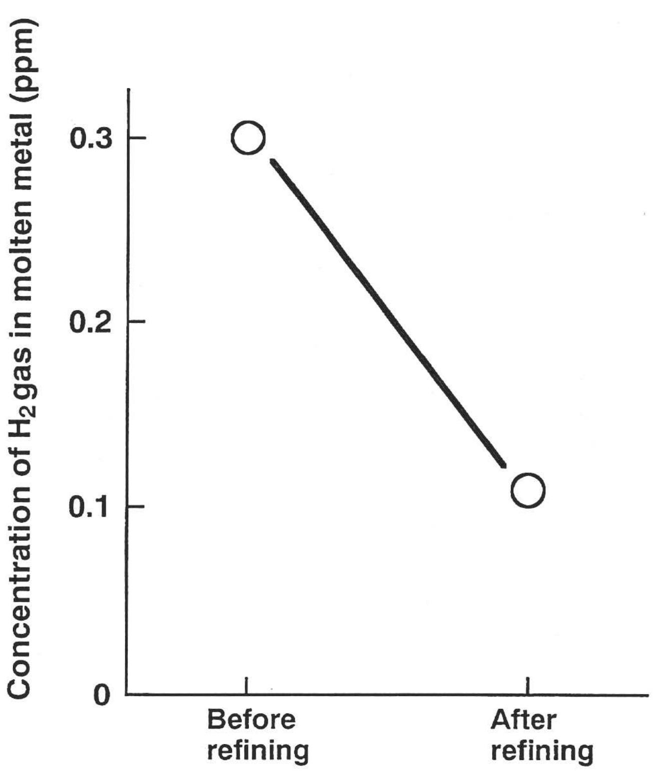

Fig.6 Degassing behavior in molten metal by dried flux.

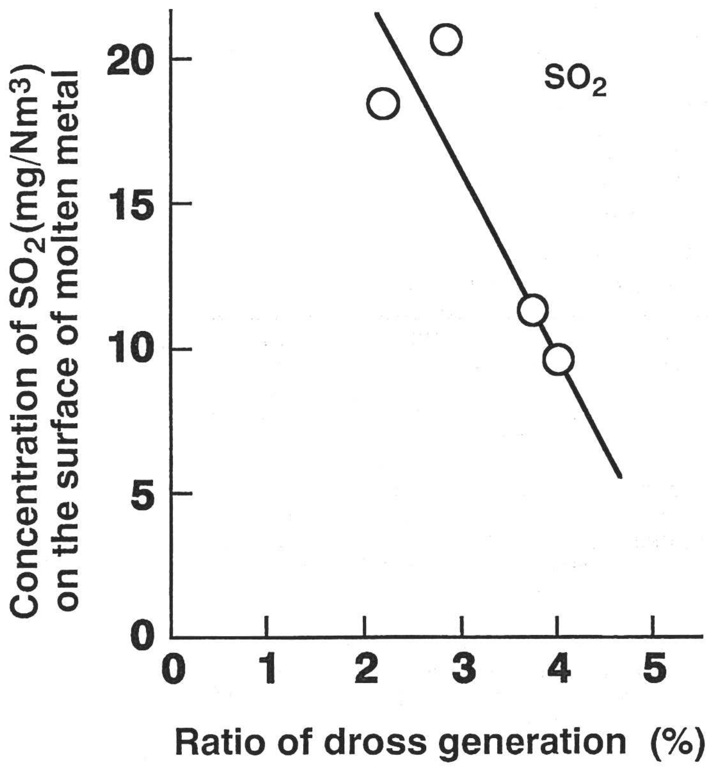

Fig.7 Effect of concentration of SO_2 on the surface of molten metal versus ratio of clross generation.