IMPACT OF PARAMETER CHANGES
ON THE ALUMINUM RECOVERY IN A ROTARY KILN

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Abstract

The remelting process of a coarse metal fraction in a rotary kiln was investigated to research the effects of salt flux quantity, fluoride addition, aluminum oxide content, temperature and rotation speed of kiln on metal yield, salt slag properties and its constitution.

The metal recovery of the aluminum scrap remelting in a short rotary kiln is stromg influenced by metal losses in salt slags due to the lack of coalescence of dispersed droplets.

The effects of fluoride type and concentration, kind of aluminum alloy and temperature on the coalescence of aluminum droplets in salt flux was investigated. In order to explain the observed behaviour of CaF_2, the polythermic section of the ternary system NaCl-KCl-CaF_2 related to salt fluxes was studied.

Flour ion is discussed as an active constituent of salt melts promoting the coalescence and also affecting the interfacial tension between aluminum and flux.

Introduction

Remelting of aluminium scrap in a rotary kiln under a molten flux bath is widely used. For rotary drum furnaces the "salt factor" (ratio of salt flux charge to non-metallic part of scrap) is 0.9-1.8 and for tiltable rotary furnaces is 0.4-0.8(1, 2). As a salt flux NaCl and KCl mixtures with additions of fluorides are used. There are many flux compositions for remelting of aluminum, Peterson(3) in 1990 noticed that there are more than 130 patented and non-patented salt fluxes. In Germany a mixture of 70 w. % NaCl and 30 w. % KCl with additions of CaF_2 is used as a standard flux.

Remelting of aluminum scrap without flux cover leads to increased oxidation of metal and alloying elements and dross building. On the other hand the salt bath process requires additional costs to process salt slags. To optimize the process it is important to quantify the effects of process parameters on the metal yield, metal content in slag etc.

With help of the experimental design impacts of parameters such as the flux/scrap ratio, the type of fluoride addition and its concentration in the standard flux (NaCl:KCl=70/30), the melt temperature, the initial concentration of the aluminum oxide in the flux, and the rotation rate of the rotary kiln on the metal yield was studied by remelting of the metallic fraction from the salt slag processing in a pilote-scale rotary kiln of 50 kg melt capacity. It was found, that major factors affecting the metal yield are the temperature and concentration of fluoride in the salt flux. The increase of the aluminum oxide content in the flux increased the metal losses as dispersed droplets of metal in the slag.

Two fluorides were compared, CaF_2 and cryolite, and it resulted, that the fluoride type has no effect. To investigate the behaviour of CaF_2 in the flux the polythermal section [70 % NaCl-30 % KCl]-CaF_2 was studied.

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Also the coalescence of aluminum alloy droplets in the melts consisting of 70% NaCl and 30% KCl with addition of fluorides CaF_2, cryolite (Na_3AlF_6) and NaF was studied. The tests showed that the rate of coalescence is controlled by the concentration of "active" fluoride ions in the salt melt wich depends only on the concentration of used fluoride addition.

Experimental

The purpose of the experimental work was to determine the main factors impacting on the metal yield from aluminum scrap and to quantify their effects. Controlled parameters were:

- salt flux/scrap ratio, %
- type of used fluoride, CaF_2 or cryolite
- concentration of fluoride in the salt flux, w. %
- initial concentration of the alumina in the salt flux, w. %
- temperature, °C
- rotation rate of the kiln, rpm

A fractional factorial design of experiment 2^{6-2} for the linear model was applied to reduce the number of experiments (Table I).

The experiments were carried out in a rotary kiln with an internal diameter 60 cm and a length of 60 cm. The kiln was heated by natural gas by means of an air-gas burner at a constant power. A kiln driver allowed to regulate the rotation rate from 1 rpm up to 4 rpm. As salt flux the standard flux composition based on 70 w. % NaCl and 30 w. % KCl (standard flux) with fluoride additions was used. The flux was charged in the kiln, melted and heated to the required temperature and then the aluminum scrap was charged. As aluminum scrap the metal fraction recovered from salt slags (Table II) with a mean composition Si 3.74 %, Mg 0.22 %, Cu 1.42 %, Mn 0.41 %, Zn 0.45 % was charged into the kiln. The total amount of 25 kg of the scrap was charged into molten flux by 4 smaller portions 6-6.5 kg each.

The initial alumina content in the flux was regulated by means of addition of salt slag, which was produced by remelting of the same material, but without fluoride addition into salt flux. These salt slags were ground by means of a roller crusher. During the grinding a metal fraction was separated from slag as a oversize fraction of the screen with 4 mm opening. The slag fraction –4 mm was added into flux to regulate the alumina concentration.

After melting the metal and the slag melts were poured out in a pre-heated to 200°C cast-iron mould. After freezing and cooling ingots and slags were separated from each other and weighed with an accuracy of ±0.025 kg. The slags were crushed and ground to size –4 mm. During the grinding the metal fraction +4 mm was screened out. To determine a metal content in the undersize fraction –4 mm, a sample (150-200 g) of undersize was ground further. A metal fraction +0.71 mm from the sample was washed, dried and weighed with an accuracy of 0.01 g. The slag sample –0.71 mm was analysed for metallic aluminum. The total metal content in the slags was calculated as a sum of the metal contents in 3 fractions: +4 mm, +0.71 –4 mm, -0.71 mm.

As the salt flux a recycled salt (70% NaCl-30% KCl) recovered from salt slags with fluoride additions was applied.

Results

As a result of the evaluation of the experimental data (Table III) the equations of regression for the metal yield, and metal Al content in slags were obtained depending on the monitored factors for investigated interval (equations 1-2).

Table I The experimental design matrix

Exp No	T, °C	Flux*, %	rpm	Al_2O_3, %	Fluorid, %	
1	750	25	1	0	CaF_2	0
2	850	25	1	3	CaF_2	0
3	750	25	1	3	Cryolite	5
4	850	25	1	0	Cryolite	5
5	750	75	1	3	Cryolite	0
6	850	75	1	0	Cryolite	0
7	750	75	1	0	CaF_2	5
8	850	75	1	3	CaF_2	5
9	750	25	4	0	Cryolite	0
10	850	25	4	3	Cryolite	0
11	750	25	4	3	CaF_2	5
12	850	25	4	0	CaF_2	5
13	750	75	4	3	CaF_2	0
14	850	75	4	0	CaF_2	0
15	750	75	4	0	Cryolite	5
16	850	75	4	3	Cryolite	5
17	800	50	2.5	1.5	CaF_2	2.5
18	800	50	2.5	1.5	CaF_2	2.5
19	800	50	2.5	1.5	CaF_2	2.5

*Flux/Scrap ratio

Table II Size distribution of Al from salt processing

Size fraction mm	weight %
-0.71	0.42
+0.71 –1.0	0.52
+1.0 –2.0	0.69
+2.0 –4.0	32.50
+4.0 –6.0	30.70
+6.0	23.17

Table III Expeimental data for the remelting in the rotary kiln

Exp. No	Al yield, %	Metallic Al in slag, %*
1	77.0	2.21
2	-	-
3	-	-
4	85.2	0.71
5	79.4	5.31
6	81.5	2.64
7	81.4	3.15
8	83.9	1.12
9	82.2	1.50
10	81.8	1.91
11	80.4	2.76
12	85.6	0.86
13	79.4	5.48
14	82.7	2.32
15	83.4	1.02
16	85.2	0.85
17	82.0	1.41
18	83.6	1.78
19	85.1	1.43

*Metal amount in the slag in % of the charged material

An equation for the metal yield is obtained:

$$Al(yield)=58.07+0.0287\cdot T+0.521\cdot C_F \qquad (1)$$

Where *Al(yield)* is the metal yield in % from the weight of charged material, □ is the temperature in °C and C_F is the concentration of fluoride in flux in %. The confidence interval for tests at the zero level (tests 17-19) was calculated to be 0.64% and for remaining tests about 1.2 % at the confidence level 0.9.

The amount of the metalic aluminum in slag may be expressed by the following equation:

$$Al(slag)=12.45-0.0138\cdot T-0.272\cdot C_F+0.019\cdot m_F+0.302\cdot C_{Al2O3} \qquad (2)$$

Where *Al(slag)* is the metal content in slag in % from the charged material, □ is the temperature in °C, C_F is the concentration of fluoride in the flux in %, m_F is the flux/scrap ratio in % and C_{Al2O3} is the initial content of the alumina in the flux in %. The confidence interval for the tests at the zero level (tests 17-19) was ±0.41%, for remaining tests about ±0.96% at the confidence level 0.9.

From analysis of equations (1) and (2) it follows, that the increase of temperature and fluoride concentration increases the metal yield and, accordingly, decreases the metal losses with slags. Van Linden and Stewart(13) also obtained the positive effect of the temperature and a fluoride concentration on the metal yield. The fluoride concentration up to 5% had a significant effect on the metal yield(3, 14). The alumina content in the flux increased the metal content in slags, as expected. An unexpected influence on the metal content in slags has the flux/scrap ratio – the more flux charge the more metal losses in slags in the investigated interval of factors.

The impact of the fluoride type in the investigated interval of concentrations appeared not to be significant. The rotation rate of the kiln between 1 up to 4 rpm didn't effect on the ingot yield and the metal losses in the slags (a speed of the kiln liner relative to the melt calculated to be 3.1-12.6 cm/s).

In the slag of the test 11 the highest aluminum oxide concentration was reached (19.8 %). After the last charge of the metal portion into the kiln, the slag became so viscous, that couldn't build a salt bath layer over the metal.

To explane the effects of the fluorides, the coalescence behaviour of aluminum droplets in molten salts depending on the fluoride type and its concentration, the temperature and an aluminum alloy was studied. Also the polithermic section (70 w. % NaCl-30 w. % KCl)–CaF_2 of the ternary diagram were investigated.

Coalescence of aluminum droplets

The presence of an oxide film on the aluminum surface prevents the coalescence of droplets. The gravity and hydrodynamic forces can break the oxide film on the metal droplets. But for smaller droplets these forces are not suffucient to break the oxide film. A fluoride salt addition into the salt flux favour the oxide film stripping from the metal surface to the flux melt which promotes the coalescence of the aluminum droplets.

In a molten equimolar mixture of sodium and potassium chlorides the coalescence of aluminum droplets is very slow(4). An addition of fluoride salts accelerates the coalescence. The type of fluoride and aluminum alloy influences on the coalescence rate of droplets in the salt flux(3-10). Different fluorides have a different power to accelerate the coalescences. By the increasing power one can arrange the fluorides in the following order: $MgF_2<CaF_2<$(NaF, KF, LiF, cryolite). Alloying elements in the aluminum can change the coalescence rate, e. g. the coalescence of droplets of pure aluminum in the same conditions is faster, than the coalescence of aluminum alloys containing magnesium(4, 7). The impurities in salts NaCl and KCl can cause the slowing down of the coalescence rate, e. g. a presence of sulphates in the salts results in a decelerating of coalescence due the formation of a sulphide „skin" on the aluminum surface(8).

Experimental

From in the literature described methods of study of coalescence(8) we have used the method of coalescence of large number of droplets in a melt.

The kinetics of coalescence and the influence of fluorides on the coalescence rate were studied on the experimental set-up (Fig. 1) in a fused quartz crucible placed on the bottom of an electrical furnace with a slope of 20° to the horizontal plane. 5 g of the salt flux was charged into the crucible. After reaching the required temperature in the furnace, previously prepared 200 aluminum spheric particles (size +0.8 -1.0 mm) were put into the crucible within 5 sec by means of a quartz tube. After a given coalescence time, the crucible was carefully taken from the furnace, and after cooling the crucible content was leached by water. The aluminum droplets were dried and weighed to calculate their size and the total surface area of droplets after the coalescence.

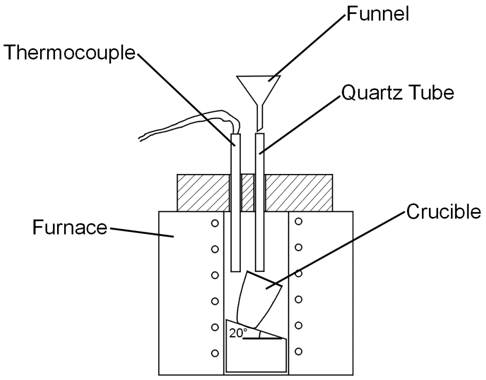

Figure 1: Experimental set-up for coalescence tests

The temperature in the furnace was measured by means of a Ni-NiCr thermocouple, which was calibrated at the melting points of aluminum and zinc. A measurement error of temperature was less than 3°C. To obtain a minimal difference between the temperatures in the furnace camera and the crucible, it was hold 10 mines after stabilizing of the temperature in the furnace.

Aluminum particles of the spheric shape were prepared by melting of aluminum chips in a melt 70 % NaCl-30 % KCl without a fluoride addition. After aluminum chips were melted and obtained the spheric shape, crucible was taken out from the furnace, cooled down and its content was leached with water. Then the aluminum globules were dried and screened to obtain a fraction +0.8 –1.0 mm. Such a preparation was required, because aluminum chips splited into several smaller droplets when melted.

According to the theory of coalescence of Tuorila(11) the coalescence kinetics in the bidisperse system (in a system with droplets only of two sizes) can be described by an exponential equation:

$$n=n_0exp(-\square t) \qquad (3)$$

Where n is the number of droplets, n_o is the initial number of droplets, □ is a coefficient (min^{-1}), and t is the coalescence time.
For polydisperse systems the theory of coalescence is not developed due to the complexity of the mathematical expression of process of coalescence.

Assuming the constant total weight of droplets and a complete coalescence as a boundary condition, the following equation can be derivated from the equation (3):

$$S=S_{min}+(S_0-S_{min})exp(-kt) \qquad (4)$$

Where S is the total surface area of droplets at time t (mm^2), S_{min} $=101$ mm^2 is the minimal possible surface area of droplets in case of complete coalescence, $S_0=603$ mm^2 is the initial surface area of 200 droplets, and k is a coalescence rate coefficient.

Results

Coalescence of pure aluminum The preliminary tests have shown, that for tested pure aluminum (0.14 % Si, 0.0067 % Cu, 0.0006 % Mg), the remelting to spheric globules does not influence on the coalescence rate in further tests.

The first set of tests were carried out to study the influence of CaF_2 concentration on the coalescence rate in the salt flux 70 % NaCl-30 % KCl 70 % (standard flux). At 830°C, 200 prepared spherical globules (size +0.8 –1.0 mm) were put into a fused quartz crucible. The extent of the coalescence was evaluated by the total surface area of droplets after the coalescence.

The results of coalescence tests on different CaF_2 concentrations in the standard flux and the calculated coalescence rate coefficients are shown in Fig. 2.

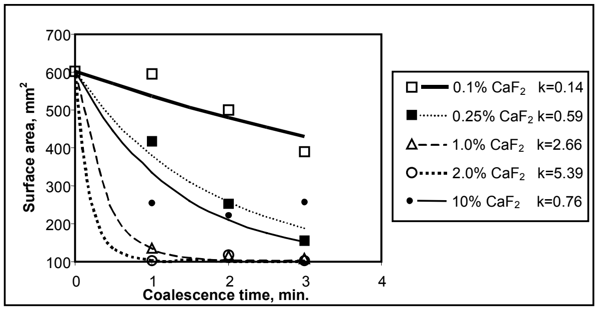

Figure 2: Coalescence of aluminum droplets in salt flux at 830°C

Coalescence rate coefficient increases when CaF_2 concentration is increased and has a maximum at 2-3% of CaF_2 (Fig. 3), and the futher increase of CaF_2 concentration decreases the coalescence rate. In the test with 5% of CaF_2 the salt melt was cloudy, and at the bottom of the crucible there was an indissolved material. At 10% of CaF_2 there was so much undissolved material, that aluminum droplets couldn't reach the bottom of the crucible.

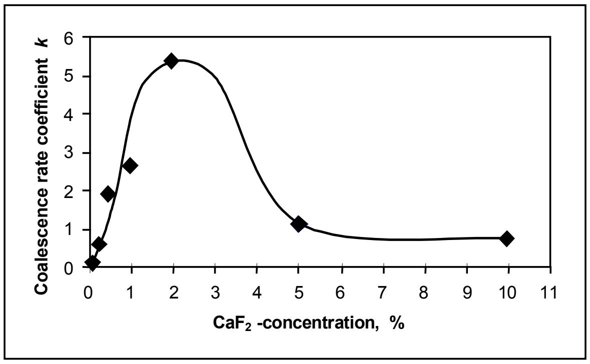

Figure 3: Coalescence rates with CaF_2 at 830°C

At the same concentrations of the fluoride addition, the coalescence rate of aluminum droplets is higher with cryolite and NaF than with CaF_2 (Fig. 4).
The lowering of the temperature decreases the coalescence rate of aluminum droplets (Fig. 5) for CaF_2 additon.

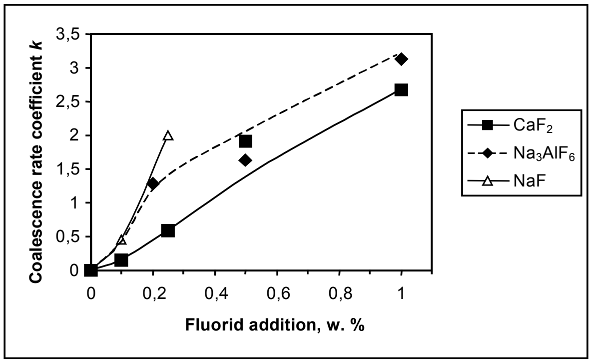

Figure 4: Coalescence rates with different fluorides at 830°C

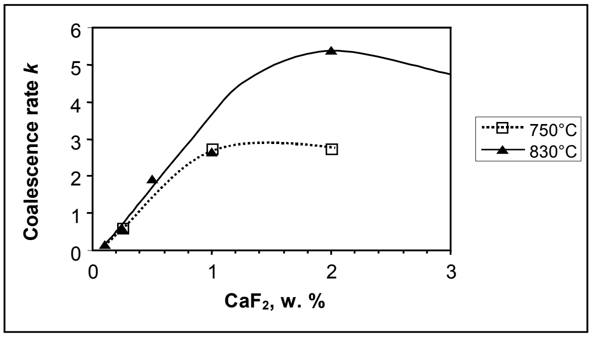

Figure 5: Effect of temperatures on coalescence rate

Coalescence of UBC alloy The coalescence of UBC alloy was studied at 830°C on fluoride concentration in the salt flux composition based on NaCl-KCl with ratio 70/30. The coalescence of UBC alloy was studied on plates, because the spherical globules prepared by remelting had a higher coalescence rate as plates. For the coalescence tests the body of a beverage container was cut into small plates. The body of UBC is made from alloy AA3004 (0.8-1.3% Mg, 1.0-1.5% Mn and 0.30% Si)$^{(12)}$.

The UBC plates had the same weight as spherical droplets used for the coalescence tests with pure aluminum. The UBC alloy used in the coalescence tests had the following composition: 1.11% Mg, 0.85% Mn and 0.23% Si.

The UBC plates didn't coalesce during 5 min at 830°C and CaF_2 concentration up to 1% (Fig. 6). At 2% of CaF_2 the coalescence is almost complete in 10 min. At 5% of CaF_2 in the salt melt an undissolved material was noticed, it could hinder the coalescence.

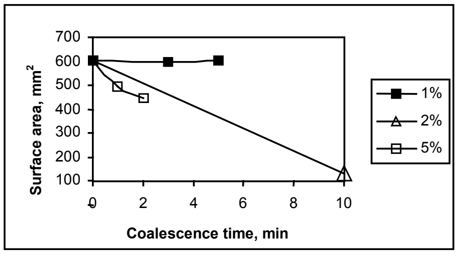

Figure 6: Coalescence of UBC alloy at 830°C with CaF_2 addition

The coalescence of UBC alloy was complete in less than 1 min at 5% of cryolite and 2% of NaF (Fig. 7 and 8).

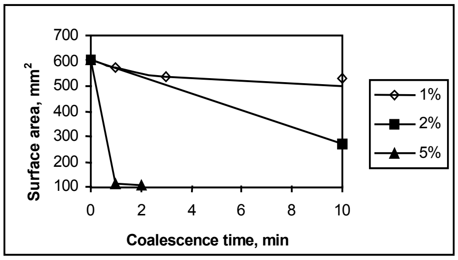

Figure 7: Coalescence of UBC alloy at 830°C with Na_3AlF_6 addition

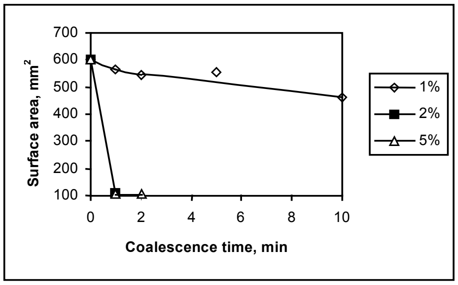

Figure 8: Coalescence of UBC alloy at 830°C with NaF addition

Cast alloy The coalescence of droplets from aluminum cast alloy was faster than the coalescence of UBC alloy and pure aluminum (Fig. 9). The coalescence was complete in 2 min in salt flux with 0.25% of CaF_2.

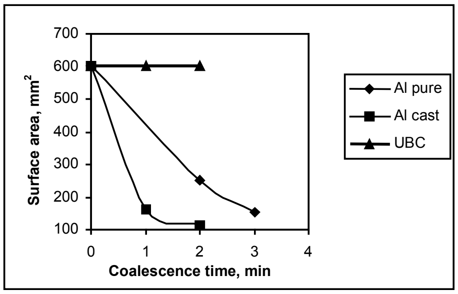

Figure 9: Coalescence of cast Al-alloy at 0.25 % CaF_2 and 830°C

Polythermal section

To investigate the influence of fluorides on the coalescence of aluminum droplets the polythermal section CaF_2-[70% NaCl-30% KCl] of the ternary diagrams wase studied. The solubility of CaF_2 in NaCl-KCl$^{(15)}$ wasn't in agreement with our observations. At 800°C and about 4%, CaF_2 was found in flux in a solid phase$^{(2)}$. Using data from the literature$^{(15)}$ and topology rules of multicomponent systems$^{(16)}$ and our experimentally determined temperatures of phase transformations, the polythermal section CaF_2-[70% NaCl-30% KCl] could be drawn (Fig. 10). Cooling curves of samples with 3 and 5 w. % of CaF_2 were used to prove the statement (DTA Netzsch STA 409, Germany).

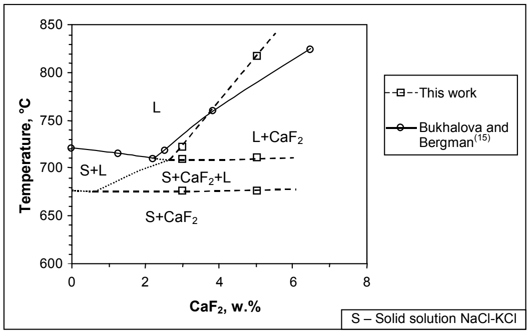

Figure 10: Polythermal section CaF_2-(70 w. % NaCl-30 w.% KCl)

Obtained results for the solubility of CaF_2 at the temperatures above ~760°C are less than according to Bukhalova and Bergman$^{(15)}$.

Discussions

The effect of fluorides in the slat flux can be explaned through the actions of anions and cations, which concentrations depend on their degree of dissociation in the salt flux melt. Only fluoride salts can promote the coalescence$^{(3-10)}$. We supposed, that the oxide layer stripping rate and consequently the coalescense rate of aluminum droplets depends basically on the "active" fluor ion concentration in the salt melt. For it the concentrations of "active" fluor ions in flux depending on fluoride salt and its concentration was calculated.

To find out the fluoride dissociation reactions the polythermic sections [70% NaCl-30% KCl]-fluoride salt of the ternary diagrams were used(15, 17, 18). The freezing point lowering □*T* of solvent (NaCl-KCl) by fluoride salt (Fig. 11) obeys the following equation 5(19):

$$\square T=mnK \qquad (5)$$

Where *K* is the cryoscopic constant of the solvent, *m* is the molality of solute, i .e. mols of fluoride salt dissolved in 1000 g of NaCl-KCl mixture, *n* is a freezing point depression factor or the number of independent particles which differ from those already present in the solvent and which are introduced upon the dissolution of one molecule of solute.

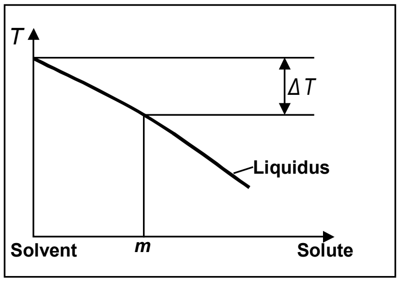

Figure 11: Freezing point lowering

The cryoscopic constant of the solvent is calculated:

$$K=R\cdot T^2\cdot M_A/(\square\cdot 1000) \qquad (6)$$

Where *T* is the melting point of a the solvent in □, *R* is the universal gas constant in J/(mol·□), $\square_\square$ is the molar mass of solvent in g/mol, □ is the molar heat of fusion of solvent in J/mol.

Assuming the NaCl-KCl mixture as a single solvent and polythermal sections of the ternary diagrams, cryoscopic constants of solutions $K_s=\square T/m$ of fluorides in NaCl-KCl were calculated (Fig. 12 and 13).

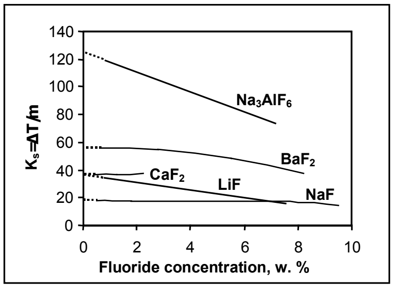

Figure 12: Cryoscopy of fluoride salts in the salt melt of 70% NaCl-30% KCl

Probably, the dissociation degree of cryolite could drop significantly with concentration growth.

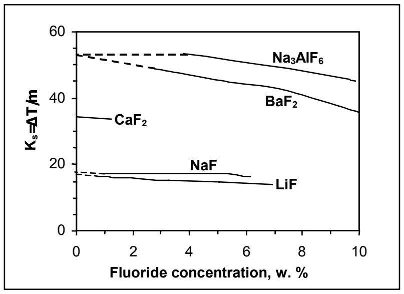

Figure 13: Cryoscopy of fluoride salts in the equimolar NaCl-KCl composition

Extrapolating the lines of cryoscopic constants of solutions to *m*=0 and dividing by the the cryoscopic constants (it is 18.6 for the 70% NaCl-30% KCl and 17.6 for the equimolar composition) the freezing point depression factors are obtained (Table IV).

Table IV Freezing point depression factors of fluorides in NaCl-KCl melts

Fluoride	n		Reaction of dissociation
NaCl:KCl	70:30	eqm.	
CaF_2	2	2	$CaF_2=CaF^++F^-$
NaF	1	1	$NaF=Na^++F^-$
Na_3AlF_6	7		$Na_3AlF_6=3Na^++Al^{3+}+6F^-$
Na_3AlF_6		3	$Na_3AlF_6=3Na^++AlF_4^-+2F^-$
BaF_2	3	3	$BaF_2=Ba^{2+}+2F^-$
LiF	2		$LiF=Li^++F^-$
LiF		1	$2LiF=Li_2F^++F^-$ (?)

The melting point depression factors of cryolite and LiF in equimolar NaCl-KCl composition are obtained different from those in 70% NaCl-30% KCl composition. The dissociation of cryolite and LiF in molten NaCl-KCl compositions seems to be more complex than presented in the Table IV. The depression factors of NaF in case of complete dissociation and without dissociation are the same, which doesn't allow to calculate the degree of dissociation. Fluorides such as KF, LiF and in NaCl dissociate completely in the molten NaCl(20) and it was assumed for further calculations that NaF in NaCl-KCl melts could dissociate completely. In Fig. 14 the resulting "active" fluor ion concentrations depending on the fluoride and its concentration in flux (NaCl:KCl=70:30) are shown.

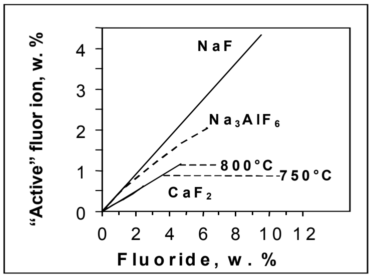

Figure 14: Calculated concentration of "active" fluor-ion in flux

If the experimentally determined coalescence rate values for different fluorides (Fig. 4) are plotted on the "active" fluoride ion concentrations, they lie very close to each other (Fig. 15). The coalescence rate is supposed to depend basicly on the "active" fluoride ion concentration and practically not to depend on the type of cation of the fluoride salt.

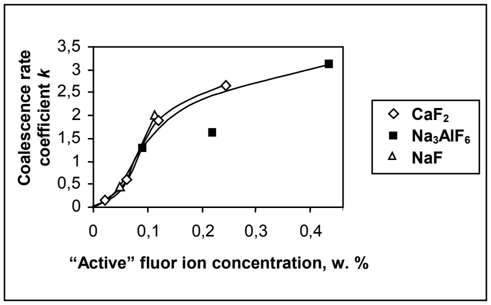

Figure 15: Coalescence rate on "active" fluor-ion

According to the polythermal section (Fig. 10) the solubility of CaF_2 in 70% NaCl-30% KCl is about 5 w. % at 830°C. Assuming that undissolved CaF_2 doesn't affect on the coalescence rate, CaF_2 can provide not more than about 1.2 % of "active" fluor ions in the melt 70% NaCl-30% KCl at 830°C. NaF and cryolite can provide into flux about 2 times more "active" fluor ions (Table V). Unfortunately, there is no data for degrees of dissociation of fluorides in NaCl-KCl melts.

Table V Equivalent amounts of fluoride salts for flux

Fluoride	Concentration equivalent to 1% of CaF_2
NaF	0.54
Na_3AlF_6	0.45*
LiF	0.33
BaF_2	1.12
KF	0.74

*at low concnentrations (up to ~0.5%)

It was supposed that interfacial tension between molten salts and aluminum is conditioned by fluor ions(21). The interfacial tensions between aluminum and equimolar NaCl-KCl composition(22) can be plotted on "active" flour ion concentration (Fig. 16).

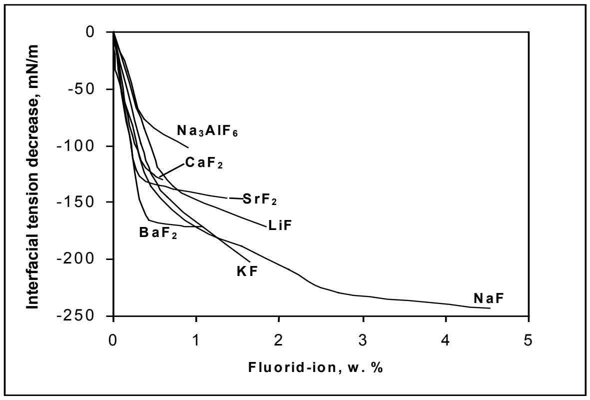

Figure 16: Interfacial tension between molten aluminum and molten equimolar NaCl-KCl composition depending on fluor ion concentration

Discrepancies between interfacial tensions values especially at the higher fluor ion concentrations could be due to experimental error and uncertainty of the assumption of full dissociations.

A specific adsorption of the fluor ions on the aluminum surface probably could take place, which would decreas the interfacial tension between aluminum and flux.

The interfacial tension between aluminum and equimolar NaCl-KCl flux depending on CaF_2 concentration was investigated at various temperatures by various authors(14, 22, 23, 26) (Fig. 17). At 800-825°C the CaF_2 solubility in the equimolar NaCl-KCl is about 2.5-3%, and at 720-750°C is 1.5-2%(15). The interfacial tension aluminum/flux decreases up to the CaF_2 solubility limits. Further CaF_2 addition into the flux doesn't decrease the interfacial tension significantly, though lower interfacial tensions can be obtained by NaF addition(14, 21-26), when a higher fluor ion concentration in a melt can be achieved. CaF_2 addition above the solubility should increase the viscosity of fluxes and, concequently, reduce the metal yield, what was observed by Van Linden and Stewart(13).

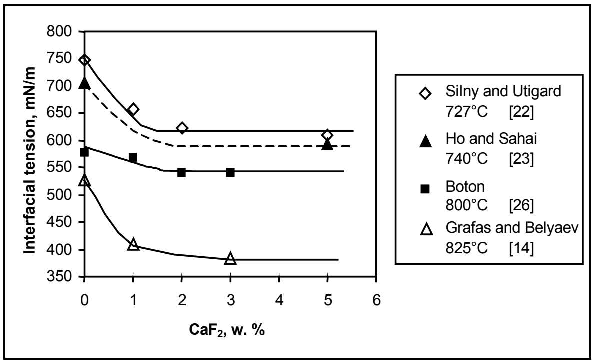

Figure 17: Interfacial tension between aluminum and salt flux Approximate lines were drawn based on the CaF_2 solubility in equimolar NaCl-KCl(15)

Conclusions

Equations for metal yield and metal content in slags were experimentally obtained for remelting of cast aluminum alloy.

The increase of the temperature (from 750 to 850°C) and fluoride concentration in flux (from 0 to 5%) increased the metal yield and reduce the metal content in salt slags.

The growth of alumina concentration in flux (from 0 to 3%) and flux/scrap ratio (from 25 to 75%) increased the metallic aluminum cintent in slags.

The effects of the rotation rate of the furnace (from 1 to 4 rpm) on the metal yield and metallic aluminum content in slags was insignificant.

Fluoride type (CaF_2 or cryolite) had insignificant effect on the metal yield and the metallic aluminum content in slags due to the high coalescence rate of metal droplets (cast aluminum alloy) at investigated fluoride concentration levels. E. g. in the coalescence tests on the cast aluminum alloy at 0,25% of CaF_2 and 830°C the complete coalescence succeeded in 2 min, which is negligible in comparison with the remelting process duration.

Fluor ion was discussed to be an active constituent of fluoride salts promoting the aluminum oxide layer stripping and consequently the coalescence of aluminum droplets in flux, also in lowering the interfacial tension between molten aluminum and salt flux.

In the laboratory experiments, the coalescence rate depends on aluminum alloy type, temperature and on the "active" fluor ion concentration. Higher temperatures and fluor-ion concentrations result higher coalescence rates.

Fluoride type and its concentration in flux should be chosen taking into concideration the remelted aluminum alloy type. CaF_2 concentration in the standard German flux (NaCl-KCl=70:30) above 3 % seems not to be reasonable. For UBC alloy higher "active" fluor ion concentrations are required.

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