KCl-reduced salt application in aluminium recycling

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Abstract

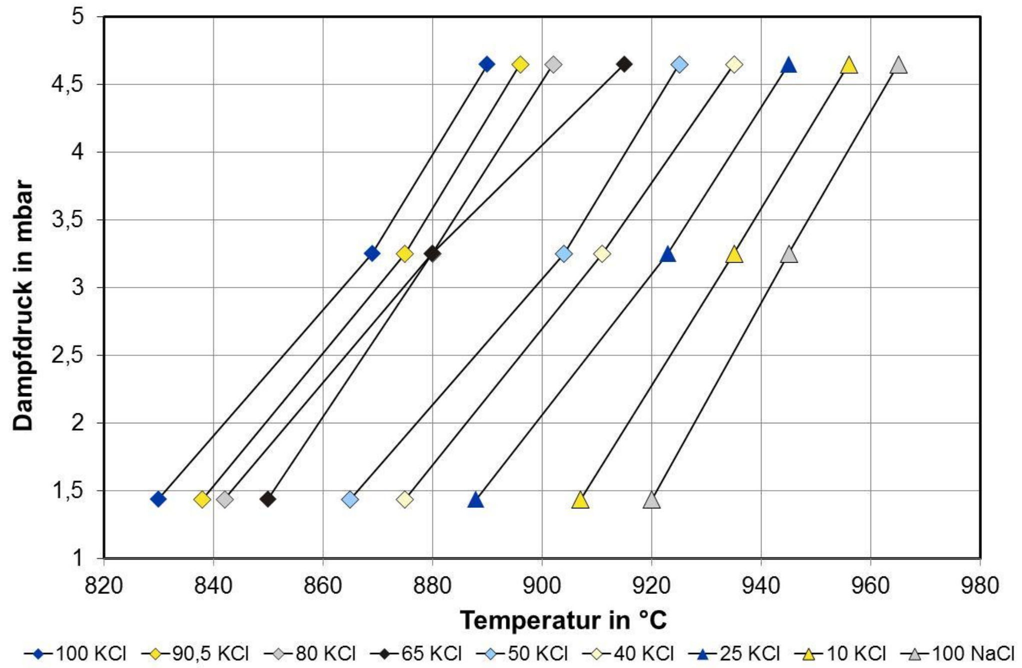
Common way to recycle strongly contaminated aluminium scraps is the treatment in salt melts. Because of the steadily increasing KCl prices by growth in demand for fertilizers, the state of the art becomes an uneconomic process and from this reason further development is necessary. Beside the economic point of view, the effect of KCl on the aluminium salt treatment has still not been properly established. During the melting KCl losses by evaporation are noticed. Under same conditions the evaporation of KCl can be 2.5 times larger than of NaCl. [1] Content of this study is the investigation of KCl-reduced salt systems for aluminium recycling. Appropriate salt mixtures and process conditions are chosen based on thermochemical calculation via FactSage®. Experiments due to evaluate the evaporation rate were carried out. The influence on coalescence varying both the KCl-content and the content of additives such as CaF2 and Cryolite was investigated in continuation of IME´s lab-scale test published in 2009 in World of Metallurgy. Furthermore a lab scale-rotary drum furnace was built up due to evaluate the various salt mixtures also in stirred melts.

Introduction

Following functions of salt fluxes are well known.

- Removal of oxides and other surface contaminants from aluminium.
- Promotion of coagulation and coalescence of aluminum droplets to form the molten bath.
- Protection of aluminum from further oxidation.

The knowledge about the properties of fluxing salts and their impact on e.g. coalescence of aluminium droplets is incomplete. Properties like density, viscosity, interfacial tensions for the common were investigated. Content of this study are the initial investigations of not common flux salt systems. First step is to clarify the impact of evaporation phenomena and examine the proposition that the useable amount of KCl decrease during process.



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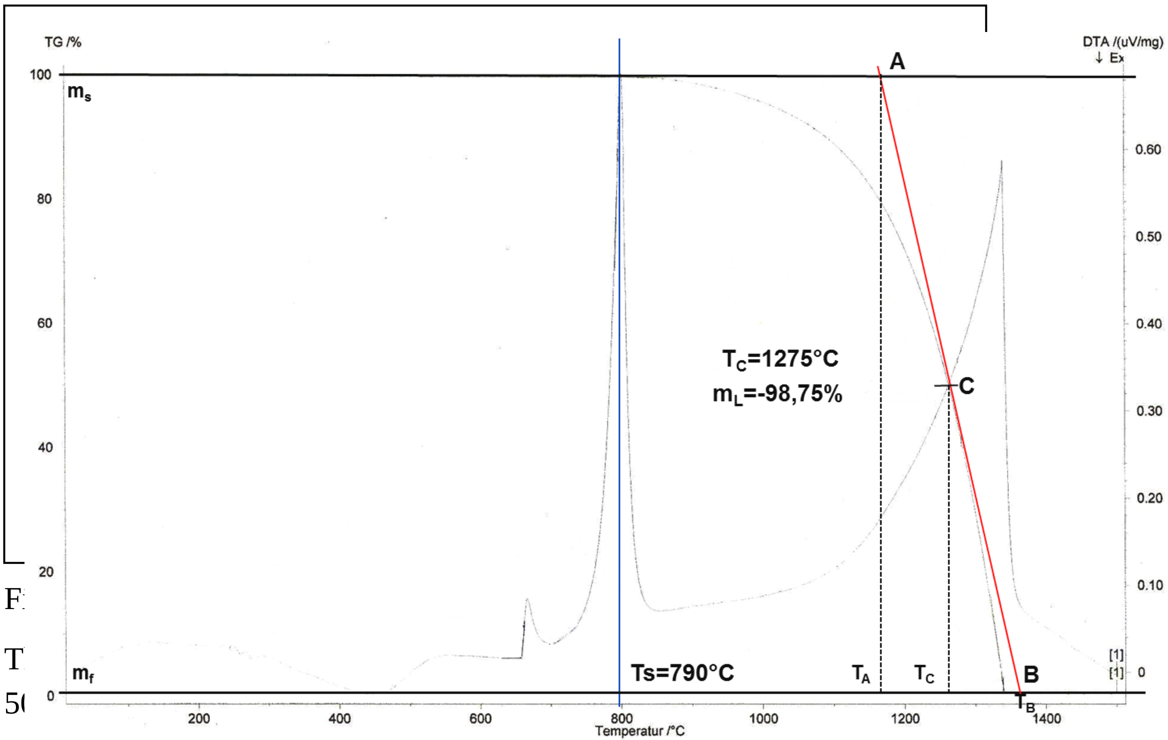
T reasing the con- ce pour. The evaporation of this salt system induces an increase of the NaCl concentration in the melt. Salt systems with reduced KCl-content have a boiling point at higher temperature ranges. Preferential evaporation of KCl was observed also in practice. The concentration of KCl in filter dust is higher than in the inserted material. [2][3]

Experimental Set up

After FactSage® calculation DTA/TGA measurements were carried out, seen in Figure 2 exemplary. The measured flux salt system consists of 95 mol % -NaCl and 5 mol % KCl. By TGA Analyses the weight changes were detected. The points A, B, C are achieved by using the tangent construction. With point A the initial temperature and with B the end temperature of evaporation can be determined. At Point C the temperature (T_c) is given at which half of the material is evaporated. The results of the measurements are given in Table 1. The results reflect the values shown in literature. [4] The weight losses by decreasing KCl decrease also.

Table 1: characteristic Point of DTA/TGA curves

Salt system NaCl: KCl	Melting point T_S in °C	Total weight change M_L in %	Weight loss at 1000°C in %	Char. Temperature		
				A	C	B
50:50	650	98,74	10	1100	1230	1360
70:30	710	97,58	6,5	1110	1230	1360
80:20	745	98,37	5,3	1150	1250	1360
85:15	770	98,48	5,2	1160	1260	1360
95:5	790	98,75	5	1160	1260	1360



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T om 5% to 5 n electric resistance heated furnace (Figure 3). The salt was melted in an aluminium oxide crucible, which was free hanging on a scale. Temperature and weight changes were detected continuously. Salt systems were tested in the first series without aluminium and in the following experiments with charged aluminium cubes in order to determine the evaporation rate of the salt components and to clarify the influence of aluminium presents.

F tion test: 1: furnace, 2: controller, 3: scale, 4: d be (left)

As Figure 4 shows a strong impact of decreased KCl concentration in inserted flux salt was observed in the first series. When the KCl content decreases, the evaporation rate and the lost amount of KCl decrease also.

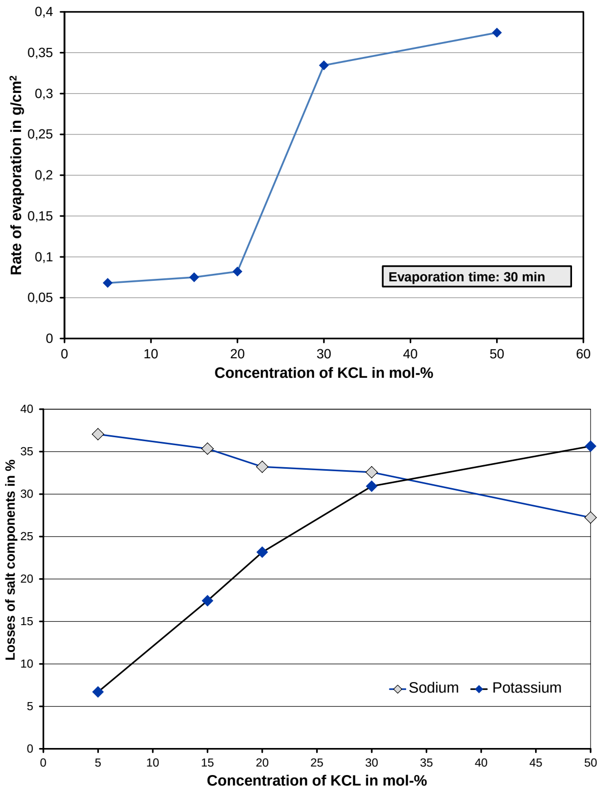

Figure 4: Evaporation rate depending on KCl concentration; dwell time 30 min. (left) Evaporation of single components regards to initial concentration varying KCl-content from 5% to 50% (right)

The evaporation rate is confirmed in the second series. Behaviour changes when aluminium is added. The ICP-AES, XRF and XRD analyses will be carried out on the leaching residues in order to understand the effect of KCl-reduced salt systems.

The results of the analysis are transferred to a series of experiments with a) pyrolysed UBC-scrap and b) non-pyrolysed UBC-scrap. The aim is to determine the components of the salt slag as well as to determine possible influences on the melt yield.

A melting yield over 98% can be reached for series a). Nevertheless there are differences considering the appearance of aluminium that are dependent on the mixture of the salt. The melt yield value cannot be reached for series b). The contamination of the material in series b) forms several additional multi-component phases that hinder the aluminium to settle. Further investigation of the results in case a) and b) is necessary and is undertaken at IME Aachen at the moment. The results of series a) recommend a salt mixture with about 20 mol-% KCl. In this experimental Set up a total substitution of KCl is not useful because viscosity as well as density rise dramatically.

The trials to examine the coalescence efficiency of aluminium chips in KCl-reduced flux salts were carried out aluminium oxide crucibles. The salt was heated up within the salt first and aluminium chips were charged after reaching the melting point. To achieve a clear view inside, the crucible was covered with a quartz glass plate. (Figure 5)

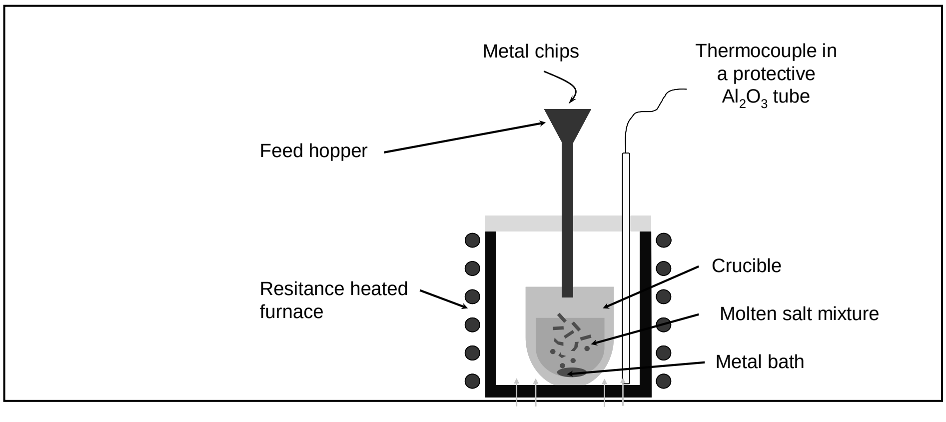

Figure 5: Experimental set up f[illegible]nce test

Because the set-up is static the initial salt bath has to be high enough to entrap the charging chips. In the next charging step that trapping impact the coalescence negatively. Furthermore a salt/aluminium ratio about 3 leads to a high amount of unused salt residue in the salt slag with aluminium droplets. (Figure 6)

Figure 6: ag with entrapped aluminium droplets (right)

As both experiment set up are static and the impact of stirring cannot be clarified, a lab scale tiltable rotary furnace was recently built up at IME. (Figure 7) This new equipment allows the investigation of flux systems with a lager surface but lower salt/aluminium ratio. Also the oxidation of aluminium on the salt melt surface can be minimized through submerged stirring.

Figure 7: M ale 1l usable volume)

Summ

Initial tests have proven that the proposition that KCl becomes concentrated in the gas phase. The evaporation rate as property allows a new point of view to evaluate flux salt systems. First results recommend a salt mixture with about 20 mol- % KCl. Furthermore this study is occupied with the influence on coalescence varying both the KCl-content and the content of additives such as CaF2 and Cryolite. ICP-AES, XRF and XRD analyses were carried out on the leaching residues in order to understand the effect of KCl-reduced salt systems. To achieve appropriate conditions a lab scale-rotary drum furnace were build up and experiments will be carried out. All results and assessments will be published in detail after the conference as peer reviewed article.

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