# **Acidic Leaching of EAF Steelmaking Dust**

Tomas Havlik, Frantisek Kukurugya, Dusan Orac, Ludovit Parilak

This work deals with the possibility of acid leaching of electric arc furnace (EAF) dust in dilute sulphuric acid in steelmaking company Železiarne Podbrezová a.s. The effect of temperature, acid concentration and leaching time on zinc, iron and calcium extraction in the solution was investigated. The leaching experiments were carried out at the temperatures of 20, 40, 60, 80 and 95 °C in an aqueous solution of sulphuric acid at concentrations of 0.05, 0.1, 0.25, 0.5 and 1 M. The liquid to solid ratio (L:S) was equal to 50. The maximum zinc extraction of 95 % was achieved in 1 M H<sub>2</sub>SO<sub>4</sub> at 80 °C after 60 minutes of leaching, while the iron extraction

under the same conditions was 66 %. As the objective of the experiments was to determine the conditions under which the maximum amount of zinc passes into the solution with the minimum amount of iron passing into the solution, the following conditions are considered optimal at the given L:S ratio: 0.1 M  $H_2SO_4$ , 60 °C. The zinc extraction under these conditions was 65 %, while the amount of iron which passes into the solution under the given conditions was ~ 5 %.

## Keywords:

EAF dust - Leaching - Sulphuric acid - Zinc - Iron

# Saure Laugung von Stahlhütten-Flugstäuben aus elektrischen Lichtbogenöfen

Die vorliegende Arbeit befasst sich mit den Möglichkeiten der sauren Laugung von Stahlhütten-Flugstäuben aus elektrischen Lichtbogenöfen der Ges. Stahlwerk Podbrezová in verdünnter Schwefelsäure. Untersucht wurde der Einfluss von Temperatur, Säurekonzentration und Laugungszeit auf die Ausbeute von Zink, Eisen und Kalzium in der Lösung. Die Laugungsexperimente wurden bei Temperaturen von 20, 40, 60, 80 und 95 °C in wässrigen Schwefelsäurelösungen mit Konzentrationen von 0,05, 0,1, 0,25 und 1 M durchgeführt. Das Verhältnis der wässrigen zu den festen Phasen (L:S) betrug 50, jedes einzelne Laugungsexperiment dauerte 90 min. Die maximale Ausbeute von 95 % Zink wurde in 1 M Schwefelsäure bei 80 °C nach 60 Minuten erreicht, die Ausbeute von Eisen betrug bei diesen Bedingungen 66 %. Ziel der Experimente war die Bestimmung der Bedingungen, bei denen der höchste Gehalt von Zink bei minimalem Übergang von Eisen in die Lösung erreicht wird. Als optimale Laugungsbedingungen bei gegebenem Verhältnis L:S ergaben sich eine Konzentration von 0.1 M Schwefelsäure und eine Temperatur von 60 °C. Bei diesen Bedingungen wurde eine 65% ige Ausbeute von Zink erreicht, wobei die in die Lösung übergegangene Menge an Eisen ca. 5 % betrug.

#### Schlüsselwörter:

Elektrischer Lichtbogenofen – Flugstaub – Laugung – Schwefelsäure – Zink – Eisen

# Lixiviation acide des poussières fines provenant des fours à arc électrique des aciéries

Lixiviación ácida de polvo generado en las acerías por hornos eléctricos de arco voltaico (EAF)

# 1 Introduction

In 2008, more than 1.33 billion tons of steel were produced worldwide. The main producers were: China (37.6 %), EU-27 (14.9 %), Japan (8.9 %), USA (6.9 %) and Russia (5.2 %). In Slovakia, almost 4.5 million tons of steel were produced in the same year; 7.8 % of this amount was produced in electric arc furnaces (EAF) [1].

During the steel production in EAF, around 15 to 20 kg of dust per 1 ton of produced steel is generated as a by-product [2].

Due to the high content of heavy non-ferrous metals, mainly Zn, Pb, Cd, Cr and others, these dusts are classified as hazardous waste according to US EPA (United States Environmental Protection Agency) [3]. On the other hand, due to the high content of iron and zinc, this material can be considered as a suitable secondary raw material for obtaining these metals. Metal contents in EAF dust from various sources are shown in Table 1.

The data in Table 1 show that it is a heterogeneous material, and content of each metal changes depending on the source. According to Table 1, the iron content in EAF dust was 24 to 49 wt.-% and zinc content 8 to 30 wt.-%. The zinc content in the primary raw material is between 5 and 15 %, which is significantly lower than in EAF dust.

Differences in chemical composition of EAF dust depend mainly on differences in chemical composition of steel scrap fed into EAF, and also on the type of steel to be pro-

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Metals content [%]										
Zn	Fe	Ca	Pb	Cr	Mn	Si	Cd	Ni	Cu	Source
33	26.5	0.9	2.17	0.2	2.3	-	_	0.1	0.2	[4]
28.47	36.46	1.73	4.05	0	1.95	1.12	0.07	0.04	0.35	[5]
29.1	24	3.16	3.64	0.14	4.11	0.34	0.11	-	0.25	[6]
8.08	45.24	-	2.12			-	0.04	-	-	[7]
17.99	45	3.85	0.201	0.46	1.94	0.42	< 0.01	0.03	0.14	[8]
8	45	3.7	2.1	-			0.04	_		[9]
18.96	32.09	3.42	2.05	0.12	1.68	2.5	0.05	0.07	0.3	[10]
20.32	-	-	5.585	0.1324	-	-	0.0398	0.0184	-	[2]

duced. The source of zinc in EAF dust is galvanized steel scrap, the source of Pb is upper paint on steel scrap; metals such as Cr, Ni, Mn, Ti pass into EAF dust through remelting alloyed steel, and source of Ca, Mg, K are slag formers [5].

In terms of processing EAF dust in order to obtain Zn and Fe, it is very important to know, in addition to the content of individual metals, also their mineralogical form occurring in dusts. Zinc is present in EAF dust mostly as zincite, ZnO, and franklinite,  $ZnFe_2O_4$ , or franklinite with isomorphously substituted metals  $(Zn_x, Me_y)$  Fe<sub>2</sub>O<sub>4</sub>, where Me = Mn, Co, Ni, Cr, Ca, etc. Iron is present in the form of magnetite, Fe<sub>3</sub>O<sub>4</sub> and/or franklinite [4].

The methods of processing EAF dust can be divided into pyrometallurgical, hydrometallurgical and their combination. The basis of pyrometallurgical processing is the reduction of EAF dust, which results in lower iron oxides or sponge iron. At the same time, oxides of zinc, lead and other easily reducible oxides of non-ferrous metals are reduced. Metals with high vapor tension, such as zinc, lead and cadmium, pass into the flue gas, which is re-oxidized and collected on filters. This secondary dust is used for the production of metallic zinc and lead or their compounds, mainly ZnO, by hydrometallurgical, or less frequently, pyrometallurgical method. The disadvantages of these methods are high electricity consumption and also the creation of raw ZnO with low commercial value [11].

The form of the zinc presence in EAF dust is an essential indicator of the efficient EAF dust processing. ZnO is a compound which is easy to be processed both pyro- and hydrometallurgically, while ferrite is highly resistant to any kind of processing. Moreover, it is practically impossible to predict the form of zinc presence [4].

The best known practical pyrometallurgical method for processing zinc containing materials is the Waelz rotary kiln process. Other pyrometallurgical processes include: the Lurgi process, the Kawasaki process, the IRRR process, the Ausmelt process, the Radust process, the Rapid process, the Primus process, the Rotary hearth process and the Recumet process.

Table 1:

Chemical composition of EAF dust from various sources

Nowadays, hydrometallurgical processes are getting more and more prominence, mainly because of their higher flexibility, lower investment and operating costs, and last but not least, fewer problems associated with dust nuisance and noise [11].

In general, hydrometallurgical methods for processing EAF dust can be divided into acid and alkaline performed at normal or elevated pressure. Table 2 presents some of the works dealing with acid leaching of EAF dust. It results from the table that sulphuric acid is the most widely used leaching agent in the case of acid leaching, which is due to its low price and relatively well-known zinc electrolysis from sulphate solutions.

When studying alkaline leaching of EAF dust, NaOH is the most commonly used leaching agent.

The best known hydrometallurgical processes used in practice include the following processes: Ezinex, Zincex, Terra Gaia, UBC – Chaparral, Versatic, Cardiff, Cebedau and the Hatch process [11].

The aim of this work is to study the kinetics of EAF dust leaching, and find the optimum leaching conditions ( $H_2SO_4$  concentration, temperature) for EAF dust from Železiarne Podbrezová, a.s., Slovakia for the purpose of the maximum zinc extraction and the minimum amount of iron passing

Source	Used leaching agent	Optimal conditions of leaching*	Achieved yield	Table 2:
[2]	2-3 N H <sub>2</sub> SO <sub>4</sub>	$3 \text{ N H}_2\text{SO}_4, 60 \text{ °C}, \text{L:S} = 10, \text{ at atmospheric}$ pressure	80 % Zn, 45 % Fe	Experimental studies focused on acid leaching of EAF dust
[7]	H <sub>2</sub> SO <sub>4</sub>	0.1-0.3 M $H_2SO_4$ , 80 °C, L:S = 10, 6 h, at atmospheric pressure	30 % Zn, Zn/Fe ratio = 9	
[10]	0.2-2 M H <sub>2</sub> SO <sub>4</sub>	$0.4 \text{ M H}_2\text{SO}_4$ , 60-80 °C, L:S = 10, 60 min., at atmospheric pressure	60 % Zn, 3-6 % Fe	
[4]	0.1-1 M H <sub>2</sub> SO <sub>4</sub>	$0.5 \text{ M H}_2\text{SO}_4$ , 70-90 °C, L:S = 12.5, 60 min., at atmospheric pressure	60-65 % Zn, 5-10 % Fe	
[9]	H <sub>2</sub> SO <sub>4</sub>	$0.3 \text{ M H}_2\text{SO}_4$ , 260 °C, at elevated pressure	92 % Zn	
[6]	HCl, H <sub>2</sub> SO <sub>4</sub> , HNO <sub>3</sub>	0.1 M H <sub>2</sub> SO <sub>4</sub> , 50 °C, 10-20 min.	72 % Zn	
*conditi	ions, which the authors o	of the article described as optimal conditions		

into the solution, and thus obtain a solution, which, after removing impurities (Fe, Cd, Pb), would be suitable for the electrolysis of zinc.

## 2 Experimental

# 2.1 Material

The EAF sample supplied by Železiarne Podbrezová a.s., Slovakia was used for the experiments. The sample was subjected to chemical analysis by the atomic absorption spectroscopy (AAS) on an atomic absorption spectrometer Varian Spectrophotometer AA20+. The results of the chemical analysis are shown in Table 3.

Table 3: Chemical composition of the EAF dust sample from Železiarne Podbrezová a.s., Slovakia (LOI = lost of ignition)

Element	Zn	Fe	Ni	Cr	Mn	Pb	Cd	Ca	LOI
Amount [%]	17.05	27.23	0	0.81	1.03	1.28	0.09	4.42	7.08

The results of the analysis showed high contents of zinc and iron, which is characteristic for this kind of material. It results from Table 3 that iron and zinc are essential metals in this EAF dust.

In order to determine particle morphology of the EAF dust, the sample was subjected to observation under a digital microscope Dino-Lite Pro AM413T (Figure 1). Magnification used during the observation was 190×.



Fig. 1: Morphology of EAF dust particles

Table 4: Semi-quantitative microanalysis of EAF dust particles

Particles	Content [mass-%]									
	Na	Mg	Si	S	Cl	K	Ca	Mn	Fe	Zn
bigger B	2.13	0.83	15.62	0.54	0.51	0.69	26.38	3.10	27.83	21.37
fine F	1.31	-	3.42	1.09	1.89	2.41	2.31	5.74	56.45	25.38



In the next step the sample was subjected to observation under a scanning electron microscope (SEM) and to chemical microanalysis. A scanning electron microscope JEOL 5800 was used for the study of morphology. Chemical microanalysis was made by an Energy-Disperse Analyzer LINK 3.1 installed on the scanning electron microscope JEOL 5800. Micromorphology of the sample is shown in Figure 2. The results of chemical microanalysis are listed in Table 4.

It can be seen from Figure 1 that the sample consists of two main fractions (coarse and fine spherical particles), where bigger particles are covered with smaller ones. This fact was confirmed also by the granulometric analysis results, which affirmed two groups of particles: bigger particles ( $-22 \mu m + 2 \mu m$ ) and smaller particles ( $+47 \mu m - 28 \mu m$ ).

In order to identify the mineralogical composition, the EAF dust sample was subjected to X-ray (XRD) qualitative diffraction analysis on an X-ray diffractometer PANalytical X'Pert PRO MRD using CoK $\alpha$  radiation. The XRD diffraction pattern of the sample is shown in Figure 3 and phases identified from the XRD pattern are listed in Table 5.



Fig. 3: XRD pattern of the EAF dust input sample

Table 5: Phases identified on the basis of XRD diffraction analysis

		CALL DO DO DA LA COMPANY
Ref. Code	Compound	Chemical formula
01-075-1614	Manganese chromium oxide	MnCr <sub>2</sub> O <sub>4</sub>
01-070-2551	Zinc oxide	ZnO
01-089-3854	Iron oxide	Fe <sub>3</sub> O <sub>4</sub>
01-077-0011	Zinc iron oxide	ZnFe <sub>2</sub> O <sub>4</sub>
00-001-1136	Zinc oxide	ZnO
00-045-0504	Manganese chromium oxide	CrMn <sub>2</sub> O <sub>4</sub>
00-041-1476	Potassium chloride	KCl
01-075-0306	Sodium chloride	NaCl



Fig. 2:

ticles

Micromorpholgy of EAF dust par-

The XRD analysis proved the presence of zinc in the form of zinkite, ZnO, and in the ferritic form as franklinite,  $ZnFe_2O_4$ . Iron occurred as already mentioned franklinite, and in oxidic form as magnetite  $Fe_3O_4$ . In addition to these major phases, also other phases were identified, such as: ferrites,  $MnCr_2O_4$ ,  $CrMn_2O_4$  and chlorides, KCl and NaCl. Phases of lead and calcium were not identified, probably because their amounts were under the detection limit of the method.

## 2.2 Experimental set-up and procedure

The leaching experiments were carried out in the leaching apparatus shown in Figure 4.

The leaching experiments were performed in a glass reactor of 800 ml, which was placed into a water thermostat allowing to automatically maintaining the desired leaching temperature. The pulp was mixed with a glass stirrer connected to the electric motor with variable speed. Temperature was measured by a mercury thermometer. The



Fig. 4: Scheme of the leaching apparatus in the system solid-liquid phase (1 – mechanical stirrer with adjustable constant speed; 2 – propeller; 3 – leaching pulp; 4 – sampler; 5 – thermometer; 6 – feeder; 7 – thermostat; 8 – sample)

volume of the leaching reagent used for the experiments was 500 ml.

Sulphuric acid solutions of 0.05, 0.1, 0.25, 0.5 and 1 M·I<sup>-1</sup> concentrations were used as a leaching reagent. The weight of the sample was 10 g, which gives the L:S ratio equal to 50. Kinetics measurements were carried out at temperatures of 20, 40, 60, 80 and 95 °C measured by a mercury thermometer. In each experiment, the pulp was stirred at a constant speed of 300 rpm, which was determined by auxiliary experiments.

The experimental procedure was following: The sulphuric acid solution of the desired concentration was poured into the reactor and heated up to the desired temperature with constant stirring. After reaching the desired temperature, a pre-weighted amount of the sample was poured into the reactor. After the sample was poured into the leaching solution, the time began to be measured. The liquid samples of 10 ml were taken according to a fixed schedule after 1, 5, 10, 15, 30, 60 and 90 minutes. The liquid samples were filtrated in order to remove solid residues of the pulp. The chemical analysis, carried out in order to determine zinc, iron and calcium content, was made by means of the AAS method (Varian Spectrometer AA 20+). All results were recalculated due to the change of the pulp volume caused by sampling and evaporation.

The effect of temperature and sulphuric acid concentration on the extraction of zinc, iron and calcium into the solution was observed in this work.

# 3 Results and discussion

## 3.1 Thermodynamic study

It results from the mineralogical study that important metals (Zn, Fe, etc.) are present in the sample mainly in the form of franklinite  $ZnFe_2O_4$ , zinkite ZnO, magnetite  $Fe_3O_4$ , calcite  $CaCO_3$  and silica  $SiO_2$ . These phases could react with the present leaching reagent ( $H_2SO_4$ ) and other present components ( $H_2O$ ) and potentially present components ( $O_2$  from air), or with intermediate products of partial reactions, thus producing reaction products according to the basic chemical equations (1-9) shown in Table 6.

The values of the standard Gibbs free energy change for the reactions (1) to (9) are given for temperatures 25 and 100 °C. From these values it is possible to get an idea which reactions are more likely to take place than others.

Reaction		$\Delta G_{25}^{\circ}$ [kJ/mol]	$\Delta G^{\circ}_{100}$ [kJ/mol]	Table 6:
$ZnO + H_2SO_{4(a)} \rightarrow ZnSO_4 + H_2O$	(1)	-63.682	-57.973	The values of standard Gi
$ZnFe_2O_4 + 4H_2SO_{4(a)} \rightarrow ZnSO_{4(a)} + Fe_2(SO_4)_{3(a)} + 4H_2O$	(2)	-31.224	8.29	and 100 °C
$ZnFe_2O_4 + 4H_2SO_{4(a)} \rightarrow ZnSO_{4(a)} + Fe_2(SO_4)_3 + 4H_2O$	(3)	-0.99	-79.823	
$ZnFe_2O_4 + H_2SO_{4(a)} \rightarrow ZnSO_{4(a)} + Fe_2O_3 + H_2O$	(4)	-52.702	-45.377	
$4Fe_{3}O_{4} + 18H_{2}SO_{4(a)} + O_{2(g)} \rightarrow 6Fe_{2}(SO_{4})_{3(a)} + 18H_{2}O$	(5)	-65.995	-50.811	
$4\mathrm{Fe_3O_4} + 18\mathrm{H_2SO_{4(a)}} + \mathrm{O_{2(g)}} \rightarrow 6\mathrm{Fe_2(SO_4)_3} + 18\mathrm{H_2O}$	(6)	-95.644	-579.49	
$3\text{ZnFe}_2\text{O}_4 + 2\text{H}_2\text{SO}_4 \rightarrow \text{ZnO} \cdot 2\text{ZnSO}_4 + \text{Fe}_2\text{O}_3 + 2\text{H}_2\text{O}$	(7)	-54.672	-156.085	
$CaCO_3 + H_2SO_{4(a)} \rightarrow CaSO_4 + H_2O + CO_{2(g)}$	(8)	-130.265	-134.870	
$CaO + H_2SO_{4(a)} \rightarrow CaSO_4$	(9)	-260.993	-251.069	

From the thermodynamic calculation using van't Hoff reaction isobar it results that reactions (1) and (3), i.e. the reaction of ZnO and ZnFe<sub>2</sub>O<sub>4</sub> in the sulphuric acid solution producing zinc sulphate or ferric sulphate, will take place with high probability. The formation of a binary compound ZnO·2ZnSO<sub>4</sub>, reaction (7), is most likely. Assuming that oxygen gets into the system either from the atmosphere or purposely, reaction (6) will take place with the highest probability. In any case, the reaction of sulphuric acid with calcite or lime, reactions (8) and (9), has the highest actual probability, which is an important fact on the assumption of the balance of free sulphuric acid consumption in the system.

Of course, these values describe the situation in the equilibrium state, and therefore in reality there may be deviations from the calculated state, regardless of the fact that the calculated values relate to reactions of individual phases. However, these phases are present together in the system, and therefore it is necessary to verify how the system will behave under the given conditions. A thermodynamic study using potential–pH or E–pH diagrams is suitable for this purpose. These diagrams show the stability areas of individual compounds in the system, in the coordinates of potential–pH in solution, at the selected temperature and concentration of chosen compounds. The results of such analysis for the temperatures of 20 °C and 100 °C in the system Zn–Fe–Ca–H<sub>2</sub>SO<sub>4</sub> are shown in Figures 5 to 7.

It follows from the above that zinc creates an area of soluble compounds (Figure 5) in a wide range of pH from 0 to about 5 practically in the whole range of the water stability area, i.e. potential higher than 0 V. Calcium (Figure 7) also creates soluble compounds in this whole area. In case of iron (Figure 6), it is more complicated. In a very acidic area, with pH about 0 and potential higher than 0.77 V, iron forms an area of ferric ions. This potential is maintained, as it is apparent from the probability of the reaction (3). However, increasing the pH value causes that iron passes into the stability area of goethite, which is a solid substance, and therefore it hydrolytically precipitates out of the solution.



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Of course, the above considerations are valid for the system in equilibrium. In real situation, hydrometallurgical processes are far from equilibrium. A real process is affected by kinetics of the process as well as by the properties of individual compounds. For example, the solubility of calcium sulphate is very low, and therefore it is expected that it will gradually precipitate out of solution as a solid phase.

# 3.2 The behaviour of zinc

Figure 8 shows the kinetics dependencies of the zinc extraction at different sulphuric acid concentrations (0.05 to 1 M) and temperatures 20 to 95 °C.

It results from Figure 8 that the process of zinc leaching is very fast and practically the maximum amount of zinc passing into the solution at a given acid concentration is achieved already in the first minute, and this amount does not change significantly over time. It can be also seen that at lower acid concentrations (0.05, 0.1 and 0.25 M), increasing the temperature does not have significant impact on the zinc extraction into the solution. On the other hand, at higher acid concentrations (0.5 and 1 M), it can be seen that increasing the temperature increases zinc extraction as well. The maximum zinc extraction of 95 % into the solution was achieved at 1 M  $H_2SO_4$  and temperature of 80 °C after 90 minutes of leaching.







Fig. 8:

Kinetics dependencies of the zinc extraction on temperature at acid concentrations 0.05, 0.1, 0.25, 0.5 and 1 M

Figure 9 shows the dependence of leached zinc on sulphuric acid concentrations at different temperatures after the 60 minutes of leaching. It results from the figure that for the L:S ratio = 50, the sufficient sulphuric acid concentration is 0.25 M at all temperatures. Increasing the acid concentration above 0.25 M does not cause increasing the zinc extraction into the solution.

# 3.3 The behaviour of iron

Figure 10 shows kinetics dependencies of the iron extraction from EAF dust on the temperature at sulphuric acid concentrations of 0.05, 0.1, 0.25, 0.5, 1 M and the L:S ratio = 50.

It can be seen from Figure 10 that the iron extraction at the acid concentration of  $0.05 \text{ M H}_2\text{SO}_4$  is practically zero. Increasing the sulphuric acid concentration increases iron extraction into the solution. The maximum iron extraction of 80 % was achieved at 1 M H<sub>2</sub>SO<sub>4</sub> and the temperature of 95 °C.

Figure 11 shows that unlike zinc, where the maximum sufficient acid concentration was  $0.25 \text{ M H}_2\text{SO}_4$ , the iron

extraction raises above this concentration, and in case of higher temperatures it does not reach its maximum even at  $1 \text{ M H}_2\text{SO}_4$ .







#### Fig. 10:

Kinetics dependencies of the iron extraction on temperature at sulphuric acid concentrations 0.05, 0.1, 0.25, 0.5 and 1M From Figure 11 it can be said that the influence of temperature on the iron extraction is more significant than in the case of zinc.

# 3.4 The behaviour of calcium

Figure 12 shows kinetics dependencies of the calcium extraction from EAF dust on the temperature at sulphuric acid concentrations of 0.05, 0.1, 0.25, 0.5, 1 M and the L:S ratio = 50.

It can be seen from Figure 12 that the kinetics of passing calcium into the solution is fast at all temperatures and acid concentrations. The maximum amount of calcium capable of passing into the solution under given conditions will pass in the first minute. In Figure 13 it is possible to see the dependence of leached calcium on the sulphuric acid concentration at different temperatures, where can be clearly seen that the acid concentration of 0.25 M is sufficient at different temperatures, and above this concentration the calcium extraction does not increase anymore.

Calcium is present in the EAF dust mostly as CaCO<sub>3</sub>. It reacts preferably with sulphuric acid, forming gypsum,

 $CaSO_4$ , which precipitates out of the solution due to its low solubility. However, this is a kinetic process and depends on given conditions in the system, mainly on temperature, concentration of present compounds and time.







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References

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Kinetics dependencies of leached calcium on temperature at sulphuric acid concentrations 0.05, 0.1, 0.25, 0.5 and 1M

#### 4 Conclusion

This work confirmed the possibility of hydrometallurgical processing of EAF dust, where the first and the most important step is leaching, i.e. the transfer of compounds of interest into the solution. The aim of this study was to optimize the conditions so that as much zinc (and others heavy metals) as possible would pass into the solution, while iron would remain in the solid leaching residue.

It can be said from the shape of the kinetics curves that it is a very fast process and practically all zinc capable of passing into the solution under given conditions, passes into the solution already in the first minute. The maximum zinc extraction of 95 % was achieved in 1 M  $H_2SO_4$ , at 80 °C after 60 minutes of leaching. However, 66 % Fe and 40 % Ca passed into the solution as well under the same conditions.

The amount of leached iron at different acid concentrations depends on used leaching temperatures. With the increase of the acid concentration, the amount of leached iron increases as well. The optimal conditions for zinc passing into the solution, with respect to the iron extraction, were achieved using 0.1 M  $H_2SO_4$  as a leaching reagent at the temperature of 60 °C and the L:S ratio = 50. The zinc extraction under these conditions was 95 %, while the amount of iron passed into the solution was about 5 %.

It results from the study of E-pH diagrams that it is possible to precipitate iron, which passed into the solution during the leaching process, out of solution by adjusting pH, and thus prepare a solution for further processing, especially for zinc electrolysis.

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