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Physical treatment of zinc skimmed from galvanized process using fluidized bed up-stream column

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ABSTRACT

The Egyptian general metallic company produces a huge amount of zinc skimmed during galvanization process. This work aims to study physical treatment of zinc skimmed from galvanized process of Egyptian general metallic company to attain fractions reach with zinc suitable for alloying process and preparation of chemical compounds. The suggested experimental program involves hand sorting to remove iron pieces, sieving of representative sample of zinc skimmed and dividing it to four groups according to size from 10mm to 75 micron in order to treat each group separately. The grinding process was carried out for the coarse fractions. The physical separation such as fluidized bed up-stream column, air classifier and flotation was carried out on the fine fraction less than 75 micron. Results showed that the zinc assay and distribution increase in the coarse fraction of the skimmed zinc. The grinding process of coarse fractions larger than 1.161mm leads to increase zinc assay from 70% to 83% and about 27% by weight of the sample was obtained with zinc assay 83% by weight. The grinding of size fraction (-1.161+0.075mm) showed that zinc assay increases from 48% to 76%. The treatment of fines (less than 0.075mm) using fluidized bed, air classifier and flotation improves the zinc assay and recovery. The zinc assay increases from 44% to 56%.

Keywords: Zinc skimmed; Size reduction; Physical treatment

1. INTRODUCTION

The development of industries in different field based on new technology created waste materials, which causes environmental problems. These problems are air, soil, water pollutions, and solid waste disposal (Schmelzer, 1995). Industrial wastes are defined as low quality and not confirming to the desired specification of raw materials, intermediates, or finished products (Misra and Das, 2002). Large volume of solid wastes can cause problems in handling, disposal and environmental pollutions to great extent.

Zinc, being a reactive metal takes its place in the manufacture process and ends up as a coating (e.g. galvanizing), as alloying metal (in brass), as a pigment (zinc dust) and as a chemical (Wyatt, 1996). Galvanized coatings used for protecting steel from corrosion are by far the largest consumer of zinc. The bath-skimming step to remove the accumulated dross from the surface is essential for the production of the high surface quality required for galvanized strip product (Green, 1993). The galvanizing process produces five waste products (Kim *et al.*, 1989). They are zinc ash (oxidized) zinc from the zinc bath's surface; zinc dross (zinc-iron alloy) that accumulated on the bottom of zinc bath; zinc fumes; spent acid (containing zinc and iron chloride in solution) and waste water (containing low level of zinc or iron or both). Zinc ashes (or skimming) are skimmed from the top of general galvanized baths. They contain oxides formed on the surface of the bath together with entrained metal. The overall metal content is generally larger than 70%. Zinc ash and zinc dross have considerable commercial value and enter the recycling stream to allow the recovery of metallic zinc and zinc oxides, and in the production of zinc dust and zinc oxides from zinc dross residues (Dunbar, 1988).

The Egyptian general metal company produces a very huge amount of zinc skimmed during the galvanized process. It causes problems in handling and storage.

Fluidized bed up-stream column is widely used for cleaning contaminated soil. The separation is based on particle diameter and density. Under liquid-fluidized conditions with water, particles segregate according to their density and size, vertically in height in the fluidized bed. Fine particles and particles with low density will be carried away with up-ward water flow and the heavier particles will be in the bottom of the bed.

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The particles accumulate near the top of the bed due to their density and size as results of a balance of both drag and buoyancy forces. The void fraction of the bed adjusts itself so that the local interstitial liquid velocity creates enough drag force on the particles to counteract there settling velocities.
Evers *et al.* (1998) produced classified sand using fluidized bed separator of type "Hydrosort I" with a single chamber and "Hydrosort II" with a double chamber. Trawinski (1972) described the fundamental of classifying and separating materials with the help of up-word currents of water for mineral processing. Schmidt and Werther (2002) developed centrifugal fluidized bed classifier for separation in the micron range. It is based on the transfer of the up-current classification into centrifugal field. They showed that the classifier allowed very sharp separation with cut size below 10 micron.

This work aims to study physical treatment of zinc skimmed from galvanized process of Egyptian general metallic company. The physical treatment includes sieving, grinding and fluidized bed up-stream column to attain fractions reach with zinc suitable for alloying process and preparation of chemical compounds.

2. EXPERIMENTAL

2.1. Material

A representative sample about 200 kilogram of zinc skimmed was supplied by General Metallic company. The sample contains coarse fraction, iron pieces and fine fraction. A representative sample about 10 kg was taken after sampling using coining and quartering technique. A hand sorting was carried out to remove the iron pieces followed by screen analysis.

The sieve test of representative sample of zinc skim about 10kg was carried out on a set of sieve ranges from 10mm to 0.075mm sieve. The weight percentage of each fraction was calculated. The sample after sieving was divided into four groups to treat each group separately. The size of group I was (-10+6.775mm). The group II contains all size ranges from 6.775 to 1.161mm. The size of group III ranges from 1.161 to 0.075mm. The group IV contains all fines less than 0.075mm.

The grinding of group I (-10+6.775mm) and group II (-6.775+1.161mm) was performed using "Wedag" rod mill (15.1x30cm) to clean this fraction and remove the fine fraction less than 0.075mm. The mill filling was 40% with 12 stainless steel rods and the grinding time was one hour.
Grinding of group III (-1.161+0.075mm) was performed using ball mill to pass 0.075mm sieve.

2.2. Fluidized bed up-stream column

Fluidized bed up-stream column is representing in plate I. A representative sample less than 75 micron about 50 gram was stirred for 25 minute using magnetic stirrer. The stirred sample was transferred to the column through the top of the column where an upward flow exists. Water is fed to the column through a perforated plate at the bottom. The experiments were carried out at different water velocity. The particle size analysis was carried out using "Beckman Coulter" laser particle size analyzer.

2.3. Air classification

The air classification of zinc skim fine less than 75 micron was carried out using "Alpine" air classifier. The classification was carried out at different air speed and air volume according to the chart present in the manual to separate different fine fraction. The size was measured using "Beckman Coulter" laser particle size analyzer.

2.4. Flotation

The flotation test was carried out using "Denver D12" flotation cell. A representative sample about 250 gram was conditioned with sodium sulphide at pulp density 50% and rotation speed 2500rpm for 15 minute at pH 7. A potassium ethyl xanthate as collector was putted for another 5 minute. The pulp was diluted to 20% and the rotation speed was decreased to 1500rpm. The air was introduced through the air opening and skimming of the froth was carried out until dematerialized froth.

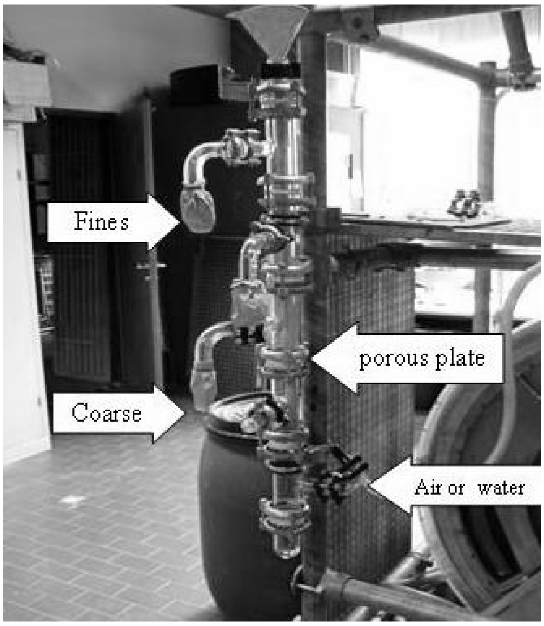

Plate I. Fluidized bed up-stream column

3. RESULTS AND DISCUSSION

3.1. Size and chemical analysis of zinc skimmed

The results of hand sorting for zinc skimmed to remove iron pieces showed that about 6.54% was hand picked and it looks like iron disk and broken iron pieces. This fraction could be recycled in iron industry. Figure 1 shows the results of size analysis of zinc-skimmed sample. The sample passed 100% (10mm) size. The d_{75} and d_{50} of the zinc skimmed were 6.775 and 1.7mm respectively. Therefore it is suggested to divide the sample to four groups. The weight percentage, chemical analysis and size of each group are representing in table 1. The zinc assay and distribution increase in the coarse fraction from group (I) to group (III) as shown in table 1.

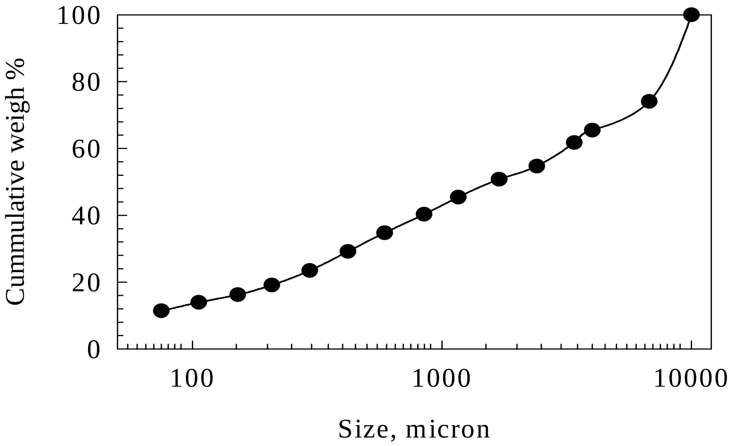

Figure 1. Size analysis of zinc skim

Table 1
Sieve and chemical analysis of zinc skim groups

Size,mm	Weight%	Zn%	Distribution%	SiO_2%	Distribution%
-10.00 + 6.775 (I)	19.37	70.70	24.47	7.78	11.02
- 6.775 + 1.161(II)	28.69	64.21	32.92	10.32	21.66
- 1.161 + 0.075(III)	34.01	47.95	29.14	26.86	66.83
- 0.075 (IV)	11.39	33.99	6.92	17.01	14.17
Total	93.46	55.96	93.46	13.67	93.46
Iron Pieces Picked	6.54				
Total	100.00				

3.2. Physical treatment of (-10.00+6.775mm) group I

Grinding of group I was carried out using “Wedag” rod mill in order to clean this fraction to remove sand and other contaminants. Table 2 shows the results of grinding of group I. It has been seen that the zinc percent increases in the coarser fraction and silica percentage decreases. About 13.33% by weight of the zinc skimmed with 83% zinc and 2.89% silica was obtained from feed contains 71% zinc and 7.78% silica. This fraction could be used in alloying process for producing zinc alloys. The fine fraction -0.075mm that represents about 6.04 by weight was treated using wet fluidized bed, air classifier separation and flotation to recover zinc.

Table 2
Result of grinding of group I

Size, mm	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
-10 + 0.075	68.54	13.33	82.50	79.98	2.89	25.46
- 0.075	31.46	6.04	44.98	20.02	18.57	75.09
Total	100.00	19.37	70.70	100.00	7.78	100

3.2.1. Wet separation of fine fraction (-0.075mm) using fluidized bed

Wet separation for fine fraction produced from grinding size larger than 1.16mm was carried out using fluidized bed. Figure 2 shows the results of recovery and assay of zinc at different speed of water for underflow fraction (coarser fraction). It is noticed that the recovery percentage decreases with increases speed of water and zinc percentage increases. It has been shown that at water speed (1.699cm/sec) a 65% by weight was separated with assay 55.5% zinc with recovery 80% and 9.43% SiO_2 from a feed containing 44.8% zinc and 18.65% SiO_2. This fraction could be used for leaching to produce chemical products.

3.2.2. Treatment of fine fraction using flotation

Table 3 shows the results of flotation of fine fraction. The flotation was carried out in presence and absence of sodium sulphide and potassium ethyl xanthate as collector. The results are nearly the same. It has been noticed that the float fraction enriched with silica and has low amount of zinc. The non-floated fraction represents 5.17% by weight with 51% zinc and 92.58% recovery table 3.

3.2.3. Dry separation using "Alpine" air classifier

The dry separation was carried out using “Alpine air classifier at speed of 10000cm/sec and 45 meter cubic air. Figure 3 shows the size analysis of separated products. It was noticed that the d_{50} of overflow fraction was 5 micron whereas d_{50} of coarser fraction was 33 micron. Table 4 represents the results of chemical analysis of separated products. It has been shown that the overflow fraction enriched with silica while the under flow fraction enriched with zinc. The results of flotation table 3 matched with the result of dry separation table 4.

3.3. Treatment of group II (-6.775+1.161mm)

The grinding of (-6.775+1.161mm) group two was carried out using “Wedag” rod mill to clean this fraction and remove silica coated with it. Table 5 shows the result of grinding. It is seen that the coarser fraction rich with zinc and contains low amount of silica.

It represents about 12.82% by weight of the zinc skimmed with 83.05% zinc and 1.17% SiO_2. It could be used in alloying process to prepare zinc alloys. The fine fraction (-0.075mm) is enriched with silica.

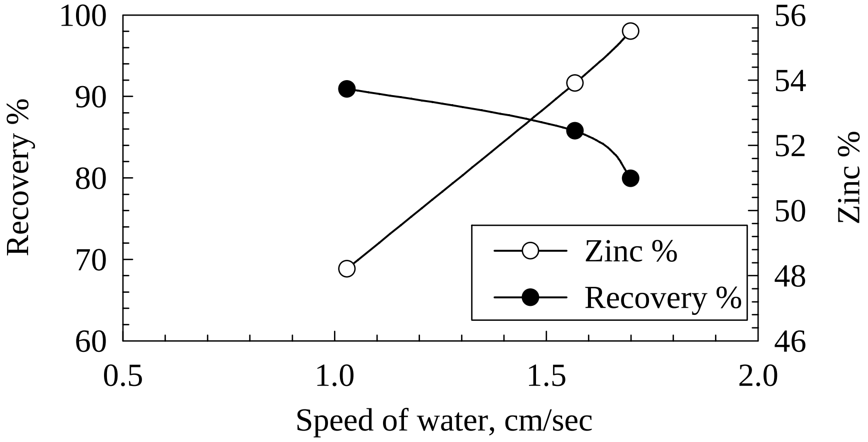

Figure 2. Recovery and assay of zinc for underflow fraction

Table 3
Result of flotation tests

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Float	14.35	0.87	24.36	7.42	22.56	20.13
Non-Float	85.65	5.17	50.89	92.58	14.99	79.84
Total	100	6.04	47.08	100	16.08	100

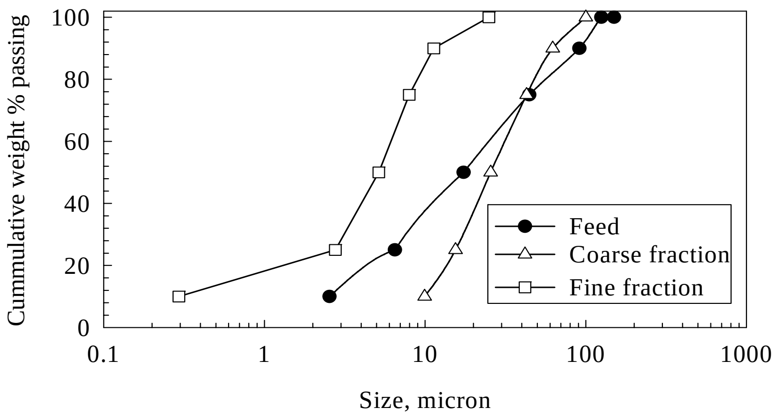

Figure 3. Size analysis of dry separation

Table 4
Result of air classifier separation at speed 10000cm/sec and 45m^3 air

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Overflow	13.83	0.64	28.23	8.68	22.93	17.08
Underflow	86.17	5.4	50.76	97.24	17.39	80.62
Total	100	6.04	44.98	100	18.57	100

3.3.1. Grinding (-0.840+0.075mm)

The size fraction (-0.840+0.075mm) was ground to pass 0.075mm using ball mill. Table 6 shows the results of grinding. Figure 4 shows the results of size analysis of both fine and coarse fraction. The fines produced from grinding (-6.177+0.075mm) and (-0.840+0.075mm) were treated using wet fluidized bed, flotation and air classifier to separate zinc.

3.3.2. Wet separation for fine produced from grinding (-6.775+1.161mm)

Figure 5 represents the recovery of zinc and assay of underflow fraction using fluidized bed at different water speeds. It is seen that the zinc increases with increase water speed. At water speed (1.029cm/sec) about 60% by weight separated with 45.02% zinc with recovery about 75% from feed containing 36.31% zinc. This fraction represents about 4.02% by weight of all zinc skim.

3.3.3. Wet separation of fine fraction produced from grinding (-0.840+0.075mm)

Table 7 represents the results of wet separation of fine produced from grinding (-0.840+0.075mm). It is seen that the weight of overflow increases with increase speed of water, in the mean time the zinc percentage in the underflow nearly the same. This means that the speed of water has effect only on the weight percentage and not on the zinc assay. A 66% by weight underflow fraction with 60% zinc and 71% recovery was obtained from a feed containing 56.17% zinc.

3.3.4. Flotation of fine produced from grinding (-0.840+0.075mm)

Table 8 shows the results of flotation of the size fraction 75µm which produced from grinding (-0.840+0.075mm). It is seen that the silica content increases in float fraction and zinc decreases while the silica decreases in the non-float and zinc content increases. Result shows that non-float fraction represents about 7.51 by weight of skim sample with assay 66% zinc and recovery 90%.

3.3.5. Dry separation of fine produced from grinding (-0.840 + 0.075mm)

Dry separation for 75µm produced from grinding size (-0.840+0.075mm) was carried out using "Alpine" air classifier at speed 10000cm/sec and 45m^3. Figure 6 shows the size distribution of the separated products. Table 9 represents the results of chemical analysis of separated products. It was seen that the coarse fraction enriched with zinc. It represents about 7% by weight of all sample assays 62.78% zinc with recovery of zinc 83%. This fraction could be used in alloying processing to produces zinc alloys.

3.4. Treatment of group III (- 1.161 + 0.075mm)

Grinding of fraction (-1.161 + 0.075mm) group III was carried out using ball mill to pass 75 micron before separation using fluidized bed, dry separation and flotation. Figure 7 shows results of the size analysis of ground products. Table 10 represents results of chemical analysis of ground products. It was seen that the coarser fraction larger than (0.075mm) represents about 7.3% by weight of zinc skim with assay 75.55% zinc, 3.05% SiO_2 and zinc recovery about 34%. The fine fraction enriched with silicate. It needs further treatments to recover zinc.

3.4.1. Wet separation using fluidized bed for fine 0.075mm of grinding (-1.161+0.075mm)

Figure 8 shows the results of recovery and assay of zinc in the underflow fraction. It was noticed that increasing water speed the recovery of zinc decreases and the assay of zinc increases as shown in figure 8. It was seen that at water speed 1.029cm/sec a fraction about 55% by weight with assay 48% zinc and recovery 65% was obtained from feed assaying 40% zinc. This fraction could be used to prepare some zinc salts through leaching process.

3.4.2. Dry separation using air classifier for fine 0.075mm of grinding (-1.161+0.075mm)

Figure 9 shows the result of dry separation using air classifier. It is seen that by increasing the speed of air and decreasing the amount of air to separate the very fine fraction from about 10 micron the separation did not improve. The result at speed 5000cm/sec and 50cm^3 air matched with the wet separation using fluidized bed technique.

Table 5
Result of grinding of group II

Size,mm	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
- 6.775+0.840	44.70	12.82	83.05	57.82	1.17	5.07
- 0.840 0.075	31.96	9.17	58.21	28.97	13.51	41.83
- 0.075	23.36	6.70	36.31	13.21	23.47	53.11
Total	100.00	28.69	64.21	100.00	10.32	100.00

Table 6
Result of grinding of (- 0.840 + 0.075mm)

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Coarse	10.70	0.98	75.27	13.84	4.55	3.6
Fine	89.30	8.19	56.17	86.16	14.58	96.40
Total	100.00	9.17	58.21	100.00	13.51	100.00

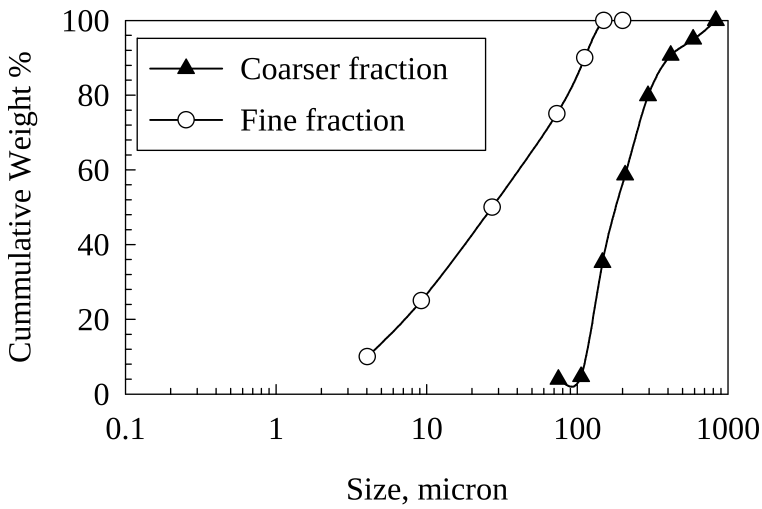

Figure 4.Size analysis of ground products of (-0.840 + 0.075mm)

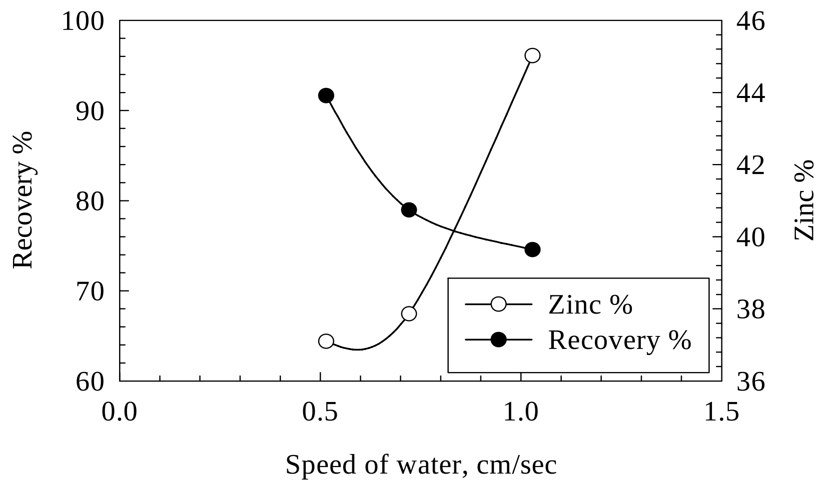

Figure 5. Recovery and assay of zinc of underflow fraction as a function water speed

Table 7
Results of wet separation for fine produced from grinding - 0.840 + 0.075mm

Speedcm/sec	Fraction	Wt.% op.	Wt.% ov.	Zn%	Rec.%	SiO_2%	Rec.%
1.029	Overflow	33.94	2.78	48.55	29.34	17.34	39.42
	Underflow	66.06	5.41	60.08	70.66	13.69	60.58
	Total	100.00	8.19	56.17	100.00	14.93	100.00
1.727	Overflow	51.01	4.18	48.78	44.31	16.9	57.42
	Underflow	48.99	4.01	63.84	55.69	13.05	42.58
	Total	100.00	8.19	56.17	100.00	15.01	100.00

Table 8
Result of flotation of ground product of -0.840 + 0.075

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Float	18.08	1.66	32.27	9.79	17.43	28.15
Non-Float	81.92	7.51	65.63	90.22	9.82	71.85
Total	100.00	9.17	59.59	100.00	11.20	100.00

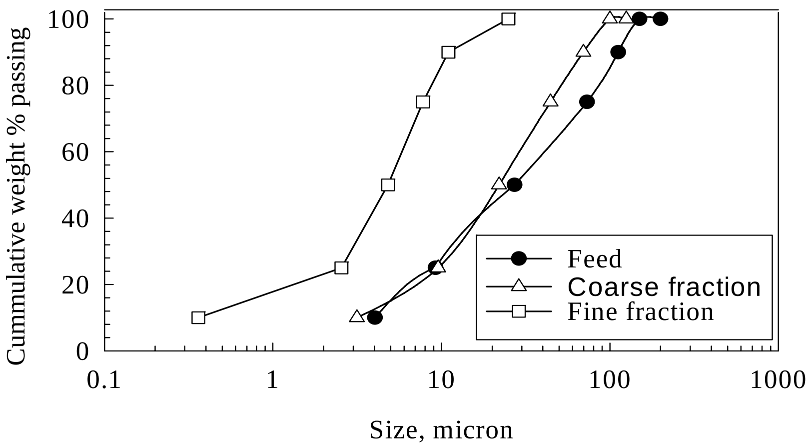

Figure 6.Dry separation of fine fraction produced from(-0.840+0.075)

Table 9
Dry separation of fine grinding of size (-0.840 + 0.075mm)

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Overflow	24.11	2.21	39.89	16.80	16.41	25.13
Underflow	75.89	6.96	62.78	83.20	15.53	74.87
Total	100	9.17	57.26	100	15.74	100

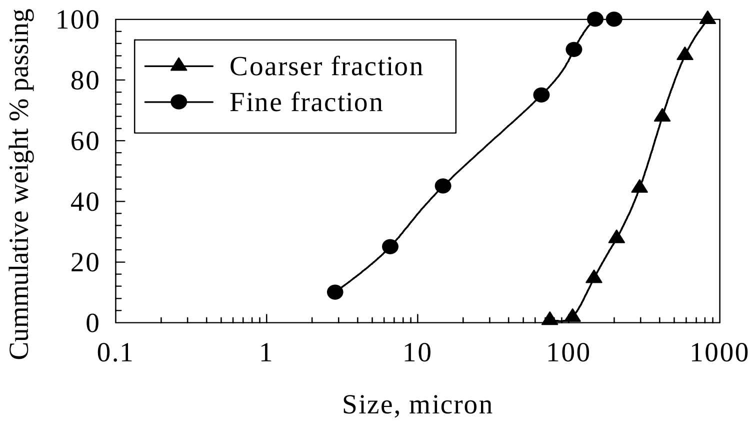

Figure 7. Size analysis of grinding group(III) (-1.168+0.075)

Table 10
Grinding size fraction (-1.161 + 0.075mm)

Fraction	Operational weight%	Overall weight%	Zn%	Recovery%	SiO_2%	Rec.%
Coarse	21.47	7.30	75.55	33.83	3.05	2.44
Fine	78.53	26.71	40.40	66.17	33.37	97.56
Total	100.00	34.01	47.95	100	26.86	100

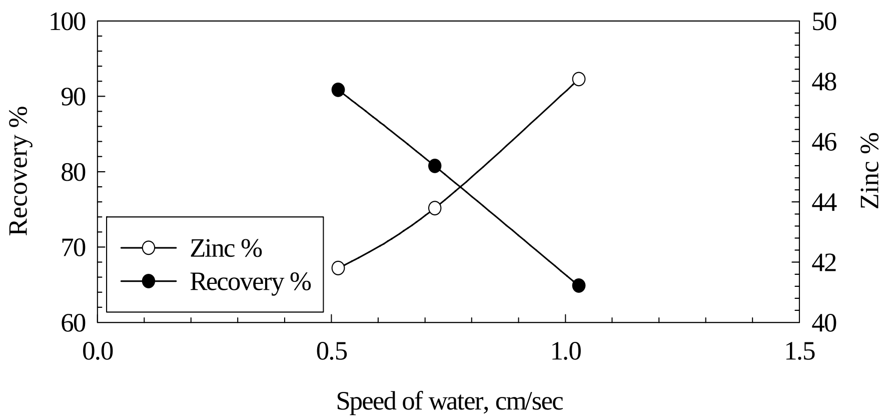

Figure 8. Recovery and assay of zinc as a function of water speed for the underflow fraction

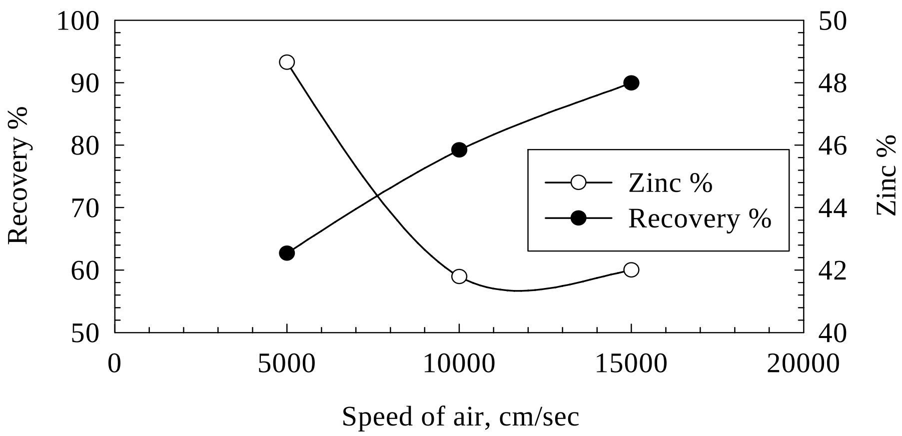

Figure 9.Recovery and assay of zinc in coarse fraction of dry separation

3.5. Treatment of fine fraction group V (-0.075mm) of all zinc skim using fluidized bed

Wet separation of fine fraction of all zinc skim group IV was carried out using fluidized bed. Figure 10 shows the results of size analysis of separated products. Figure 11 shows the relation between zinc assay and recovery with water speed for the underflow fraction. It was noticed that by increasing speed of water zinc assay increases and the recovery decreases. At water speed 1.699cm/sec, about 60% by weight was obtained with 37.56% zinc and recovery 67% zinc from feed containing 33.9% zinc. This fraction could be used for preparation of some zinc salts through leaching process.

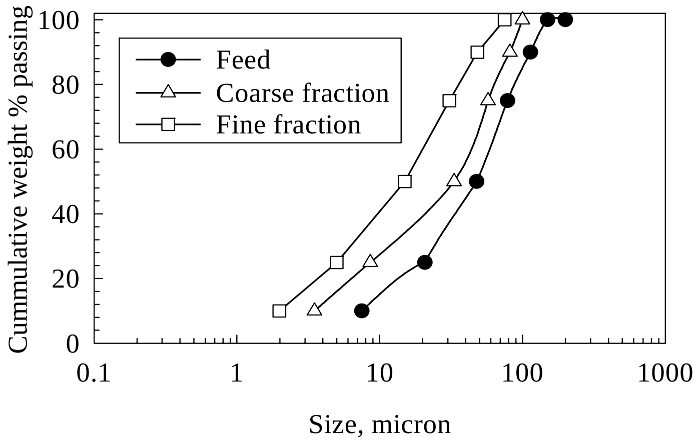

Figure 10. Size analysis of separated products

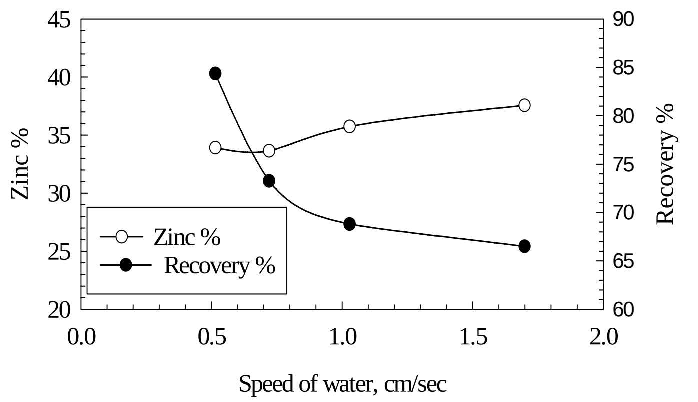

Figure 11. Zinc assay and recovery as a function of water speed

4. CONCLUSIONS

Physical treatment using hand sorting, sieving, grinding, dry separation and fluidized bed for zinc-skimmed successfully separate fraction enriched with zinc. The results of hand picking showed that the sample contains about 6.5% iron pieces and it looks like disk. It could be recycled in iron industry.

The zinc assay is concentrated in the coarse fractions. The grinding process of coarse fractions larger than 1.161mm leads to increase zinc assay from 70% to 83%. About 27% by weight of the sample was separated with zinc assay 83% by weight. It could be used in alloying process to produce zinc alloy. The grinding of size fraction (-1.161+0.075mm) showed that zinc assay increases from 48% to 76%.

The treatment of fines (less than 0.075mm) using fluidized bed, air classifier and flotation improves the zinc assay and recovery. The zinc assay increases from 44% to 56%. This fraction is very fine and easily leached to prepare zinc salts.

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