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For The Atomic Energy Commission

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UNITED STATES ATOMIC ENERGY COMMISSION

**ENGINEERING B DATA [PITCHBLEND
PROCESSING ENGINEERING]; PROGRESS RE-
PORT II (APRIL 2 TO MAY 11, 1945)**

By
Earl I. Miller

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May 15, 1945

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St. Louis, Missouri**

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Summary

Experiments were tried using a small Oliver filter and FEino test leaf. The results show that under the proper conditions both barium sulphate and gangue may be successfully handled on a continuous rotary drum type filter.

The numerical rates obtained on the small Oliver were subject to considerable error because of cloth blinding. The FEino results should be used with allowance for the fact that the apparatus was available for only a few experiments.

Washing experiments were tried but analytical results are not available at present.

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ENGINEERING B DATA [PITCHBLEND PROCESSING ENGINEERING]
PROGRESS REPORT II
(April 2 to May 11, 1945)

By Earl I. Miller

Introduction

In the flow sheets submitted by the Army, Oliver Rotary Drum filters were designated as the filtering machines for handling gangue, lead, and barium cakes. Rotary continuous filters have several obvious advantages. The foremost are tabulated here:

A. Small Amount of Handling

The Oliver and similar filters have the advantage that the material passing through them is handled by the machine and little labor is required. Not only does this result in a saving where large amounts of materials are handled but in this particular case is important from a health standpoint.

B. Automatic Operation

The control of the filtering cycle by the main valve reduces the human factor in operation. Mistakes in working time, blowing time, filtering time, etc., by the operator are practically eliminated because these times once set are automatically maintained.

C. Easy Observation

Because of the open view of the cake discharge, washing and cake drying operation, observation of any irregularities in filtration is relatively easy.

The principal disadvantages of the Rotary drum type filter are:

A. Small Filtering Area Per Unit Floor Space

The rotary drum filter by virtue of its design has considerably less filtering area per unit of floor space than plate and frame type presses, Sweetland's, etc. Ordinarily only 35% of the drum area is in use at one time.

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B. High Cake Moisture

The continuous rotary drum types of filters depend on pulling air through a thin cake to dewater. When the cake cracks, this operation is defeated. Likewise, it is not uncommon to blow back moisture into the cake during discharge. This is not true of the FEinc type filter which employs a cake compressor and string discharge.

C. $\frac{1}{4}$ -inch Cake Required

To obtain a positive discharge by "air blowback," cakes should be at least $\frac{1}{2}$ inch thick, preferably $\frac{3}{8}$ inches. With string discharge, however, it is possible to handle cakes $\frac{1}{8}$ inch thick; this of course is qualified by the character of the cake.

D. Cloth Replacement

Should any failure occur in the filtering medium, it is necessary to remove the entire cloth and rewind a new cloth on. This is a tedious and time-consuming job with large filters.

In order to determine whether or not an Oliver type filter would successfully handle the slurries involved in the 45-15 process, a small 12" x 2" stainless steel Oliver filter was borrowed by the Army and installed at Yale by Mallinckrodt. The following experiments are concerned with this filter and a small FEinc leaf.

Object

To determine whether or not rotary drum filters such as the Oliver and the FEinc have any practical application in the 45-15 process.

Experimental

A. Oliver

The Oliver used in these experiments was a 12" x 2" Precoat, the top casing of which had been removed. A sheet metal knife was substituted for the regular precoat knife which was attached to the top casing. The Oliver was connected to two receivers, one for filtrate and the other for wash. Both receivers were connected by a common blade to the overflow tank, which was immersed in an ice bath and served as a condenser. The overflow tank connected directly to a piston vacuum pump (reversed air compressor).

The experimental procedure was to fill the casing until the slurry level was about two inches from the top. This submerges 39% of the drum. The area of the drum submerged is the actual filtering area, but it is customary to use the total area of the drum in rate calculations.

With the casing filled, the vacuum was turned on and the rotation of the drum started. The drum speed, temperature of slurry, vacuum, and cake thickness were noted. Runs were made for a period of about ten minutes, at the end of which time the volume of filtrate and weight of wet cake were recorded.

The data collected from digestions XXI and XXII are tabulated here.

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OLIVER DATA
FILTRATION OF GANGUE

XXI
4-28-45

2X + 20% NaNO₃

Time Minutes	Temp. °C	Drum Speed MPR	Vacuum in Hg	Filtrate Volumes Gallons	Wash Volumes Gallon	Wt. Wet Cake Pounds	Pounds Dry Cake per ft	Pounds per ft ² per hr	Gallons Filtrate per ft ²	Gallons per ft ² per hr	Remarks
0		4	15								
1	70	4	12								
2	67	4	11								
5.5		4	13								
7	40	4	18								
		4		0.106		1.12	1.01	8.7	0.212	1.81	
0			13								
3	39	4	15								
8	37	4	16								
10	40	4	19								
13	37	4	13								
15	40	4	21								
				0.211		1.80	1.63	6.5	0.421	1.69	
0	38	4	22								
3		4	16								
4	40	4	17								
7		4	16								
9	45	4	20								
10		4	17	0.221	0.220	1.45	1.31	7.9	0.443	2.66	
0	38	4	18								
3		4	18.5								
5	37	4	18.5								
8		4	21								
10	37	4	17	0.153	0.190	1.19	1.07	6.5	0.306	1.84	

³/₁₆" cake - fair
discharge

Cake cracked; Tem-
porary leano cloth
fixed

Cake about ¹/₄" thick
breaks off evenly
and cleanly

Work started - top
part of cake appears
to be well worked
cake about ¹/₄ inch
thick

Filtrate clear but not
brilliant

Cake about ¹/₄" thick

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OLIVER DATA
FILTRATION OF GANGUE (cont.)

XXI
4-28-45

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Time Minutes	Temp. °C	Drum Speed MPR	Vacuum in Hg	Filtrate Volumes Gallons	Wash Volumes Gallon	Wt. Wet Cake Pounds	Pounds Dry Cake per ft	Pounds per ft ² per hr	Gallons Filtrate per ft ² per hr	Gallons per ft ² per hr	Remarks
3		2	22								
5	37	2	22								Cake down to about $\frac{1}{8}$ " thickness
7		2	22.5								
10	35	2	26								
14		2	27								Poor discharge
15		2		0.407	0.356	2.78	2.54	10.0	0.814	3.26	Some blinding
2	37	4	22								
5	37	4	16								
7		4	17								
9	38	4	16								
10		4	20	0.222		1.85	1.67	10.0	0.444	2.66	No wash attempted

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RESLURRY

2	37	4	10								
6		4	11								
7	37	4	12								
8		4	17								
9	38	4	17								
12		4	14	0.435	0.254	2.18	1.99	10.0	0.870	4.35	

Notes: Filter Medium: Style 0185 glass cloth from Filter Media Corporation

Average Cake Moisture: 54.8%

Reslurried Cake Moisture: 55.3%

For digestion conditions see report "Work Done at Yale, April 2 to May 11, 1945," Digestion XVI.

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OLIVER DATA
FILTRATION OF BARIUM SULPHATE

XXI
4-30-45

Time Minutes	Temp. °C	Drum Speed MPR	Vacuum in Hg	Filtrate Volume Gallons	Wash Volumes Gallons	Wt. Wet Cake Pounds	Pounds Dry Cake per ft	Pounds per ft ² per hr	Gallons Filtrate per ft ²	Gallons per ft ² per hr	Lbs. Wash per lb. Dry Cake	Remarks
0	42	4	3									
2	47	4	16									
4		4	23									
5	52	4	25									
6.5	50	4	25									
				0.687	--	0.176	0.291	2.70	1.37	12.6		Cake about $\frac{1}{16}$ " thick - poor discharge Turbid filtrate
0	60	4	25									
2		4	22									
7		4	19									
8	57	4	20									
				0.179	0.185	0.084	0.140	1.05	0.358	2.68	22.8	Wash started Very poor thin cake About $\frac{1}{16}$ " thick cloth blinded Filtrate turbid
1	60	4	11									
6	55	4	14									
7		4										
				0.720	--	0.072	0.120	0.90	1.440	12.3	--	Filtrate turbid filtration attempt abandoned

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Notes: Filter Medium: Glass Cloth, style 0185, from Filter Media Corporation

Per Cent Moisture in Cake: 17.0%

This filtration was very erratic and unsatisfactory. The results are of no weight. The precipitation conditions were very poor. See "Work Done at Yale, April 2 to May 11, 1945," Digestion XXI.

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OLIVER DATA													XXII	8
FILTRATION OF GANGUE													5-1-45	
Time	Temp.	Drum	Vacuum	Volume	Volume	Wt. Wet	Pounds	Pounds	Gallons	Gallons	Lbs. Wash	No. Wash	Remarks	
Minutes	°C Slurry	Speed MPR	Inches Hg	Filtrate Gallons	Wash Gallons	Cake Pounds	Dry Cake per ft ²	per ft ² per hr	Filtrate per ft ²	per ft ² per hr	per lb Dry Cake	displace- ments		
0	67	2	5										Cake cracked	
4	71	2	10										before dis-	
7	66	2	15										charge	
10			18	1.13	0.066	1.90	1.75	10.5	2.26	13.6	0.63	0.74	Cake 3/16" thick	
0	64	2	18										Fairly clear	
3	63	2	17										filtrate	
6	63	2	18										Cake cracked	
10	62		18	0.178	0.291	2.00	1.84	11.0	0.356	2.14	2.60	3.05	Cake 1/4" thick	
0	57	2	22											
3		2	22											
10	48		22	0.166	0.245	1.89	1.74	10.4	0.332	1.99	2.73	3.21	Fair filtrate	

Notes: Filter Medium: Glass Cloth, Style 0185, from Filter Media Corporation
 Moisture Content: 54%
 Per Cent Solids in Slurry: 31%
 Value 13.6 seems out of line - given no weight.
 For conditions of digestion see report, "Work Done at Yale, April 2 to May 11, 1945," Digestion XXII.

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OLIVER DATA
FILTRATION OF BARIUM SULPHATE

XXII
5-3-45

Time Minutes	Temp. Slurry °C	Drum Speed MPR	Vacuum Inches Hg	Volume Filtrate Gallons	Volume Wash Gallons	Wt. Wet Cake Pounds	Pounds Dry Cake per ft ²	Pounds per ft ² per hr	Gallons Filtrate per ft ²	Gallons per ft ² per hr	Remarks
0	52	4	10								
1		4	12								Cake 1/8" thick
2	53	4	12								
5		4	17								Cake 1/8" thick
7	51	4	17								
Avg	52	4	13.6	0.791	0.330	0.557	0.936	8.02	1.58		Filtrate fairly clear Wash turbid
0	49	4	17								Cake 3/32" thick
3	47	4	11								Some indication of cloth blinding
5		4	8								
7	45	4	17								Cake sticks - doesn't break off
9	42	4	17	0.404	0.367	0.266	0.447	2.98	0.808	5.38	

Notes: Filter Medium: Glass Cloth, Style 0185, from Filter Media Corporation
Moisture Content of Cake: 16.1%
For conditions of precipitation, see report, "Work Done at Yale, April 2 to May 11, 1945," Digestion XXII.

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The valve mechanism leaked so badly that it was impossible to use the "air blowback" during the foregoing experiments. As a result, considerable "cloth blinding" was experienced. This mechanical difficulty could not be remedied with the facilities available at Yale.

B. FEinc Test Leaf

A small ($\frac{1}{6}$ ft²) test leaf was obtained from Filtration Engineers, Inc. This leaf was equipped with strings to simulate the string discharge of these type filters. The apparatus was available only at the end of the period covered by this report, so that the data is very limited.

The leaf is supposed to represent a section of a large FEinc apparatus and experiments are carried out on this basis. The leaf is immersed in slurry for a time equal to that time a section of a large filter would be filtering, the vacuum being maintained at fifteen inches of mercury, the value ordinarily used on FEinc filters. At the end of the filtering time, the leaf is removed from the slurry, inverted and allowed to dewater for a time corresponding to the dewatering time on a large filter. The leaf is then immersed in water for washing, the time being on the same basis as the foregoing. After washing, the cake is again dewatered and compressed by rolling a small roller across the cake. Before discharging, the cake is trimmed around the edges and the weight of the cake edges recorded. The discharge is effected by pulling the strings, lifting the cake off the leaf. The amount of wet cake is weighed wet and after drying to permit dry cake calculations. The difference in rates at which different slurries filter is compensated for by varying the drum speed in a FEinc filter. This is accomplished with a leaf by varying the time of filtration, dewatering, etc., but not the ratio of the filtration time to the washing time, etc.*

The data obtained on the filtration of gangue and barium sulphate from digestion XXII are given here as well as that on the raffinate precipitates from digestions XXI and XXII.

* Note: For further information on test leaves see Chemical Engineers Handbook, pp. 1661, 1943 Ed.

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FEinc Test Data Sheet

Material: Gangue XXII A

Date: 5-1-45

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
1. Temp. of Slurry	34°C	40°C	35°C	37°C	33°C
2. P.H.	0	0	0	0	0
3. Slurry %	31.0	31.0	31.0	31.0	31.0
4. Sp. G. of Slurry					
5. Filter Cloth	Duck	Duck	Duck	Duck	Duck
6. % Submergence	37.5	37.5	37.5	37.5	37.5
Filtration	15	15	15	15	15
Initial Dewatering	15	15	15	15	15 →
7. Vacuum in Hg					
Washing	21	21	21	21	21
Final Dewatering	21	21	21	21	21 →
8. R.P.M.	1/4	1/4	1/6	1/2	1
Filtering	88	88	132	44	22
9. Time Before Rolling	12	12			
in			33	12	3
Sec. Washing	64	64	96	32	16
Dewatering	20	20	30	25	5
10. Compression	O.K.	O.K.	O.K.	O.K.	cracked
11. Discharge from Cloth	Good	Good	Good	Good	None
12. Cake Thickness	5/16"	5/16"	6/16"	3/16"	1/8"
13. Clarity of Filtrate	Fair	Poor	Fair	Poor	Poor
14. Temp. of Wash Water	33°C	60°C	41°C	41°C	33
15. C. C. of Wash and Filtrate					
16. C. C. of Wash Water	122	130	105	51	60
17. C. C. of Filtrate	238	243	309	142	35
18. Wet. Wt. of Cake	177	196	232	127	107
19. Dry Wt. of Cake	78.5	90.5	102	62.3	50.3
20. Water Removed	98.5	105.5	130	69.7	56.7
21. % Water in Cake	55.7	53.8	56.0	51.0	53.0
22. Dry Wt. Lbs/Sq. Ft.	1.03	1.20	1.35	0.823	0.750
23. Lbs./Sq. Ft./Hr.	15.4	18.0	13.5	24.7	45.0
24. Gals. Filtr./Sq.Ft.	0.377	0.383	0.489	0.224	0.056
25. Gals. Filtr./Sq.Ft./Hr.	5.65	5.78	4.89	6.74	3.36
26. Wet Wt. Cake Edges	55	59	50	35	17
27. Lbs. Wash Water/Lb.	1.18	1.11	0.85	0.68	1.04
Dry Cake					
28. No. Wash Displacements	1.5	1.26	1.08	0.71	1.16
29. % Soluble in Cake	Samples submitted				
30. Filtration Rate					
Gals./Hr./Ft ² of Filtering	15.4	15.7	13.3	18.3	9.2
Area					

* Note: Test 5 gives no weight.

For digestion conditions see report, "Work Done at Yale, April 2 to May 10, 1945," Digestion XXII.

FEinc Test Data

Material: Barium Sulphate XXII

Date: 5-2-45

For precipitation conditions, see report "Work Done at Yale, April 2 to May 11, 1945," Digestion XXII.

	Test No. 1	Test No. 2
1. Temp. of Slurry	67	40
2. % Solids in Slurry	8.6	12
3. Filter Cloth	Clairtwil	Clairtwil
4. % Submergence	37.5	37.5
5. Vacuum		
Filtration	15	15
Initial Dewatering	15	15
Washing	21	21
Final Dewatering	21	21
6. R.P.M.	1/2	1/4
7. Time in Seconds		
Filtering	44	88
Before Rolling	6	13
Washing	32	64
Dewatering	16	32
8. Compression	O.K.	O.K.
9. Discharge from Cloth	Good	Good
10. Cake Thickness	1/8"	3/16"
11. Clarity of Filtrate	Fair	Good
12. Temp. Wash Water	42°	60°
13. C.C. Wash Water	278	280
14. C. C. Filtrate	884	900
15. Wet Wt. Cake	99 grams	130 grams
16. Dry Wt. of Cake	70 grams	98.2 grams
17. Water Removed	29 grams	31.8 grams
18. % Water in Cake	29.3	24.4
19. Dry Wt. lbs./sq.ft.	0.925	1.298
20. Lbs./sq.ft./hr.	27.7	19.5
21. Gals. Filtr./sq.ft.	1.40	1.43
22. Gals. Filtr./sq.ft./hr.	42.1	21.4
23. Wet Wt. Cake Edges	13	18
24. Lbs. Wash/lb. dry cake	3.50	2.50
25. No. of Wash Displacements	8.4	7.7
26. Soluble in Cake (%)	Samples submitted	

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FEinc Test Data

Material: Raffinate Precipitates

Date: 5-5-45

5-6-45

For precipitation data, see report, "Work Done at Yale, April 2 to May 11, 1945," Raffinate Precipitation.

Sample	221-34-RP	221-34-RP	222-35-RP	222-35-RP
Test	1	2	1	2
Temp. of Slurry	60°C	45°C	62°C	82°C
Per Cent Solids	18	18	12	12
Filter Cloth	Clairtwil	Clairtwil	Clairtwil	Clairtwil
Per Cent Submergence	50%	50%	50%	50%
Vacuum (in Hg)				
Filtration	15	15	15	15
Dewatering	15	15	15	15
RPM	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{1}{3}$
Time in Seconds				
Filtering	54	80	54	80
Dewatering	30	44	30	44
Discharge	Fair	Good	Good	Good
Cake Thickness	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{1}{8}$
Clarity of Filtrate	Good	Good	Good	Good
C.C. of Filtrate	120	100	185	135
Wet Wt. of Cake	39 gms	47 gms	44 gms	65 gms
Dry Wt. of Cake	17.4 gms	25 gms	25.9 gms	40.3 gms
% water in cake	55.5	46.8	59.0	62.0
Dry Wt. lbs./ft ²	0.23	0.33	0.34	0.53
Lbs./ft ² /hr.	6.9	6.6	10.2	10.6
Gals. Filtr./ft ²	0.19	0.16	0.29	0.21
Gals. Filtr./ft ² /hr.	5.70	3.20	8.70	4.20
Filtration rate				
Gals./ft ² of actual filtering area/hr.	12.7	7.2	19.3	8.1

Cake density calculated to be 80 lbs./ft³

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The cake discharges were for the most part good in these experiments which thus were not subject to the error introduced by cloth blinding.

Discussion

For the purposes of comparison, the average filtration rates for the Oliver and FEinc are tabulated by digestions.

Gangue—Average Filtration Rates

Digestion	XIX (1.3X)	XI (2X 70% + NaNO ₃)	XII (2.5X)
Oliver (gals./ft ² /hr.	1.06	2.6	2.1
rates (lbs./ft ² /hr.	0.25	8.5	10.7
FEinc (gals./ft ² /hr.	---	--	5.7
(lbs./ft ² /hr.	---	--	17.6

Here it will be noted that the FEinc leaf gave higher rates, which is to be expected since little clothing blinding was experienced.

Barium Sulphate—Average Filtration Rates

Digestion	XXI	XXII
Oliver (gals./ft ² /hr	9.2	6.4
Rates (lbs./ft ² /hr	1.5	5.5
FEinc (gals./ft ² /hr	--	31.7
Rates (lbs./ft ² /hr	--	23.6

Here again the rates on the Oliver are inferior to those obtained on the test leaf.

It is evident from the data presented that further experiments should be carried out using either a test leaf or a good Oliver. A second reason would be that the character of the precipitations and filtrations depend largely on the initial digestion conditions and subsequent precipitation conditions. In other words, the process should be fixed as far as digestion and precipitation conditions are concerned before reliable engineering data can be collected.

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An example of this will be found in comparing the filtration results for a 2X and a 1.3X digestion; the slurry from the 2X filtered about twice as fast as the 1.3X slurry.*

Data originally collected during the course of My experiments give some clue as to the effect of acid concentration. The data collected by Tomas and Tomocufik during the course of My researches provides an indication which should not be given much weight, since the object was My data, not filtration rates. Rates (gallons/ft²/hr) are tabulated for different digestion conditions.

Stoichiometric Equivalent of Nitric Acid

Conc. of HNO ₃ added	2.08 X	3.12 X	4.0 X
20%	0.74	0.72	0.96
30%	5.43	3.96	6.45
40%	3.31	4.77	6.15

This indicated that higher acid concentrations as well as greater amounts of acid favor filtration. This is in agreement with the observation that a 1.3X filtered more difficulty than a 2X digestion. A series of small scale experiments is underway at Yale to determine the effect of acidity and sodium nitrate upon gangue filtration rates.

Although washing was attempted on the Oliver, the results are not valid for large filters because the greater curvature of the small filter caused the water to run off the cake. This condition is not so serious in large drum sizes where the surface is relatively flat. Washing experiments were conducted on the FEinc apparatus, but the analyses are not available at this writing. Normally, filters of this type are capable of washing down to 1-0.5% soluble salts; for lower soluble salt contents, reslurrying is necessary.

On the advice of Mr. Kenney, of Oliver United Filters, attempts to use a rotary drum type filter for lead sulphate were abandoned. With a very dense material it is impossible to keep the solid phase in suspension by agitation without slushing the cake off the drum. This situation is aggravated by the small amount of solid phase present in the slurry (cicca 1%).†

* Note: See Engr. B. Progress Report, pp. 5-7.

† Note: For further information on handling lead sulphate see "Engineering B Data, Progress Report III."

The experiment on the raffinate precipitate was conducted merely to obtain a rough idea of the filterability of this material, which is comparable to that of gangue.

Since the cake formation and clarity were fairly satisfactory for both the gangue and barium filtrations, it is safe to conclude that both can be handled on rotary drum filters, despite the low filtration rate of the gangue.

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