UTILIZATION OF STEAM HOODS IN HORIZONTAL TABLE FILTERS

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ABSTRACT

One of the three horizontal table filters for product hydrate filtration was modified by installing a steam hood on the filter. Other modifications included changing the bridge-inserts in the filter valve in order to obtain a better vacuum distribution for longer drying time, and a stronger air blow-back.

Plant test were carried out in order to find the optimum steam rate to the hood based on its effects on the moisture and soda contents. It was found out that with a steam rate of about 0.0392 ton/m^2 of filtration area (2.0 t/h vapor) the moisture content decreased 16% while the soda recovery increased by 44%.

The results of the tests performed led to the installation of a second steam hood in another filter, obtaining results that corroborate those obtained in the first filter.

In addition to the improvements in terms of reduced cake moisture an soda content, the operation of the fluid bed LURGI calciners, located downstream from the filters, improved considerably with much stabler operation of the airlift used in hydrate transfer, reduced plugging tendencies in the underflow of the separating cyclones and better handling of oscillation in the filter feed.

INTRODUCTION

The appropiate filtration of alumina trihydrate prior to calcination is of capital importance, in order to produce the desired moisture and soda content (4). The residual moisture content is related to the drainage of liquor from the cake in the drying step of the filtration cycle, with the viscosity known to play an important role. The passage of steam through the filter cake, if properly applied, was expected to raise the temperature of both the cake and liquor, diminishing the liquid viscosity and increasing the deliquoring rate (5). The initial test showed that if steam was not properly applied, an excess of steam only produced a sudden vaporization of the entrained water moisture, which of course led to a drier cake, but no reduction in soda content was achieved (1). The term "soda content" as used in this report refers to only "soluble soda content in the hydrate", determined in the laboratory by washing the filter cake with hot distilled water.

The reduced soda content is imposed by stringent standards of Aluminium smelters, besides that, an improved soda recovery produces important money saving.

High moisture content in the filter cake adversely affects operation of the fluid bed calciners due to excessive pressure drop in the trihydrate elevator (Airlift) and causes cyclone plugging. Of course, high moisture content in the calciner feed, increases energy comsumption of the process due to the additional energy needed to vaporize the excess of water, the amount depending on the design and type.

EXPERIMENTAL

ORIGINAL FILTER SET-UP

The filter used is a 8.1 m diameter DORR OLIVER horizontal table filter (52 m^2 of filtration area) fitted as illustrated in Figure 1 with:

1.- Discharge Scroll

2.- Feed Dam

3.- Feed manifold consisting of six duck bill distributors covering the radius of the filter

4.- 1st wash sprays (recycled process condensate)

5.- 2nd wash sprays (Hot process condensate at 95 °C)

The cloth used is polypropylene monofilament with undercloth. Vacuum is provided by water ring SIEMENS ELMO-F 2BA pumps, giving a vacumm of about -0.5 bar, with a suction capacity of 4.5 m^3/m^2 min. Wash water flow is about 0.4 kg/Kg $Al(OH)_3$ and the recycled wash amounts to 0.30 Kg/Kg $Al(OH)_3$. The Filtrate temperature is 70 °C . The pan rotation is adjustable between 0.3 and 2 rpm by means of a hidraulic type drive variator (PIV) (3).

MODIFICATIONS

A steam hood spanning over a 90° angle was installed on the filter table, as shown in Figure 1, also the bridge-inserts in the filter valve were changed in order to provide a dead space under the steam hood, obtaining thus a better vacumm distribution for longer drying time, and a stronger air blow-back produced by changing the angle of blow-back from 4° to 6° by means of these same inserts.

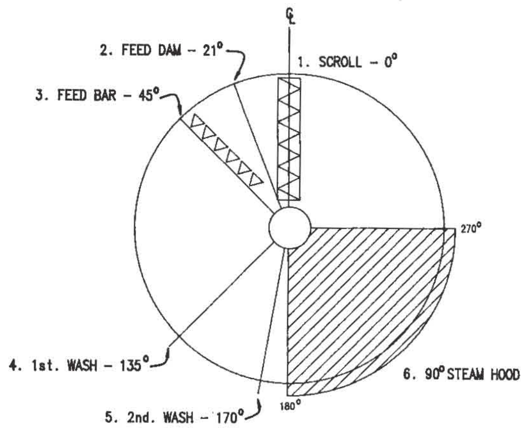

FIG 1. HORIZONTAL TABLE FILTER ARRANGEMENT

PLANT TESTS

The Plant tests were divided into two steps.

The first step consisted in finding out the optimum application of steam to the hood judged by the decrease of moisture and soda content in the filtered hydrate cake. The second step involved comparing the results obtained with the steam hood with those obtained without.

SERIES I TESTS:

The first series of plant tests were carried out as follows:

a) The steam flow was varied by opening the gate valve regulating flow to the hood, through various opening increments, until its maximum opening (0%, 25%, 50%, 85%, 100%). For each percentage of the valve opening, one (1) hour of filter stabilization was allowed before sampling the cake. Six (6) samples of hydrate cake were taken in the discharge of the scroll: 2 samples at the beginning of the sampling hour, two samples half hour after, and two samples at the end of the sampling period. All the collected samples, placed in sealed plastic bags, were immediately analysed in the plant laboratory for % moisture and % Na_2O soluble present in the product hydrate.

   A grand total of thirty seven (37) test were carried out for this series.

SERIES II TESTS:

The second series of plant tests were performed in the following manner:

a) The gate valve regulating steam flow to the hood was fully closed, and one (1) hour of filter stabilization was observed.

   After this stabilization period, a sample was taken in the discharge of the scroll, placed in a sealed plastic bag and sent to the laboratory for moisture and soda content analysis.

   This same procedure was followed for a valve opening allowing a flow of 2.0 t/h of steam to the hood, optimum flow rate found in the series I tests. A total of twenty (20) test were carried out at a rate of two tests per day (one with 0 t/h steam and the other with 2.0 t/h steam flowing to the hood).

b) As a way of monitoring the net effect of the steam hood by itself the following procedure was carried out: with the hood condition stable, with a 2.0 t/h steam flow to the same, a sample was taken just before the entrance to the hood (just after the second wash spray bar), and another at its exit.

   As in the other tests, the samples were placed in plastic bags and sent to the lab for analysis. Only a total of four (4) tests were done for this particular plant test; due to the potentially hazardous sampling mode that was needed in order to pick up the hydrate cake, and which involved getting close to the working filter, hot condensate spray bar and the steam hood itself.

RESULTS

SERIES I: OPTIMIZING STEAM APPLICATION

The operational conditions for the tests, as well as, the results of the laboratory analysis for moisture and soda content are presented in Table I. Figure 2 shows the plot of t/h steam vs % moisture (solid line), which indicates a sharp decrease in cake moisture with a increase of vapor flow to the hood, while the plot of t/h steam vs % soda (dashed line) shows that the soluble soda content also tends to drop with increasing steam rates but after about 5 t/h it raises to high values again; probably because the plug flow of steam through the cake, pushing out the water and soda adhered to the surface of the hydrate particles does not occurs, instead, the heat trasmitted by the high rate of steam only flashes away the water leaving the soda in the cake untouched (1). Both plots indicate that the best flow of steam to the hood for moisture and soda recovery lies between 1.0 and 3.0 t/h (1).

SERIES II: COMPARATIVE ADVANTAGE OF INSTALLING THE STEAM HOOD

Test conditions are presented in Table II, along with the relevant laboratory data. This data is rearranged in table III to directly quantify the relative advantage of steam aplication for each test in terms of moisture and soda reduction. Also, statistical analysis of the data is anexed to the same table. In spite to the experimental error included by the variation of test parameters (Table II) it can be observed that acceptable values for the standard desviation of the mean of

TABLE I - SERIES I EXPERIMENTAL CONDITIONS AND RESULTS OF THE EFFECT OF STEAM FLOW ON MOISTURE AND SODA CONTENT

VALVE OPENING	T/H STEAM	TEST No.	OPERATING CONDITIONS FOR TEST (FILTER): FEED DENSITY (Kg/m3)	1ST WASH FLOWRATE (m3/h)	2ND WASH FLOWRATE (m3/h)	PROCESSING RATE OF FILTER (T/H)	Na_2O IN FEED (g/l)	LAB RESULTS [2]: % Moisture	% Na_2O Soluble
0	0.00	1-6	1607	38	49	130	110	8.2	0.13
25	0.77	7-12	1617	38	49	134	110	8.4	0.07
50	2.70	13-18	1615	38	48	135	110	7.2	0.06
30	1.01[1]	19-24	1607	39	49	135	110	7.7	0.06
85	4.60	25-30	1650	38	38	130	111	5.9	0.06
100	> 5	31-37	1636	30	37	122	110	5.0	0.14

1 STEAM FLOW RESTRICTED FOR PERFORMANCE CHECK ON THE HOOD (NOT GRAPHED)

2 AVERAGE FOR ALL SAMPLES IN THE ROW

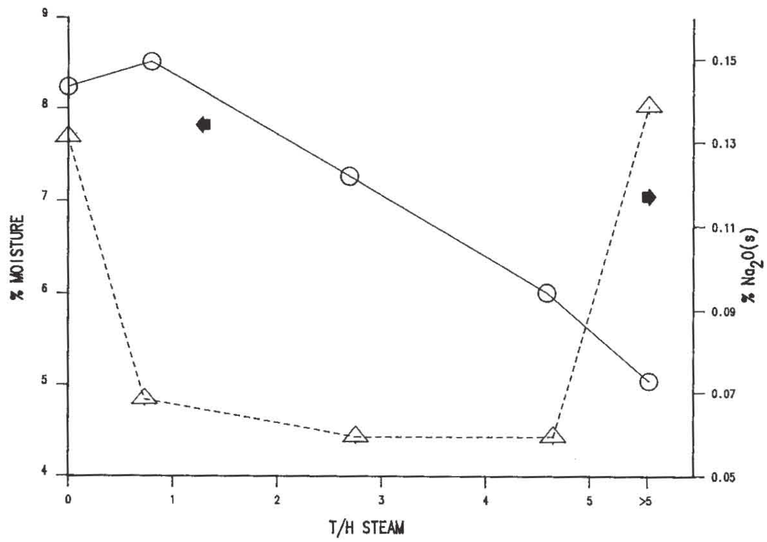

FIG 2. EFFECT OF STEAM FLOW ON MOISTURE AND SODA CONTENT OF TABLE FILTER CAKE (1st. SERIES).

the % moisture and % Na_2O soluble are found.

Figures3 and 4 show the results of the moisture and soda content variance with and without steam for each test.

A notable decrease in both parameters can be observed with the application of a steam flowrate of 2.0 t/h, optimum steam rate found in the first set of tests. As indicated in Tables II and III the last two set of tests were discarded from the data evaluation. This was due to a sudden drop in density from the slurry fed to the filter (1631 kg/m^3 to 1420 kg/m^3) and the processing rate of the filter (130 t/h to 115 t/h).

Table IV show the results for the samples taken before and after the steam hood working with a 2.0 t/h steam load; also are shown the percentage reduction in moisture and soda content from one sampling point to the other, as well as, the filter operating conditions for each sampling situation. The foregoing is presented graphically in figures 5 and 6, where it can be appreciated that the decrease in the % moisture and % Na_2O soluble content for the samples taken at the steam hood exit is considerably more than that would be expected without steam application (2).

IMPROVEMENT OF CALCINER OPERATION WITH STEAM APPLICATION TO FILTERS

A sampling of the airlift pressure and venturi I exit temperature variance against steam rates of 0 and 2.0 t/h being applied in the steam hood of the filter feeding fluid bed calciner no.1 is shown in table V. These values were taken during the series II tests from hourly averages presented by the process control computer TDC-4500. Figure 7 presents the airlift pressure variance against steam flowrates of 0 and 2.0 t/h being applied to the hood in the feed filter. It shows an important decrease in pressure drop when steam is being loaded to the hood (2.0 t/h) due to a drier trihydrate feed charge. Figure 8 confirms that

TABLE II- SERIES II EXPERIMENTAL CONDITIONS AND RESULTS OF THE EFFECT OF STEAM DRYING VS. AIR DRYING

		OPERATING CONDITIONS FOR TEST (FILTER)					LAB RESULTS	
TEST No.	T/H STEAM	FEED DENSITY (Kg/m^3)	1ST WASH FLOWRATE (m^3/h)	2ND WASH FLOWRATE (m^3/h)	PROCESSING RATE OF FILTER (T/H)	Na_2O IN FEED (g/l)	% Moisture	% Na_2O Soluble
1	0	1552	43.2	41.6	105	120	9.13	0.13
2	2.0	1552	43.2	41.6	105	120	7.29	0.09
3	0	1570	43.1	45.9	119	76	8.37	0.09
4	2.0	1585	40.8	38.0	122	76	7.95	0.08
5	0	1609	43.1	38.0	115	117	8.38	0.14
6	2.0	1508	43.1	37.4	105	117	6.95	0.04
7	0	1483	43.3	38.0	95	86	8.98	0.09
8	2.0	1475	43.3	38.0	89	86	7.18	0.07
9	0	1521	43.3	37.0	108	93	9.35	0.11
10	2.0	1499	43.3	41.0	113	93	7.84	0.06
11	0	1560	43.2	46.6	130	90	9.31	0.14
12	2.0	1553	43.0	46.0	126	90	8.48	0.07
13	0	1615	43.0	40.1	120	88	9.76	0.10
14	2.0	1615	43.0	40.1	118	88	7.47	0.04
15	0	1576	43.2	40.0	119	110	7.94	0.05
16	2.0	1615	43.2	45.0	129	110	6.64	0.03
17	0	1501	43.0	38.0	94	114	7.21	0.12
18	2.0	1519	43.2	41.0	88	114	6.16	0.04
19[1]	2.0	1631	43.2	44.8	130	120	7.02	0.09
20[1]	2.0	1420	43.2	41.0	115	120	7.00	0.05

1 Sample Results Discarded from Analysis due to sudden change in feed Density to the filter.

TABLE III - SERIES II % MOISTURE AND % Na_2O SOLUBLE REDUCTION WITH AND WITHOUT STEAM

	0 T/H STEAM		2.0 T/H STEAM			
TEST No.	% Moisture	% $Na_2O_{(s)}$	% Moisture	% $Na_2O_{(s)}$	% Moisture Reduction	% $Na_2O_{(s)}$ Reduction
1–2	9.13	0.13	7.29	0.09	20	31
3–4	8.37	0.09	7.95	0.08	5	11
5–6	8.38	0.14	6.95	0.04	17	71
7–8	8.98	0.09	7.18	0.07	20	22
9–10	9.35	0.11	7.84	0.06	17	45
11–12	9.31	0.14	8.48	0.07	9	50
13–14	9.76	0.10	7.47	0.04	24	60
15–16	7.94	0.05	6.64	0.03	16	40
17–18	7.21	0.12	6.16	0.04	15	67
19–20[1]	7.02	0.09	7.00	0.05	0.3	44
Number of values	9	9	9	9	9	9
Mean	8.71	0.108	7.329	0.060	16	44
Standard Deviation	0.80	0.029	0.707	0.019	5.798	20.337

1 Sample Results Discarded from Analysis due to Sudden Change in Feed Density to the filter.

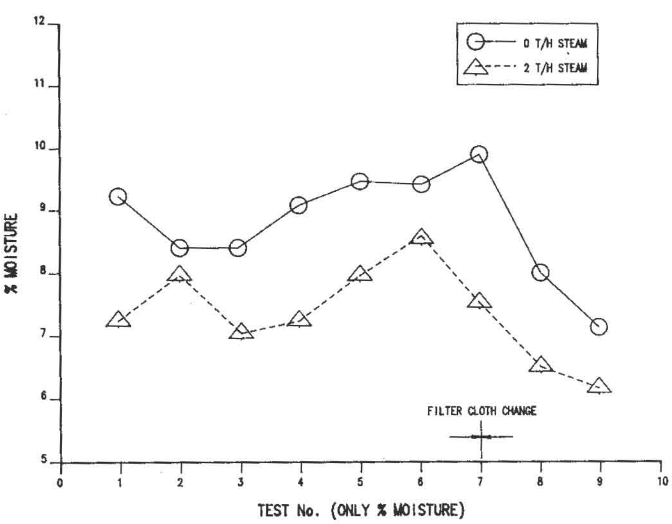

FIG 3. EFFECT OF STEAM DRYING ON MOISTURE CONTENT OF TABLE FILTER CAKE (2nd. SERIES)

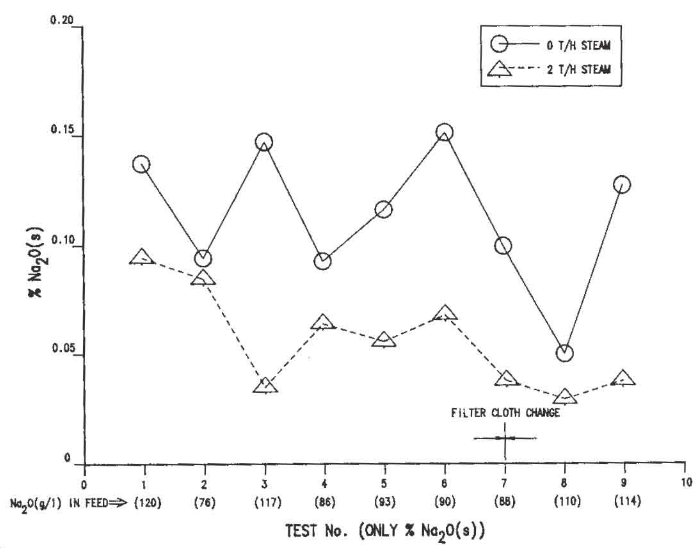

FIG 4. EFFECT OF STEAM DRYING ON SODA CONTENT OF TABLE FILTER CAKE (2nd. SERIES)

TABLE IV - SERIES II RESULTS FOR SAMPLES TAKEN BEFORE AND AFTER STEAM HOOD (@ 2 t/h STEAM)

TEST Nº	POSITION[1]	FEED DENSITY (Kg/m3)	OPERATING CONDITIONS FOR TEST (FILTER): 1ST WASH FLOWRATE (m3/h)	2ND WASH FLOWRATE (m3/h)	PROCESSING RATE OF FILTER (T/H)	Na2O IN FEED (g/l)	LAB RESULTS: % Moisture	% Na2O Soluble	% Moisture Reduction	% Na2O Reduction
1	B	1551	19	35	105	124	18.3	1.37		
1A	A						10.0	0.30	45	78
2	B	1481	17	34	105	122	28.8	2.58		
2A	A						10.0	0.46	65	82
3	B	1503	22	38	111	114	28.4	0.38		
3A	A						7.2	0.05	75	87
4	B	1576	12	34	100	114	19.9	0.96		
4A	A						7.4	0.10	63	90

1 B = BEFORE, A = AFTER

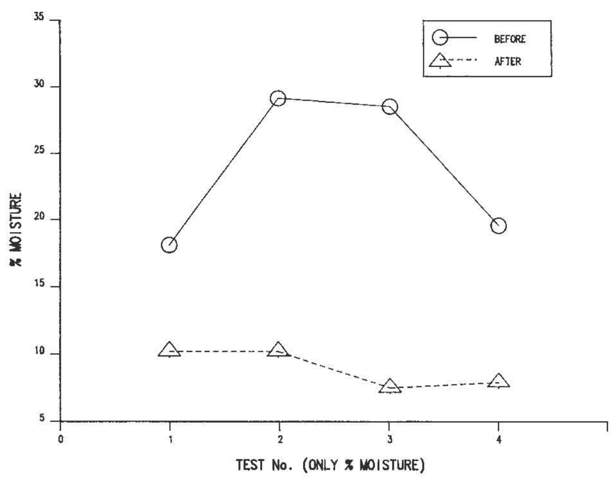

FIG 5. EFFECT OF STEAM DRYING ON FILTER CAKE MOISTURE CONTENT FOR SAMPLES TAKEN BEFORE AND AFTER THE STEAM HOOD (@2T/H STEAM)(2nd SERIES)

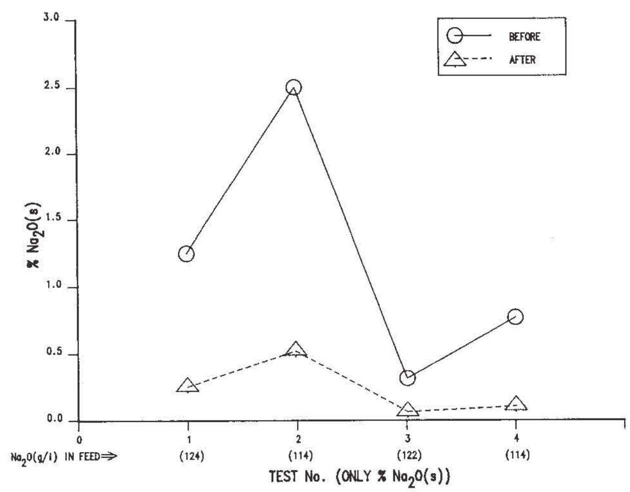

FIG 6. EFFECT OF STEAM DRYING ON FILTER CAKE SODA CONTENT FOR SAMPLES TAKEN BEFORE AND AFTER THE STEAM HOOD (@2T/H STEAM)(2nd SERIES)

for a drier hydrate charges, the product of applying 2.0 t/h of steam to the filter hood, the venturi I exit temperature tends to rise, due to the less water that the incoming hot gas flow must vaporize (2).

This positive variation of the airlift and venturi I is similar to that observed in the first tests, but not reported in detail (1). The main benefits of the lower moisture cake fed to the fluid bed calciners seems to be operation wise because, as reported by plant operators, it allows them to counter sudden changes in feed density and flowrate, increasing and/or maintaining the charge rate of the feedscrews to the calciner in periods when a high alumina production is desired, being a limiting factor the airlift pressure, which shuts down the calciner at a 14% moisture content in the feed (overloading moisture content equivalent to about 450 Mbar) (1). In rotary calciners, with a lower heat exchange capacity between gases and solids, a lower feed moisture could signify very im-

TABLE V - VARIATION OF AIRLIFT PRESSURE AND VENTURI I EXIT TEMPERATURE

TEST Nº	T/H STEAM	AIRLIFT PRESSURE[1] (Mbar)	VENTURI I[1] TEMPERATURE (°C)
1	0	396	190
1A	2.0	350	205
2	0	410	170
2A	2.0	390	186
3	0	340	190
3A	2.0	290	230
4	0	350	190
4A	2.0	330	215
5	0	341	200
5A	2.0	330	210

1 FROM PROCESS COMPUTER TDC-4500

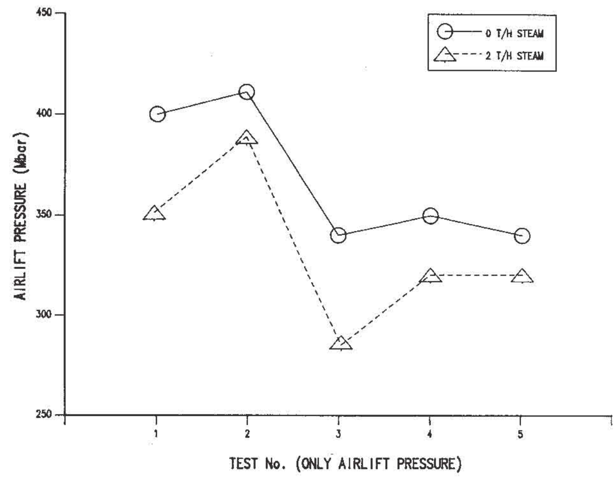

FIG 7. EFFECT OF STEAM DRYING ON AIRLIFT PRESSURE DROP (CALCINER No.1)

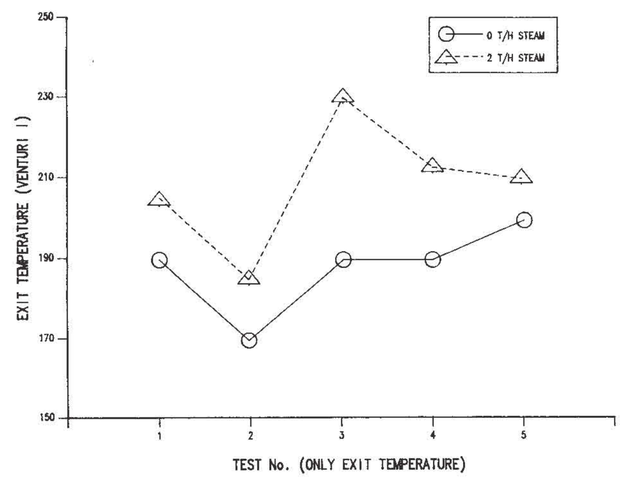

FIG 8. EFFECT OF STEAM DRYING ON EXIT TEMPERATURE OF VENTURI I (CALCINER No.1)

portant energy savings. As said before, a high moisture content in the trihydrate will require additional fuel, needed to vaporize this excess moisture.

CONCLUSIONS

The results of this study allows for the establisment of the following conclusions:

1.- The % moisture content in the filter cake tends to drop as the steam flow to the hood is increased.

2.- The % Na_2O soluble also diminishes as the steam load to the hood is increased but above 5 t/h steam flow the soda content tends again to raise, due to the "flash" effect already explained in the results section of this study.

3.- The best results of reduction in moisture and soda content are produced at steam flowrates to the hood between 1 and 3 t/h.

4.- The use of the steam hood in the table filter with a steam rate of 2.0 t/h helps to keep the % moisture and % Na_2O (s) parameters close to the target values of 7% and 0.04%, respectively, specially in front of the variability of such feed parameters as density and soda content of the feed slurry.

In INTERALUMINA, the results of the plant tests carried out in filter No. 1 have led to the installation of a second steam hood in filter No. 2, where ongoing plant tests corroborate the results found for the first filter. Moreover, a third hood will be installed in the third filter, while the two new table filters being installed for the ongoing plant expansion will also have steam hoods on them.

5.- Conclusively, the application of steam hood in the table filters, by effect of reduced feed cake moisture, improves the operation of the airlift pot in the LURGI calciners reducing greatly its working pressure.

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