Optimisation Studies on a Venemark Apparatus

L. N. Chowdhary

Introduction

Venemark apparatus is a valuable piece of equipment for the recovery of H_2S in the gases from the last effect of a multiple effect evaporator system in a kraft mill. The vapors from the last effect go to a condenser and the non condensible gases are vented to atmosphere either by a jet ejector or a vacuum pump. These gases contain foul smelling sulphur gases. Part of sulphur in these gases can be recovered and can be used to improve the over all sulphur balance of the kraft cycles. This system should gain importance in our Indian conditions because of chronic sulphur shortage and the dwindling supplies and price increase of sodium sulphate every day.

Most of the Indian kraft mills have high sulphur losses compared to sodium losses in the kraft recovery cycle with the result that sulphur bearing makeups are needed in greater quantities. Caustic makeups also deplete the sulphur sources. If sulphur losses are minimised/or recovered somehow then this will go a long way in meeting the twin demands of air pollution abatement and sulphur make up in cycle at a very reasonable cost. Most of the Indian mills which have stationary tapping type of recovery furnace suffer due to low sulphidity liquors. The melting point of smelt is high if sulphidity is below 20–25%. Lower sulphidity has resulted in frequent stoppages of smelt and consequent cleaning of air ports and smelt holes. This has its own hazards. Recovery of sulphur will help in maintaining sulphidity levels.

Essentially Venemark apparatus is very simple technique to recover H_2S by spraying weak white liquor on the gases from last effect of multiple effect evaporator system prior to its going to condenser. Details vary from plant to plant and their layout. Mr. Venemark has made a claim of recovery of 4 Kg. sulphur per ton of air dry pulp. The present study was undertaken to optimise the working of this equipment with a view to get maximum sulphur recovery and find out the important operating variable on which this depends. The studies were conducted by the author in the kraft mills of OY Wilhalm Schaumann AB. Pietarsaari, Finland during the winters of 1967/68.

The problem was studied from the angle of temperature dependence of the system. Initially the temperature of weak white liquor going into the sprays was 56.5°C which was considered to be high. It was considered that a flash over is taking place with the shower of W.W.L. at the operating vacuum. Since a heat exchanger could not be made available for chilling the W.W.L. a cold water line was laid to the delivery of the pump which fed W.W.L. to the Venemark showers. The water line had enough pressure so that the temperature of W.W.L. mix could be varied between a desired limit. But this system had a great disadvantage because of the fact that as sodium concentration came down, the recovery of H_2S also became low.

Experiment

In series I of the experiment the W.W.L. going to Venemark and coming out of it were determined for total sodium. Along with this such shift operating data were also noted like i) Steam to I effect. ii) Dry solid contents of Inter and thick liquor. iii) Quantity of water to condenser. iv) Outlet water temp. from condenser v) Raw water temp. vi) W.W L. rotameter to Venemark sprays. The amount of W.W.L. was varied from 22 l/m to 68 l/m.

In series II of the experiments the flow of cooled W.W.L. was kept in certain range and the temperature was varied.

In the analysis of liquors before and after Venemark apparatus the total alkali was determined as Na_2SO_4/litre by flame photometer. The total sulphur was determined as Na_2S/litre by Colorimetric method. For the determination of recovered sulphur, it was necessary to know the amount of dilution the W.W.L has undergone due to

L. N. Chowdhary,
Soda Recovery Supdt.,
Star Paper Mills Limited,
Saharanpur.

condensible gases in the gas stream. This dilution factor was determined by the amount of sodium in ingoing W.W.L. to the amount of sodium in the outgoing sulphur laden liquor from thc Venemark. It will be appreciated that no sodium is being added to the system by this treatment. So by the increase in the quantity of Na_2S in the outgoing liquor sulphur recovered can be calculated as enumerated in the tables 1, 2 & 4.

Table 1

Average Recovered Sulphur
Recovered S as Na_2SO_4

Date	Kg Na_2SO_4 / day	Kg Na_2SO_4 / Ton of A. D. Pulp.	W.W.L. 1/min.	Raw water temp. in condenser inlet °C.
24.8.67	1850	5.3	22	16.5
26.9.67	2895	5.4	42	12.0
6.11.67	1960	3.4	46	6.0
28.11.67	860	1.4	45	3.0
29.11.66	722	1.1	46	1.0
30.11.67	625	1.0	62	1.0
12.12.67	665	1.2	65	1.0

Results

i) The temp. of the liquor which is being sprayed should be as equal to the vapour temperature as possible or even lower than the vapour temperature. For optimum conditions it is necessary that W.W.L. should be cooled without dilution.

ii) A higher amount of alkali in W.W.L. is better for sulphur recovery.

iii) Bigger quantities of W.W.L. create unbalance in the system. A liquor flow of around 30 1/min gives a good recovery.

iv) Nozzles of wide solid angle should be used for better performance.

v) After all this is a problem of mass transfer, and to achieve a better mass transfer co-efficient the flow of liquor, gas velocity and reaction time are the most important variables. Gas velocity is solely

Series I Table 2

Date	Time	Weak white liquor			Liquor after		Venemark		Recovered Sulphur as N_2SO_4			Tons
		Rotameter 1/min.	Na_3SO_4 9/1 (a)	Na_4S 9/1 (b)	Na_3SO_4 9/1 (c)	Dilution factor (a/c)	Na_2S measured 9/1(c)	Determined Na_2S 9/1 (a/c) x (d)	9/1	Kg/ day	Kg/ton of A.D. pulp	Air dry Pulp production/ day.
14.12.	10 40	68	85	13.9	34	2.50	6.7	16.8	5.3	525	0.9	570
14.12.	13.40	45	77	14.5	18	4.27	5.0	21.4	12.6	815	1.4	570
15.12.	9.25	46	96	14.4	39	2.46	10.6	26.1	21.3	1410	3.1	450
16.12.	10.45	62	72	10.0	32	2.25	6.6	14.8	8.6	780	1.5	510
18.12.	10.15	49	91	14.2	32	2.89	7.4	21.0	12.4	875	1.8	480
18.12.	13.20	30	87	13.0	18	4.83	5.3	25.6	22.9	990	2.1	480
19.12.	9.00	30	90	10.7	18	5.00	4.6	23.0	22.4	970	1.9	510
19.12.	12.45	41	90	12.6	30	3.00	4.8	14.4	3.3	195	0.4	510
20.12.	10.30	30	88	13.7	18	4.88	5.5	26.8	23.8	1030	2.0	510
20.12.	10.20	22	95	14.0	10	9.50	4.0	38.0	43.7	1385	4.6	300
8.1.	9.30	35	118	13.4	25	4.73	7.0	33.0	35.7	1800	3.8	480
9.1.	10.10	34	138	30.7	40	3.45	17.4	60.1	53.5	2130	5.2	510

Shift operating details Series I Table 3

Date	Time	Steam t/h	Dry content Inter liquor %	Thick liquor %	I condenser Top Ton/hr.	Section Outgoing water temp °C	Bottom Ton /hr.	Section Outgoing water temp. °C	II Condenser Top Ton/hr.	Section Outgoing water temp. °C	Bottom Tons/hr.	Section Outgoing water temp. °C	III Condenser Tons/hr.	Outgoing water temp. °C
14.12.	10.40	41.0	33.4	59.0	123	45	—	49	120	45.5	120	41	117	29
14.12.	13.40	41.0	33.6	58.8	122	46	—	50	118	46	120	42	123	28
15.12.	9.25	44.0	33.3	59.0	115	48	—	51	112	48	112	45	143	22
16.12.	10.45	36.5	32.4	59.0	95	48	—	47	98	48	97	44	142	27
18.12.	10.15	38.0	32.4	59.0	105	46.5	—	46	93	46	98	42	148	26
18.12.	13.20	38.5	32.4	59.0	105	47	—	46	93	48	98	44	150	25.5
19.12.	9.00	38.5	33.4	59.4	105	47	—	46.5	92	48	98	42	150	25
19.12.	12.45	38.0	33.4	59.2	105	46	—	46	93	48	97	44	152	25
20.12.	10.30	33.5	33.3	59.4	92	47.5	—	48	92	48	75	46.5	150	26
21.12.	10.20	38.0	33.3	59.0	90	51	—	51	90	50.5	75	50	150	28
8.1.	9.30	30.5	34.2	59.6	77	51	50	50.5	80	50	50	50	143	28
9.1.	10.10	35.0	34.6	59.6	115	44	80	42	115	43	92	42	50	36

Series II Table 4

Date	Time	W. W. L. Before dilution Na_2SO_4 9/1	After dilution Na_2SO_4 9/1	Dilution Co-efficient	Rotameter reading 1/min.	Temp °C	Na_2S 9/1	Liquor after Vanemark Na_2SO_4 9/1	Dilution factor	Na_2S measured 9/1	Determined Na_2 9/1	Recovered sulphur as Na_2SO_4 9/1	Kg/day	Kg/ton of A.D. pulp	A. D. Pulp production/day
12.1.	12.40	93	72	1.29	56	46.5	15.0	40	1.80	14.0	25.2	18.6	1500	2.6	570
15.1.	9.95	80	78.5	1.02	57	51.5	20.4	41	1.91	17.3	33.1	23.1	1895	3.1	615
23.1,	9.30	88	75	1.17	46	46	11.7	36	2.08	10.0	20.8	16.6	1100	2.4	465
23.1.	10.00	88	61	1.44	45	40	9.0	30	2.03	8.0	16.2	13.1	850	1.8	465
24.1.	9.30	95	72	1.32	55	40	12.0	42	1.71	10.0	17.1	9.3	810	1.6	495
24.1.	10.30	95	91	1.04	44	50	15.7	42	2.16	10.7	23.1	13.5	855	1.7	495
25.1.	8.45	95	90	1.05	55	49.5	14.3	52	1.73	12 0	20.8	11.8	950	1.9	510
25.1.	9.15	95	75	1.27	45	40	11.3	36	2.08	8.6	17.9	12.0	780	1.5	510
26.1.	9.30	72	50 5	1.42	45	34.5	8.0	21	2.40	7.3	17.3	17.3	1120	2.6	435
26.1.	10.30	72	54	1.33	55	35.5	9.6	24	2 25	8.6	19.4	17.8	1410	3.2	435

Table—5
Shift operating details Series II

Date	Time	Steam to 1 effect	Dry % Inter liquor	Content % Thick liquor	I Condenser Top section Ton/hr.	Water Outgoing temp.°C	Bottom Section Ton/hr.	Water outgoing temp.°C	II Condenser Top Section Ton/hr.	Water Temp. outgoing °C	Bottom Section Ton/hr.	Water Temp. °C outgoing	III Condenser Ton/hr.	Outgoing water temp.
12.1	12.40	39.5	34.0	59.2	120	44	112	41	118	44	104	40.5	50	26
15.1	9.45	36.0	34.5	59.2	115	42.5	95	41	112	42	97	40	50	36
23.1	9.30	37.5	34.6	59.2	120	42	102	40	115	42	100	40	30	40
23.1	10.00	37.5	34.6	59.2	120	42	102	40	115	42	100	40	30	40
24.1	9.30	32.0	34.0	59.6	110	42	100	39	110	41	100	39	30	37
24.1	10.30	32.0	34.0	59.6	110	42	100	39	110	41	100	39	30	37
25.1	8.45	33.5	34.6	59.4	112	42	87	40	110	41	95	40	37	33.5
25.1	9.15	33.5	34.6	59.4	112	42	87	40	110	41	95	40	37	33.5
26.1	9.30	36.5	34.3	59.2	120	42	85	41	118	42	95	40	37	36.5
26.1	10.30	36 5	34.3	59.2	120	42	85	41	118	42	95	40	37	36.5

guided by the operating conditions of the evaporator plant. For better results bigger reaction time should be provided and this can be achieved by staggering the nozzles. Also the nozzles should not be too near to the condenser inlet.

Conclusions

This is rather a very simple piece of equipment and can be installed at a relatively little cost in most of the evaporator systems in the kraft mills. The benefit obtained in terms of sulphur recovery and pollution abatement justify its application.

The author wishes to acknowledge its deep gratitude to the management of OY Wilhalm Schaumanu AB. Finland, for conducting these trials at their work and permission to publish these results.