Retrofit of Evaporator Plant And Free Flow Falling Film Evaporator At Star Paper Mills Ltd.

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ABSTRACT

Star Paper Mills is among the leaders in Paper Industry producing 53,500 tonnes of Writing, Printing & Packaging grades of quality paper/ annum. The existing evaporator plant in Soda Recovery was supplied by Ernest Scott for 90 T/day of paper production. In 1972 the capacity of Evaporator plant was further increased by introducing Forced Circulation Concentrator. The total water Evaporation capacity was increased to 40 T/hr. with 52% B.L. Solids outlet concentration. This was just sufficient to meet the present pulp production. By introducing a concentrator with LTV, the overall steam economy had come down drastically to 3.2 besides Heavy power consumption. As we are going in for 180 T/day production level, there was need for complete retrofitting of Evaporator Plant and also installing one FFFF Concentrator.

INTRODUCTION

Star Paper Mills Ltd. is among the pioneers in the Paper Industry in the country. It has commenced its production activities way back in 1938 with 480 tonnes, mostly of writing and printing paper at Saharanpur in the foothills of Sivalik range of Western U.P. The unabated journey with ups and downs continued all these years and it has attained its present prestigious position by producing 53,500 tonnes of finished paper/annum of Superior quality product of writing, printing & packaging grades of paper.

General description of Evaporator Plant:

The Chemical Recovery Plant at Star consisted mainly five bodies LTV Evaporators supplied by ERNEST SCOTT of U.K. & commissioned in 1961 for 90 T/day of paper production. There were five bodies of LTV Evaporators followed by a surface condenser. In 1972 the capacity of Evaporator Plant was further increased by introducing Forced Circulation Concentrator supplied by Perton Scott, Faridabad. The five bodies LTV Evaporators were followed by Forced Circulation Concentrator. There were 3 Nos. of external preheaters. The W.B. Liquor feed was entering third body in quintiple effect evaporator plant and the sequence of Liquor flow was PH_1-III-IV-V-PH_2-PH_3-II-I-FE. During 1988-89, a new higher capacity surface condenser with M.S. tubes was added with 430 M^2 heating surface.

Retrofitting of Evaporator Plant

1. Need for Retrofitting of Evaporator Plant:

After introduction of Forced Circulation Concentrator and New Surface Condenser with M.S. tubes, the total water evaporation capacity was 40 T/hr. with outlet concentration of 52 to 54% B.L. Solids. This was just sufficient to meet out the present pulp production. The introduction of Forced Circulation Concentrator and LTV separately in LTV Street had led to overall steam economy coming down to 3.2 besides there was heavy power consumption in forced circulation concentrator.

Major constraints in Evaporator Plant before Retrofitting

1. The overall steam economy achieved from Evaporator plant was 3.2 only.

2. The Black liquor carry over from Evaporator was high due to lower vapour space and duct size. The water coming out of surface condenser tail pipe was slightly coloured and foamy.

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3. The black liquor heaters were not at appropriate places according to liquor flow sequence. Moreover, the heater capacity was also very low and steam was being used separately for heating.

4. The liquor flow sequence in Evaporator Plant was PH_1-III-IV-V-PH_2-PH_3-II-I. Even by introducing two liquor heaters in series in between V effect to II effect the preheated liquor temp. was around 15 to 20 °C less than the boiling point of II effect. This was resulting in inefficiency of II LTV which was partially working as both liquor heater and Evaporator.

5. The surface condenser was of M.S. tubes resulting of frequent choking of tubes with dirt and loose scale and also puncturing of tubes. This was leading to downtime for its cleaning and maintenance.

6. There were no entrainment separators in LTV side.

7. All non condensable vapours were going to surface condenser resulting in fouling of surface condenser tubes from vapour side.

The details of Evaporator Plant before Retrofit are as follows:

As we are going in for a new 300 T.D.S. Recovery Boiler and also to increase the production level to 180 T/day, it was decided to go in for complete retrofit of Evaporator Plant. The major changes needed was an extra Evaporator Body and rebuild of Evaporator Plant. For the rebuild of Evaporator Plant, ENMAS Process Technologies Pvt. Ltd. were contacted for supplying a Free Flow Falling Film (FFFF) Concentrator and also for required modifications.

Table-1

Unit	Material of Construction	Heat Transfer Area
I effect	S.S	493 M^2
II effect	S.S	495 M^2
III effect	Carbon steel	538 M^2
IV effect	-do-	538 M^2
V effect	-do-	538 M^2
F.E. Callandria 1, 2	S.S	152 M^2
Old Surface Condenser	S.S.	370 M^2
New Surface Condenser	S.S.	430 M^2
Preheaters (Liq. heaters)	M.S.	13 M^2 each

Major Modifications done in Evaporator Plant

1. In the first stage all the dummied (or blanked) tubes in Evaporator bodies I & II were removed and replaced with new tubes to increase the heating surface and also to create additional evaporation capacity. The heating surface of both bodies was restored to 538 M^2.

2. Top pan on vapour space of IV & V Body LTV were increased by 2 Mt. in height to cope up with increased evaporation load. Thus the vapour space in two bodies was increased.

3. The tubes in New Surface condenser were replaced by S.S. tubes. This had to be done as there was huge scaling in M.S. tubes and also due to corrosive nature of tube material. The tubes were getting punctured frequently.

4. The vapour duct size in between Evaporator bodies was increased.

5. All the three steam preheaters for Black liquor were replaced by three New Liquor vapour heaters each having 30 M^2 heating surface. The Black liquor in these heaters were heated by vapours generated from L.T.V.

6. Pumps sizes at different stages were changed with that of higher capacity & efficiency.

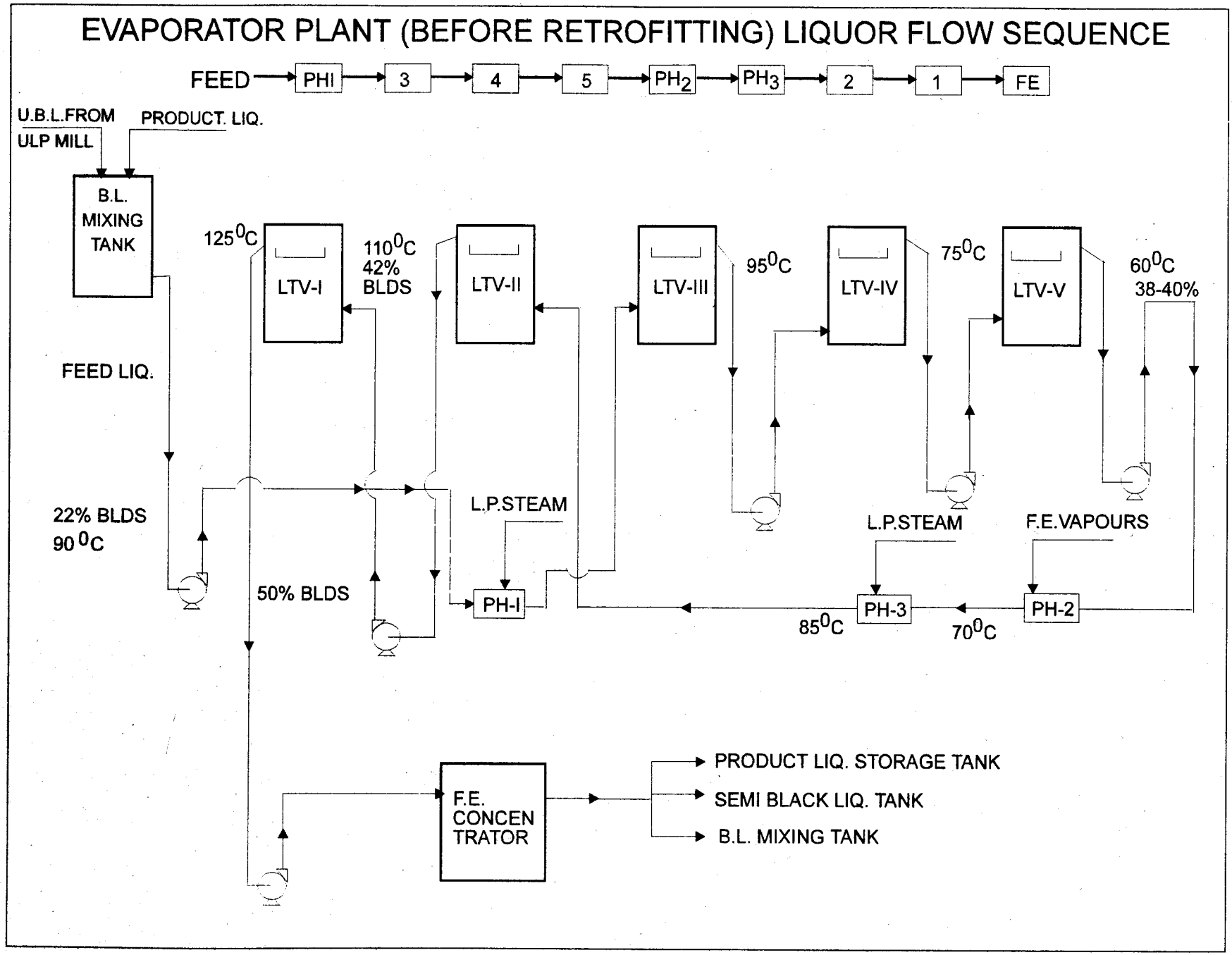
7. Entrainment Separators were provided in each effects of LTV Evaporators.

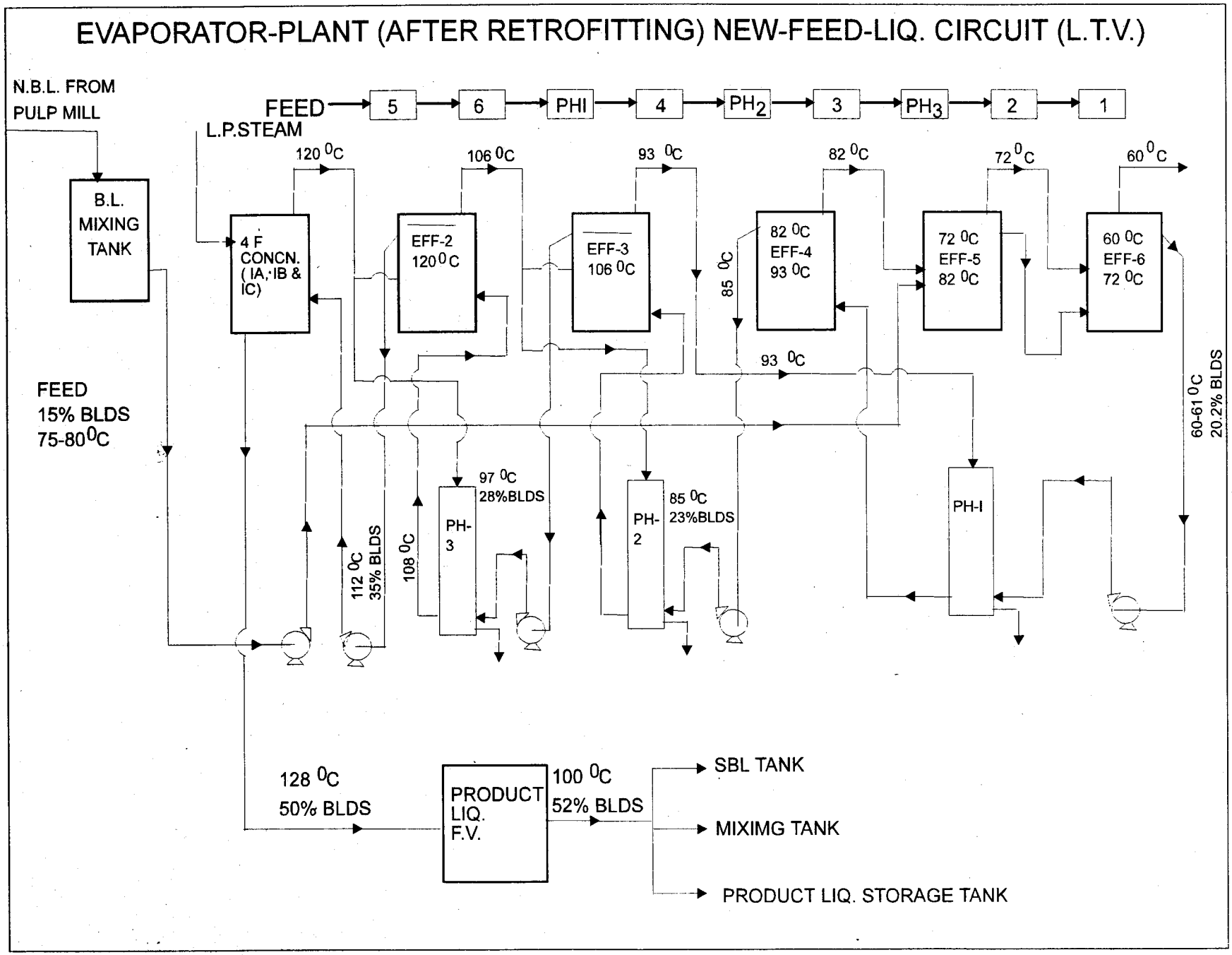
8. Two New Booster pumps have been installed for increasing the water flow to surface condenser. By this water flow to surface condenser will be increased from existing 450 M^3/hr. to 650 M^3/hr.

9. One FFFF Concentrator was installed having 3 bodies with circulation pumps.

10. Complete New ejector system for vacuum with pre and after condenser were installed.

11. Complete New non-condensable lines with orifice control were laid for discharge directly to ejector system.


EVAPORATOR PLANT (BEFORE RETROFITTING) LIQUOR FLOW SEQUENCE
FEED
PHI
3
4
5
PH2
PH3
2
1
FE
U.B.L.FROM ULP MILL
PRODUCT. LIQ.
B.L. MIXING TANK
125⁰C
LTV-I
110⁰C 42% BLDS
LTV-II
LTV-III
95⁰C
LTV-IV
75⁰C
LTV-V
60⁰C 38-40%
FEED LIQ.
22% BLDS 90⁰C
50% BLDS
L.P.STEAM
PH-I
L.P.STEAM
F.E.VAPOURS
PH-3
PH-2
85⁰C
70⁰C
F.E. CONCEN TRATOR
PRODUCT LIQ. STORAGE TANK
SEMI BLACK LIQ. TANK
B.L. MIXING TANK


EVAPORATOR-PLANT (AFTER RETROFITTING) NEW-FEED-LIQ. CIRCUIT (L.T.V.)
N.B.L. FROM PULP MILL
FEED
5
6
PHI
4
PH2
3
PH3
2
1
L.P.STEAM
120 0C
106 0C
93 0C
82 0C
72 0C
60 0C
B.L. MIXING TANK
4 F CONCN. (IA, IB & IC)
EFF-2 120 0C
EFF-3 106 0C
85 0C
82 0C EFF-4 93 0C
72 0C EFF-5 82 0C
60 0C EFF-6 72 0C
93 0C
60-61 0C 20.2% BLDS
FEED 15% BLDS 75-80 0C
97 0C 28%BLDS
PH-3
112 0C 35% BLDS
108 0C
PH-2
85 0C 23%BLDS
PH-I
128 0C 50% BLDS
PRODUCT LIQ. F.V.
100 0C 52% BLDS
SBL TANK
MIXIMG TANK
PRODUCT LIQ. STORAGE TANK

12. New Secondary condensate header with level controlled was provided.

13. New Primary condensate system was provided with level and conductivity controller.

14. New Product liquor flash vessel vapours were connected to LTV side.

Evaporator Plant after Retrofit

The Evaporator plant after retrofit is 6 effect plant. The capacity of Evaporation Plant is 59.3 T/hr. water evaporated with strong liquor leaving the concentrator at 52%, feed to evaporator being 15%. The steam economy to be achieved from evaporation plant will be about 5.0. From 52%, the strong Black liquor will be further concentrated to 65% in Cascade Evaporator when New Recovery Boiler will be commissioned.

Free Flow Falling Film Evaporator

The free flow falling film evaporator operates on the falling film principle. By means of circulation pump, the liquor circulates on the outside of the heating surface upto a liquid distributor located above heating elements. The liquor flows over the edge on both sides of the heating elements, falls and forms a film covering the entire heating surface. Due to the curved nature of the heating surface, it causes wetting of heating surface at all times thereby increasing the area of contact between the black liquor and the heating surface and also increasing the rate of evaporation.

The flow pattern after the retrofit in Evaporator Plant is as follows:

Liquor flow

Weak black liquor is first fed to V effect and then to VI effect by pressure difference (flows due to gravity) between the bodies thereby eliminating the transfer pump between the bodies. From VI effect, liquor flows to IV effect through a liquor heater and then to III and II effect with a liquor heater before both III and II effects. From II effect, the liquor is fed to new concentrator i.e. FFFF Evaporator. The New FFFF Concentrator has 3 bodies. The liquor from A body goes to B body and then to C body. This flow between the bodies is by gravity and also due to difference in concentration in each body. The sequence of these bodies can be changed after certain time interval.

Steam flow

The live steam is fed to the 3 bodies of new FFFF Concentrator which is working as I effect and subsequently the other effects i.e. LTV are using secondary vapours released from liquor and escaping through entrainment separators. These vapours cascade through the effects before getting condensed in condenser after 6th effect.

The details of FFFF Concentrator and Evaporator plant after retrofit are as follows:

PERFORMANCE AFTER RETROFIT AND OUR EXPERIENCE WITH FFFF

The six effect evaporator plant after complete retrofit was started and commissioned on 22nd Feb., 1997 and after about 4 to 5 hrs. of running, the plant was fully stabilised. As our new 300 TDS Recovery Boiler has still not been commissioned, the six effect

Table-2

FFFF & Evaporator Plant After Retrofit

Free Flow Falling Film Evaporator:		
Heating Surface	:	385 M^2 of each body
Heating element	:	22
Material-Body	:	Carbon steel
Lamella	:	SS-2333-28
Liquor Preheater	:	
Heating surface	:	30 M^2
No. of tubes	:	42
Material tube	:	SS-304 L
Shell	:	Carbon steel
LTV Evaporators	:	
Heating surface	:	538 M^2
Material tube	:	S.S. for I & II body Carbon steel for III, IV & V body.

Table-3

Capacity of Six Effects Evaporator Plant

Total water evaporation	:	59 T/hr.
Weak black liquor	:	83.3 T/hr. 15% T.S. at 80°C
Live steam	:	2.5 kg/cm^2
Live steam flow	:	11.9 T/hr.
Cooling water	:	645 T/hr. Inlet 35 °C, Outlet 45 °C
Strong Liquor	:	24 T/hr. 52% T.S. at 100°C
Steam economy	:	5.0

Table-4				
Savings in Evaporator Plant After Retrofit				
1.	Feed to Evaporator	(TPH)	8O	77
2.	Inlet concentration	%	24	22
3.	Outlet concentration	%	52	56
4.	Product wt.		36.92	30.25
5.	Water Evaporation	(TPH)	43.08	46.75
6.	L.P. Steam consumption	(TPH)	13.46	9.54
7.	Steam economy		3.2	4.9
8.	L.P. Steam consumption (Based on 3.2 steam economy)		-	14.60
9.	Savings in L.P. Steam	(TPH)	-	5.06
10.	L.P. Steam saving/month	(Based on 30 days)	-	3643
11.	Equivalent coal saving (Saving based on 5.44 T/T of coal)		-	670 Tons
12.	Savings in Coal (Cost of coal Rs. 2145/- per ton)		-	14.37 lacs
13.	Loss in Co-generation due to reduction in L.P. Steam consumption:			
i)	L.P. Steam savings	(TPH)	-	5.06
ii)	Loss in Captive Power from L.P. Extraction Kwh/T		-	55.6 KWH
iii)	Total loss in power Kwh		-	281.0
iv)	Cost of own generated power from L.P. Steam	(Rs.)	-	0.30/KWH
v)	cost of UPSEB Power	(Rs.)	-	3.55/KWH
vi)	Loss in Cogeneration	Rs. lacs	-	6.57
14.	Savings in Power	Kwh/day	-	1500
15.	Savings/month	Rs. lacs	-	3.51
16.	Net Savings/month (12-13 vi + 15)	Rs. lacs	-	11.31

evaporator plant is not running upto its full capacity. At present we are feeding the evaporator plant with black liquor at 20-22# and are taking strong liquor FFFF Concentrator at about 56-58%.

Although the plant was stabilised within a very short time of start-up, we had to face some minor problem initially such as:

1. Contamination of secondary condensate which was investigated and traced up to tube leakage of liquor heater. This heater was isolated for tube repairing.

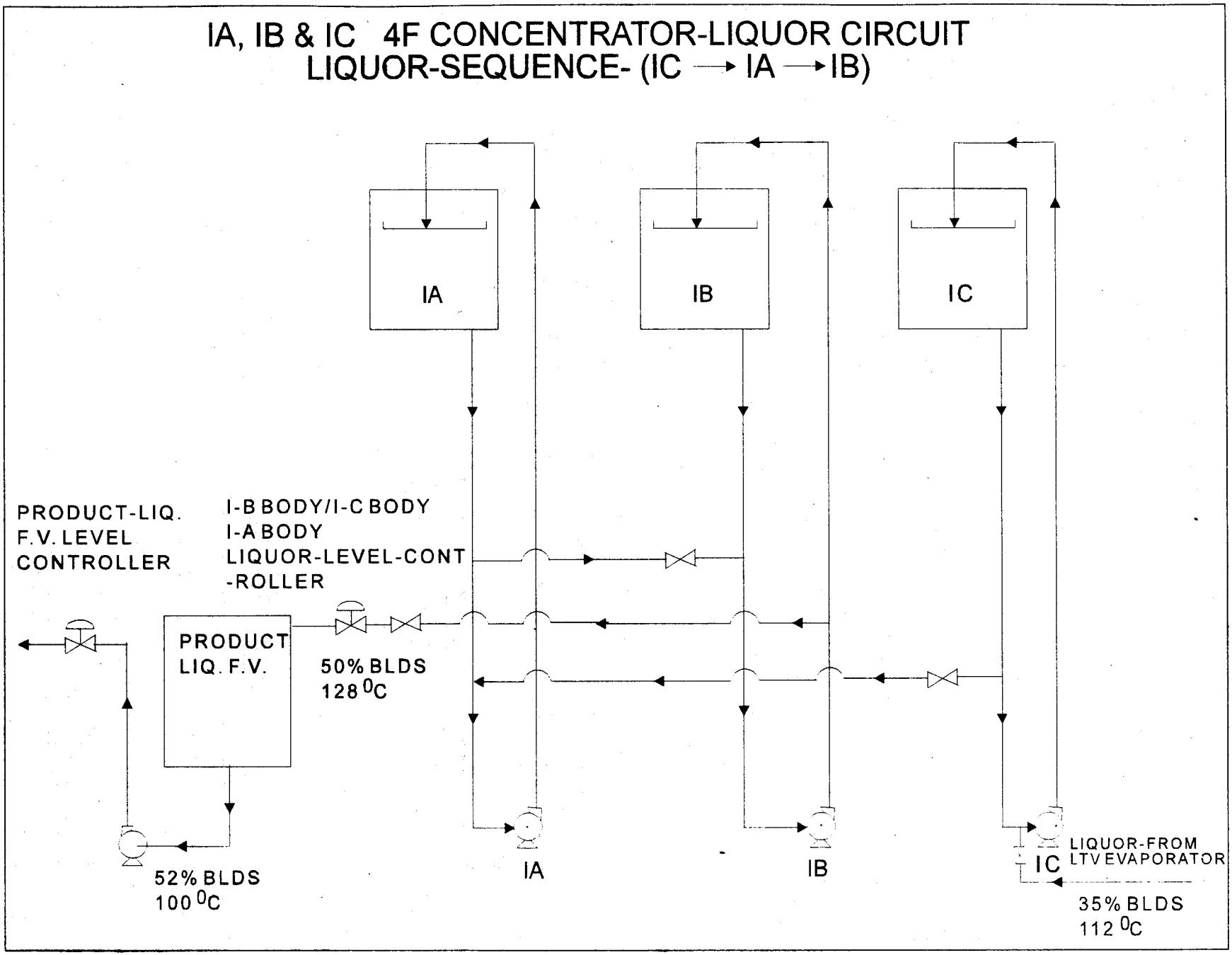
2. We had gone for selector switch for FFFF body level control with common Level Controller. This Selector switch was going out of order because of frequent use of switch and thus giving false signal leading to build up of levels in FFFF & LTV bodies. Matter was discussed and problem was emphasised. It was decided to go for individual level controller in 3 bodies.

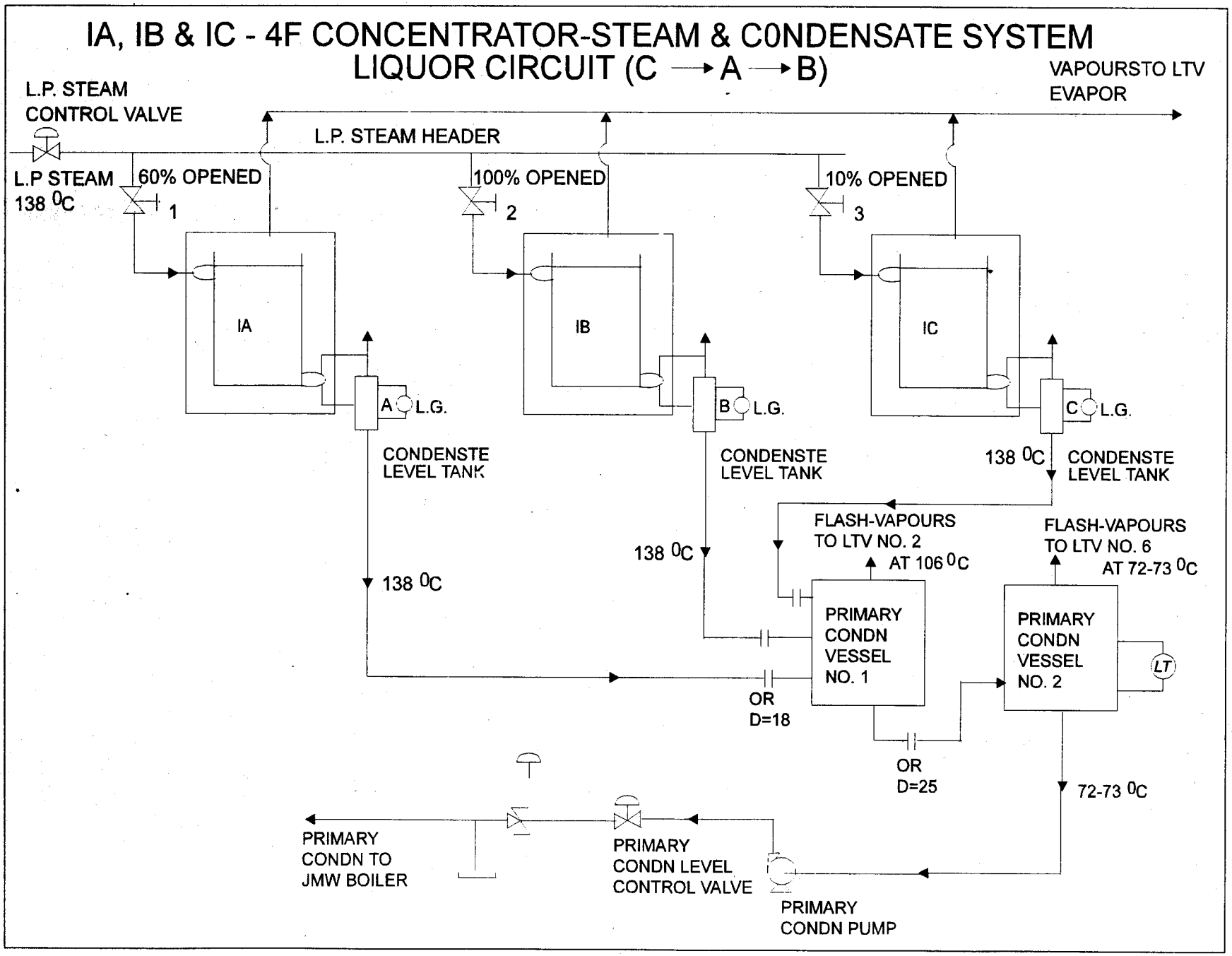
3. There was build up of condensate in Liquor heater and also there was no arrangement for draining them. This was modified.

4. Since the liquor heaters are heated with LTV Vapours, opening of valve for vapour inlet to liquor heaters leads to drop of vacuum. This was overcome by gaining experience in operation. Presently valve opening has been fixed for liquor feed flow.

PREPARATORY TRAINING TO OPERATIONAL CREW

In consultation with HRD Deptt., Training classes for operating crew were conducted and Sup-


IA, IB & IC 4F CONCENTRATOR-LIQUOR CIRCUIT
LIQUOR-SEQUENCE- (IC → IA → IB)
IA
IB
IC
PRODUCT-LIQ.
F.V. LEVEL
CONTROLLER
I-B BODY/I-C BODY
I-A BODY
LIQUOR-LEVEL-CONT
-ROLLER
PRODUCT
LIQ. F.V.
50% BLDS
128 0C
52% BLDS
100 0C
IA
IB
IC
LIQUOR-FROM
LTV EVAPORATOR
35% BLDS
112 0C


IA, IB & IC - 4F CONCENTRATOR-STEAM & CONDENSATE SYSTEM
LIQUOR CIRCUIT (C → A → B)
L.P. STEAM
CONTROL VALVE
L.P. STEAM HEADER
VAPOURSTO LTV
EVAPOR
L.P STEAM
138 0C
60% OPENED
1
100% OPENED
2
10% OPENED
3
IA
IB
IC
A L.G.
B L.G.
C L.G.
CONDENSTE
LEVEL TANK
CONDENSTE
LEVEL TANK
138 0C
CONDENSTE
LEVEL TANK
FLASH-VAPOURS
TO LTV NO. 2
AT 106 0C
FLASH-VAPOURS
TO LTV NO. 6
AT 72-73 0C
138 0C
138 0C
PRIMARY
CONDN
VESSEL
NO. 1
PRIMARY
CONDN
VESSEL
NO. 2
LT
OR
D=18
OR
D=25
72-73 0C
PRIMARY
CONDN TO
JMW BOILER
PRIMARY
CONDN LEVEL
CONTROL VALVE
PRIMARY
CONDN PUMP

pliers were requested to impart the training through audio visual system. Operating Crew was encouraged to clear their doubts through open discussions. At the time of commissioning, additional operating personnel were kept to learn the operation with Commissioning Engineer for 3 days. We found that this way our operating crew was able to handle the equipment efficiently.

CONCLUSION

Considering the same production level before and after retrofit of Evaporator Plant in LTV and addition of FFFF Evaporator, the following savings (approx.) have been achieved:

1. Reduction of L.P. Steam consumption per day of about 100 T.
2. Power savings of 1500 KWH/day.
3. Higher concentration being achieved from FFFF.
4. Downtime in Evaporator Plant was reduced by 75% due to lesser cleaning time of Evaporator tubes.

ACKNOWLEDGEMENT

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