OPTIMISATION OF DE-INKED PULP (DIP) HD TOWER DILUTION CONTROL (RE-ENGINEERING)



S. Annapoorani *M. Shanmugavadivel* *C. Raguraman*

Abstract :

As continual improvement is a necessity for any company to grow, TNPL has been consistently improving the quality of the product, increasing the productivity, improving the safety for Men and Machine & reducing the cost by implementing the required level of Automation.

It has been a continuous exercise to find out the exact requirement of Automation by evaluating the need, viability, financial implication, return on investment and above all ease of operation. The automation is not so expensive when compared with machine cost; the best results are achieved by optimizing the process and utilizing all the available resources to the maximum extent possible. TNPL is consciously upgrading the technology and increasing the productivity by incorporating the state of the art Technology.

The Pulp consistency plays a major role in Paper Making and it is very important parameter to be measured and controlled. If the consistency is not maintained in nominal range, it will directly affect the Critical Paper Qualities like GSM, Caliper, Moisture etc., and Productivity.

The pulp requirement for three Paper Machines - PM#1, PM#2 & PM#3 in TNPL is being catered by three pulping streets viz., Hard wood Pulp, Chemical Bagasse Pulp & De inked Pulp at required rate.

Efforts were taken to maintain the Final tower discharge pulp consistency within the nominal range and required results were achieved.

DIP tower dilution operation has become smooth and the manual tower dilution control is totally eliminated.

INTRODUCTION

The DIP final tower provides De-inked Pulp for Paper Machines and Wet lap Machines, which is mixed with the other varieties of pulp with certain proportion to produce the quality of Paper based on Market order. After storing the De-inked pulp in final tower, it is being transferred to the receiving chests of respective Paper Machines which are located almost one Km away from the DIP Tower. The Tower & Trim dilution of High consistency Pulp and transferring to the receiving chests is monitored and controlled by certain parameters like Receiving Chest Level, Pulp Flow and Consistency.

De-Inking Plant:

Design capacity	:	300 BD tpd
Quality	:	Printing and Writing (P&W) grade pulp
Raw material	:	Mix of 50 ~ 80% Sorted Office Paper (SOP#37) and 20 ~ 50 % Local Office paper
Brightness Gain	:	18% - 21% (Pulper accept to DIP storage)

DIP System Design:

The system configuration for the Deinking Plant is three (3) loop deinking system which comprises of

- **Pulping :** Drum pulping, HD cleaning, multistage coarse screening, Dump tower.
- **Loop 1 :** Multistage MC screening, First loop flotation (with primary and secondary), Multistage LC cleaning (fo ward), multistage fine screening, Thickening (disc filter + screw press), HC dispersing.
- **Loop 2 :** Second loop flotation (with primary & secondary), Thickening (disc filter + screw press), HC dispersing with oxidative bleaching.
- **Loop 3 :** Third loop flotation (with primary & secondary), Thickening (disc filter), Reductive bleaching and MC storage at 12% Cy.

De-Inked Pulp:

De-Inked Pulp is being transferred to the following chests based on requirement from the respective areas;

1. DIP receiving chest for PM#1 & PM#2 at PM#1
2. DIP receiving chest at PM#3
3. Pulp receiving chests at Wet lap machines

The DIP Pulp demand varies from 2 tons to 8 tons for each Paper Machine & 4 tons to 8 tons for Wet Lap Machines. It leads to an unstable state of the DIP Receiving chest level & Consistency control. In-turn, the cumulative pulp drawl from DIP storage tower varies continuously in the range between 0 ¬ 29.4 TPH, even though the average pulp drawl is normally below 12.5 TPH.

The following picture depicts the control system of DIP Tower control.

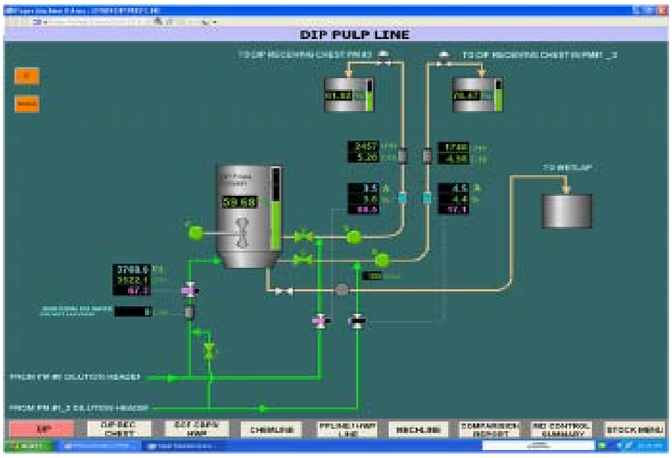

Figure #1: DIP Pulp Transfer from DIP HD Final Tower to PMC Receiving Chests Control Page

ISSUES FACED:

The following issues were faced in DIP Final tower dilution and transferring of the pulp to Receiving Chests;

1. More fluctuation in pulp consistency at the Paper Machine receiving chests (between 2.5 % and 7.0 %)
2. The average consistency at receiving chests couldn't be raised above 3.4 %.
3. Often, the discharge pumps were not able to lift properly due to inadequate tower dilution.
4. More vibration was also observed in discharge pumps and pipe lines.
5. DIP storage tower level raised sometimes due to excess tower dilution.
6. Dilution water line pressure was also fluctuating from 0.5 bar to 3.0 bar at DIP storage tower.
7. Meeting the tower dilution water demand by manual operation was very difficult as it had to be done cautiously and continually.

Root Causes for Consistency variation;

The root causes were identified and they were as follows;

1. Improper tower dilution control
2. More fluctuation in dilution water header pressure and
3. More fluctuation in cumulative pulp drawl from DIP HD Tower

Study carried out to address the issues;

Volume of dilution water required to decrease the consistency from C1 % to C2%.

The consistency of a pulp suspension is defined as

$C = Wp / Vs$,

Where **C** is consistency,

Wp is the mass of pulp & solids present in the suspension and

Vs is the total mass of the pulp suspension

If the suspension is diluted with a water of **Vd** volume, the consistency changes from $\mathbf{C_1}$ to $\mathbf{C_2}$, the total mass of the suspension is increased by **Vd** and **Wp** remains unchanged.

If the final mass of the suspension is $\mathbf{Vs_2}$,

$\mathbf{Vs_2 = Vs_1 + Vd}$; $\mathbf{Vs_1}$ is the initial mass of suspension

$Vd = Vs_2 - Vs_1$

$C_2/C_1 = (Wp/Vs2) / (Wp/Vs1)$; $C_1 = Wp/Vs1$; $C_2 = Wp/Vs_2$

$\mathbf{C_2/C_1 = Vs_1/Vs_2}$

$Vs_1 = (C_2/C_1)*Vs_2$,

Volume of dilution water added to decrease the consistency from C1 to C_2 is

$Vd = Vs_2 - Vs_1$

$Vd = Vs_2 - (C_2/C_1)*Vs_2$

Dilution water demand is calculated as below;

- Discharge Pump#1 & Discharge Pump#2 Capacity are 7000 LPM & 7000 LPM respectively (Total 14000 LPM)
- The pulp drawl rate for the flow of 14000LPM at 3.5% Cy is 29.4 TPH.
- Dilution water required to decrease the pulp consistency from 12% to 3.5% for 14000 LPM discharge flow is

  Vd = Vs2-Vs1

  = Vs2-(C2/C1)*Vs2

  = 14000 - (3.5/12)*14000

  = 9917 LPM
- The maximum dilution water demand DIP HD Tower Operation is 9917LPM.
- The amount of water required for DIP operation is 5000 LPM (Max).
- The Total water demand for both DIP operation and tower dilution is varying from 0 to 14917 LPM (9917+5000).
- The capacity of Paper Machine back water supply pump for DIP is 11500 LPM which is located in Paper Machine#3. Max trim dilution water supply from PM1&2 is ~1000 LPM. Thus, Max PM/c back water available is 12500 LPM.
- There was a gap between back water demand and Max PM/c back water available.
- Dilution water demand was varying from 0 to 9917 LPM due to variation of cumulative pulp drawl rate from 0 to 29.4 TPH
- The Tower dilution Flow control was in Auto mode with the constant Set Point and it was being changed as and when required. The required dilution water demand was not matching with the set point often.

ACTIONS CARRIED OUT TO ADDRESS THE ABOVE ISSUES:

a) Effort to maintain dilution water header pressure:

In PM#3 DCS, a new Pressure control loop was introduced to maintain the dilution water header pressure as it was fluctuating from 0.5 bar to 3.0 bar by

- Installed a new Pressure Transmitter

- Introduced a new Closed loop control Logic (PID)
- This PID controller output was given to the Dilution water Pump VFD to control its speed to maintain the desired header pressure.
- A pressure gauge (0 – 5 bar) was introduced in Dip final tower area to monitor the header pressure locally.

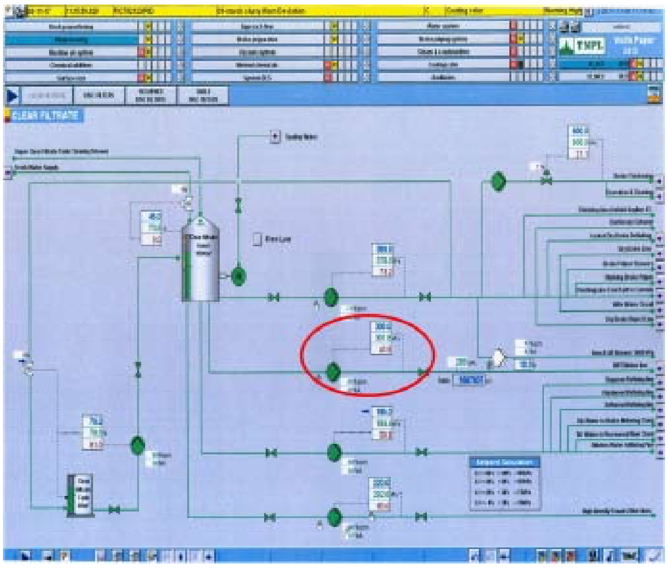

Figure #2 : Highlighted Circle depicts the PM#3 Back Water Pressure Control Loop to DIP Plant Operation & HD Tower Dilution

b) Fine Tuning of DIP receiving chest pumps to reduce the cumulative Pulp drawl fluctuation

Discharge pump delivery line control valves at Receiving chests in PM#1 and PM#3 were fine tuned in the following manner;

Control valve opening was limited between

- Minimum opening as 20 %,
- Maximum opening as 70%
- Discharge Pumps Auto start / stop logics were introduced, Pump Starts at 40% & Stops at 90% of the respective receiving Chests Level.

Thus, the maximum cumulative pulp drawl got reduced to 23 TPH from 29.4 TPH and the maximum demand of DIP back water requirement also got reduced to 12800 LPM (7800 + 5000) from 14917 LPM. The above changes almost met the demand of DIP water requirement.

c) Auto Correction of Tower Dilution water requirement (operating the control loop in E1 mode):

Pulp discharge rate from DIP final storage tower varies frequently as

- Pulp being transferred to three different locations
- Transfer pumps runs intermittently or flow varies according to the Receiving chest level and its level set point

DIP Tower dilution water Flow control was in Auto mode and it was set at constant set point.

When Pulp discharge rate varies, the Tower dilution water Flow should also vary to maintain the consistency. Hence, it was decided to operate the DIP Tower dilution water Flow control in E1 mode (External Set point, changes automatically according to the demand to maintain uniform consistency).

A formula was derived to address the above issue and the application software required for the above formula was developed in PM#2 DCS on 10/09/2016. Then, the tower dilution flow set point was taken into E1 mode from Auto mode for trial on 27/09/2016, 01/10/2016, 11/10/2016, 14/10/2016 & 15/10/2016. The initial performance was not found satisfactory and corrections were carried out as per the trial results.

The formula required for DIP Tower dilution in E1 mode was finally derived as below after a series of correction during the trial run:

$$F_{TD1} = \left[\left(\frac{Out1}{100} \times 1.78 \times \frac{F1}{14000}\right) + \left(\frac{Out2}{100} \times \frac{F2}{14000}\right)\right] \times 30000 + w$$

F1 : Delivery Flow of Discharge pump-1 to PM1 & PM2

F2 : Delivery Flow of Discharge pump-2 to PM3

Out1 : Trim dilution Controller output of Discharge pump-1 to PM1 & PM2

Out2 : Trim dilution Controller output of Discharge pump-2 to PM3

1.78 : Correction factor as trim dilution line size differs for pump-1 and pump-2

14000 : Sum of Capacities (LPM) of the discharge pumps

30000 : 3 Times of Dilution water required (3 X 9917 ~ 30000) to get 14000 LPM of pulp at 3.5% consistency from 12% consistency pulp in tower to operate the controller in nominal range ~ 30 to 35 %.

W : Dilution water additionally required for wet lap Pump.

During the trial, the following formula was also derived to avoid excess dilution in case of any restriction of dilution water flow in the trim dilution line or malfunctioning of Consistency transmitter.

Dilution water required to get 14000 LPM of pulp at 3.5% consistency from 12% consistency pulp in tower is

$$F_{TD_2} = 9917 \times (F_1+F_2) / 14000$$

The Tower Dilution Control loop E1 set point will be selected either from the formula FTD1 or FTD2 whichever is lower. The system was completely fine tuned.

The DIP tower dilution operation is found working well since 15/10/2016 in E1 mode.

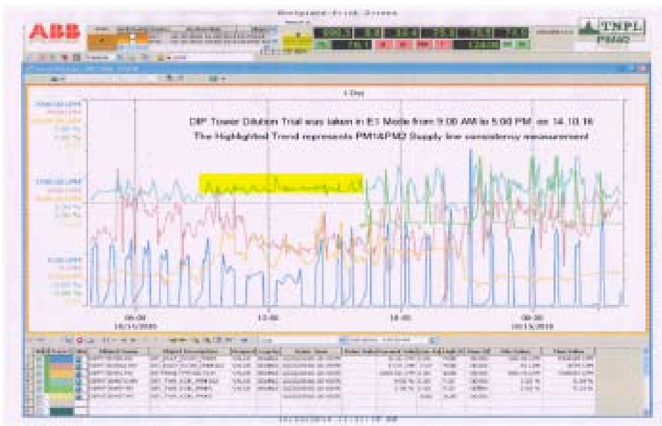

Figure #3: Trending of Discharge Pumps 1 & 2 Pulp Flow, Consistency and Tower Dilution Flow on 14.10.16

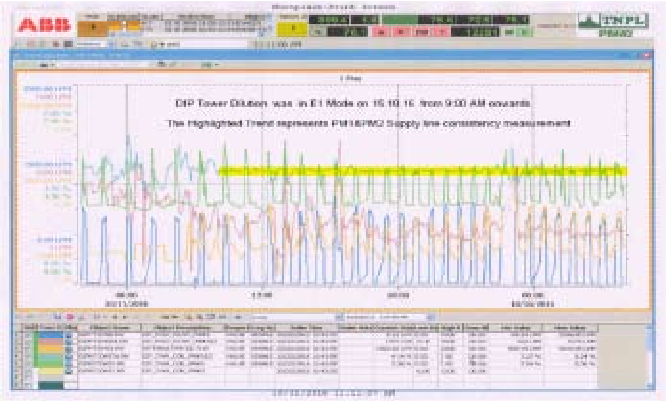

Figure #4: Trending of Discharge Pumps 1 & 2 Pulp Flow, Consistency and Tower Dilution Flow on 15.10.16

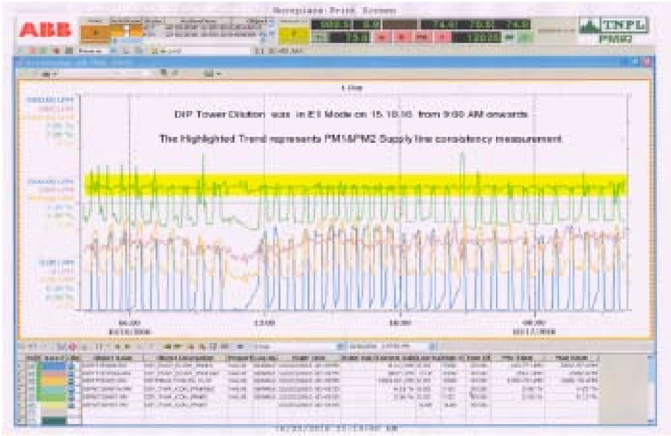

Figure #5: Trending of Discharge Pumps 1 & 2 Pulp Flow, Consistency and Tower Dilution Flow on 16.10.16

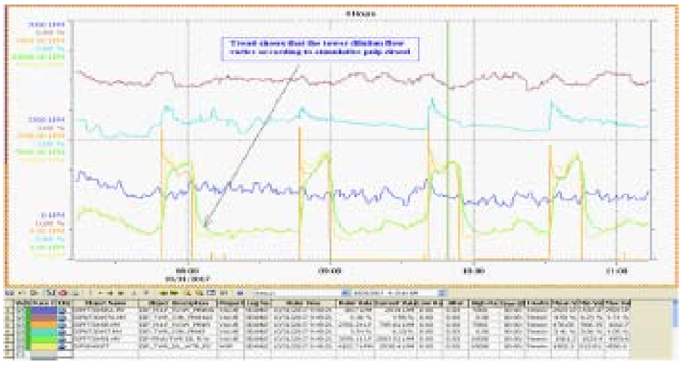

Figure #6: Trending of Discharge Pumps 1 & 2 Pulp Flow, Consistency and Tower Dilution Flow E1 Set Point & Actual on 31.10.17

RESULT :

1. Fluctuation in pulp consistency got reduced enormously and it is being maintained close to the set point.
2. Average pulp consistency could be raised from 3.2% to 4.4%
3. Pump poor lifting problem is totally averted.
4. Tower level raising due to excess tower dilution is avoided.
5. DIP tower dilution operation has now become very smooth with less effort from the operator.
6. The above results are achieved without any financial implication.

CONCLUSION:

The DIP tower dilution control operation is being taken care automatically; which resulted in

- supplying consistent quality of Pulp to Paper Machines,
- improvement in productivity,
- improvement in safety of Equipments,
- Elimination of frequent attention and
- Ease of operation

The above discussed Case Study proves that the continuous monitoring of operating conditions, applying of technical knowledge & implementing the required level of Automation can help in addressing such issues and make the plant operation more stable, trouble free and more productive.