ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 36, E2, 2024, p. 164-168

Improvements in Recovery Boiler for Energy Savings


K Thiruselvam *
DGM (Pulp & SRP)


Nagen Chandra Nayak*
Chief Manager (Chemical Recovery)


P Muthu Kumar*
Senior Manager (Chemical Recovery)


S Karthick *
Assistant Manager (Chemical Recovery)


K Mehanathan *
Deputy Manager (Electrical)


P A Jeyanthkarthikeyan *
Manager (Electrical)


J Niranjan Kumar*
Deputy Manager (Instrumentation)

*TNPL UNIT-II, Manapparai, Trichy
Tamilnadu, India, PIN-621306

Abstract:

Reduction of energy consumption has become one of the most important tool for the industry striving to achieve excellence in cost competitiveness. Energy cost, one of the major components of the production cost, not only necessitates the installation of energy-efficient technologies but also inculcates energy-efficient best practices and innovative methods in operation. In this paper we are mentioning various Electrical, automation and process improvements done in Recovery Boiler to reduce electrical energy consumption and process improvements.

Keywords: *Feed water pump, Deaerator Feed Pump, VFD, ESP, Motion sensor, Power-off rapping*

Introduction

TNPL Unit-2 commissioned a new 400 TPD Pulp Mill In the year 2022 at Trichy, Tamilnadu. Along with pulp mill a new 950 TDS Chemical Recovery Boiler was commissioned. In order to save energy and resolve various operational issues faced in Recovery Boiler many actions were taken using latest technology and process innovations. This resulted in significant cost reduction and other benefits.

A. ENERGY SAVINGS BY INSTALLING VFD IN BOILER FEED WATER PUMP

Boiler feed water pump is used to pump water to steam boiler drum at desired pressure and temperature. These pumps are normally very high pressure units that take suction from deaerator tank. The boiler is running at a constant pressure,, but the steam demand is changing continuously with time. The boiler feed water capacity must vary with the steam demand, but the pressure or head must remain almost constant according to steam drum pressure.

PUMP PERFORMANCE CURVE:

The increases in discharge flow rate, the discharge pressure decreases. The increases in discharge flow rate, the discharge pump power consumption increases. The increase in discharge flow rate the pump efficiency first increasing linearly then decreases. NPSH Required: (The minimum pressure required at the suction port of the pump to keep the pump from avoiding cavitation)

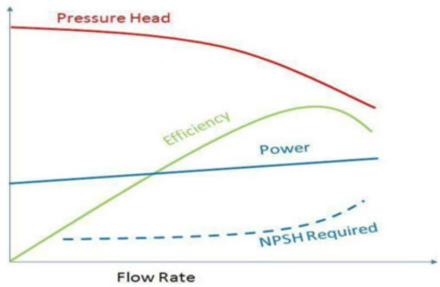

Figure: 1 :- Typical Pump efficiency curve

VARIABLE FREQUENCY DRIVE (VFD)

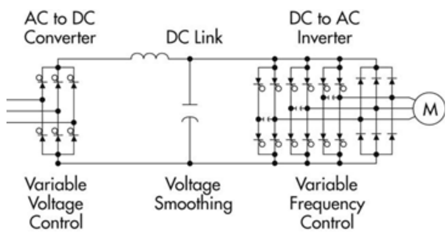

Figure: 2 :- Typical Variable Frequency Drive

AC motor in variable speed operation. The variable frequency drive (VFD) converts the supply frequency and voltage to the required frequency and voltage to drive a motor. Hence, VFD converts the supply frequency and voltage to the frequency and voltage required to drive a motor at a desired speed other than its rated Variable frequency drive is also called variable speed drive(VSD), frequency inverter or AC drive etc. It is an electric device to change utility power source to variable frequency to control speed.

FEED WATER FLOW CONTROL MECHANISM

Control valve:

In this system boiler drum level is controlled by feed control valve, which is automatically operated by boiler pressure head.

VFD Only:

In this system, The boiler drum level is controlled by variable frequency drive, which controls the pump flow rate of the boiler feed pump with constant pressure head. The design discharge pressure must be maintained constant to ensure the water gets to its intended location. As compared to above two methods VFD is efficient controlling and power saving.

Feed control valve and VFD:

In this system both feed control valve and VFD are used, to control the flow rate with constant head pressure.

ENERGY SAVING:

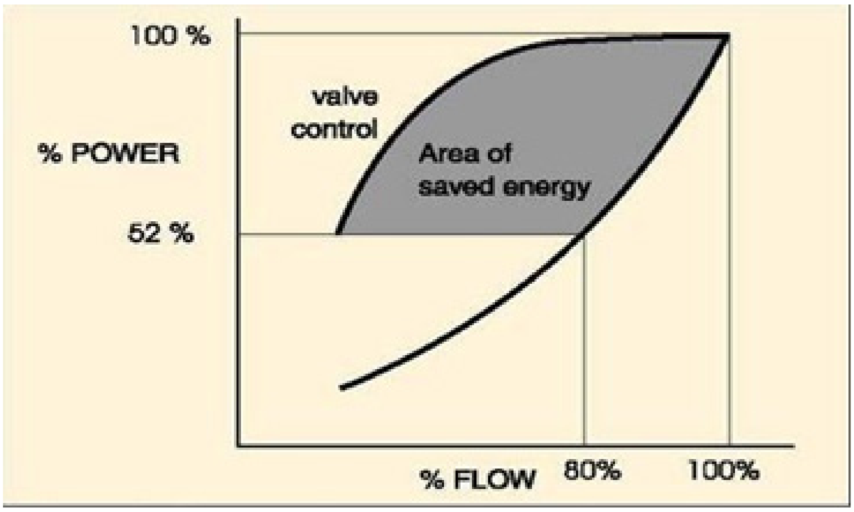

Figure -3 : Energy saving with VFD

The fixed speed motor load application such as the boiler feed pump supplies direct AC power. The energy saving is obtained by variable speed drive by using pump affinity laws. By using a Variable Frequency Drive (VFD) to slow down a pump motor speed from 100% to 80% can save 50% of energy. Reducing pump speed not only reduces energy consumption but also reduces noise and vibration. "A pump or fan running at half speed consumes only one-eighth of the power compared to one running at full speed.

CONTROL PHILOSOPHY OF BOILER FEED WATER PUMP AT TNPL UNIT-2

A Cascade control mechanism is used to maintain steam drum level. Differential pressure across the steam drum level control in the feed water line is measured .

Delta P = Pressure before the Feed water control valve - Pressure after the Feed water control valve.

According to steam drum pressure Delta P varies, if steam drum pressure increases pressure after control valve increases and vice versa. So when steam drum pressure increases Delta P reduces, so in order to maintain same Delta P, the pressure before the control valve has to increase, by cascade logic control that increases the speed of Feed water Pump. So according to steam drum pressure the speed of the feed water pump varies by using cascade logic. The Final Level of the drum is controlled by the level control valve by using 1P or 3 P level control.

DCS SCREENSHOTS FEED WATER PUMPS/ CONTROL SYSTEMS IN TNPL UNIT-2

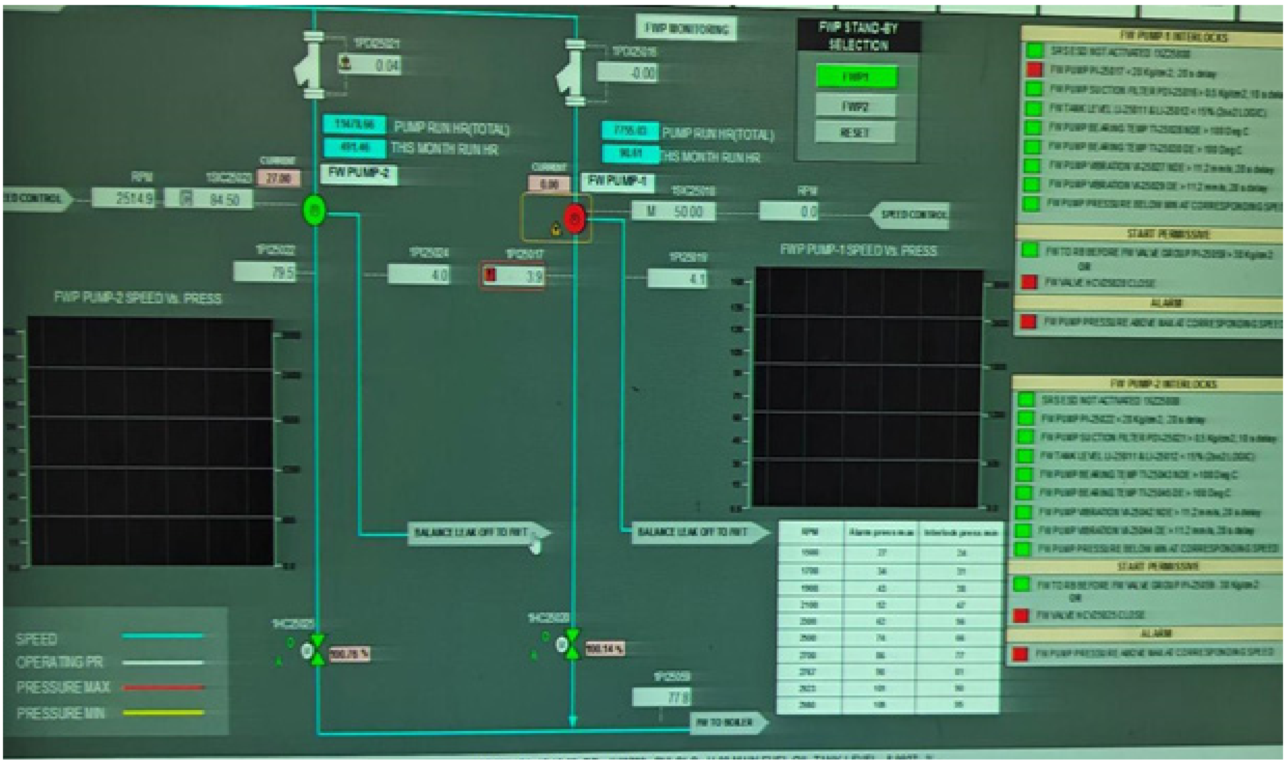

Figure 4 :- RPM Control in feed water pump

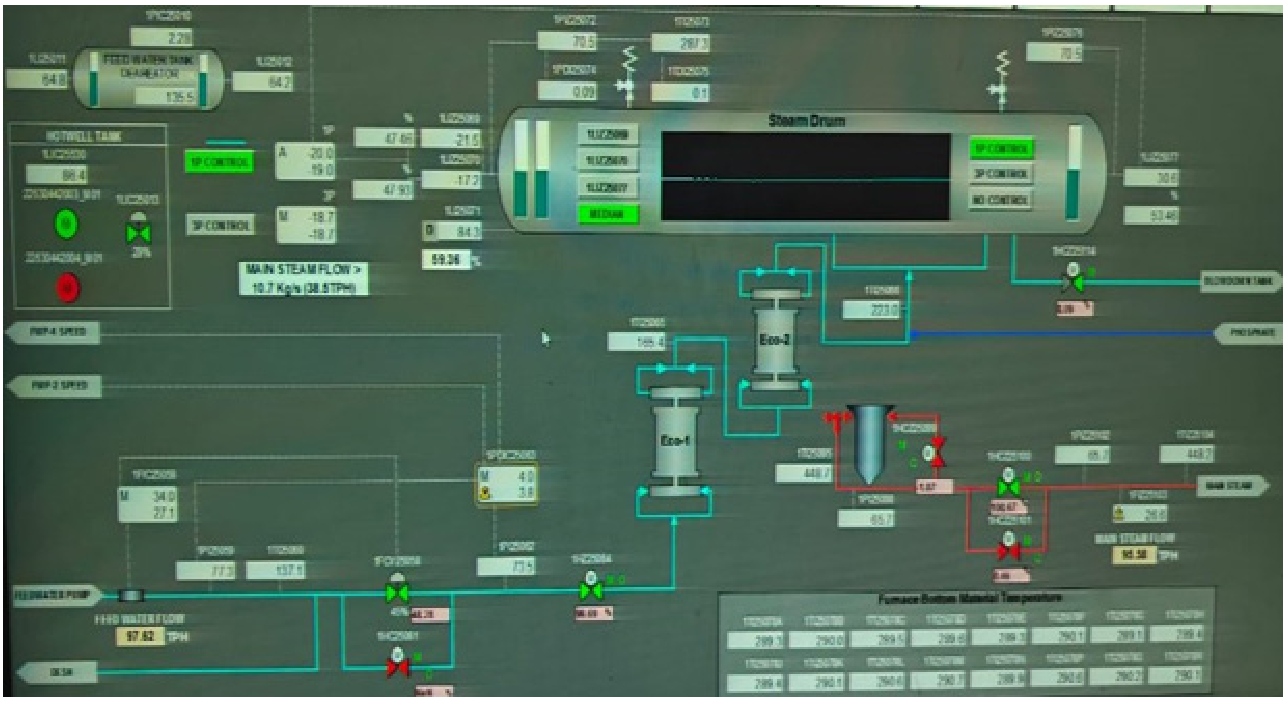

Figure -5 Steam Drum Level Control

POWER SAVINGS DUE TO INSTALLATION OF VFD FOR BOILER FEED WATER PUMP

Feed water pump Motor installed capacity: 800 KW

Running power for DOL starter – 680 Units/ hour

Running power for VFD starter – 490 Units/ Hour

Power Savings due to VFD – 190 Units / hour

Power rate – rupees 7 per unit

Annual Cost saving (with 340 working days) approximately 1.1 Crore rupees.

OTHER INTANGIBLE BENIFITS

1. Reduction of vibration in feed water pump and delivery line

2. Reduction in noise in feed water pump area

3. Gasket leakage frequency reduced.

B. ENERGY SAVINGS BY INSTALLING VFD IN DEAERATOR FEED PUMP

In order to reduce power , VFD was installed in DE-aerator feed pump. It also reduced vibration

and noise in Boiler control room which is situated in the DE-aerator building. The gasket leak frequency of the DE-aerator feed line has also reduced.

Hot well pump in Recovery Boiler (90 KW)was started in DOL starter. At present boiler is being operated at 75 % load. So pump was operated with delivery valve 50 % closed condition, It leads to abnormal sound and vibration during start-up also frequent failures in pump discharge line gaskets was noticed. To overcome the above issue it was planned to change the drive to VFD from DOL starter. For saving energy and controlling the motor speed, Equipment starting arrangements changed from DOL to VFD. Instead of DOL starting VFD starter power consumption was less. Details of power savings are enclosed.

POWER SAVINGS DUE TO INSTALLATION OF VFD for Deaerator feed Pump

Deaerator feed pump Motor installed capacity: 90 KW

Running power for DOL starter – 80 Units/ hour

Running power for VFD starter – 45 Units/ Hour

Power Savings due to VFD – 35 Units / hour

Power rate – rupees 7 per unit

Annual Cost saving (with 340 working days) Approximately 20 Lac rupees.

C.IMPROVEMENTS IN ELECTROSTATIC PRECIPITATOR

Electrostatic precipitator remove fly ash particles entrained in the flue gas by applying an electric field between the discharge and collection electrodes. Discharge electrodes are thin tubes or wires that are negatively charged, while collection electrodes are positively charged .

As the flue gas passes between two collection plates, the applied high voltage causes the gas molecules near the discharge electrode to ionize. The negatively charged gas molecules then adhere to surface sites of ash particles, making them negatively charged. The charged ash particles are subsequently attracted to the positively charged collection electrodes or plates and form an ash layer on the plates , resulting in a cleaner outlet gas stream .The collected ash layer is periodically removed by rappers or vibrators, which mechanically drop the ash layer to the collecting hoppers at the bottom of the precipitator.

A thick Ash Build up on electrode surfaces can deteriorate the electrical conditions and adversely affect the precipitator performance.

ASH RESISTIVITY

Resistivity is a material property that describes its tendency to resist the flow of current. The higher the resistivity of a material, the more difficult it is for the material to become charged. In the context of ESP operation, resistivity is one of the most important ash properties that determines the particle migration velocity and hence the required size of the precipitator. The resistivity of a material sample is defined:

$$\rho = R \cdot \frac{A}{l}$$

where ρ is the resistivity , R is the electrical resistance of the sample, A is its cross-sectional area (m^2), and l is its length (m)

A higher resistivity particle requires a longer exposure time to become charged and cannot achieve as high of a charge as an identical particle of lower resistivity. This, in turn, will result in a lower migration velocity and a lower ESP collection efficiency. Ash resistivity also determines how strongly an ash layer adheres to the collection electrode. Particles with high resistivity are difficult to charge; however and so are more difficult to remove by rapping due to their strong electrostatic attraction to the plate / sticky nature.

Due to increase in Chlorides and potassium content in ESP Ash the resistivity of ESP Ash increases , that affects the overall ESP performance.

Actions taken to improve ESP Performance :

a. In TNPL Unit-2 due to continuous build up in the system Chloride (as NaCl) contents raised up to 30 % level. So we have made system to purge ESP Ash from the conveyor going to Ash Mixing tank. This ESP Ash purged are collected in Jumbo bags and sold to detergent and textile industries. By continuous purging we have reduced Chloride (as NaCl) Up to 20 %. This has reduced the resistivity of ESP Ash and has improved ESP performance.

b. Tertiary air in Recovery Boiler has been increased up to 35 % of total Air and it has helped in reducing carryover and help improve ESP performance.

By the above actions we have reduced ESP current during 80- 100 % Black liquor firing rate as following . We have two ESP's with each ESP having four fields. During lower firing rate current of fields are further reduced to take maximum advantage and power saving.

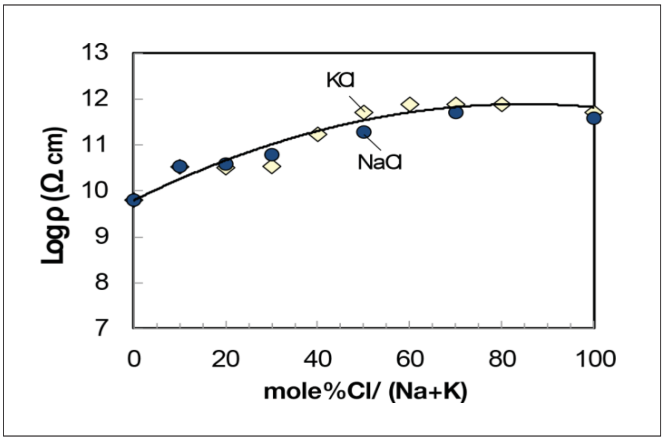

Figure-6: Effect of chloride on ash resistivity

TABLE-1 : ESP FIELD CURRENTS – BEFORE AND AFTER IMPROVEMENT

MCR	80 % to 100 % MCR		Below 80 % MCR	
ESP Field Number (Total two ESPs are in operation)	Before improvement m A	After (reducing Chlorides and increasing Tertiary Air) m A	Before improvement m A	After (reducing Chlorides and increasing Tertiary Air) m A
1	200	200	200	100
2	300	200	300	200
3	600	400	600	200
4	800	500	800	300

POWER SAVING DUE TO CURRENT REDUCTION IN ESP

80% to 100 % MCR running (20 days per month)

Power consumption before taking action: 6200 units/Day

Power consumption after taking action: 4800 Units /day

Annual Power savings during higher production days: Rs.20 Lac

Below 80 % MCR running (10 days per month)

Power consumption before taking action: 6200 units/Day

Power consumption after taking action: 3300 Units /day

Annual Power savings during lower production days: Rs.21 Lac

Total Power savings per Annum due to process improvements and ESP Fields current reduction about Rupees 40 Lac

OTHER INTANGIBLE BENEFITS DUE TO REDUCTION IN CHLORIDE CONTENT AND INCREASED TERTIARY AIR

1. Improved runability of Boiler
2. Lesser corrosion of super-heater coils and ESP internals
3. Reduction in ESP conveyors breakdown

TABLE-2 SUMMARY OF POWER SAVINGS IN RECOVERY BOILER:

Improvement	Annual savings (in rupees Lac)
VFD in Boiler Feed water pump	110
VFD in Deaerator feed pump	20
Reduction in ESP Field currents after improvements	40
Total savings	**160**

OTHER AUTOMATION DONE IN ESP FOR PERFORMANCE IMPROVEMENT

1. Motion Sensor in scrapper drive.

Two numbers motion sensors were installed at different locations for ensuring rotation of the scrapper, instead of zero speed switches in both the scrapper Conveyors bottom and the signals are displayed both in field and DCS. This has helped us to identify any internal breakdown and prevent ash build up inside by taking immediate corrective action.

Figure -7:- Motion sensors at scrapper bottom

2. Delay timer in ESP Filed Tripping due to scrapper tripping

Whenever scrapper conveyor stopped or tripped due to overload or zero speed switch failures, ESP transformers was tripping immediately leading to high ESP dust emission from boiler stacks, till ESP is bypassed. So to avoid this problem we have included 11 minutes delay timer logic's for tripping the ESP transformers field after stopping scrapper conveyors. By introducing the above logic's following benefits were achieved.

a. Sufficient time for bypassing the particular ESP without exceeding the PCB norms.

b. Small maintenance work in all conveyors (like ZSS malfunction, loose cable etc.) was done without bypassing the ESP.

c. Minimizing the environmental impacts due to less dust discharge.

3. Introduction of Auto Power off rapping logics in ESP field-1 and Field-2

An auto power off rapping sequence logic's was introduced in 1st and 2nd field of both ESP after commissioning of recovery boiler was given the following benefits.

a. Periodic removal of dust particles from the collecting plates.

b. Less number of spark rates in the field was observed.

c. Frequent tripping of scrapper conveyors was eliminated.

d. Improving dust collection efficiency due to clean electrodes.

Conclusion:-

In Chemical Recovery Boiler there is a huge scope for power savings in feed water pumping and Electrostatic Precipitator area. By suitably selected VFD and control mechanism significant energy savings can be achieved. Also reducing carryover in Recovery Boiler by maintaing sufficient tertiary air and control of chlorides and potassium in ESP Ash, the efficiency of ESP will be improved. With improved ESP performance Field currents can be reduced to get power savings, without affecting stack emissions.

We gratefully acknowledge the TNPL management for giving support and permission to publish this article in IPPTA.