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# ENERGY EFFICIENCY IN CHILLED WATER SYSTEM & COMPRESSED AIR SYSTEM

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## Abstract:

*The heat generated in electronic components in DCS, servers, control rooms, iMCCs has to be dissipated or cooled for avoiding failures of electronic components. For this purpose, there are HVAC or AHU systems running are chilled water will be available in the manufacturing areas. These operate on closed loop chilled water which is chilled by Chillers in the mill. These chillers and AHUs run continuously and consume lot of power. The HVAC energy consumption will be about 5 to 8 % of total mill energy. Also, the refrigerant gas tops up for ACs and chillers also a major contributor for GHG emissions. Hence energy efficiency, shifting to FCUs and green refrigerant can optimize chillers energy consumption and emission reduction.*

*For operation of pneumatic equipment in paper machines, pulp and recovery and utilities – Instrument air (6-7 kg/cm2) is required. For paper passing, ash conveying purpose – Service air (3-4 kg/cm2) is required. The compressed air system is energy intensive and about 5 to 8 % of mill energy consumption. Centralized compressed air system, shifting from reciprocating to centrifugal compressors, Intelligent flow controllers at user ends are some energy efficiency methods opted in unit BCM.*

***Key words:*** *Vapor Absorption Chillers (VAC), Vapor Compression Chillers (VCR), Air Handling Unit (AHU), Heat & Ventilation Air Conditioning (HVAC), Air Conditioner (AC), Fan Coil Unit (FCU), ENCON- Energy Conservation Cell, Electronically Commuted fan (EC fan), Reciprocating air compressor, centrifugal air compressor, IFC Units – Intelligent Flow controller unit, ETP – Effluent treatment plant, MBBR – Moving bed biological reactor, ENCON- Energy Conservation Cell*

## Introduction:

**Chilled water system at ITC PSPD:** Unit BCM has its own thermal power plant running on coal procured from Singareni mines in vicinity. Owing to lower coal cost in previous decades, all the chilling requirements were met through VACs which were running on steam. Over the years the steam cost was increasing due to increasing fuel costs. However, with upgradations in Boilers and advanced turbines, power cost is relatively cheaper than steam cost. So, ITC has slowly phased out VACs and moved to VCCs in the mill which resulted in energy savings.

**Compressed Air system at ITC PSPD:** In 2000, there were 2 compressor houses Bhadrachalam unit, which were running with reciprocating compressors. Along with these compressors, all the boilers were having individual reciprocating air compressors for ash conveying purpose. Over the years, these were converted into centralised centrifugal air compressors supplying compressed air to entire mill, which resulted in huge energy reduction. Some other practices like IFC units at user ends, zero air loss traps, periodic leakage audits have resulted in energy savings.

## Method:

**Chilled water & HVAC system energy saving measures:**

The coefficient of Performance (COP) of VA chillers is around 1.3 to 1.5 while the COP of VC Chillers is around 4. These are some of energy saving in chilled water system:

1. Plan for centralized chilled water system at Utilities instead of scattered chillers across the mill. Such system will have optimum loading on chillers making it energy efficient.
2. Switch over to electrical chillers in place of steam operated chillers:

   The following table shows over years, how steam operated VACs are replaced with electrical chillers:

| Year | Chillers | Locations | Electrical Power consumed | Steam saved | Net Annual Savings |
|---|---|---|---|---|---|
| | | | Kw | TPH | Lacs Rs |
| 2018 | VAM chiller replaced with **325 TR** Screw Chiller | PM6 | 202 | 1 | 8.24 |
| 2019 | VAM chiller replaced with **340 TR** Screw Chiller | PM4 | 206 | 1 | 15.51 |
| 2019 | 2 nos VAM chillers replaced with 1 nos **600 TR** Centrifugal Chiller | Pulp mill ClO2 plant | 390 | 3 | 51 |
| 2021 | 2 nos VAM chiller replaced with 2 nos 600 TR Centrifugal Chillers **(1200 TR)** | Pulp mill Ozone plant | 780 | 5 | 160 |

The investments in electrically operated chillers are as follows:

Screw Chillers (2018, 42 lacs investment & 2022, 38 lacs investment)

Centrifugal Chillers (2019 & 21, 450 lacs investment)

Total investment in electrically operated chillers is 5.3 crores, **the payback is about 2.25 years.**

3. Installation of Auto Tube Cleaning Systems in condensers of screw chillers. A clean condenser has effective heat transfer from the refrigerant to cooling water, this will result in energy saving in compressor in the complete refrigeration cycle.

   Total investment in 8 nos ATCS for 8 nos running chillers is 0.5 crores, **the payback is about 2.39 years.**

4. If there is margin in chiller replace Air Conditioners with AHUs or FCUs.

   Centrifugal Chiller: 600 TR, Power: 400 kw, **Specific power: 0.6 kw/TR**

   Screw Chiller: 340 TR, Power: 206 kw, **Specific power: 0.6 kw/TR**

   Air Conditioner: 1.5 TR, Power: 1.6 kw, **Specific power: 1.05 kw/TR**

   Air conditioner shifting to Chilled water not only saves power, but also saves in GHG emissions by reduction in refrigerant top up in operational years.

5. While selecting higher capacity vapor compression chillers, there is option of low-pressure refrigerant R514a which is energy efficient as well as green refrigerant.

| Description | R514a | R134a |
|---|---|---|
| Global Warming Potential | < 2 | 1320 |
| Ozone Depletion Potential | 0 | 0 |
| Energy Efficiency | 13.5% over next competitor | Baseline |
| Leakage Rate | < 0.5% per year | 2 % per year |
| Short Atmospheric Lifetime | 22 days | 13.4 years |

   Pulp mill ClO2 plant and Ozone plant chillers are replaced with the same. Investment 450 lacs, savings per annum 211 lacs, **payback period 2.13 years.**

6. Addition of Nano particle additives in Chilled water will reduce load on chillers by 15%. This is implemented in ITC hotels division and under **feasibility study in ITC PSPD division. (Approximate savings envisaged is 200 kw)**

7. There is hexagonal IR mat which will break moisture clusters in air path in AHU and homogenize it thereby improving the heat transfer and reducing load on chiller at the end. The mats in the air path of the system will reduce the energy by 20%. This is implemented in ITC Hotels and ITC Foods division and **under feasibility study in ITC PSPD division. (Approximate savings envisaged is 250 kw, 1st phase starts in 2024-25)**

   Hexagonal IR mats for AHUs/ACs which break the moisture clusters through IR radiations, thereby improving heat transfer and reducing load on chiller or AC by 20%.

8. Replacement of Air handling unit's centrifugal fans with EC fans in AHUs and cooling towers will reduce the energy by 20% of AHUs centrifugal fan power and cooling tower fan power. This is implemented in ITC ITD division and pilot proved in ITC PSPD Division, scaling up in all AHUs in phase wise in ITC PSPD BCM. **(Approximate savings envisaged is 250 kw, 1st phase starts in 2024-25)**

   Energy saving EC fans in cooling towers & AHUs in place of Conventional centrifugal fans in AHU's.

9. Digitalization of Chillers and AHUs for monitoring and taking proactive maintenance based on seeing various online parameters would also optimize energy in HVAC equipment. Chiller's digitization project started and under progress. Ahu's digitization will be taken up at BCM in 2024.

## Compressed Air system energy saving measures:

1. Plan for centralized compressed air system at Utilities instead of scattered compressors across the mill. Such system will avoid bleed off/unload loss in individual compressors.

2. Invest in Centrifugal compressors in place of reciprocating compressors. Even though investment is high, the life cycle cost will be low owing to lower specific power in centrifugal compressor.

   The following table shows over years, how compressors were **centralized to Utilities** compressor house and also shift from reciprocating compressors to **centrifugal air compressors**:

| Year | Compressors Details | Locations | Power | Air | Sp. Gen | Sp. Power |
|---|---|---|---|---|---|---|
| | | | Kw | NM3/Hr | NM3/kw | kw/NM3 |
| 2000 | 14 reciprocating compressors | 4 areas in mill | 1940 | 14928 | 7.695 | 0.130 |
| 2010 | 3 centrifugal & 6 reciprocating | 5 areas in mill | 4120 | 34348.8 | 8.337 | 0.120 |
| 2020 | 4 centrifugal & 1 reciprocating | 2 areas in mill | 4550 | 38730 | 8.512 | 0.117 |
| 2024 | 4 centrifugal compressors | 1 area in mill | 4540 | 42000 | 9.251 | 0.108 |

The investments in compressors are as follows:

Centac1 (2003, 0.65 Crores), Centac2 (2006, 0.9 Crores), Centac3 (2007, 1.17 Crores), Centac4 (2019, 1.3 Crores), Centac5 (2021, 1.6 Crores), New Centac (2023, 1.87 Crores)

Total investment in centrifugal compressors is 7.49 crores, the **payback is about 2.5 years.**

3. Installation of intelligent flow controller(IFC) at user end and maintaining set point in IFC unit as per user end has led to saving in compressor power.

| Year | Investment Description | Investment in Crs |
|---|---|---|
| 2022-23 | 17 IFC units installation at user ends | 1.38 |

There was saving of 52 lacs per annum with **payback of 2.22 years**

4. Replacement of timer-based traps with "zero air loss trap" has resulted in avoiding air loss in 23 no receivers through traps.

| Year | Investment Description | Investment in Crs |
|---|---|---|
| 2017-18 | 23 no's zero air loss traps | 0.15 |

There was saving of 5.9 lacs per annum with **payback of 2.53 years.**

5. Lobe blowers were replaced with high-speed centrifugal blowers with aerofoil non-contact bearings in 2017, its power consumption is very low in comparison. This was done in ETP MBBR compressor house.

| Description | UOM | Lobe Blower1 | Lobe Blower2 | Centri-Blower |
|---|---|---|---|---|
| Actual air flow | Nm3/hr | 4200.0 | 4550.0 | 8000.0 |
| Actual power consumed | kW | 191.7 | 156.1 | 186.6 |
| **Specific Power Consumption** | **kW/hr/Nm3** | **0.0456** | **0.0343** | **0.0233** |

Investment 65 lacs, savings per annum 48 lacs, **payback period 1.35 years, also Dissolved oxygen levels improved from 0.3 to 1.4 ppm in ETP MBBR.**

| | No of leaks | Air loss in CFM | Eq Energy loss in kw |
|---|---|---|---|
| 2020 | 1345 | 2133.8 | 305.142 |
| 2022 | 567 | 1145.4 | 167.767 |

6. Periodically do leakage assessment study in compressed air network using ultrasonic leak detectors and address them immediately. 2 audits were done in ITC PSPD BCM unit.

Third party was engaged to identify leaks and tag them, ITC inhouse team addressed the leaks immediately.

7. Plan for avoiding compressed air at usage like pneumatic tools, cleaning of clothes by operators at dust handling operations. At ITC PSPD BCM, pneumatic tools were replaced with battery operated or electrically operated portable tools. Transvector nozzles and blowers were provided for human cleaning applications in place of compressed air.

By implementing all the above energy saving investments and practices, the specific power brought down from **0.130 kw/NM$^3$ to 0.108 kw/NM$^3$** (equivalent to saving of about 0.9 MW for ITC PSPD BCM unit compressed air consumption of 42000 M3/Hr)

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