Improving The Efficiency of The Air Preheater Tubes In Cogeneration Power Plant

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Abstract- *Although designers and manufacturers continue to strengthen the links between designs and manufacturing the failures of the component still occur and will continue to occur for one reason or another. In view of this, the cause or reason for failure is par amount for future designs. Rake type conveyor drives are the primary systems used in the sugar mill industries to convey the fiberized bagasse form one mill to another. Conveyor chain components that suffer premature failure on a regular basis due to stress induced in the chain link component. The main objective of this project is to determine the cause of failure of the chain links of a rake type conveyor by carrying out stress analysis on a failed chain link component and to determine the point of initiation of the fracture by analyzing the mechanism of failure. In order to reduce the stress induced on a chain link material the area of cross section of the attachment link area has to be increased. By increasing the area at the cane carrying point at discharge end of the mill the load in the carrying spikes are distributed uniformly and the tension induced in the belt reduces enormously. Thus, by this project we are able to improve the life expectancy of the chain link by reducing the stress and wear of the material due to continuous load application.*

I. INTRODUCTION

OVERVIEW OF E.I.D PARRY INDIA LIMITED

E.I.D. – Parry (India) Limited (E.I.D. Parry) is a listed company engaged in the business of Sugar and Nutraceuticals. Headquartered in '**Dare House**' a heritage building, in Chennai, India, the Company is a part of the INR 369 Billion Murugappa Group, one of India's leading business conglomerates. Founded in 1788, 'Parry' has been a household name for over 225 years.

The Company holds the distinction of setting up India's first sugar plant at Nellikuppam in 1842 and even today continues to pioneer new paths in each of its businesses.

Amongst the leading sugar manufacturers in India, E.I.D. Parry's 9 sugar plants are spread across South India. These state-of-the-art plants with a total sugarcane crushing capacity of 43,400 TCD, co-generation capacity of 160 MW and Distillery capacity of 234 KLPD across units are located at Nellikuppam, Pugalur, Pudukottai, Pettavathalai and Sivaganga in Tamil Nadu, Ariyur in Puducherry, Sankili in Andhra Pradesh and Bagalkot, Haliyal and Ramdurg in Karnataka.

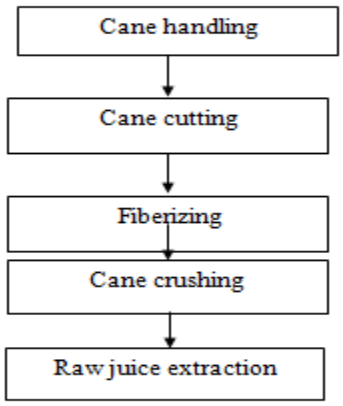
E.I.D. Parry is a pioneer and world leader in organic spirulina and micro algal products in the Nutraceuticals space. 'Parrys Spirulina', with 3 major international certifications, is sold in more than 41 countries across the globe. The highly specialised manufacturing Plants of the Nutraceuticals business for micro algal production are located at Oonaiyur and Saveripuram in Tamil Nadu.

Renowned brands like BSA, Hercules, Montra, Mach City, Ballmaster, Ajax, Parry's, Chola, Gromor, Shanthi Gears and Paramfos are from the Murugappa stable.

SI NO	DESCRIPTION	MAGNITUDE
01	Cane capacity	7500 TCD
02	Cogeneration power output	25 MW
03	Distillery facilities	75 KL/ day

1.1 FLOW CHART

1.1.1 PROCESS FLOW DIAGRAM



1.1.1.1 CANE HANDLING

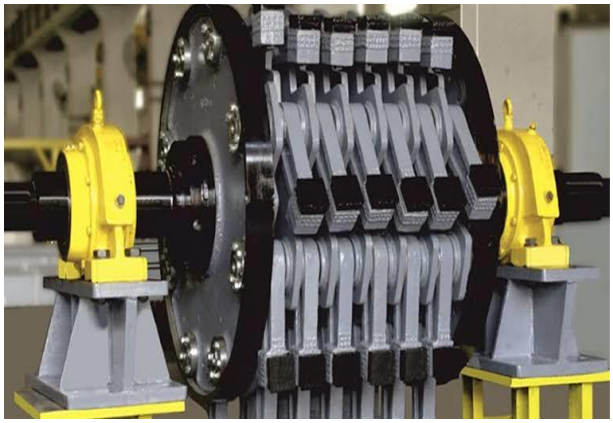
Cranes are used to unload the sugarcane from the trucks. The overhead Cranes lifts the sugarcane from the truck and its transports the cane to the feeder table. The feeder table is used to transport the sugarcane to the fibrizing plant.

1.1.1.2 CANE CUTTING

The chopper is used to cut the sugarcane into small pieces. The chopper uses a series of blades which are held parallel to each other. The chopped sugarcane is feeder to the fiberize plant by means of a belt conveyer which is driven by a electric motor.

1.1.1.3 FIBRIZING

Fiberizes are used for shredding of sugarcane into fibers and open cells to enable prepared cane to be crushed in between the rollers of the mills to extract juice. This allows the mill to maximize the removal of the sugar juice from the prepared cane. This also increases the bulk density of the prepared cane thereby increasing the capacity of the extraction plant and hence the absorbed power by milling is reduced.



1.1.1.4 CANE CRUSHING

Mill rollers are used for crushing the sugarcane. Sugar Mill Rollers that can extract the juice efficiently out of the canes. The material reduces the moisture in bagasse and stops juice from reentering them. The structure is made from low carbon content steel to avoid corrosion and oxidation. In between the mill roller the sugarcane is feeder and squeezed for the extraction of primary juice by means of application of hydraulic pressure.

1.1.1.5 RAW JUICE EXTRACTIO

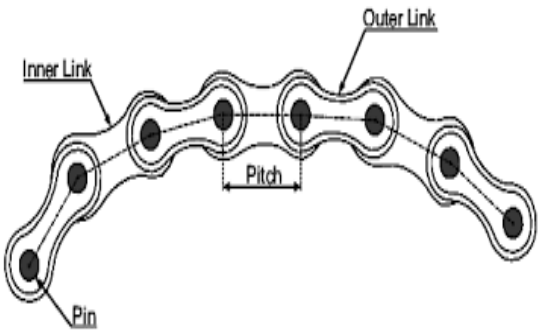
The juice collected from the milling process are collected in a primary juice tank and then screened and filter by means of a rotor screen in which the dust and sedimented particles are separated and it is collected in a raw juice tank and the raw juice is further processed for the sugar manufacturing process.

There are a number of steps in producing raw sugar from cane.Cane receiving and unloading (receive the cane at the factory and unload it from the transport vehicles)Cane preparation (cutting and shredding cane to prepare it for juice extraction)Juice extraction (two technologies are in common use; milling or diffusion)Juice clarification (remove suspended solids from the juice, typically mud, waxes, fibres)Juice evaporation (to concentrate the juice to a thick syrup of about 65°brix)Syrup clarification (remove suspended solids from the syrup, typically colloid syze of mud, waxes, fibres, etc.)Crystallisation. Centrifugation (Separation of the sugar crystals from the mother liquor, done by centrifugal machines). Sugar drying. Packaging and delivery

II. COMPONENTS OF RTC

2.1 CHAIN

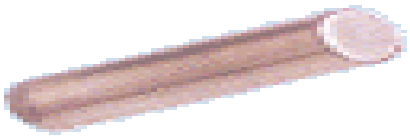
Chain drive is a way of transmitting mechanical power from one place to another. It is often used to convey power to the wheels of a vehicle, particularly bicycles and motorcycles. It is also used in a wide variety of machines besides vehicles. A Chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. Chain drives are flexible and made of number of links and it acts as a intermediate between belts and gear drives. Chains can only be used to transmit power between parallel shafts. Unlike belt drives, chain drives uses special toothed wheels called sprockets.



2.1.1 CHAIN COMPONENTS, CONSTRUCTION AND CONNECTING LINKS.

2.1.1.1 PINS

The member, which bears the entire chain load and acts as bearing, together with the bush as the chain engages with the sprocket. Thus the pin is usually subjected to wear, shear and bending.



2.1.1.2 BUSH

Together with the pin, it acts as a bearing at times of engagement with the sprocket. It also protects the pin from impact loads. High resistance to wear and fatigue strength is its essential requirements.

2.1.1.3 ROLLER

Essentially a shock absorber that reduces the impact effects resulting from engagement with the sprocket and permits rolling engagement with the sprocket. It should have high resistance to wear, fatigue and impact loads.

2.1.1.4 LINK PLATES (INNER AND OUTER LINK PLATES)

The members hold the pin and bushes and are subjected to tension. Therefore, its requirements are high tensile strength and resistance to fatigue and impact loads.

2.2 COMPONETS OF CHAIN

2.2.1 INNER LINK

An inner link consits of six parts. Two bushings are press fitted into two plates and two free-rotating rollers are assembled over the bushings.

2.2.2 OUTER LINK

An outer link consists of four members. Two pins are press-fitted into two plates. In the riveted type outer link, the pins are riveted on both ends. In the cotter type outer link one end of the pin is riveted, and the other end has a hole and extends beyond the outer the outer plate just far enough to receive the cotter pin.

2.2.3 CONNECTING LINK –COTTER TYPE

There are two types of connecting type links. Two pins are press-fitted into one plate and riveted at one end. The other end of each pin has a hole to allow installation of cotter pin. The connecting is designed for a slip-fit with the pins.

2.2.4 CONNECTING LINK – SPRING CLIP TYPE

Two pins are press-fitted into one link plate and riveted at one end. The other end of each pin is grooved to permit installation of the spring clip which holds the connecting plate in place. The connecting plate is a slip-fit on the pins.

2.2.5 OFFSET LINK – SINGLE

In this link, half of the link is like an outer link and half is an inner link. One bushing is press-fitted into two cranked plates, and one free-rotating roller is assembled slip-fit in the cranked plates, and flat milled at one end to prevent its turning in the plate hole. This can alone be used as a connecting link.

2.2.6 OFFSET LINK – DOUBLE

This link consists of one roller link and one offset link assembled together and riveted. This is to be used in combination with connecting links.

III. MAJOR COMPONENTS OF A THERMAL POWER PLANT

3.1BOILER

❖A boiler (or steam generator) is a closed vessel in which water, under pressure, is converted into steam. The heat is transferred to the boiler by all three modes of heat transfer i.e. conduction, convection and radiation.

❖Major types of boilers are: (i) fire tube boiler and (ii) water tube boiler

❖Generally water tube boilers are used for electric power stations.

Fire Tube Boiler

The boiler is named so because the products of combustion pass through the tubes which are surrounded by water. Depending on whether the tube is vertical or horizontal the fire tube boiler is divided into two types

1. Vertical tube boiler
2. Horizontal tube boiler

A fire tube boiler is simple, compact and rugged in construction. Its initial cost is low. Water being more and circulation being poor they cannot meet quickly to changes in steam demand. As water and steam ,both are in the same shell, higher pressure of steam are not possible , the maximum pressure which can be had is 17.5 kg/cm2 with a capacity of 15,000kg of steam per hour. For the same output the outer shell of a fire tube boiler is much larger than that of a water tube boiler.

3.2WATER TUBE BOILERS

In this boiler, the water flows inside the tubes and hot gases flow outside the tube. Water tube boiler are classified as

1. Vertical tube boiler
2. Horizontal tube boiler
3. Inclined tube boiler

The circulation of water in the boiler is may be natural or forced. For Central steam power plants large capacity of water tube boilers are used. The tubes are always external to the drum they can be built in smaller size and therefore withstand high pressure. The boiler drum contains both steam and water, the former being trapped from the top of the drum where the highest concentration of dry steam exists.

3.3 SUPERHEATER AND REHEATERS

The function of the super heater is to remove the last trash of moisture from the saturated steam leaving the boiler tubes and also increases its temperature above the saturation temperature. For this purpose, the heat of the combustion gases from the furnace is utilized. Super heated steam is that steam which contains more heat than the saturated steam at the same pressure. The additional heat provide more energy to the turbine hence power output is more. Superheated steam causes lesser erosion of the turbine blades and can be transmitted for longer distance with little heat loss. A superheater may be convention type, radiant type or combination. However, convention superheaters are more commonly used.

3.4 REHEATER

In addition to super heater modern boiler has reheater also. The function of the reheated is to superheat the partly expanded steam from the turbine, this ensure that the steam remain dry through the last stage of the turbine. A reheater may be convention type, radiant type or combination.

Feed Water Heaters: These heaters are used to heat the feed water by means of blend steam before it is supplied to the boiler. Necessity of heating feed water before feeding it back to the boiler arises due to the following reasons. Feed Water heating improve overall efficiency. The dissolved oxygen which would otherwise cause boiler corrosion are removed in the feed water heater. Thermal stresses due to cold water entering the boiler drum are avoided. Quantity of steam produced by the boiler is increased. Some other impurities carried by steam and condensate, due to corrosion in boiler and condenser, are precipitated outside the boiler.

3.5 ECONOMIZER

Boilers are provided with economizer and air pre-heaters to recover heat from the flue gases. An increase of about 20% in boiler efficiency is achieved by providing both economizer and air pre-heaters. Economizer alone gives only 10-12% efficiency increase, causes saving in fuel consumption 5-15 %. The feed water from the high-pressure heaters enters the economizer and picks up heat from the flue gases after the low temperature super heater. Economizer can be classified as an inline or staggered arrangement based on the type of tube arrangement.For pressure of 70 Kg/cm2 or more economizer becomes a necessity. The tubes are arranged in parallel continuous loops. Feed water flows through the tubes and the flue gases outside the tubes across them.The feed water should be sufficiently pure not to cause forming of scales and cause internal corrosion and under boiler pressure. The temperature of the feed water entering the economizer should be high enough so that moister from the flue gases does not condense on the economizer tubes.

3.6 AIR PREHEATERS

After the flue gases leave economizer, some further heat can be extracted from them and is used to heat the incoming air for combustion. Air preheaters may be of following types:

- Plate type
- Tubular type
- Regenerative type

Cooling of flue gases by 200increase the efficiency of the plant by 1%. The use of air preheaters is more economical with pulverized fuel boilers because the temperature of flue gases going out is sufficiently large and high air temperatures (250 to 3500 C) is always desirable for better combustion. Air preheaters should have high thermal efficiency, reliability of operation, less maintained charges, should occupy small space, should be reasonable in initial cost and should be accessible.

3.7 STEAM TURBINES

Steam entering from a small opening attains a very high velocity. The velocity attained during expansion depends on the initial and final content of the steam.The difference in initial and final heat content represent the heat energy to be converted to kinetic energy.There are two types of steam turbines:

1)Impulse turbine and
2)Reaction Turbine

3.8 CONDENSERS

The function of the condenser is to condense the steam exiting the turbine. The condenser helps maintain low pressure at the exhaust.
Two types of condensers are used.

Table: Jet and Surface Condensers

Jet condenser (contact type)	Surface condenser (non-contact type)
Exhaust steam mixes with cooling water.	Exhaust steam mixes with cooling water.
Condensate cannot be recovered.	Condensate recovered is fed back to the boiler.
Heat exchanged by direct conduction	Heat transfer through convection.
Low initial cost	High initial cost.
High power required for pumping water.	Condensate is not wasted so pumping power is less.

3.9 DEAERATORS

A deaerator is a device that is widely used for the the feed water to steam-generating boilers. In particular, dissolved oxygen in boiler feed waters will cause serious corrosion damage in steam systems by attaching to the walls of metal piping and other metallic equipment and forming oxides (rust).There are two basic types of deaerators,

1. the tray-type an
2. the spray-type

The tray-type (also called the cascade-type) includes a vertical domed deaeration section mounted on top of a horizontal cylindrical vessel which serves as the deaerated boiler feed water storage tank.

3.10 COOLING TOWERS AND SPRAY PONDS

Condensers need huge quantity of water to condense the steam.Water is led into the plants by means of circulating water pumps and after passing through the condenser is discharged back into the river.If such a source is not available closed cooling water circuit is used where the warm water coming out of the condenser is cooled and reused.In such cases ponds and cooling towers are used where the water loses heat to the atmosphere.

3.11 ELECTROSTATIC PRECIPITATORS

An electrostatic precipitator (ESP), or electrostatic air cleaner is a particulate collection device that removes particles from a flowing gas (such as air) using the force of an induced electrostatic charge.

The basic idea of an ESP:

❖Charging

❖collecting.

❖removing

Every particle either has or can be given a charge positive or negative. we impart a negative charge to all the particles in a gas stream in ESP. Then a grounded plate having a positive charge is set up. The negatively charged particle would migrate to the grounded collection plate and be captured. The particles would quickly collect on the plate, creating a dust layer. The dust layer would accumulate until we removed it. The structural design and operation of the discharge electrodes (rigid-frame, wires or plate) and collection electrodes.

❖tubular type ESP

❖plate type ESP

The method of charging

❖single-stage ESP

❖two-stage ESP

The temperature of operation

❖cold-side ESP

❖hot-side ESP

The method of particle removal from collection surfaces

❖wet ESP

IV. RESULTS AND DISCUSSION

Numerical analysis is carried out for heat exchanger using counter flow approach. Ansys CFX 12.0 is been used for simulate the HX process in the selected HX domain. Geometrical configurations are shown in the geometry and meshing part. The cold air is entering into the domain with ambient condition at 35 C, and hot flue gas will enter into the tubes bundle domain with hot condition at 200 C. Flue gas is the mixture of CO2 and N2.

The Geometry modelling and meshing, a) 3 by 3 matrix HX tubes with flues gas and air flow ducts‟ b) Structured meshed computational model view for HX tubes alone with 3 by 3 matrixes‟ c) Tetrahedral meshes for flue gas path with baffles are in positions‟ d) Boundary condition graphical representations.

V. CONCLUSION

The heat transfer, temperature variation, velocity of both flue gas and air and heat flux is reported in this study. From fig 3(a, b) the baffles are providing the hindrance to the flow path of flue gas, so that the maximum heat flux is observed at this point of HX tubes it can be seen from fig 4d So it can be concluded that by providing baffles the rate of heat transfer will be increased. An optimum air side pressure drop is observed, which depicts the installation of medium quantity of air blower, by which energy consumed will be less, from that the overall efficiency of the plant will increase. From incorporating the proposed design in the existing plant, the temperature of the primary air would increase by about 60oC. Then the efficiency of the boiler would increase by 2.7%, their by reducing the coal consumption.

REFRENCES

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