A harmonizing technology meant for chemical recovery in pulp and paper mills

Moni Kuntal Bora
M.Tech in Thermal Engineering,
Bharath University,
Chennai, Tamilnadu, India.
E-mail: *boramonikuntal@gmail.com*

***Abstract*-A process industry preciselypaper mill produces a waste stream of reacted inorganic chemicals and organic wastes called black liquor. The inorganic chemicals and the organic by-products coming out from production processes of paper mill should be recycled from the monetary and environmental point of view. Presently recovery boilers are the standard means to recycle the inorganic chemicals and organic waste to produce a huge part of the energy required to operate a large pulp and paper mill. Energy investigation has proved that gasification of the black liquor would recover the inorganic chemicals and meet a mills heat / steam requirements. Moreover, gasification would produce fuel gas that can then be used in recovery boiler furnace to generate steam and electricity that will fulfil the needs of a pulp and paper mill's paper production and electrification. Air emissions, effluent discharge, and enhancement in energy recovery and utilization are the top challenges of this process.To overcome these issues explanations are available, but they are expensive. Adaptation new technology may consequence in vital energy benefits.**

Keywords-Black Liquor; Green Liquor; lignin, causticizing and recovery boilers.

I. INTRODUCTION

The increased energy demands and threat of global warming nothing short of an Energy Revolution - a transformation that has already started, as renewable energy markets exhibit huge and steady growth. At the core of this revolution will be a change in the way that energy is produced, distributed and consumed. For this reason more countries and companies start believing in renewable and climate neutral fuel such as wood or biomass in general. The pulpwood arrives to the pulp mill and the crushed and chipped. The woodchips are digested in white liquor in order to separate lignin and cellulose. The pulp is screened and washed. The wash liquor together with the spent cooking liquor is evaporated. The Black Liquor containing the materials dissolved from the wood and the spent chemical is washed from the pulp, concentrated in the evaporator plant and burned in the recovery boilers. The recovery furnace converts the combustible materials extracted from the wood into usable steam energy and reduces the sulfur compounds to sodium sulfide and sodium organic compounds to sodium carbonate. The recovered chemicals are then discharged from the furnace bottom as molten smelt. The smelt is dissolved in weak white Liquor from the caustic zing section to become Green Liquor.

The energy released from the combustion processes is used to generate process steam, which is expanded through a backpressure turbine to generate electricity and process steam of suitable pressure. In a pulp and paper plant the sodium salts used for extracting the lignin from wood during cooking have to be recovered to make the process viable. A cooking liquor recovery cycle retrieves white liquor for the cook from the black liquor spent chemicals obtained from the pulp wash. Weak black liquor containing about 15% inorganics and the lignin organic is concentrated in multiple-effect evaporators to about 50% strong black liquor. Due to liquor characteristics, further concentration is often better done in a cascade evaporator where hot gaseous stream from a boiler contacts the liquor.

Cycle make-up chemicals, usually salt cake, are added to the resulting 68% heavy liquor. At this concentration, the heating value is high enough to provide self-sustaining combustion with air to evaporate the remaining water, provide heat of reduction for chemical recovery, and to provide additional heat liberation to warrant heat recovery in the steam generating sections of the recovery unit.

II. BLACK LIQUOR

In paper mill, black liquor is the waste product from the Kraft process when digesting pulpwood into paper pulp removing lignin, hemicelluloses and other extractives from the wood/bamboo to free the cellulose fibres.

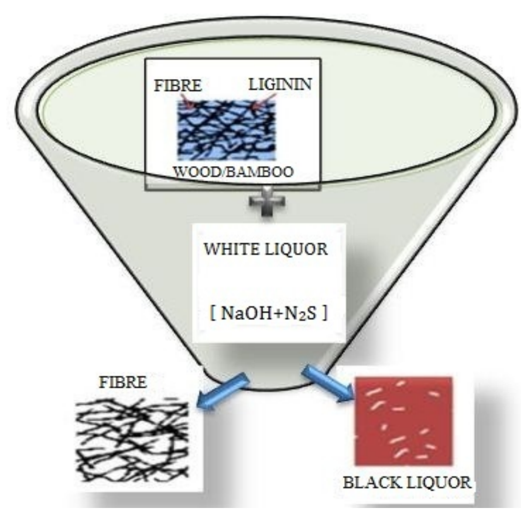

Figure: Pulping Process.

A. Black liquor and its important properties:

Black liquor is distinctly alkaline pH varies from 10.5 to 13.5, but not caustic owing to the fact that a large part of the alkali is present in form of neutral compounds.The lignin has intense black colour shading to reddish brown on dilution and retains a dark straw to yellow colour even when diluted to 0.04% with water.It is foamy at low concentrations. Black liquor from the sulfate process is generally foamier than that from the soda process. The foaming increases with an increase in resin content of wood used for pulping. The amount of total solids in black liquor depends on the quantity of alkali charged to the digester and the yield of pulp. Under average conditions, black liquor going to evaporators will contain 14-18% solids for wood and bamboo.In general, the inorganic compounds in black liquor tend to decrease specific heat and thermal conductivity, increase density, specific gravity, viscosity, boiling point elevation, and have practically no effect on surface tension.The organic constituents of black liquor tend to decrease specific heat, thermal conductivity, and surface tension, and increase density and viscosity values.The numbers also shows that there are considerable differences among values for the different liquors attributed to the diversity of organic constituents in black liquors caused by the variation in pulping species, pulping conditions, and pulp yields.

The black liquor obtained from agricultural residues, wheat straw, rice straw, and bagasse, etc. are characteristically different.Black liquor generally contains 50%-70% organics and 30%-50% inorganics. It also contains minor amounts of impurities such as lime, iron-oxides, sodium chloride, and alumina. High silica content is a major obstacle in any recovery process. The concentration of silica is particularly high in rice and wheat straw black liquors. The presence of silica leads to problems related to scaling, clarification, and precipitation.The non-wood fiber black liquors have a high percentage of silica: 4 - 6% (even more) in case of straw and 1 % in case of bagasse. Silica enters both as intrinsic and external silica with raw material and cooking liquors. The magnitude of silica for different liquors is: rice straw 3 - 16%, wheat straw 3 - 6%, bamboo 2 - 5%, bagasse 1 - 3%, and eucalyptus 0.1 - 0.8%.The density of black liquor varies from species to species for both wood and non-wood materials. The specific gravity of BL at any particular concentration and temperature depends upon the ratio of organic to inorganic matter and increases with an increase in inorganic matter and decreases with an increase in temperature. The important properties controlling pressure drops, heat and mass transfer rates, mixing rates, etc. and plays a vital role in the design and estimation of piping systems, selection of pumps and their efficiency, estimation of power costs for pumping black liquor, deposition of scales in the evaporator tubes, diminishing the evaporation rate etc. and ultimately the overall economy and capacity of a recovery system. The viscosity of black liquor (62 - 64% solids) is usually reduced by preheating to a temperature of 383.15K to393.15K before spraying in the recovery boiler. The size distribution of the droplets in the black liquor spray to the recovery boiler depends upon the viscosity characteristics of liquor. At lower temperatures, storage and handling of strong black liquor poses problem.The higher heating value of black liquor depends upon the type of wood/wood mix and the type of pulp produced. The typical HHV of black liquor from different sources varies from 2700 kcal/kg to 4000 kcal/kg of dry solids. The higher heating value of black liquor is an important parameter in sizing a recovery furnace and significantly influences the combustion stability of the bed. The heating value of liquor is inversely proportional to the yield of pulp and depends on the raw materials. As the HHV increase, the carbon and hydrogen content of the liquor increase with a corresponding decrease in the sodium and sulfur content. Hence, the losses due to dry flue gas and moisture due to hydrogen slightly increase. However, the heat of reaction correlation and heat in smelt decreases. The net effect is an increase in efficiency.

B. Boiling point raise and viscosity:

When dimensioning an evaporation plant, one needs to know the boiling rise and the viscosity of liquor to be evaporated at the dry solids contents and the process condition, such as temperature, prevailing during evaporation.

The temperature where black liquor boils is higher than the boiling point of water at the same pressure. The temperatures difference is called the boiling point raise. As the dry solids content of black liquor increases, the boiling point.

C. Prominent features of black liquor composition:

- Higher alkali consumption indicates degree of degradation of carbohydrates, more proportion of organic acids and less RAA level.
- Higher Sodium Carbonate indicates less caustisizingefficiency.
- Higher Sodium Sulphate indicates less reduction efficiency and/or more make up chemicals.
- High organically bound sodium indicates more degradation of carbohydrates, more formation of organic acids.

D. Heating value:

The heating value of black liquor expresses the amount of heat that is released when combusting a specified amount of black liquor dry solids. The types of organic compounds presentin black liquor and inorganic material in black liquor influence the heating value of black liquor. The different types of black liquor components and their heating value are shown:

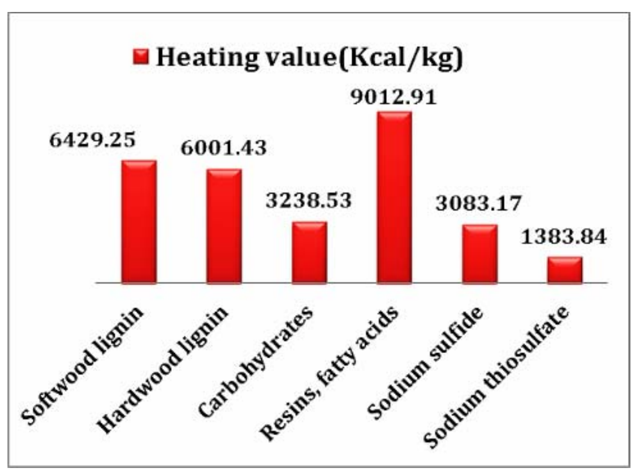

Figure: Black liquor components and their heating value

III. RECOVERY SECTION

To recover the chemicals used in the cooking of wood and other fibrous raw materials used for production of pulp and to recover beneficially use the thermal energy from combustion of the organics. The Black Liquor containing the materials dissolved from the wood and the spent chemical is washed from the pulp, concentrated in the evaporator plant and burned in the recovery furnace. The recovery furnace converts the combustible materials extracted from the wood into usable steam energy and reduces the sulphur compounds to sodium sulphide and sodium organic compounds to sodium carbonate. The recovered chemicals are then discharged from the furnace bottom as molten smelt. The smelt is dissolved in weak white Liquor from the causticizing section to become Green Liquor. The green liquor is reacted with lime in the causticizing plant to form white liquor which is used as cooking liquor at pulp mill. Lime mud formed in the causticizing reaction is separated washed with hot water, thickened and converted to lime in Rotary Lime Kiln. When processing wood chips into pulp in the cooking plant, organic materials such as lignin, hemi cellulose, and a minor part of the cellulose dissolve in the cooking liquor. These organic materials with the inorganic components of the cooking liquor form the spent cooking liquor, commonly referred to as black liquor. The organic material in the black liquor contains chemical energy recovered as heat in the recovery boiler. Inorganic materials are recovered simultaneously and regenerated in the recovery boiler and recausticizing plant to a form that allows their reuse in the pulp cooking process. The Chemical Recovery operation involves four processes such as; Evaporation of Weak Black Liquor, Incineration of concentrated Black Liquor in to Recovery Furnace/Boiler, Preparation of Cooking Liquor (White Liquor) – Recausticizing process and Lime Reburning.

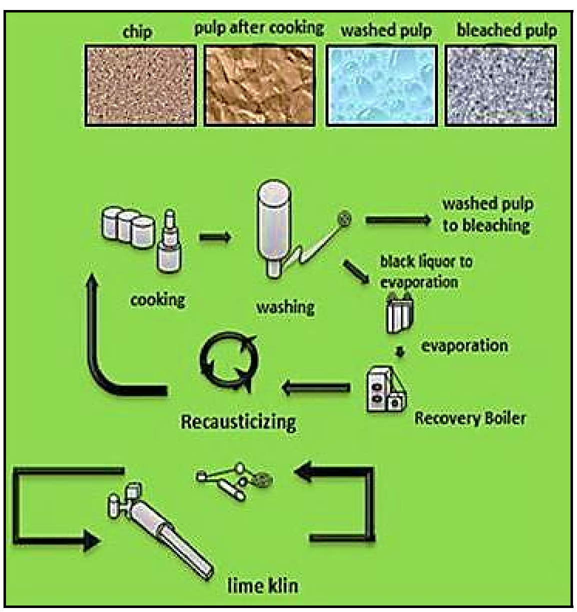

Figure: Typical Recovery Process.

A. Different phases ofthe process:

There are four typical stages for black liquor combustion.

Stage	Characterized by
Drying	**Water evaporation.**
Devolatilization	**Appearance of flame, ignition.**
Char burning	**Disappearance of flame.**
Smelt	**Re-oxidation**

Drying is the evaporation of water from the black liquor droplet with the absence of combustion (visible flame). Devolatilization is typically the onset of the increase of black liquor droplet volume, release of volatile gases from the black liquor droplet, and appearance of visible flame. During devolatilization, many reactions occur. The main form of sulphur release is dimethyl sulphide and methyl mercaptance. Hydrogen sulphide, H_2S, forms rapidly during decomposition reactions after gases release from the droplet.

During the char combustion, reduction reactions occur. Sodium sulphate, Na_2SO_4, reacts with carbon to form sodium sulphide, Na_2S. While the carbon in the char bed burns, it causes the reduction of sodium. At the end of char combustion, the inorganic residue remains which is taped out as molten smelt. Smelt is dissolved in weak white liquor, received from causticizing plant in Main Dissolving tank to produce green liquor.

B.Evaporation of Weak Black Liquor:

Evaporation is the separation of water from a solution containing nonvolatile solutes. Supplying heat to the solution causes vaporization. An evaporation plant usually consists of several heat transfer units connected in series with steam or vapor as the heating media and black liquor as the heated media.
The black liquor is separated from the pulp during the pulp washing as a watery solution with a dry solids content of 14%-18% depending on the raw material and the efficiency of the washing plant. This weak black liquor contains too much water for direct use as fuel in the recovery boiler. The energy from burning the organic material is less than the energy necessary to evaporate the water in the liquor.
The main purpose of the evaporation plant is to increase the dry solids content of the black liquor by evaporating water until reaching a concentration that allows burning in the recovery boiler. This concentration is normally 65%-75% dry solids.

In our plant we have Septuplet tubular type Falling Film Evaporator. In this evaporator type, theliquor is fed to the bottom of the evaporator body where a fixed level is maintained. It is then raised to the top of the heating elementby a circulating pump, and flows downward on the heating surface by gravity. The concentration within the effect is practically constant at the concentration of the out-feed liquor. The circulation rate is also constant. These features make the FF evaporator insensitive to variations in the evaporation load.

C. Incineration of Heavy Black Liquor:

The recovery boiler serves three main purposes. It burns the organic material in the black liquor to generate high-pressure steam. The second purpose is to recycle and regenerate used chemicals in black liquor. Finally, it minimizes discharges from several waste streams in an environmentally friendly way. In a recovery boiler, concentrated black liquor burns in the furnace with the simultaneous emergence of reduced inorganic chemicals in molten form.

The Recovery Boiler operating in our mill is bi-drum type boiler with furnace screen and three stages of long tube vertical economizer. Its capacity is 500 tons/day dry solids firing. It is designed to fire black liquor at 65% solids concentration. Since recovery boiler falls under Indian Boiler Act and water and molten smelt involved in the process, several safety measures are to be taken in operating the boiler.

It is always economical to operate recovery boiler at high solid concentration because steam generation increases with increasing dry solids content. This is primarily because the drier black liquor requires less preheating for water present in black liquor and thusLHV of Black liquor increases.

Black liquor combustion occurs as a droplet sprayed to the furnace from a liquor gun or in the char bed at the bottom of the recovery boiler furnace. Black liquor is sprayed into the furnace through many liquor guns, to produce very small droplets to maximize combustion rates and temperature but not finely atomized as it enters the furnace. The aim is to produce sufficiently large droplets so that unburned material can reach the char bed.

D. Green LiquorRe-causticizing Process:

The recausticizing process has two targets. One is to produce clean, hot white liquor containing a minimum amount of unreactive chemicals for the cooking process. The other is to prepare clean and dry lime mud to burn in the limekiln for reuse as lime with minimum energy usage.

Smelt contains primarily Na_2CO_3 and sodium sulfide (Na_2S). Dissolving smelt in water or weak wash produces green liquor. Reaction of Green liquor with Lime (CaO) produces white liquor that is an aqueous solution of NaOH and Na2S and simultaneously precipitates lime mud ($CaCO_3$). Lime mud is filtered and washed with secondary condensates or hot water. The resulting filtrate is weak white liquor that is used to dissolve smelt in the dissolving tank.

Two consecutive reactions occur during recausticizing: slaking and causticizing. Both occur in the solid phase of the heterogeneous mixture of lime and green liquor.

When green liquor is mixed with calcium oxide, CaO, it slakes with water and forms calcium hydroxide, $Ca(OH)_2$. This continues to react with sodium carbonate, Na_2CO_3, in the green liquor to produce sodium hydroxide, NaOH, and calcium carbonate, $CaCO_3$.

The slaking of lime is a strongly exothermic reaction:

$$CaO + H_2O \quad Ca(OH)_2 \quad \rightarrow$$

Since slaking occurs rapidly at elevated temperatures of green liquor and lime, the green liquor is heated/cooled up to 360.15Kto 365.15 K before mixing it with lime. The slaking reaction takes about 10-30 min to complete depending on the quality of lime. The subsequent causticizing reaction begins simultaneously with slaking. The temperature of the solution still has a major influence on the reaction rate. Normal operating temperature at this stage is 373.15K.

The causticizing reaction is an equilibrium reaction:

$$Na_2CO_3 (aq) + Ca (OH)_2 (S) \rightleftharpoons 2NaOH (aq) + Ca_2CO_3(s)$$

The equilibrium in the causticizing reaction is reached with some reactants still present in the mixture. The total liquor strength, will determine the equilibrium composition. An increase in the concentration of the liquor will shift the equilibrium to the reactant side. In dilute liquors, the equilibrium will shift to the product side resulting in higher causticizing efficiency.

E. Lime Reburning:

Lime reburning is part of the chemical circuit called lime cycle in a Kraft pulp mill. After causticizing, lime is essentially in the form of calcium carbonate. The objective of lime reburning is to convert calcium carbonate back to calcium oxide. Reburned lime is a recirculating chemical used in converting green liquor to white liquor in the causticizing plant. Lime regeneration is called reburning because it involves treating lime mud at high temperatures in a limekiln. Makeup lime or limestone or Seashell compensate for lime losses in the lime cycle.

The lime reburning process uses a counter-currently operating, heat exchanging reactor where heat transfers from combustion gas to lime particles by direct contact. The heat source is Furnace oil.

F. Calcination reaction:

$$CaCO_3 \quad CaO \rightarrow CO_2$$

Dissociation of $CaCO_3$ to CaO and CO_2 begins when temperature goes above 1093.15K. Temperature increase greatly accelerates the reaction. To obtain sufficient reaction rate, reburning uses a temperature of approximately 1373.15K to 1473.15K.

The objective of lime reburning is to obtain homogeneous and porous lime that will slake easily and produce lime mud that will separate easily from the liquor. Lime activity or causticizing power is a criterion for the slaking rate. It is proportional to lime porosity and surface area of the particles. Lime activity reaches its maximum value at a certain calcining temperature and then decreases. If the temperature in the kiln is too high, it causes changes in the lime crystal structure. This result in poorly slaking, hard, burnt lime.

IV. RECOVERY BOILER

A. Functions of Chemical Recovery Boilers:

- To recover the inorganic chemicals from black liquor.
- To produce high pressure and high temperature steam for captive power generation and also provide steam for use in Pulp and Paper mill operations.

Pulp mill operations totally depend upon the chemical recovery boiler. Generally, each paper mill is linked up with one recovery boiler and hence its availability and efficient operation are of utmost importance. Unlike other types of boiler in chemical recovery boiler the combustion takes place in reducing atmosphere and with coarser particle sizes.

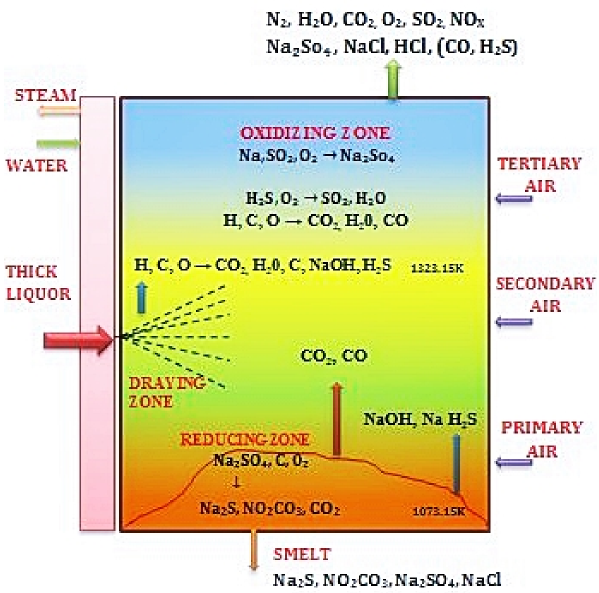

Figure: Recovery boiler and inside chemical reaction.

B.Types of Chemical Recovery Boilers:

Depending upon black liquor concentration available from MEE, following types of chemical recovery boilers can be chosen.

1. Conventional units having direct contact evaporator (like cascade evaporator) wherein black liquor at 45 to 50% from multiple-effect evaporators is concentrated to 62% to 70% solids before firing into furnace.
2. Large economizer units. In these units, black liquor at 62 to 70% from multiple-effect evaporators is directly fired in to the furnace. In this case a vertical tube extended surface economizer replaces the direct contact evaporator.

C. Striking features of a Chemical Recovery Boiler:

- Fully welded furnace waterwall construction with no refractory on vertical waterwallls.
- Decanting hearth with multiple smelt spouts. Suspension firing of black liquor with multiple black liquor guns
- Properly proportioned drying, reducing, and oxidizing zones with tangential concentric air system above the black liquor guns
- Widely spaced tangent tube superheater with flexible connectors and steam cooled spacers
- Single pass baffle-less boiler bank. Vertical straight tube economizer.
- Twin wheel cascade evaporator system. Concrete cased electrostatic precipitator with collecting electrode of Corten steel, weather resistant steel.. .
- Forward curved bladed radial induced draft fans.
- High energy arc igniters with visible light scanners for startup oil burners.
- Furnaces safeguard supervisory system.
- Fully automatic soot blower control system.
- Use of seamless steel tubes for boiler pressure parts.

D. Effect of Various Parameters in Operation:

As the combustion in black liquor fired chemical recovery boiler takes place under a reducing atmosphere, the effect of various parameters are critical.

The basic input parameters to the recovery boiler are:

- Black liquor quality which includes concentration (% dry solids), temperature, Higher Heating Value, composition, % organic to inorganic ratio, and other physical properties
- The feed water temperature and feed water chemical quality.
- The combustion air temperature which plays a major role in bed stabilization

E. Performance Optimization of Chemical Recovery Boiler:

Optimized operation of the chemical recovery boiler means more steam and chemical recovery. Energy savings of major proportions can be realized in recovery boiler operation by focusing attention to the following:

Develop and maintain a properly tuned process control system. Better control on input streams such as dry solids concentration, excess air, and salt cake make-up. Optimize the boiler cleaning system steam usage. The black liquor which is input into the boiler should be optimized first for the correct concentration, i.e. the maximum concentration that can be achieved. This reduces the moisture loss in the boiler.

The firing pressure and temperature are to be optimized to minimum value so that liquor is fired as coarsely as the boiler can accept. Normally the pressure is first brought down by using different sizes of black liquor gun tips.

After this, the liquor temperature has to be optimized. A liquor temperature of around 388.15 K is good to start with. Once the liquor is burning properly, liquor temperature may be changed in small steps of ½ ° C with a time interval of an hour between every setting to allow furnace equilibrium to be established. While doing the above, the liquor burning profile has to be watched and brought to the optimum point as this is an important variable governing the reduction efficiency of the furnace.

The bed height can be adjusted easily by slight changes in black liquor temperature entering the furnace. However, this method of control should be avoided, if at any time it forces the use of a fine liquor spray. A better method is to regulate bed height by changing the ratio of primary to secondary air. The peak height of the bed should be about 1m from the primary airport bottom.

The next very important parameter to be optimized is the total air flow, meaning the air flow proportion between primary and secondary, and air temperature. Increasing primary air quantity will tend to increase char bed temperature, increase the burning rate, and lower the reduction efficiency. It is equally important to distribute the primary air around the char bed. The total air flow can be maintained in such a way to get an excess air level around 15% at cascade evaporator inlet. The change in thermal efficiency of the recovery boiler due to excess air changes is low. The air temperature maintained in black liquor fired chemical recovery boilers is around 423.15to473.15 K, which results in very good bed stabilization.

It is necessary to avoid fine spray low bed operation of the boiler. Low bed fine spray operation is a safety hazard also. In suspension firing type recovery boilers, operating with a Fine Spray Low Bed (FSLB) leads to a lot of problems and causes high maintenance of the boiler. The reason why FSLB is resorted to by many operators is ease of operation, minimum attention required, and no rodding of the air ports needed. It gets rid of the black liquor easily and creates green liquor.

The various problems caused due to FSLB operation are:

- Increased mechanical carryover of ash.
- Increased ash fouling of heat transfer surface.
- Increased primary airport fouling rate.
- Decreased reduction efficiency.
- Increased smelt leak potential.
- Decreased burning stability.
- Increased smelt water explosion hazard.

F. Graphical Representation:

It is seen that increasing amount of solid percentage in black liquor leads to increase the recovery boiler efficiency. This will save the energy hence reduction in production cost of steam.

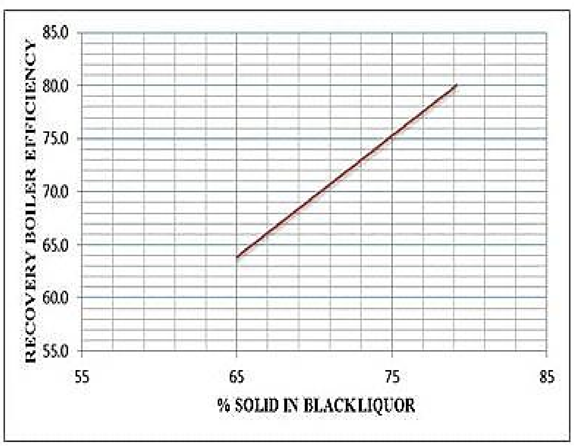

Figure: In the graph, x-axis and y-axis contains various values of Black liquor solid % and boiler efficiency.

V. GREENHOUSE GAS EMISSIONS AND CONTROL

Greenhouse gas emissions from recovery section in pulp and paper mill are predominantly CO_2 with smaller amounts of CH_4 and N_2O.

A. Greenhouse gas (GHG) Emissions:

Emissions source	Types of pulp and paper mills	Type of GH Emissions
Chemical recovery furnaces –Kraft & soda	Kraft and soda pulp mills	fossil CO_2, CH_4, N_2O ,biogenic CO_2, CH_4,N_2O
Chemical recovery furnaces –sulfite	Sulfite pulp mills	fossil CO_2, CH_4, N_2O biogenic CO_2, CH_4, N_2O
Chemical recovery combustion units – stand-alone semi chemical	Stand-alone semi-chemical pulp mills	fossil CO_2, CH_4, N_2O,biogenic CO_2, CH_4,N_2O
Kraft and soda lime kilns	Kraft and soda pulp mills	fossil CO_2, CH_4, N_2O,process biogenic CO_2
Makeup chemicals ($CaCO_3$,Na_2CO_3)	Kraft and soda pulp mills	process CO_2
Anaerobic wastewater treatment	Chemical pulp mills--- Kraftmostly	biogenic CO_2, CH_4

B.Control Measures:

The control measures and energy efficiency options that are currently available for pulp and paper mill processes are:

Chemical Recovery Furnaces:
(1) Boiler control measures and energy efficiency options.
(2) Recovery furnace deposition monitoring.
(3) Black liquor solids concentration Quaternary air injection.
(4) Improved composite tubes for recovery furnaces.

Kraft and Soda Lime Kilns:
(1) Piping of stack gas to adjacent PCC plant.
(2) Lime kiln modifications.
(3) Lime kiln oxygen enrichment.
(4) Lime kiln ESP.

Makeup Chemicals:
(1) Practices to ensure good chemical recovery rates in the pulping and chemical recovery processes.
(2) Addition of Na and Ca in forms that do not containcarbon.

VI. CURRENTPROPOSITION

Byminorenlargements in the elementary technologythe current Kraft recovery process is established. Asignificantprogress in recovery boiler operation is the "highsolids firing (HSF)" which refers to burning black liquor at solids contents greater than two third of total constituent.This helps inincreasing steam generation and progresses combustion steadiness, resulting lower TRS and sulphur dioxideemissions. Other thanthis, reduces boiler fouling and blocking hence proper boiler operation and performance. It also delivers more capability in standing units.The power generation capacity of a recovery boiler depends on steam pressure and temperature and black liquor combustion. Typically, recovery boilers have operatingsteam pressures 9 MPaand temperatures below753.15K.These limiting valuesare for preventing over superheater corrosion and for expensivematerial structure. But for better performance higher pressures and temperatures are first and foremost necessity. Today there are a number of recovery boilers operating at 11 MPa and783.15K. Steam generation rates can be as high as 4 kg steam per kg black liquor solids and power generation, as high as 0.6 kWh/kg. A sophisticated mill may have high-solids evaporators which produces the black liquor of 80-85% solids concentration for burning in the recovery boiler.A modern recovery boiler design consists of a single drum, high solids firing unit with multiple levels of air supplied by separate fans.Instead of using conventional high pressure steam new recovery boilers use headers where pressure of steam is lowered to 1 to 1.5 mega Pascalafter the steam turbine for sootblowing with different sootblowers like rotary, long retractable or wall blowers, helps in better heat transfer by removing accumulated soot insulation. Slakers with cyclones and scrubbers are provided in the causticizing plant to reduce dust buildup.Kraft mills which are based on high controlling,for Cl and K eliminationuses methods likedisposal of a considerable portion of the precipitator ash or use elegant ash treatment systems for removing Cl and K.In bleached Kraft mills, there will be increased absorption of some of the process streams from the bleach plant into the recovery cycle. O_2-delignification liquor will be disposed of in the recovery cycle. There will be improvedinducements for bringing alkaline stage effluents back into the pulping cycle through countercurrent washing.

VII. FUTUREPROSPECTIVE

In recent years, black liquor gasification has received extensiveconsideration as a potential replacement for recovery boilers. Now the main focus on greater electricity generation.For that, different experiments, simulation are carried out to burn the produced gas in a gas turbine for combined-cycle power generation. Nevertheless, many materials and gas clean-up questions remain to be fixed. Attention is now shifting to on bio refinery concept, analogous to today's petroleum refinery where black liquor gasification process is used to produce synthesis gas as a raw material by which chemicalscan be produce having higher market value.

The Borate Autocausticizing process involves adding sodium borate into the liquor system so that it forms tri-sodium borate (Na_3BO_3) in the recovery boiler smelt. Na_3BO_3 dissociates into sodium hydroxide (NaOH) and $NaBO_2$ in the dissolving tank. Thus, it is possible to causticize a portion of Na_2CO_3. With zerofunds investment partial autocausticizing is astrikingsubstitute for Kraft mills where incremental causticizing and lime kiln capacity are needed. Various mill experiments, modeling have been conducted and complicationswhich are comeacross have been fixed. The technology is now being used at several mills in the world.

VIII. CONCLUSION

The chemical recovery process commands the quality and quantity of the white liquor, which in turn, limits pulp production and the productivity of the Kraft pulp mill. There are numerous ways in which the economics, energy efficiency, and environmental security related with the recovery process can be improved. Development of process sensors and control is an area experiencing rapid change. Much remains to be learned about the science of the Kraft recovery cycle and about application of that science through improved processes and equipment. With today's increasingly high energy and chemical costs, and strict environment regulations that limit particulate and gaseous emissions, solid waste disposal and mill effluent discharge, the need for improved recovery of energy and chemicals from the black liquor has become a critical economic factor in pulp mill operation. It is essential for mills to maximize the steam and power production capacity, reduce recirculating chemical deposition, and minimize chemical losses. The reliability and efficiency of recovery boilers, evaporators, causticizing plants and lime kilns have a direct impact on the quantity and quality of white liquor, and ultimately the quantity and quality of pulp produced by the mills.

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