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Analysis of Energy Feasibility and Integration for Paper Industry

Nachiket Nagare[1], Prateek Armarkar[2]
[1]*Research Scholar, Department of Mechanical Engineering SRIST, Jabalpur (M.P)*
[2]*Asst. Prof., Department of Mechanical Engineering SRIST, Jabalpur (M.P)*

***Abstract* - Wood is the basic raw material used to manufacture pulp, but several other raw materials are also used. Wood typically enters a pulp and paper mill as logs or chips and is processed in the woodyard, which is referred to as the wood preparation area. The woodyard operations are independent of the type of pulping process. If the wood enters the woodyard as logs, a series of operations convert the logs into a form suitable for pulping, usually wood chips. Logs are transported to the slasher, where they are cut into desired lengths the aim of the present study, is to examine the energy efficiency performance of Indian paper industry considering as the case study. A pinch analysis has been carried out for the energy saving opportunities. On overall conclusion it can be stated that the paper mill should restructure the heat transformation i.e. heat exchanger system and it can save up to 17314kW of heat during the process. The pinch analysis is the suggestion for heat recovery.**

***Index Terms* - Pinch analysis, paper industries, pulp, wood energy savings etc.**

I.INTRODUCTION

The pulp and paper industry plays an important role in the economic growth of the country. It is, in general, highly energy intensive. Energy efficiency improvement is an important way to reduce these costs and to increase predictable earnings in the face of ongoing energy price volatility. Several pulp and paper companies have already accepted the challenge to improve their energy efficiency and have started reaping the rewards of energy efficiency investments. Energy efficiency is doing more work with the same amount of energy or doing the same amount of work using less energy. There appears to be a strong business case for investing in energy efficiency in the pulp and paper sector. Energy efficiency reductions can make a significant difference to the bottom line as energy constitutes as much as 15% of total operating costs. Investing in energy efficiency can also yield benefits from

- Reduced water and associated chemical use.
- Improving energy and water security for the plant
- Building goodwill in the regional communities in which companies operate

Pulp and Paper Production Processes and Energy Overview

The pulp and paper industry are composed of pulp mills, paper mills, and paperboard mills.

- Pulp mills – manufacture pulp from wood and other materials such as wastepaper
- Paper mills – manufacture paper from wood pulp and other fiber pulp
- Paperboard mills – manufacture paperboard products from wood pulp and other fiber

Pulp mills and paper mills are highly complex and may exist as integrated operations or separately. Integrated mills are generally larger and more cost-effective than non-integrated mills, but the smaller size of the non-integrated mills allows them to be located closer to the consumer. Pulp and paper mills integrate many different process areas as:

Raw material preparation

- Debarking
- Chipping and
- conveying
  Pulping
- Mechanical pulping
  SGW
  RMP
  TMP
  CTMP
- Chemical pulping
  Kraft process

Sulfite process
- Semichemical pulping
  Recycled paper pulping
  Other pulping processes
- Pulp processing
  Chemical recovery
  Evaporation
  Recovery boiler
  Re-causticizing Calcining
- Bleaching
- Stock preparation
- Papermaking

Indian Paper Industry

As far as Indian paper industry is concerned, it has been ranked among 35 highly specialized industries in India owing to its economic benefits like contribution to GDP, export basket, sustainable livelihood in rural areas by creating employment opportunities and social benefits in terms of providing a medium for knowledge dissemination. As on 2015-16, paper consumption in India hovers between 13 kg per head which is relatively lower than in most advanced countries of the world and is lower than global average paper consumption of 57 kg (Overview of paper industry- IPMA). However, the demand for Indian paper industry is likely to increase to 53% by 2020 (Indian paper industry at a glance- 2015-16). In addition, the industry has undergone an appreciable transformation in terms of raw material usage and has achieved sufficient standards in order to be a competent player in the international paper market.

II-LITERATURE REVIEW

Diksha Sharma et. al. (2020) review reveals that Xylanases-the hydrolytic "bleach-boosting agents" and the versatile oxidative Laccases alone or in cocktail show an effective role in bleaching by significantly minimizing the utilization of bleaching chemicals by reducing kappa number and improving grade of paper. This encourages the compliance of these biological systems and divulges novel horizons in the pulp and paper industry giving rise to a cleaner and greener environment.

Diksha Sharma et. al. (2020) suggested some alternative raw material which is economical, ecological and effortlessly accessible and is rich in carbohydrates, hence reducing burden on woods. Agricultural residues such as millets are a good choice. Conventionally postharvest agro residues (millet straw) are burnt off leading to deleterious effects on environment along with adversely affecting human health. On that account, millet straw can be used alone or in association with other agricultural residues for making paper.

Another possible alternative is the use of food waste or vegetable remains such as florets of cauliflower or leaves of radish, turnip, beetroot or potato or the peels of banana; as they are cut off and thrown.

Izharul Haq et. al. (2020) studied to set one's eyes on the contemporary research status of lignin removal from paper industry effluent and its recovery for the production of value-added products. It was focused on the benefits of obtaining valuable products from lignin valorization. Lignin depolymerization is a considerable beneficial approach. Despite its complex structure, utilization of an advanced depolymerization technique in the presence of catalysts/biocatalysts is advantageous. It is crucial to study and modify biochemical pathways of lignin degradation and omit toxic by-products such as vanillin, phenols, etc. Molecular engineering of fungal and bacterial metabolic pathways can aid in lignin valorization.

III- RESEARCH METHODOLOGY

Production Process

The existing facility consists of chipper unit, chipper grading and separation unit, chemical digesters, black liquor evaporation plant, solids firing (recovery boiler), re-causticizing unit, lime kiln and coal gasification unit to supply fuel gas to the kiln.

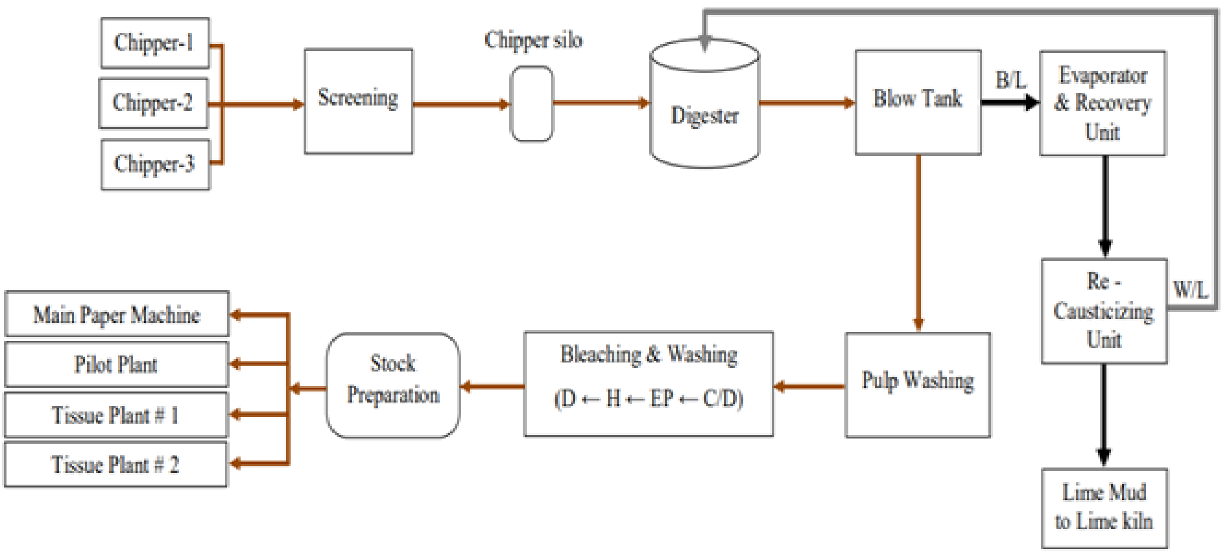

Figure 3.1 Typical Manufacturing Process

About 2400 m3/day of black liquor with 475 ADTP of solids generated from the blow-tank area is being subjected to heat recovery followed by six stage multiple evaporators to increase the consistency of the solids from 14% to 50%. The solids generated from the evaporator are further fired in a dedicated 60 TPH steam generation capacity recovery boiler. The condensate from the multiple effect evaporator is utilized in the re- causticizing plant for making the white liquor. Typical manufacturing process of the recovery process is presented in Figure 3.1. The recovery system in a kraft pulp mill has three functions:

1. Recovery of the inorganic pulping chemicals,
2. Destruction of the dissolved organic material and recovery of the energy content and
3. Recovery of valuable organic by-products.

Table 3.1 Input problem data, i.e. stream temperatures, stream names, stream properties and dTmin criteria.

Stream Name	Supply Temperature	Target Temperature	Heat Capacity Flowrate	Heat Flow	Stream Type	Supply Shift	Target Shift
	°C	°C	kW/K	kW		°C	°C
H1	75	65	31.000	310.0	HOT	67.5	57.5
H2	72	56	36.000	576.0	HOT	64.5	48.5
H3	68	51	34.000	578.0	HOT	60.5	43.5
H4	80	38	400.000	16800.0	HOT	72.5	30.5
H5	75	56	1200.000	22800.0	HOT	67.5	48.5
H6	75	58	560.000	9520.0	HOT	67.5	50.5
C1	75	90	31.000	465.0	COLD	82.5	97.5
C2	75	96	37.000	777.0	COLD	82.5	103.5
C3	75	96	55.500	1165.5	COLD	82.5	103.5
C4	43	65	54.500	1199.0	COLD	50.5	72.5
C5	18	24	300.000	1800.0	COLD	25.5	31.5
C6	18	49	306.000	9486.0	COLD	25.5	56.5
C7	49	55	107.000	642.0	COLD	56.5	62.5
C8	45	60	190.000	2850.0	COLD	52.5	67.5
C9	40	48	909.000	7272.0	COLD	47.5	55.5
C10	49	52	735.000	2205.0	COLD	56.5	59.5
C11	49	54	566.000	2830.0	COLD	56.5	61.5
C12	49	62	249.000	3237.0	COLD	56.5	69.5
C13	49	67	357.000	6426.0	COLD	56.5	74.5
C14	51	60	288.000	2592.0	COLD	58.5	67.5
H7	72	56	200.000	3200.0	HOT	64.5	48.5
H8	66	54	210.000	2520.0	HOT	58.5	46.5
H9	31	30	3957.000	3957.0	HOT	23.5	22.5

IV-RESULT ANALYSIS

Pinch Analysis

The required data has been gathered from the mill. The simulation model has been simplified by using only two components, water and wood, and chemical reactions have been considered only as a source or sink of heat. The model presents the paper machines and grinderies in detail and the steam production and water treatment in a more simplified manner.

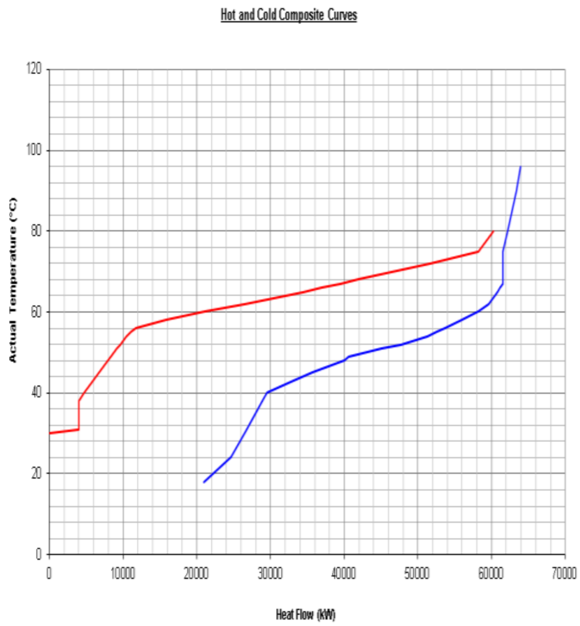

Figure 4.1 Composite curve plot

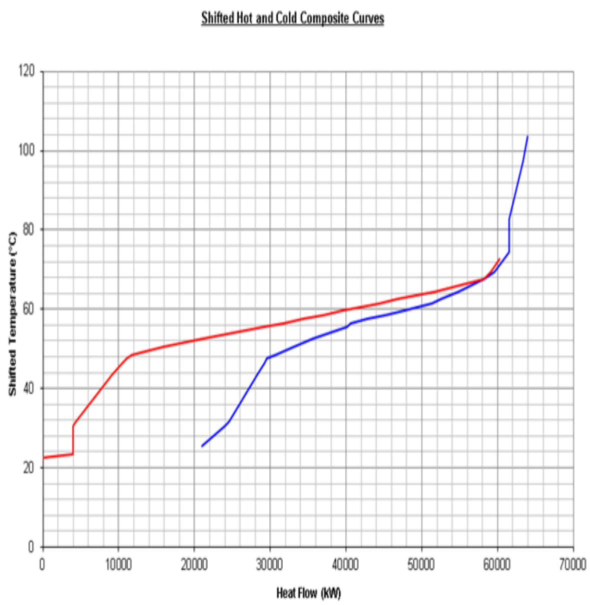

Figure 4.2 Shifted composite curve plot

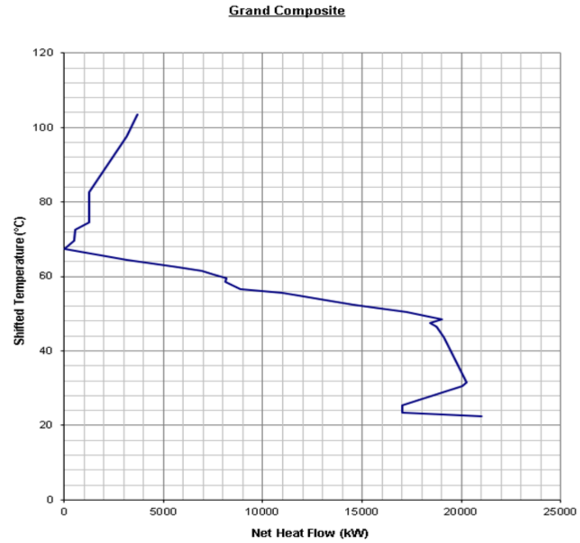

Figure 4.3 Grand composite plot.

V-CONCLUSION

The pulp and paper industry accounts for approximately 5 percent of total industrial energy consumption and contributes 2 percent of direct carbon dioxide (CO2) emissions from industries. The present study is an attempt to examine the energy efficiency performance of Indian paper industry. A pinch analysis has been carried out for the energy saving opportunities. Following conclusions can be made:

- The values of net heat flow at the top and bottom end are as: for hot utility 3677 kW, 103.5°C and cold utility targets is 20991.5 kW, 22.5°C
- The total heat recovered by heat exchange is found by adding the heat loads for all the hot streams and all the cold streams -7569 and 24884kW, respectively
- The total heat recovery of about 17314kW can be obtained by two separate routes.
- The proposed system (heat exchanger network) provides the heat recovery of 17314 kW.

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