Impact Of Cooking Conditions On Pulp Viscosity And Kappa Number Of *Leucaena Leucocephala Wood* For Kraft Pulping

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Abstract

Kraft method of delignification is an intricate operation involving various complex chemical and physical processes. There are a couple of factors (G-factor & H-factor) which effect and determine the process of delignification. . In modern plants, checking and controlling of the pulping process has been achieved by the application of computers. Controlling of a pulping process with computers require factors to indicate seizing of the process. In the last three decades a lot of empirical and semi theoretical equations and factors have been developed for defining the properties of the pulp and paper. In this study, the two important factors viz, H-factor and G-factor were extensively studied to find out their effect on two important characteristics of pulp namely kappa number and viscosity. This new method requires knowing the variation in [OH'] across the thickness of the wood chip and during the cook. These variations can be determined by solving a set of mass transfer equations with kinetic reaction terms, and is solved numerically by a computer program, which generates the values of the modified G-factor.These G-factor values are then converted to pulp viscosity.

Keywords: Kraft pulping, H-factor, G-factor, Kappa number.

INTRODUCTION:.

An extent in delignification is often accompanied by loss in the yield, since the chemicals are not specific to lignin removal. Delignification for longer time but without loss of pulp viscosity can be achieved through change in pulping chemicals and dissolved lignin alkaline processes provide the option to extract lignin and hemicelluloses before or after pulping in a separate process step,

which makes the isolation of the different wood components easier[**1-2**]. Diffusion of alkali from pulping liquor into the wood chips plays an important role in kraft pulping. The overall pulping rate is determined by the rates of reaction and diffusion. It has been shown that the lignin content of cooked chips varies across chip thickness (Gullichsen et aI.,1992).Lignin content for cooked chips is highest at the chip center and lowest at the surface. For chips less than 2 mm thick, pulping is uniform[**3**]. Pulp produced at a higher cooking temperature with a higher H-factor shows lower HexA content at a given kappa number compared to a lower cooking temperature with a lower H-factor[**4**]

Delignification:

Delignification is the removal of the structural polymer lignin from plant tissue, so that it can be used for applications like making paper. The process primarily refers to the chemical process for the removal of pulp from wood. There are two types of delignification are:

.Selective delignification

The selectivity of delignification is determined by the ratio between lignin and carbohydrate dissolution. The feasibility of using polyoxometalate (POM) salts and oxygen in the commercial bleaching of chemical pulps is herein demonstrated. A clear advantage of polyoxometalates over oxygen alone, hydrogen peroxide or ozone is their inherently high oxidative selectivity for the residual lignin in softwood kraft pulps.[5] Increasing the selectivity towards lignin dissolution involves favouring lignin degradation over carbohydrate reactions can be achieved by keeping the cooking temperature as low as possible during the kraft cook – the differences in activation energy between bulk-phase delignification and cellulose degradation can be used to increase the pulp viscosity at a given kappa number by lowering the cooking temperature, which is done in modern kraft cooking systems; Pulping uniformity is critical for improving the performances of cooking and downstream operations such as bleaching and papermaking. In spite of certain success of recent modifications of batch and continuous kraft cooking systems, there is still a lot of room for improving the contemporary cooking systems in order to address problem of heterogeneous pulping[**7-10**]

The uniform delignification of wood chips can also be described as homogenous delignification. This means delignifying all the wood chips to the same residual lignin level and all the fibres to a similar lignin content. Low cooking temperatures and thin chips should be used to achieve homogenous delignification (Hartler and Onisko 1962). Their investigation provided strong

support of the diffusion theory, as opposed to the moving interface theory (Kulkarni and Nolan 1955), of the liquid impregnation of wood chips. They concluded and recommended that as low a cooking temperature as possible should be used, since the wood substance is already completely penetrated at 130–140 °C. The cooking temperatures investigated in 1962 were 170 °C, 180 °C, and 190 °C (Hartler and Onisko 1962). Gullichsen et al. (1992) also demonstrated that pulping uniformity could only be achieved by using sufficiently thin chips (1.5–2 mm) under normal pulping conditions, which at that time was a cooking temperature of 175 °C. Temperature controls the rate of hydroxide ion consumption and the diffusion of cooking chemicals in the wood chip. In order to determine when to stop a kraft cook, it is necessary to know the extent of the reaction which is based on the rate of lignin removal. , H factor is used to determine the time required at a given AA and sulfidity to reach a desired kappa.

2. EXPERIMENTAL

2.1. Raw Material

Air-dried woods were (***Leucaena leucocephala wood***) obtained from different areas of Madhya Pradrash Such as Vidisha , Bhopal & Hoshangabad   district.

__Description of pulp__:

Chip thickness(mm)	2-4
Temperature (˙C)	170
Time to temp, min	60
Time at temp, min	240
Liquid:Wood ratio	4:1

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Fibre length ,mm	1.22
Specific gravity	70.82
Total Extractives%	18.86
Lignin%	9.74
Holocellulose%	0.597
Ash%	1.13

2.2. Calculating of H and G-Factors

As derived for application to the kinetics of delignification, Vroom's H-factor (VROOM 1957) can be defined according to Eq. 1, where Klig (373) is the delignification rate at 100 oC (373 K). Now by analog with the H-factor, we can define the G-factor for viscosity loss as a means of expressing the effect of pulping time and temperature in a single variable (Eq. 2)

$$H = 1 / (Klig(373)) \int_0^{t0} klig\ T\ dt\ (1)$$

$$G = 1 / (Kvis(373)) \int_0^{t} kvis\ T\ dt\ (2)$$

Kubes at al (1983) presents the kraft data in Figure 1 that, at constant alkali charge, straight-line plots of viscosity-1 versus time were obtained, with a different slope for Kubes at al (1983) presents the kraft data in Figure 1 that, at constant alkali charge, straight-line plots of viscosity-1 versus time were obtained, with a different slope for each cooking temperature

3. RESULTS and DISCUSSIONS

Pulping trials were conducted under the operating conditions varied over the following ranges: 7600, 15500 and 23400 G-factor level, 14%, 18% and 22% active alkali charge and 15%, 30% and 45% sulphidity charge. 20 pulping trials were conducted according to 3x3x3 experimental factorial design and each experiment was duplicated. Viscosity values belong to each pulp sample were presented in Table 1. while increasing sulphidity rate, viscosity of the pulp samples are increasing too..

Table 1. Pulping of *Leucaena leucocephala* with various pulping conditions

Pulping	Sulphidity. Rate (%)	Effective Alkali	G factor.	H factor	G/H ratio	Active Alkali Rate (%)	Kappa Number	Intrinsic Viscosity Cm3/g	Total yield(%)	Screened Yield (%)
1	15	1290	7600	800	9.5	14	11835	976	49	45
2	15	1660	7600	800	9.5	18	7600	883	38	35
3	15	2030	7600	800	9.5	22.	5070	777	38	35
4	15	1290	15500	1600	9.6	14	9540	1059	46	42
5	15	1660	15500	1600	9.6	18	4410	755	50	46
6	15	2030	15500	1600	9.6	22	2785	522	39	35
7	15	1290	23400	2400	10.1	14	8010	935	40	36
8	15	1660	23400	2400	10.1	18	3500	632	40	37

| 9	15	2030	23400	2400	10.1	22	2260	385	49	43
10	30	1290	7600	800	9.5	14	10095	1052	40	37.3
11	30	1660	7600	800	9.5	18	6105	943	45	42
12	30	2030	7600	800	9.5	22	4305	802	40	37
13	30	1290	15500	1600	9.6	14	7350	974	38	35
14	30	1660	15500	1600	9.6	18	3810	824	35	36
215	30	2030	15500	1600	9.6	22	2955	521	49	45
16	30	1290	23400	2400	10.1	14	7965	1075	46	42
17	30	1660	23400	2400	10.1	18	2930	669	47	45
18	30	2030	23400	2400	10.1	22	2030	504	48	44
19	45	1290	7600	800	9.5	14	9270	1233	50	36
20	45	1660	7600	800	9.5	18	5755	1055	50	47
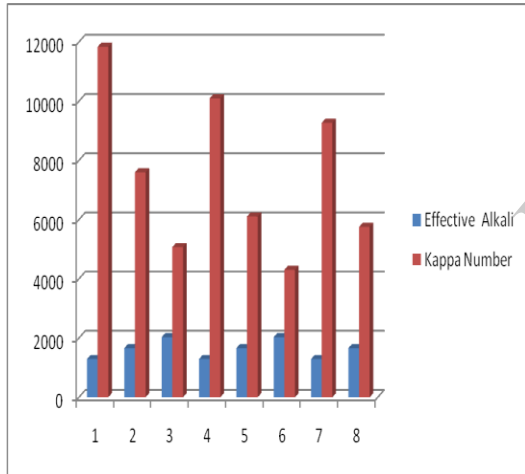
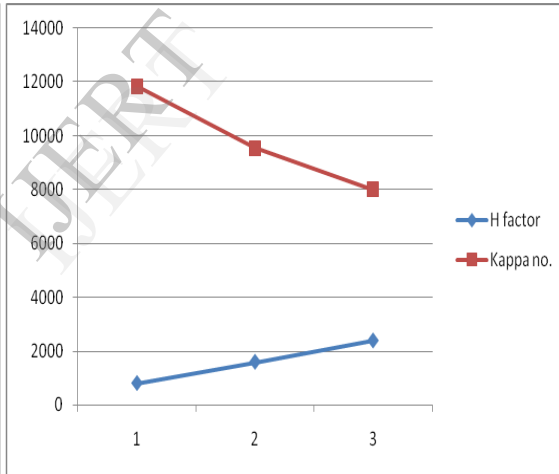**Fig.1 E.A vs Kappa no**

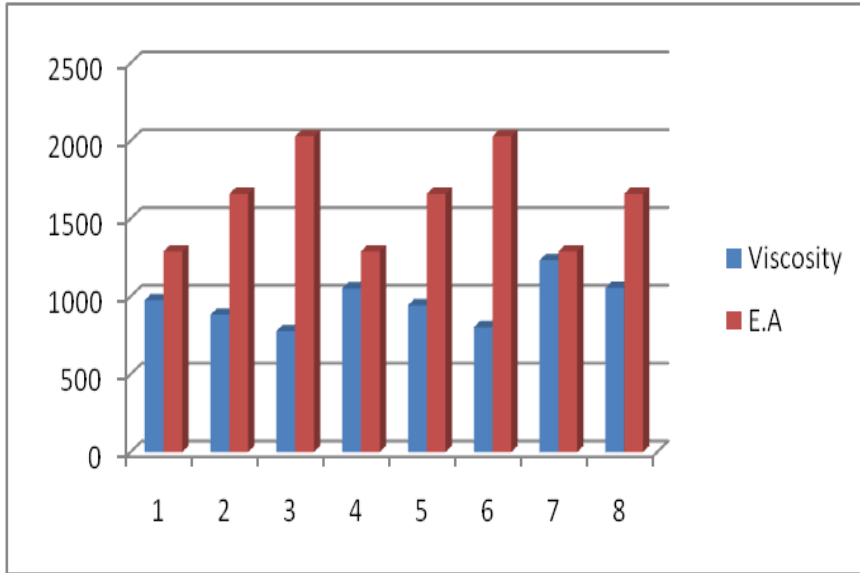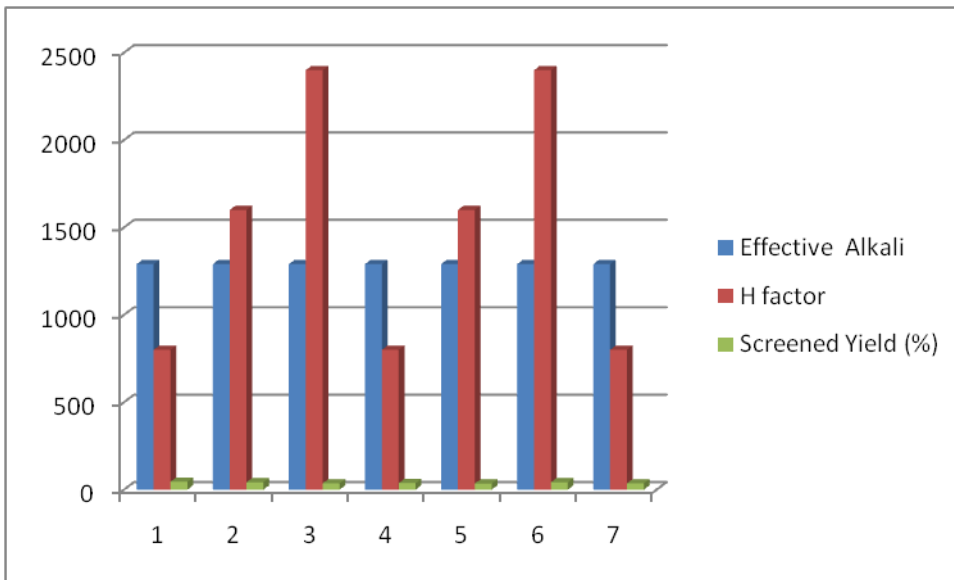**Fig.2 H factor vs Kappa no**

Fig 3. E.A vs Viscosity

Fig. Keeping E.A as constant an Increase in Kappa Number shows negative impact On pulp yield.

Effective alkali concentration is the most important factor on the viscosity. Increasing alkali charge decreases viscosity values and the most important reactions of increasing alkali concentration in Kraft white liquor are alkaline peeling and alkaline hydrolyze on carbohydrate polymers. However, keeping it constant a large number of changes can be brought by the variation of H factor and G factors.

4. CONCLUSIONS

The degradation and dissolution during Kraft cooking of the carbohydrates of Leucaena leucocephala wood was studided and the results fitted to already established facts about the factors/expressions that helps in determining and controlling the yield and pulp consistency thereby enhancing delignification and thus decreasing kappa number during the first time cooking itself. Further the most important facts that can be drawn from this study are:

- At a constant H-factor increase in Effective alkali decreases kappa number.

- At a constant G factor increase in Effective alkali decreases viscosity.

- Keeping E.A as constant it has been observed that with an increase in Kappa no. viscosity also increases.

- Further at a constant E.A with an increase in G/H ratio the intrinsic viscosity was observed to decrease.

- Pulp viscosity is determined by total EA consumption, not by any specific cooking stage EA consumption.

- Yield loss of carbohydrates in kraft pulping is linearly dependent on H-factor (i.e. cooking time)

- When EA was kept constant both H and G factors had a negative impact on screened yield of the pulp suggesting maximum defibration point can be reached by changing H and G factors.

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