Some Recent Advances in Pulp and Paper Industry

H. V. DAVE* AND K. V. MARIWALA*

IN 1854, Burgers[1] obtained a patent for the manufacture of pulp by the soda process. Since then, although there have been considerable improvements and developments in the pulping processes and equipments, the pulp and paper industry, in general, has failed to keep pace with the vast progress made by other sister industries. Recently, however, the lack of such enterprise has been aptly felt by some leading personnel in the industry, particularly in the United States of America and to a certain extent on the Continent. As a result of this, during the last decade or two, several new ideas have been successfully translated into practical application and today, the pulp and paper industry stands on the brim of a very prosperous growth. It is the purpose of this presentation to discuss some important advances made by the industry in recent years, with particular reference to the sulphate or the Kraft Process.

Pulp is a commercial cellulosic material prepared mainly from wood and to a certain extent from other raw materials like rags, straw, bagasse etc. Pulp is largely used for the manufacture of different kinds of papers, paper boards and artificial fibres. There are three methods of pulping viz., the mechanical, chemical and the semi-chemical methods. In the first method, logs of wood are ground between mechanical grinders. In chemical pulping, small chips of wood are subjected to the action of different chemicals. The soda process uses caustic soda and soda ash. The sulphate or the Kraft process uses caustic soda and sodium sulphide and the sulphite process uses calcium bisulphite and excess of sulphur dioxide gas. The function of all these chemicals is to remove lignin, which acts as a binding material between cellulose fibres. In the semi-chemical pulping, as the name suggests itself, the wood chips are digested in chemicals till they are softened and then the cellulose fibres are mechanically separated.

The preparation of wood for digestion consists in debarking the logs and cutting them into thin chips of about one inch length. At the conclusion of cooking period, pulp is washed and bleached, if necessary. The black liquor is treated for the recovery of the inorganics with a simultaneous combustion of the dissolved organics for the utilization of their heating value.

Debarking :—Debarking of wood by means of mechanical scrapers was practiced in the early stages of the industry. It has the inherent disadvantage of wasting some useful cellulosic material. An improvement over this method is drum debarking. It is commonly practiced today and it achieves debarking by allowing several logs of wood to travel simultaneously through a rotating drum. The friction between the logs and the inner surface of the drum and also the mutual friction between the logs themselves help in loosening and removal of the bark. Very lately, attempts are made to debark wood by impinging a stream of high pressure water on the logs, when the mechanical impact separates the bark from the wood. Another recent development consists in debarking wood after chipping it. The chips are suspended in a suitable medium and the whole mass agitated, when due to the difference in densities of wood and bark, the two are separated.

---

*Third year B.Chem.Eng. students.

Cooking:—The present method of digestion consists in subjecting a mixture of wood chips and cooking liquor to a pressure of about 110 pounds of steam. In the early part of the cook, called the precooking period, the liquor is supposed to penetrate into the interior of the chips. Subsequently, the chemical reaction, resulting in the dissolution of lignin, is supposed to take place. So far, most of the cooking is conducted by a batch process which involves high investment cost and which is tedious, space-occupying and time-consuming. Hence, the recent tendency in cooking is towards the development of a continuous process in which digestion of wood chips can be achieved in about 10 to 15 minutes by the use of higher temperatures and concentrations. Such drastic conditions preclude the need of a precooking period. A diagramatic sketch of a continuous digestor, suggested by Nolan[2], is given in Figure I. In order to achieve a fast rate of cooking throughout the digestor, it is necessary to maintain a constant concentration of the liquor. This is done by the addition of fortifying liquor at various points along the length of the digestor. Continuous cooking yields a more uniform pulp. But, compared to the batch process, it requires about 83.5% more chemicals and increases the evaporation load by about 32%. This, probably, will be counter-balanced by preclusion of the prehydrolyser and achievement of higher yields. Hence, attempts are being made to replace the existing batch process by a continuous process.

In addition to the rapid changes in the cooking methods, the concept of the mechanism involved in cooking is also undergoing a revolutionary change. So far, in Kraft cooking, it has been assumed that the penetration of the liquor is the rate—controlling step and that the digestion of chips cannot be carried to completion unless sufficient time is allowed for such penetration. But, very recently, the work done by Nolan and Kulkarni[3] has pointed out very impressively that it is the chemical reaction between lignin and alkali rather than the penetration of alkali that controls the rate of cooking. This concept may introduce a drastic change in the preparation of wood for cooking. More stress may have to be placed on the thinness of chips than on precooking period.

Bleaching: During bleaching, the colouring matter in pulp is destroyed by some oxidizing agent, which should necessarily be cheap and should have minimum degrading action on cellulose. Chlorine, calcium hypochlorite, hydrogen peroxide and chlorine dioxide are the main bleaching agents. Chlorine dioxide is of very recent origin and is supposed to achieve a very satisfactory bleaching, except for the fact that its highly explosive nature demands careful handling.

In batch bleaching, pulp at a consistency of about 7% is bleached with calcium hypochlorite at 95°F. The mass is agitated till desired degree of brightness is obtained. Apart from the fact that this method damages the fibre considerably, the chlorine consumption is excessive. These difficulties are overcome in a multi-stage process. In the latter process, the amount of liquor added in any one stage is not sufficient to bleach the whole lot of the pulp. This reduces the degradation of cellulose and therefore yields a considerably strong pulp. In a particular stage, when all the liquor is consumed, the charge is washed and treated with some more bleach liquor. This is repeated three or four times, but two stages are most common. In the first stage, chlorine is added instead of hypochlorite. The absorbed chlorine helps in removing a considerable amount of residual lignin. After the chlorine absorption, the charge is washed with alkali to remove lignin. The pulp is then bleached with hypochlorite.

In contrast to the present-day practice of bleaching pulp at low consistencies, the most recent tendency is to bleach it at as high a consistency as is possible. The effect of low consistency is that the actual concentration of available chlorine, which is the driving force for the bleaching rate, is very low. When 1.5% available chlorine is mixed with a pulp of 12% consistency, the actual concentration of chlorine becomes 0.202% ; but when it is mixed with a pulp of 40% consistency, its actual concentration becomes 1.0%. Thus, by increasing the consistency from 12% to 40%, the concentration of active chlorine is increased five times, resulting in a much faster rate of bleaching. Faster the rate of bleaching, less is the time of contact between chemicals and cellulose and hence the degradation of cellulose is less.

A new method of ultra-high density bleacing is being developed on this basis by Armstrong[4]. The main difficulty is that of blending the pulp and the bleach. This difficulty is overcome by the use of high speed rotary mixers. Pulp, at about 40% consistency, is passed between two toothed plates, one of which is stationary while the other rotates at a speed of 1,800 R.P.M. The combing action of the teeth goes on creating fresher surface through the bulk of pulp. At certain points along the radius of the plates, nozzles are placed through the stationary plate. The moving teeth atomise the bleach solution coming out of the nozzles and this spray mixes intimately with the charging surface of the pulp. The concentration of bleach solution is kept at a maximum possible value to prevent the consistency falling below 30%. After blending, the bulk is heated to the optimum temperature and when bleaching is complete, the pulp is diluted and discharged.

At present, high density bleaching is experimented with hydrogen peroxide only, but it is likely that greater advantages can be obtained by the use of chlorine compounds. It has been observed that the use of same percentage of peroxide for pulps at different consistencies results in marked gain in brightness in the case of high consistency pulp. In high density bleaching, therefore, the amount of peroxide to be used for the same degree of brightness is much reduced.

It is obvious from all these facts that it will not be long before the existing methods of bleaching will be replaced by high density bleaching methods for better qualitative and quantitative yields.

Black liquor recovery :—The liquor coming out of the digestors contains free chemicals in the form of unreacted inorganics from the green liquor and combined chemicals in the form of lignin derivatives. The organic matter is utilized in two ways. In one method, the liquor is concentrated to about 70% solids and then burnt in furnaces after the addition of sodium sulphate. The heat of combustion is used for boilers. Sodium sulphate is reduced to sodium sulphide and the mass obtained after burning is used for the recovery of inorganic chemicals. In the second method, lignin is recoved in two stages. In the first stage, the alkalinity of the liquor is reduced to a certain value by bubbling carbon dioxide through the liquor when sodium lignate separates out. By this method, about 500 lb. of lignin are recovered per ton of pulp produced. In the second stage, the sodium lignate is used for the preparation of chemicals like vanillin, acetic acid, methanol, acetone etc. Although at present, the handling of lignin for the manufacture of low molecular weight organic compounds is hindered appreciably by its high instability towards degrading agents, it should not be beyond the capabilities of able hands to devise means and methods for its successful utilization.

With the progress of modern science,

the methods of harnessing atomic energy are taking concrete shapes and it is very likely that atomic energy will be available for industrial use in the near future. With the availability of this cheap power, the utility of lignin as a fuel will lose significance and therefore more importance will have to be attached to the treatment of lignin as a potential source of organic chemicals.

The annual *per capita* consumption of pulp and paper in U.S.A. is about 400 lb., while that in Great Britain is about 150 lb. Compared to this, the annual *per capita* consumption of 1 lb. in India, is extremely small. With the increase of literacy and industrialization, the consumption of pulp and paper products is bound to increase in our country. This fact, coupled with the availability of vast cellulosic resources, promises a very rapid growth for the Indian pulp and paper industry. During these days of growth, it is very significant that the recent advances in the industry are kept in mind.

REFERENCES :

1. Wise and Jahn, " Wood Chemistry ", Reinhold Publishers, 1952, Vol. II p. 974.
2. W. J. Nolan and G. R. Kulkarni, Tappi, Vol. 37, No. 10, Oct. 1954.
3. G. R. Kulkarni and W. J. Nolan, The Paper Industry, Vol. 37, No. 2, May 1955.
4. W. J. Nolan and Bruce Armstrong, Paper Mill News, Vol., 77, No. 39, Sept. 25, 1954.

Acknowledgment:

The authors wish to thank Dr. G. R. Kulkarni, Lecturer in Chemical Engineering at the Department of Chemical Technology, for his valuable guidance in preparing this article.

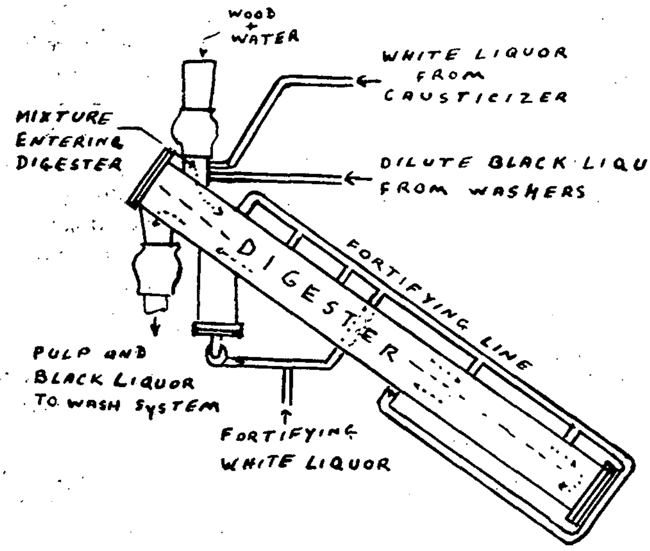

FIG. I. FLOW SHEET FOR CONTINUOUS PULPING