Studies on the Utilization of Agricultural Residues in the Manufacture of Pulp, Paper and Industrial Chemicals

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INTRODUCTION

While demand for Pulp and paper products in India is increasing at the annual rate of 7-8%. availability of cellulosic raw material to meet the ever increasing demand is becoming bad to wrose.

It has been estimated, that, Bamboo the traditional source of cellulosic raw material in India, even after ensuring the most scientific and best possible exploitation, could provide at the most. about 2.50 million tonne per year to the pulp and paper industry, which is less than 50% of the requirement at the end of the 1983–'84.

In a big agricultural country like India, agri-residues like straws and Bagasse, along with jute sticks, available in huge quantity, could provide substantial amount of cellulosic resources to the pulp and paper industry. Apart from its potentiality in bridging the gap between demand and supply position in pulp and paper industry, agri-residues could be exploited as a replenishable feed stock for the generation of multitudes of useful organic chemicals through saccarification of the carbohydrate content (major constituent in agri-residues), followed by conversion into alcohol by fermentation of reducing sugars.

Realizing the importance of agri-residue utilization in Indian economy, a series of Research Projects have been initiated and completed during the last 15 years at the Indian Institute of Technology, Bombay, to study the techno-economic feasibility of manufacturing pulp, paper and industrial chemicals, based on Rice & Wheat straws, Bagasse, and jute sticks.

In this present Work, an attempt has been made to evaluate the economic advantages of Mechano-Chemical (M–C) pulping process, as compared to the conventional pressure pulping process, for the conversion of agri-residues into pulp and paper.

For highlighting the importance of agri-residues in the field of useful chemical recovery possibilities, experimental data is demonstrated on the saccarification of agri-residues into reducing sugars by the simple acid hydrolysis route with the help of conc. Sulfuric acid.

EXPERIMENTAL PLANNIG BASED ON LITERATURE REVIEW

Commercial manufacture of paper from Rice straw dates back to as early as beginning of 19th century.[1]

In some of the European countries like Italy, Holland, and France, bleached Rice straw pulp is used in large quantity in paper furnish for the manufacture of excellent grades of fine quality papers like Bond, writing, and Glassine papers[2].

In 1949, Aronovsky et al[3] pointed out the relative advantages of M–C pulping for Rice straws, and showed, that, M-C pulping gave 25% higher yield, with pulp ash content 50% less as compared to conventional pressure pulping. In our earlier communications[4,5,6], it was pointed out the importance of lowering of pulping temperature. It was demonstrated, that, pulping temperature greater than 120°C gave higher yield loss, during Soda pulping of agri-residues.

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In this report, pressure pulping data. carried out in our earlier papers have been used, and M-C pulping data, indicated in this Work, are superimposed on pressure pulping data, for the evaluation of M–C pulping process vis-a-vis conventional pressure pulping process.

For conducting M–C pulping, Rice straw was chopped to 3 to 4 cm in length, and dusted over a 20–mesh vibrating screen. The chopped, and dusted Straw was pulped in 25 litre capacity round bottomed SS mixing reactor with vaned impeller suspended from the top. Before actual pulping with Soda chemicals, thorough wet washing was carried out inside the 'hydrapulper' with sufficient quantity of water, whereby leafy fragments, hulls, dirt, and trash materials were drained out. Wet washed straw/bagasse was pulped, by adding washed materials to the 'hydrapulper' containing required quantity of caustic soda and hot water. During addition of Straws/Bagasse, direct steam was introduced, and pulping was carried out for one hour at about 95 98°C. All analyses were carried out according to the standard TAPPI procedures.

RESULTS & DISCUSSIONS

Experimental delignification data, representing the relationship between LogL vs Pulping time (t) and degree of delignification Vs Pulping time (t), for Rice straw and Bagasse, by the pressure pulping and M–C pulping process are depicted in figures 1,2,3 and 4.

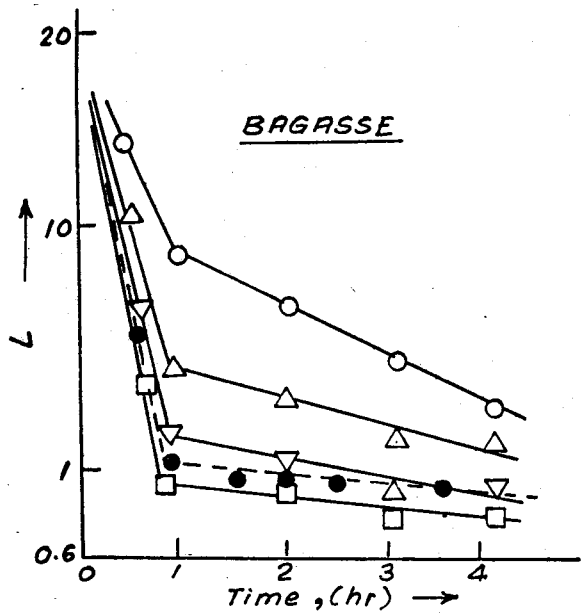

FIG. 1 LOG L VS TIME DATA

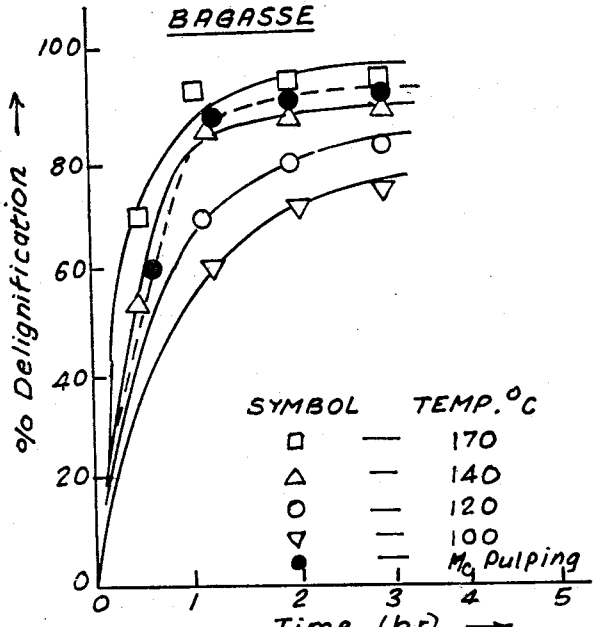

FIG. 2 % DL VS TIME DATA

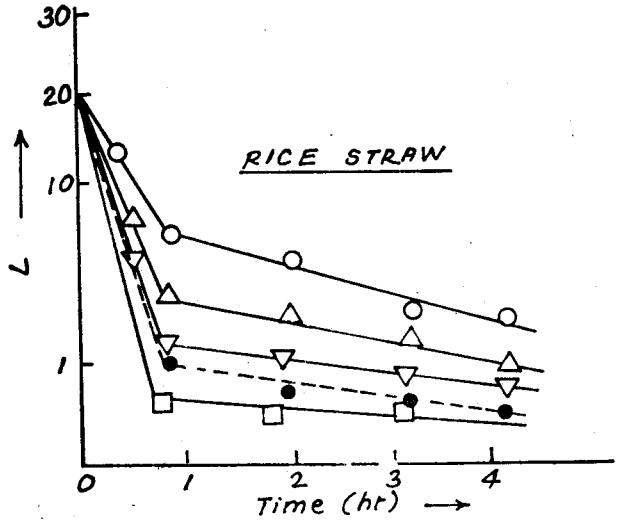

FIG. 3 LOG L VS. TIME DATA

As demonstrated in our earlier work, all data on delignification of Straw and Bagasse are well represented by a first order reaction pattern, giving two straight lines (LogL Vs t data), one representing bulk delignification having higher slopes, and the other representing slower residual delignification line.

In these figures (1–4), it is clearly demonstrated, that, M–C pulping process gives equivalent de-

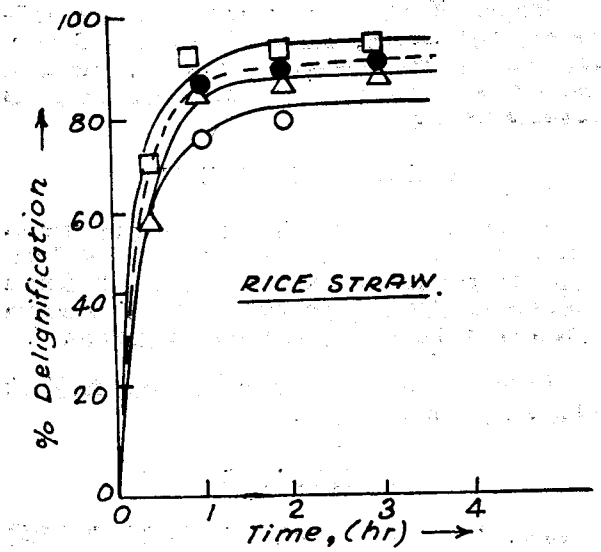

FIG.4 % DL VS TIME DATA

gree of delignification, with respect to Straw/Bagasse, which are generally obtained in conventional pressure pulping at a temperature more than 140°C.

With high degree of delignification (85%), and significantly lower amount of carbohydrate dissolution rate relative to lignin dissolution rate, as obtained in M–C pulping process (fig-5), there is substantial amount of yield improvement in M–C pulping, at the same degree of delignification. These preliminary investigations, reported in this Work, confirm the earlier observations of Aronovsky et al who showed, that, furnishing Rice straw pulp (obtained by M–C pulping process) to good grades of paper furnish improves considerably most of the strength properties of Magazine, Newsprint, Book, Bond, Waxing and Bag Papers.

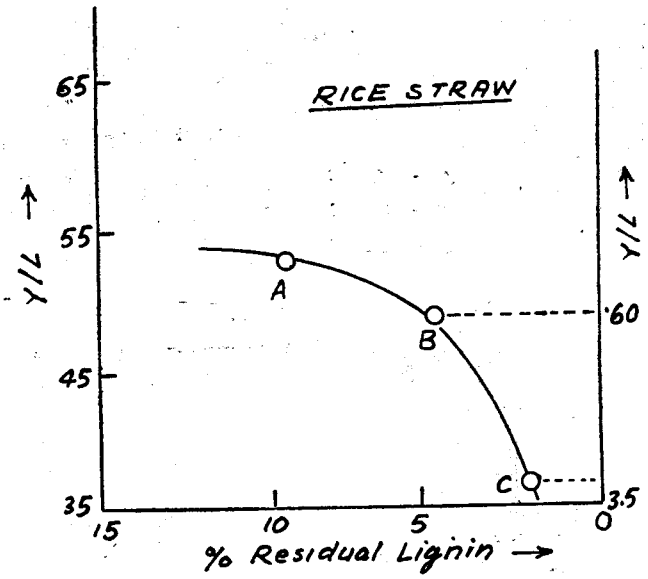

Fig. 6

By referring to the figures 7, and 8 which present the relationship between the degree of saccarification (expressed in terms of % conversion of carbohydrate content into reducing sugars, based on O.D. raw material) against reaction time with 70% Conc. H_2SO_4, it is clearly seen, that, more than 80–85% of the carbohydrate content in agri residues

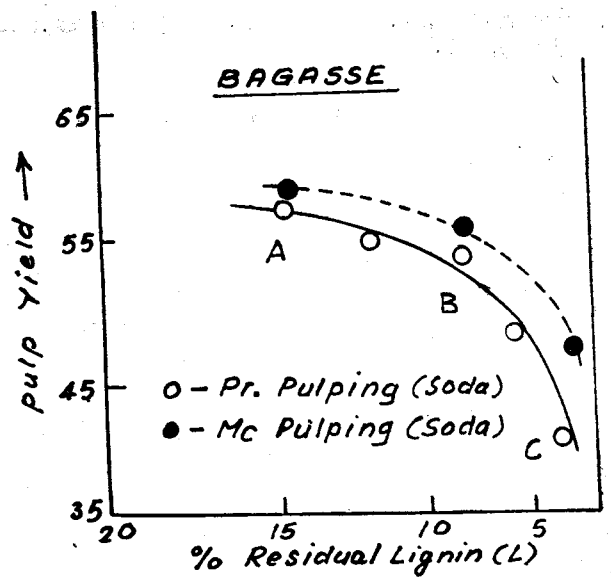

Fig. 5

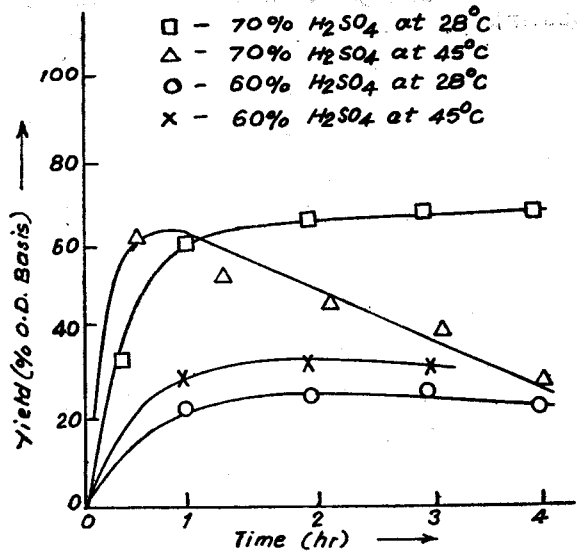

FIG.7 SACCARIFICATION DATA FOR WHEAT STRAW

(Rice straw & Bagasse) can be converted into fermentable sugars, by acid hydrolysis at room temp. If M-C pulping of Bagasse is carried out by two stages consisting of (i) Acid prehydrolysis, followed by (i) Soda pulping, on the lines mentioned in our earlier communications[7], Bagasse value can be increased to the extent of 12 times (compared to its fuel value), if pulp manufacture is intergated with one industrial product manufacture, available from prehydrolyzate, in the form of furfural.

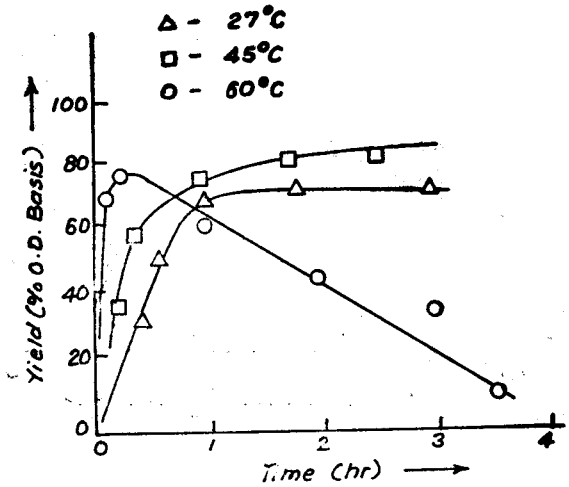

FIG.8 SACCARIFICATION DATA OF BAGASSE AT DIFFERENT TEMP. WITH 70% H_2SO_4

In a resource scarce developing coun ry like India, utilization of agri-rcsidues efficiently, coupled with intergation of Sugar-Pulp Paper-Alcohol industries could be of great benefit towards improvement of national economy, and industrial development,

Further Work is in progress at the IIT-Bombay, on bleaching characteristics of M/C pulp, saccarification and alcohol manufacture, based on agri-residues, available in abundant quantity as renewable resources.

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