

was larger than 1.5 in. after the test, as against 36 to 60 per cent of the other cokes. As shown by the interval tests in Table XI, the Illinois coke broke up much more rapidly during the first 15 min. The "average size" figures in Tables VIII and XI were calculated for the purpose of indicating by a single value the result of the screen analysis.¹¹

Comparison with the shatter test data makes it appear doubtful whether the screen analyses of the tumbler test

¹¹ Specimen calculation of average size.

BENHAM COKE					
Per cent on Screen		Av. Diameter, In.			
2-in.	11.0	×	2.5	=	0.28
1.5-in.	14.4	×	1.75	=	0.25
1-in.	16.4	×	1.25	=	0.21
0.5-in.	27.4	×	0.75	=	0.21
0.25-in.	3.6	×	0.38	=	0.01
0.25-in.	27.2	×	0.13	=	0.03
AVERAGE DIAMETER				0.99 in.	

material show any property of the coke not indicated by the shatter test. Certainly the test as at present made and reported as the percentage remaining on the 0.25-in. screen has little meaning when applied to cokes of varied physical properties.

If the abrasive factor alone is to be considered, it would seem best to use small-sized coke, *e. g.*, 0.75- to 0.25-in., and to eliminate the baffles in the apparatus. The variation in this value between the cokes tested is not large, as seen in Table III, and it is doubtful whether it has a meaning in terms of blast furnace or other operation.

ACKNOWLEDGMENT

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Sugar Formation in a Sulfite Digester^{1,2,3}

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The results of the following investigation indicate that the rate of sugar formation is influenced chiefly by the temperature and concentration of free sulfur dioxide. Time is also a factor since prolonged cooking increases the sugar production but at the expense of the cellulose.

IN A PREVIOUS paper⁵ on the manufacture of ethyl alcohol from waste sulfite liquor the desirability of investigating the rate of sugar formation in the digester was pointed out. It is known that in commercial practice a marked fluctuation occurs in the sugar content of waste sulfite liquor, a condition that is highly detrimental to the alcohol process. This variation seems to be influenced by concentration of raw acid, the sugar content of the liquor varying between 1.94 and 2.80 per cent in winter, and between 1.65 and 2.20 per cent in summer. For the ethyl alcohol process to be commercially profitable it is necessary at all times to obtain the maximum quantity of sugar with a minimum loss of pulp. This investigation was undertaken with the idea of determining the rate of formation of sugar during the pulping process and of determining the effect of sugar formation upon the quality of the pulp. An excellent opportunity was afforded for such a study since the Section of Pulp and Paper of the Forest Products Laboratory⁶ was engaged in investigating the quality of pulp produced from white spruce by the Mitscherlich process. All data contained in this paper relating to the pulp itself are taken from a paper by Miller and Swansen, which was presented before the Technical Association of Pulp and Paper Manufacturers in New York City on April 10, 1922.

One of the difficulties that such a study has always encountered has been the lack of accurate information concerning the volume of liquor contained in the digester, owing to the use of direct steam which causes a dilution to occur dur-

ing the digestion. It has also been difficult to obtain accurate samples from the blow pit because of dilution by the wash water. In this case accurate data were obtained in each cook as to the dry weight of the wood used and the quantity of liquor in the digester at the time of sampling. All of these cooks were carried out on white spruce wood in an experimental digester having a capacity of 50 lbs. of pulp.

Sugar determinations were made by means of Fehling's solution, with subsequent electrolytic deposition of the copper at intervals of 1 or 2 hrs., during the progress of 8 cooks in which the conditions such as the concentration of sulfur diox-

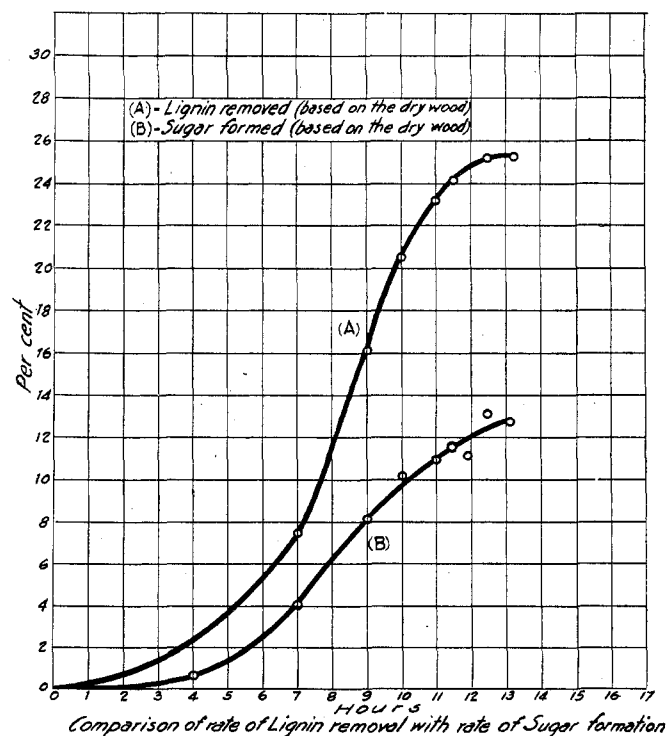


FIG. 1

¹ Presented before the Section of Cellulose Chemistry at the 63rd Meeting of the American Chemical Society, Birmingham, Ala., April 3 to 7, 1922.

² From a thesis to be submitted in partial fulfillment of the requirements for the degree of Master of Science, University of Wisconsin.

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⁵ Sherrard and Blanco, *Paper*, 24, No. 17 (1919), 746.

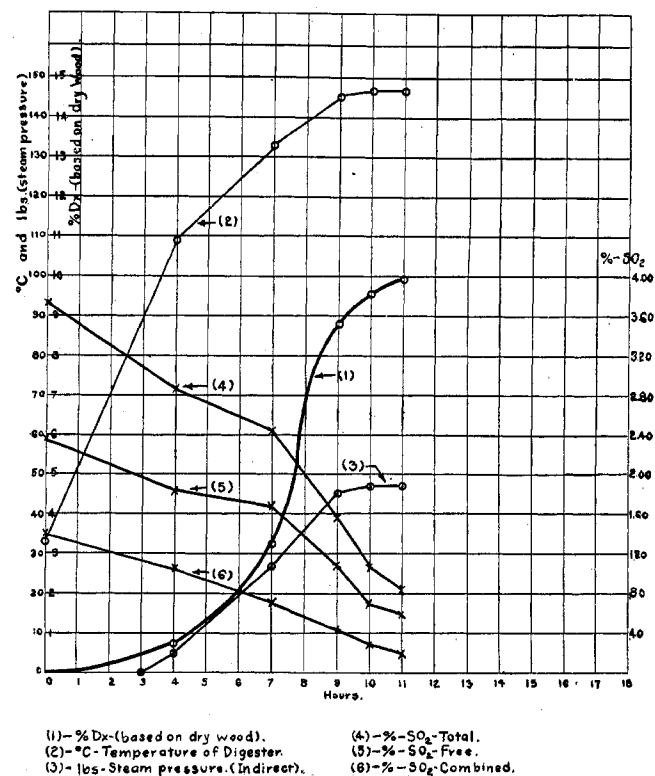


FIG. 2

ide—total, free, and combined—temperature, and pressure were held as nearly constant as possible. These cooks were blown after different periods of time in order to study the progress of the reaction in respect to the quality of the pulp and the quantity of total reducing sugar. The average per cent of total reducing sugar for all cooks at a given hour is plotted against time in Fig. 1. The total sugar is designated as glucose (Dx), since it was determined in terms of glucose by means of Fehling's solution.

The first sugar determination at the 4th hr. indicated that but little sugar forms before a temperature of 100° C. is reached. From this point the rate of sugar formation increased with the steam pressure to about the 7th hr. at which time the rate of sugar formation rose more rapidly. The cook blown at the 7th hr. contained chips somewhat lighter in color than before cooking, but the wood had not at this point lost its original form. From the 7th to the 9th hrs. the rate of sugar production was even greater and it was during this period that the chips began to disintegrate. The partly pulped material was not screenable at the 9th hr. and required beating before it could be run into a sheet. In most cases the sugar continued to increase at about the same rate until the 10th hr., after which the reaction slowed down appreciably, although the trend was still sharply upward. The best quality pulp was obtained at the 11th hr., at which time the average quantity of sugar produced corresponded to 11 per cent of the dry weight of the original wood. Those cooks that were carried beyond the 11th hr. produced pulps that were of inferior quality both in color and strength. Apparently considerable hydrolysis of the cellulose occurred after the 12th hr. since a cook of 13¼ hrs. gave the lowest yield of screened pulp of any of this series. During the 12th and 13th hrs. the rate of sugar production was much less, although at no time did the per cent of sugar become constant.

It is of interest to note the rate at which lignin was removed compared with the rate of sugar formation. As will be noticed from Fig. 1, these curves almost parallel each

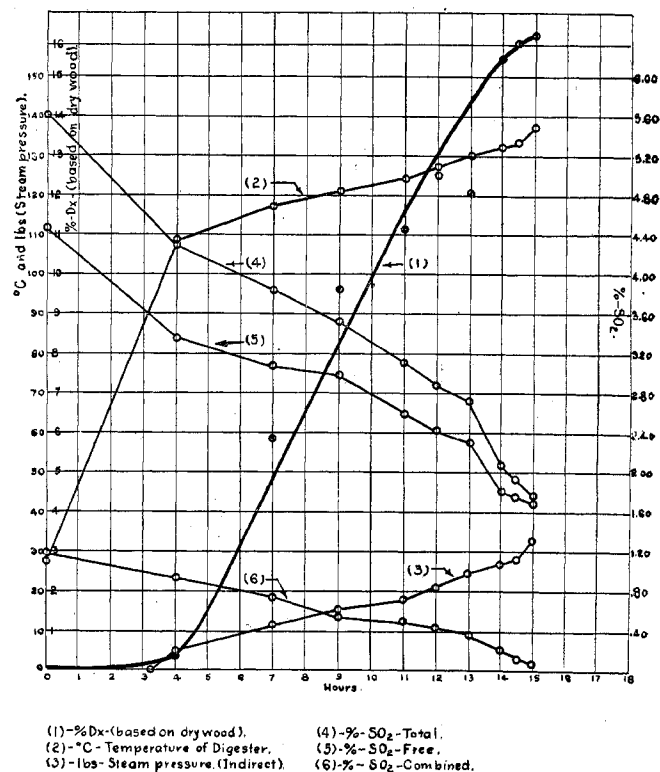


FIG. 3

other until about the 8th hr., at which time the removal of the lignin became much more rapid. When the maximum quantity of lignin (about 90 per cent of the total) had been removed, the quantity of sugar formed corresponded to about 12 per cent of the dry weight of the wood.

Fig. 2 contains typical curves indicating variations in temperature, steam, and gage pressure, sulfur dioxide as total, free and combined, and per cent of sugar (Dx) based on the dry weight of the wood.

The above cooks were carried out using a concentration of sulfur dioxide that averaged 3.80 per cent total, of which 2.39 per cent was free and 1.41 combined. A single cook was also carried out in which the total sulfur dioxide content was 5.60 per cent, composed of 4.46 per cent free and 1.14 per cent combined. The variables in this cook, such as pressure, temperature, etc., are shown in Fig. 3. Here again it was noted that but little sugar was formed before a temperature of 108° C. was reached. With the increased quantity of sulfur dioxide the rate of sugar formation was much more rapid after the 4th hr. than in the previous series and the final yield of total reducing sugar was 16 per cent of the dry weight of the original wood. This increase of about 3 per cent sugar was offset by about a 2 per cent loss in the cellulose yield. The quality of pulp produced in this cook was the best obtained in any of the experiments and compared favorably with the best commercial product. It is our intention to continue the investigation of the effect of increased quantities of sulfur dioxide on the sugar formation in both the Mitscherlich and Ritter-Kellner processes.

An "Association of Manufacturers of Non-Corrodible and Anti-Corrosive Products" is being organized in England by firms making stainless steel, anti-corrosive paints, boiler preservatives, and the like. It is proposed that the association shall act as an institution of anti-corrosion engineers and also as a chamber of commerce for firms making any material or appliance connected with the prevention of corrosion. A public exhibition of noncorrodible and anti-corrosive products is planned for the near future.