A New Experimental Pulp Digester Installation with Separate Steam Supply

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A New Experimental Pulp Digester Installation

With Separate Steam Supply

Undergraduate Thesis

by

Andre L. Breton

1953-1954
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THESIS
A NEW EXPERIMENTAL PULP DIGESTER INSTALLATION
WITH SEPARATE STEAM SUPPLY

PART I

Literature Survey

Up to now, few articles have been written on the subject of Experimental Pulp Digester Installations. In our searches we have been able to find information concerning only The Pulp and Paper Research Institute of Canada in Montreal, P.Q., Canada, The Chemical Pulp Experimental Department of the Central Laboratory in Finland, and a sulfite digester for research and instruction at the University of Washington at Seattle, Washington, U.S.A.

The Chemical Pulping Laboratory at the Pulp and Paper Research Institute of Canada.

Until 1949 the pulping equipment at the Pulp and Paper Research Institute of Canada consisted of some "bombs" of 50 to 200 g. capacity, one 1 cu.-ft. digester and one 40 cu.-ft. digester for alkaline pulping; but it was decided that the bombs and the 1 cu-ft. digester were inadequate, and the 40 cu.-ft. apparatus too cumbersome and that something intermediate in size would be more desirable (3).

Since 1949 the Chemical Pulping Laboratory of the Pulp and Paper Research Institute of Canada has been equipped with four externally heated stainless steel digesters, three of two cu.-ft. capacity and one of 100 g., with accumulator and other apparatus (3).
This new installation was made by Shawinigan Chemicals Limited (1).

The plant design is of stainless steel from acid tanks to blowpits, capable of handling either acid or alkaline liquors (3). The use of stainless steel insures a final product which is not contaminated by material dissolved from the containers. There is no chemical attack by any pulping agent (2).

Each Digester is equipped with a Foxboro cam-operated regulating pressure valve on the relief line. In addition, there is an indicating pressure gauge on each digester. There is also a thermometer well in the digester cover where a recording thermometer may be inserted (1).

The digesters can operate under automatic control up to pressures of 200 p.s.i. and have been tested to a vacuum of 25 cm. of mercury (3).

250 p.s.i. steam is available for heating (3).

Temperatures are recorded both before and after the circulation system heater (3).

**Liquor preparation**. (See figure, page 5)

The liquor preparation equipment consists of two dissolving tanks, two storage tanks, a mixing tank and an accumulator all of stainless steel. In addition there are a gas cylinder rack for a cylinder of SO₂ and a pressure vessel for measuring the volume of SO₂ used (3).

For alkaline liquors, a solution of caustic soda is prepared in one tank and of sodium sulfide in another. The impurities are
settled out and the clear solutions are discharged to the mixing tank, which is connected to the suction side of the circulating pump of the accumulator (3).

For sulfite liquors, sulfite acid is prepared directly in the mixing tank, where a solution or slurry of the base is first prepared. Liquid SO₂ from a gas cylinder is added through a perforated ring in the mixing tank (3).

The accumulator is filled from the mixing tank through the circulating pump and the heater. The cooking liquor runs from the accumulator and heater along the line of digesters and then back. By means of the accumulator it is possible to have complete control over the concentration and temperature of the cooking liquor (3).

The piping to the digesters is so arranged that liquor from the accumulator may enter the digesters either from behind the strainer in the bottom cone or through an opening at the top. In the same manner, direct steam, if required, can be admitted in either of these two places (1).

The strainer is located in the cone, since experience at the Pulp and Paper Research Institute of Canada and other Laboratories has shown that for a digester of this size its position is unimportant (3).

Digesters (see figure, page 5)

Each digester has its own circulating system, which is used during the cooking operation. The liquor is withdrawn from behind the strainer; then it travels through a thermometer well to the circulating pump, the heater, another thermometer well, and returns
to the top of the digester over a removable perforated plate. This plate distributes the liquor over the charge and also serves to keep the chips from floating (3).

The circulating pump has a capacity of 10 g.p.m. (3).

On the discharge side of the pump, there is a connection to a condenser from which samples of the cooking liquor can be withdrawn at any time during the cook without danger of flashing (3).

In pulping to high yield or in making a materials balance, the chip charge is placed in a stainless steel wire basket of 10-mesh which fits the digester snugly (3).

The digester is insulated with asbestos 1 3/4 in. thick painted with aluminum paint, and the liquor lines as well as connections forming the circulation system are insulated with asbestos 1 in. thick and are painted with aluminum paint (3).

Since the temperature of the steam supplied by the Institute is not high enough for the requirements of alkaline pulping, a steam compressor was installed. It compresses steam from 130 p.s.i. to 250 p.s.i. (3).

There is a pressure tank, with calibrated liquid-level gauge glass, for injecting dissolved chemicals into the circulating line to maintain definite concentrations during various phases of the cook. This is known as "injection cooking". The solution of chemicals is forced out of the tank by pressure of nitrogen to the suction side of the circulating pump (3).

The blow pit is cylindrical, with an opening in the bottom. The top of the blow pit is specially designed so that no pulp can escape into the ventilation duct (3).
LIQUOR CIRCULATION LINE.

ACUMULATOR

HEATER

PUMP

D, D1, D2, D3
DIGESTERS.

H1, H2, H3
HEATERS.

P1, P2, P3
PUMPS.

D, DIGESTER
H1, HEATER
P1, PUMP.
V, INLET FROM CIRCULATION
LINE OF LIQUOR.

D, DRAIN
W1, W2, THERMOMETERS
WELL.
S, STRAINER.
T, THERMOMETER POCKET
P, PERFORATED PLATE.

TO BLOW PIT
The blow gases and steam are collected in an air duct and are discharged outside the building (1).

It has now been established that the 2 cu-ft. digester operates at a rate and with a yield duplicating those obtained in commercial digesters under similar conditions of time, temperature and pressure (3).

Sulphite Digester for Research and Instruction at the University of Washington, Seattle, Washington, U.S.A.

Formerly, preparation of sulfite pulp in the laboratory was usually limited to working with heavy glassware and noble-metal containers. Such limitations frequently permitted working with only small samples. Then a 25-liter capacity rotating digester was installed which can stand a pressure of 350 p.s.i. (4). This digester is heated electrically, by means of coils wrapped around the digester and protected by a thin metal cover.

Before use of this digester for sulphite pulping studies, two series of heating rates were obtained. One was made with the digester insulated only with the electrical packing normally placed around the heating elements. The other was obtained after packing 85 per cent magnesia between the digester and the metal cover. In these runs 18 kg. (39.6 lbs.) of water was heated. The results show that 0.56 kw. maintained a constant temperature of 132° C. (270° F.) before and 146° C. (295° F.) after packing with 85% magnesia (4).

This shows the importance of insulation.
The Chemical Pulp Experimental Department of the Central Laboratory in Finland

The Pulp Experimental Department of the Central Laboratory was equipped in 1933 with three rotary digesters of the autoclave type, heated by external electrical heating units. Their capacity was 15 liters (5).

In March 1937 these digesters were replaced by two new ones made of acid-proof steel and intended for both sulfite and sulfate and run by steam heating and forced circulation. Their capacity is about 60 liters (5).

The digesters are supplied, besides, with internal heating arrangement according to Mitscherlich for indirect cooking and can also be heated directly by steam, although it is scarcely possible to apply this method in the case of small digesters with comparatively large cooking surfaces (5).

The digesters are provided with so called "programme regulators" which regulate the changes in the temperature of the digesters automatically in accordance with a schedule drawn-up in advance (5).

The apparatus for registering temperature appeared unsuitable for such laboratory digesters, since it was not possible to note all observations with sufficient accuracy, so it was recently exchanged for another system which it is hoped will fulfil its requirements better (5).

Judging by the experience gained so far, it is possible to repeat a cook with great precision (5).

xxx
We have then tried to get more information in the line of our subject by asking several companies listed in "Paper and Pulp Mill Catalogue" in the Chapter of Laboratory Digesters. The following replied:

Lukenweld, Coatesville, Pa.
The Biggs Boiler Works Company, Akron, Ohio.
Electric Steel Foundry Co., Portland, Oregon.

All companies stated that experimental digesters are always made to special order, that seemingly each institution has different ideas as to what they want.

The most interesting information came from Electric Steel Foundry Co., Portland, Oregon. This company sent a set of drawings (6) showing different types of laboratory digesters, which they have built.

Figure I, based on their drawing B-4032, shows a Rotary Digester of classic type with direct steam heating.

Figure II, based on their drawing D-4664-B, shows a Digester 1.5 cu.-ft. capacity which can be operated as both a tumbling and a stationary digester. Cooking can be direct or indirect.

Figure III, based on their drawing D-4664-C, and
Figure IV, based on their drawing E-2400, show similar Digesters the capacities of which are 2.5 cu.-ft. and 40 g.p.m. respectively.

Figure V, based on their drawing D-2064-B shows a special experimental sulphite digester with an electrically driven agitator.
Figure VI, based on their drawing E-969 shows the complete installation of an experimental digester unit with circulation, heater, and accumulator. There is a Rotameter on the circulation line in order to control the liquor circulation. Flow in the digester is from the bottom to the top. There are coolers on the relief gas line and on the sample test line, and there is a steam syphon for helping to blow cooked materials to the blowpit. Direct steam heating is possible.

Figure VII, based on drawing E-1859, shows a similar installation. However this device makes possible the following circulation combinations: circulation top to bottom of the digester, circulation top to middle and bottom to middle together. Circulation to the accumulator is possible too. Furthermore, in the case of sulfite cooking, the relief gases are injected into the accumulator for recovery of sulphite dioxide and heat. This is known as the "Chemipulp Hot Acid Recovery System," which is now used very successfully in commercial sulphite cooking.

Lastly, Figure VIII, based on drawing E-1320 shows details of a heater for Experimental Digester Units with liquor-circulation.
References


(6) The following drawings issued by Electric Steel Company, Engr. Dept., Portland, Oregon, can be seen at the Paper Technology Department of Western Michigan College, Kalamazoo, Michigan.

-Dr. B-4032 Rotary digester
-Dr. D-4664-B Tumbling and stationary digester
-Dr. D-4664-C Tumbling and stationary digester
-Dr. E-2400 Tumbling and stationary digester
-Dr. D-2064-B Special digester with agitator
-Dr. E-969 Installation of circulation type digester
-Dr. E-1859 Installation of circulation type digester
-Dr. B-1320 Heater for circulation type digester
THESIS

PART II

PLAN OF EXPERIMENTAL WORK
Thesis

A New Experimental Pulp Digester Installation

with Separate Steam Supply

Part II.

Plan of Experimental Work.

Our experimental work consists to know how works the Experimental Digester of the Pulp and Paper Laboratory at Western Michigan College. We have to find out if the actual installation can be run in a satisfactory manner and, if not so, which modifications have to be done.

Our Digester was made by Michigan Steel Casting Co., Detroit, Michigan, according to the drawing No. S-2557-2. It is made of stainless steel and thus can be used for both acid and alkaline cooking.

There is a circulating system without heater.

Heating is ensured by direct steam supplied by an electrode boiler manufactured by Livingstone Engineering Company, Worcester, Mass.

Temperature of the liquor and pressure are recorded on a Taylor recorder.

xxx

Preliminary work.

(1) Preliminary tests to gain familiarity with equipment.

(2) Insulation of Digester and piping.

Experimental work.

We shall start our experimental work by a semichemical cook
does not require high pressure and temperature. The main purpose of this first cook is to get used to the installation, mainly to the boiler.

Then we shall make a sulfite cook, making up the acid liquor by bubbling $\text{SO}_2$ gas into a slurry of lime, decanting, titrating the acid liquor and using it in the digester for cooking.

Then we shall make a soda cook.

In each of these cooks we shall control temperature and pressure as closely as possible during the cooking time, and we shall determine in each case the quantity of water which will condense, since the heating is done by direct steam.

Then it would be easy in the following cooks of each type to correct the amount of liquor to put in according to the condensation of water during the cooks.

By direct heating it is impossible to get a constant concentration of the cooking liquor because of the constant dilution with condensed water. But it is possible, at least, to use a stronger initial liquor in order to make the average of liquor concentration correspond to the concentration required for the cook.

We then should write down the result of our observations and suggestions for an efficient use of the installation for future experimentations, pointing out the way of running the boiler and the digester. We should make a clear drawing of the installation and try to establish a diagram giving the quantities of condensed water for different temperatures and pressures.

If the last digester is insulated sufficiently, should it not be possible for the 70% dilution on heating to be the same as occurs in a commercial directly heated digester?
We are not especially interested in getting a really commercial pulp, but we shall try to operate within the range of industrial cooks.

The time we can spend on each cook is limited to 5 or 6 hours - (from 11:30 a.m. to 5:30 p.m.) Under these conditions, we can realize only a regular Neutral Sodium Sulphite Semichemical process as it is done in the pulp industry: this type of cook can be made in about 5 hours, but for soda and sulphite cooks, we have to cook faster than the pulp mills usually do. Then we shall use stronger chemical liquors than the ones usually used in commercial cooks.

1. We shall start our experimentation with a Neutral Sodium Sulphite semichemical cook because it is easiest. The chemical liquor can be easily prepared, the maximum temperature is not too high and the cooking time is in accord with our class-schedule. We can make this cook exactly as described in our textbook "Pulp and Paper Manufacture," Volume II, page 535.

Liquor 8.0 lbs. of Neutral Sodium Sulphite and
3.2 lbs. of Sodium bicarbonate per 100 lbs. of O. D. chips.

Water ratio - liquor: wood = 3:1 at start

Cooking schedule:
(I) Temperature increase to 120-125°C in 30 minutes with gas relief.
(II) Impregnation 120-125°C for 30 minutes.
(III) Digestion 150-160°C for 3 hours.
(IV) Temperature decrease - in 1 hour.

2. The following cook will be a soda cook. (0% sulphidity).

Active alkali: 20% as Na₂O based on weight of dry wood.

Water ratio: liquor:wood = 2:1 at start.
Maximum temperature: 160-170°C.

Cooking schedule:
- time to reach 160°C: 1 hr. with gas relief
- cooking time at 160-170°C: 4 hrs.
- time of cooling: 1 hr.

3.- Finally, we shall try to do an acid sulphite cook.

We could use a commercial calcium-base liquor as described in our textbook "Pulp and Paper Manufacture," Volume I, page 312.

With a water-to-wood ratio of 5:1, we could obtain a liquor containing up to 35% of total SO2 based on oven-dry wood, but with such a weak liquor, the cook would not be completed within 8-9 hours. We'll make up a more expensive but stronger liquor in order to reduce the cooking time to 4-5 hours. For that purpose, we'll prepare a sodium-base liquor by passing SO2 into a solution of sodium hydroxide or, better, into a solution of sodium sulfite - SO3Na2. That way it is possible to get a liquor containing, for instance, 40% total SO2 based on oven-dry wood, or more if necessary, in a smaller quantity of liquor; the water-to-wood ratio should not be higher than 3:1 because of the latter dilutions created by direct heating.

Cooking schedule:

(I) Increase of temperature up to 110°C. in 1-1½ hr. with gas relieved at 45 p.s.i. and 65 p.s.i. pressure.

(II) Cooking at 140°C. 70-75 p.s.i. of pressure for 3-4 hours with gas relieved in order to keep the pressure down.

(III) Cooling period.

xxx
Calculation of chemical consumptions

I. Wood consumption

Effective capacity of the digester = 32 liters.
One liter of capacity can receive 174 g. of air dry wood and 165 g. of oven-dry wood.

Moisture content of the wood = 5%.
Then effective capacity of the digester in wood chips =
\[ 174 \times 32 = 5,550 \text{ g.} = 12.3 \text{ lbs. of air-dry wood} \]
and \[ 165 \times 32 = 5,280 \text{ g.} = 11.6 \text{ lbs. of moisture-free wood}. \]

II. Chemical consumption for a semichemical cook.

- Neutral Sodium Sulphite: 8% based on oven dry wood.
  \[ 0.08 \times 5,280 = 422 \text{ g.} \]
- Sodium bicarbonate = 3.2% based on oven-dry wood.
  \[ 0.032 \times 5,280 = 169 \text{ g.} \]
- Water: Water ratio 3:1
  \[ 5,280 \times 3 = 15,840 \text{ ml} = 15.8 \text{ liters}. \]

III. Chemical consumption for a soda cook.

Soda

\[ \text{Na}_2\text{O} = 20\% \text{ based on oven dry wood}. \]
\[ 0.2 \times 5,280 = 1056 \text{ g.} \]
\[ \text{NaOH} = 1056 \times 1.290 = 1,360 \text{ g.} \]

Water: water ratio 2:1
\[ 5,280 \times 2 = 10,560 \text{ ml} = 10.6 \text{ liters}. \]
IV. Chemical consumption for an acid sulphite cook

Water consumption: water ratio 3:1
5,280 x 3 = 15,840 ml = 15.8 liters

SO₂ requirements
- Total SO₂ = 40% based on oven-dry wood
  = 5,280 x 0.4 = 2112 g = 4.64 lbs.
- Free SO₂ = 56 grams per liter
  = 56 x 15.8 = 885 g = 1.95 lbs.
- Combined SO₂ = 2112 - 885 = 1227 g = 2.69 lbs.

-a If we use NaOH as base

\[
\begin{align*}
\text{NaOH} & \rightarrow \text{SO}_2 \rightarrow \text{H}_2\text{O} & \text{SO}_3\text{NaH} \rightarrow \text{H}_2\text{O}.
\end{align*}
\]

\[
\begin{array}{c}
1227 \text{ g} \\
\downarrow \\
\text{(SO}_2, \text{NaOH)} \\
1227 \text{ g}
\end{array}
\]

SO₂ consumption
Free SO₂ = 885 g = 1.95 lbs.
Combined SO₂ = 1227 g = 2.69 lbs.
Total SO₂ = 2112 g = 4.64 lbs.

NaOH consumption

\[
\begin{align*}
\text{NaOH} &= 40 \quad \text{SO}_2 = 64. \\
\text{NaOH} &= \frac{1227 \times 40}{64} = 767 \text{ g} = 1.69 \text{ lbs}.
\end{align*}
\]

-b If we use SO₃Na₂ as base.

\[
\begin{align*}
\text{SO}_3\text{Na}_2 & \rightarrow \text{SO}_2 \rightarrow \text{H}_2\text{O} & 2 \text{ SO}_3\text{NaH} \\
(\text{SO}_2, \text{Na}_2\text{O}) & \rightarrow & (2\text{SO}_2, \text{NaOH}) \\
\frac{1227}{2} & \rightarrow & \frac{1227}{2} & \rightarrow & 1227 \text{ g}
\end{align*}
\]
- SO₂ consumption as gas

as Free SO₂ = 885 g = 1.95 lbs.

as Combined SO₂ = \( \frac{1227}{2} \) = 613 g = 1.35 lbs.

Total SO₂ gas consumption = 885 + 613 = 1498 g

= 1.95 + 1.35 = 3.30 lbs

- SO₃Na₂ consumption

\[ SO₃Na₂ = 126 \quad SO₂ = 64 \]

\[ SO₃Na₂ = \frac{1227 \times 126}{2 \times 64} = \frac{1210}{g} = 2.68 \text{ lbs.} \]
PART III

EXPERIMENTAL WORK

The goal of our experimental work was to investigate the possibilities of the installation existing in the Pulp and Paper Department at Western Michigan College.

Description of the installation

(1) The Digester

The digester D is stationary, with circulation of liquor and direct steam heating.

It can hold 10 lbs. of oven-dry wood chips.

Pressure P and temperature T are recorded on a recording instrument.

Gas relief and drainage are done respectively through valves 7 and 8.

(2) The steam generator

The boiler is made of two cylinders A and B connected together top and bottom, there being an automatic valve V in the upper line.

Cylinder A has an electrode connected to a source of alternating current through an ammeter.

The boiler is fed under pressure by means of a feeding device C which does not require the use of a special pressure pump.

Sodium carbonate is added to the water in drum A so that the water becomes conductive. The electrical current flowing through the water heats it, and steam is generated.
Valve V is set for a pressure P according to the temperature T which is required for the cook. When pressure P is reached, valve V automatically closes. Then the pressure in drum A becomes higher than in drum B and the level of water falls in A and rises in B. In this way, heating is reduced, and an equilibrium is reached. Pressure P is maintained constant, as is also temperature T.

Under these circumstances, it is important not to fill the boiler more than halfway, in order to insure its functioning.

**Experimentation**

Then experimental cooks were made: a neutral sulfite semichemical cook, a soda cook, and an acid sulfite cook. Aspen chips were used in each case, and the following conditions were employed:

**Semichemical cook**

Wood: 10 lbs.: 4,540 g. oven-dry.

Neutral Sodium Sulfite: 2% of wood:

\[0.08 \times 4,540 = 364 \text{ g.}\]

Sodium Carbonate: 3.2% of wood:

\[0.032 \times 4,540 = 145 \text{ g.}\]

Water ratio: 3/1: 4,540 x 3 = 13,600 : 13.6 liters.

Cook schedule:

1. Temperature increase up to 120°C. in 30 minutes with gas relief.

2. Impregnation period at 120°C. for 30 minutes.

3. Digestion period at 150-160°C. for 3 hours.

**Soda cook**

Wood: 10 lbs.: 4,540 g. oven-dry.
Soda: 20 % of wood (counted as Na₂O):

Na₂O : 0.2 \times 4,540 : 908 g.
NaOH : 908 \times 1,290 : 1170 g.

Water ratio: 2/1 : 4,540 \times 2 : 9,080 : 9.1 liters.

Cook schedule:

1. Temperature increase up to 160°C. in 1 hour.
2. Digestion at 160-170°C. for 4 hours.

**Acid cook**

Wood: 18 lbs. : 4,540 g. oven-dry.

Water ratio: 3/1 : 4,540 \times 3 : 13,600 : 13.6 liters.

Total SO₂ : 40 % based on wood:

4,540 \times 0.4 : 1816 g.

Free SO₂ : 56 g/liter:

13.6 \times 56 : 760 g.

Combined SO₂ : 1816 - 760 : 1056 g.

SO₂-Na₂ consumption:

\[
\frac{1056 \times 126}{2 \times 64} = 1040 g.
\]

Cook schedule:

1. Temperature increase up to 110°C. in 1 hour
   with gas reliefs at 45 p.s.i. and 65 p.s.i.
2. Cooking period at 140°C. and 70-75 p.s.i. for 3-4 hours
   with gas relief in order to keep pressure down.

**Results of cooks**

Records of these cooks and samples of pulps which were
produced are shown on following pages.
ACID SULFITE COOK

2nd TRIP

TEMPERATURE INCREASE WITH GAS RELEASES

P

T

CHAT'T 0P3418

ROCHESTER, N.Y. U.S.A.

Talbot
Samples of pulp produced

SAMPLES MISSING

SEMICHEMICAL PULP

SAMPLES MISSING

SODA PULP
Methods and Suggestions for Operations

1. Semichemical and Soda Cooks

Semichemical and Soda cooks can be run without trouble with this kind of installation.

The fresh liquor can be made in a pail and poured over the wood chips in the digester.

When the cover and connection to the boiler are all set, the boiler may be started.

Boiler Operation

Start with the boiler empty, and pour into it a solution of one teaspoon of Sodium Carbonate. Turn the electrical switch on and feed the boiler with water by means of the feeding device C up to the time when the reading on the ammeter is 50 to 60 Amps. Then, pressure builds up. It is recommended to make a short relief by means of the relief valve R on the boiler after a few minutes, in order to remove air from drum B.

Maintain reading on the ammeter between 40 and 60 Amps. by feeding with water when necessary by means of valve 4.

When water tank C is nearly empty, shut off the valve 3, open up valves 5 and 6, which have to be closed again when tank C is full. Then shut off valve 2 and open valve 3. When the pressure is reestablished in the drum C, valve 2 may be opened again. At this point the system is ready again for feeding water to the boiler.

When the desired temperature T is reached, set valve V for the corresponding pressure P. Then one reaches a state of equilibrium in the boiler, and pressure and temperature are maintained constant.

At constant conditions, the power consumption is low;
the ammeter reading sticks around 10 Amps; then cooking runs smoothly, and the only attention required is to feed with water from time to time to maintain a reasonable level in the boiler. It is however recommended to operate the valves slowly in order to avoid disturbing the equilibrium in the boiler. If such a case occurs, the amperage goes up very suddenly, and the fuses burn out. Then it is necessary to drain part of the water out of the boiler before turning back the electrical switch again.

2. Acid cook

In semichemical acid and soda cooking, temperature and pressure correspond closely, so control of the cook is easy. However, in the case of an acid cook, the cooking operation is not quite as simple. A pressure increase does not always correspond to a temperature increase, and it is necessary to release some of SO₂ gas to keep the pressure down, so that correspondence between temperature and pressure is maintained.

Furthermore it is difficult to maintain amperage in a satisfactory range since some acid gas flows back into the boiler, increasing the conductivity of water. In addition, this is dangerous, since the boiler is not made of stainless steel. There is a risk of corrosion. A check valve or some kind of a trap seems to be very necessary between digester and boiler.

While relieving gas, it is advisable to shut off the liquor circulation pump in order to avoid liquor flowing out through the relief valve 7.
CAUTION: Do not forget to run the cooling water through the pump circulation pump in order not to damage the stuffing box.

Acid liquor-making

Acid liquor can be made by bubbling the \( \text{SO}_2 \) gas into a solution of neutral sodium sulfite, but this requires time, since the exchange between liquid and gas are not efficient.

Another method was tried successfully, which is much faster: the solution of neutral sodium sulfite is put with wood chips into the digester, and \( \text{SO}_2 \) gas is introduced through the drain on the inlet of the pump as shown on the following sketch:

![Diagram of acid liquor-making process]

The pump is turned on to insure circulation of liquid. A water manometer is mounted on the cover of the digester. The rate of flow of \( \text{SO}_2 \) gas is controlled by means of a needle valve in order to have a slight pressure in the digester. As long
as the liquor absorbs gas, the pressure does not increase in
the digester, but when no more gas is absorbed, pressure
increases and gas bubbles out through the manometer, and
this indicates saturation of the liquor.

Cooling and washing

After completion of the cook, one can turn the switch off
and let the digester cool slowly.

It was found possible, however, to cool quickly in the
digester itself by adding cold water as described below. This
washes the pulp and permits leaving it in the digester for
several days without risk of spoilage.

Black liquor is first removed by means of the drain 8 while
a strong stream of cold water is poured on the outlet to avoid
flashing of hot liquor.

Then a continuous washing is done by shutting valves 1, 4,
6, and 7, and opening valves 2, 3, 5, and 8. Cold water coming
from the water main flows through the water tank 9 to the
digester, and most of the remaining black liquor is removed
out of the digester.
CONCLUSIONS

The conclusions of our work are that:

1. The boiler is of sufficient capacity, since a working temperature of 160°C can be reached within one hour.

2. This temperature can be maintained fairly constant for a long period of time without any trouble in case of neutral and alkaline cooks and with more difficulty in case of an acid cook. These inconvenience in the case of acid cooking could be corrected with addition of a check valve or a trap on the steam line between digester and boiler.

________________________

Andre L. Breton
June 1954