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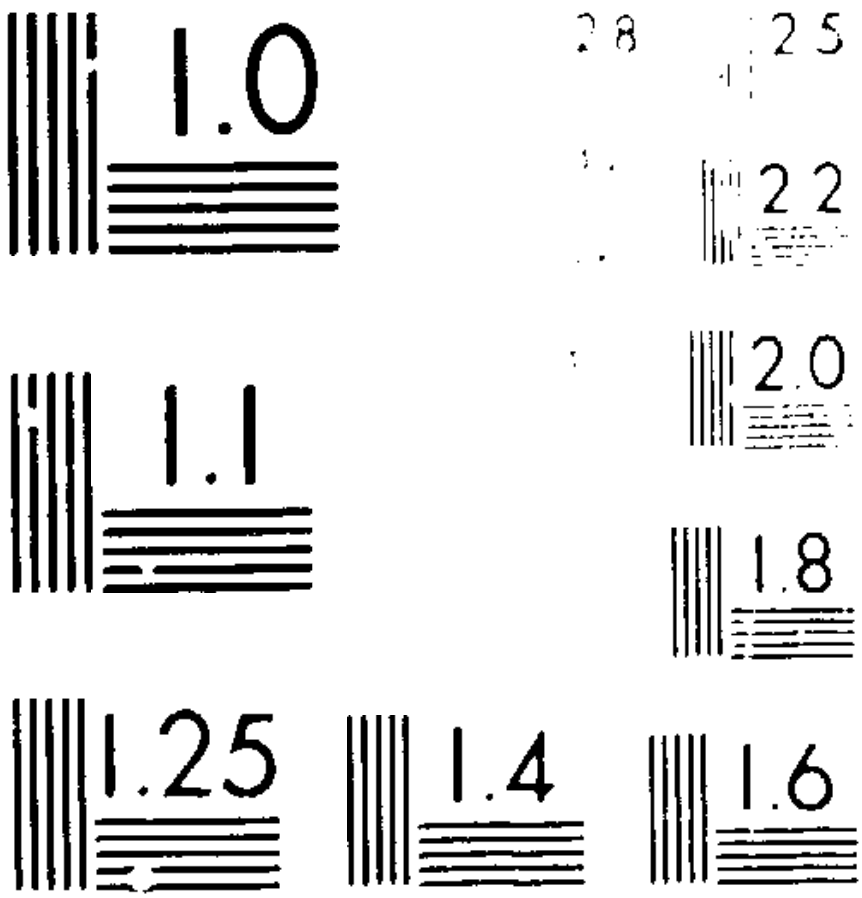
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CHEMICAL RECOVERY SYSTEM FOR A 35 TPD RICE STRAW PULP MILL IN SRI LANKA*

by

Harry J. Hackl **

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Contents:

Introduction

This paper describes the first small-scale CRS supplied by BKMI to the National Paper Corporation / Sri Lanka for their rice straw pulp mill at Embilipitiya.

The history of the project is described as well as the basic design of this PROTOTYPE Installation. The experience gained during the start-up and the initial operation of the CRS are discussed briefly.

The main objectives of the BKMI-CRS for future clients are outlined at the end.

(1) General Aspects

A lot has been issued and discussed recently about the justification to build small-scale pulp mills.

The author of this paper has also presented another paper on this subject during this conference.

Naturally, due to the two massive oil shocks occurred after 1973, increased attention must be paid to the economy of small pulp production units.

Besides some other factors to be dealt with in the design of a small to medium sized economic pulp mill, one of the most important criteria is and will be the recovery of cocking chemicals of such mills.

The reasons why this problem needs to be solved are obvious

- Cooking chemicals represent a substantial share in the overall production cost.

- In cases where such chemicals have to be imported a big amount of foreign exchange for such imports is required.

- The regulations concerning environmental control in practically all parts of the world force the existing and new mills to stop the discharge of untreated mill effluents.

(2) The History of the First BKMI CRS-Prototype

Exactly these problems were faced by the National Paper Corporation of Sri Lanka when they decided to establish their second rice straw pulp mill at Embilipitiya in 1974.

BKMI was awarded the contract to design and build the complete rice straw pulping line and engineering works were already in full swing when, due to subsequent governmental regulations which prohibited the discharge of untreated black liquor effluents into the river, NPC was suddenly forced to incorporate into the project a system for the treatment of such black liquor.

Due to the existing close relation between NPC and BKMI it was natural that BKMI would assist their client in every respect in their efforts to find an economical solution to this problem.

Several possibilities were studied and discussed ranging from simple lagoons for black liquor settlement via conventional effluent treatment plants and last but not least a chemical recovery system.

Naturally, from all available possibilities a Cooking Chemical Recovery System seemed to be the most logical and also the most professional solution.

Detailed rentability calculations have furthermore shown very attractive economical results.

The only problem was that such a system for a small pulp production unit based on rice straw was not available on the market.

The conventional systems on the market were by far too large for the Embilipitiya Mill requirements and thus too expensive. On the other hand none of the systems was adapted to the very special and critical characteristics of rice straw black liquor.

Eventually BKMI have decided to enter into this new field due to the following aspects:

- The aim to assist a long-lasting and good client in the best possible way

- The knowledge that such a system was worldwide required

- The professional challenge to develop such a system and to successfully implement such a project.

BKMI have presented their detailed quotation to NPC comprising not only a technical specification but also outlining in a very elaborated way all design parameters for the individual process areas.

This proposal was discussed at length with NPC, their Consultants Messrs. Sandwell/Vancouver as well as the Financing Institution KFW from Germany who procured a soft loan financing for this project.

It was also compared with proposals invited from other parties on a tender basis.

Since it was found that it was not only the technically most convincing but pricewise also a very competitive proposal, NPC awarded the contract for the supply and installation of the CRS to BKMI in 1975.

The implementation of the CRS was unfortunately somewhat delayed due to reasons beyond our control.

Nevertheless erection was finished late in 1979 and after commissioning and start-up in the first half of 1980 the installation is now in commercial operation.

(3) Professional Background for the Design of the CRS

It must be stated that the basic design of the BKMI-CRS is not entirely new.

In fact there still exist, to our knowledge, a few older installations in small pulp mills in Indonesia, Philippines and India which operate in the evaporation and liquor burning on a similar but more or less old-fashioned basis.

The BKMI-CRS for Sri Lanka does, however, in some vital process areas such as last-stage evaporation, liquor burning, waste heat boiler, recausticizing and a number of other points incorporate innovations which were necessary not only from the point of reliability and efficiency but also in order to comply with the technical and operating standards of today.

BKMI were able to procure to the largest extent comprehensive and first-class know-how and experience. From 25 years of successful activity as supplier of non-wood pulp mills the specific and critical characteristics of high silica containing black liquors were known and dealt with.

In the basic design BKMI could furthermore to some extent refer to data and experience from the operation of a similar CRS which was installed in a small straw pulp mill in Germany but which was shut down in the late Fifties due to economic reasons.

(4) Description of the System

4.1 Objectives

The basic objectives of NPC and BKMI can be summarized as follows:

- to process the black liquor occurring from the pulp mill at rated production and thus avoid black liquor effluents

- to achieve a recovery efficiency in the range of 75 %

- to maintain self-sufficiency in steam production from the waste heat of the recovery furnace versus steam consumption of the system

- to involve well-proven and not too sophisticated but reliable equipment

- to keep investment and operation cost at minimum level

4.2 Basic Criteria and Design Data

Utmost attention was paid in the design of the individual process areas and in the selection of the systems and equipment to make sure that the CRS was able to comply with the following conditions, which in comparison to wood black liquor are much inferior:

- high silica content of the black liquor
- unusually high viscosity of black liquor in concentrations beyond 35 %
- low heating value of the dry solids
- low settling rate of solids in the recausticizing

The capacity of the CRS is such that the requirements of the Embilipitiya rice straw pulp mill with a rated capacity of

35 BDMT/24 hrs

of bleached chemical pulp can be met.

The straight caustic soda process is applied in the digester plant.

The main design data and process data of pulp mill and the CRS are compiled in Table 1.

4.3 Description of Main Features and Process Parameters

The Overall Flow Diagram (Table 2) shows the complete system and indicates clearly the liquor flow through the system which adheres to the principles of conventional recovery systems. The 5 basic process areas are shown which consist of:

- Multistage Black Liquor Evaporation
- Direct Contact Cyclone Evaporator
- Recovery Furnace
- Waste Heat Boiler
- Recausticizing

Evaporation Plant

The arrangement and material flow is shown in Table 3.

The high scaling rate caused by the high silica content necessitated avoiding concentrations of the black liquor in the range where high scaling actually occurs (Usually beyond 35 % increased scaling rates have been observed).

Thus the evaporation was designed for an outlet concentration of 35 to 37 % only.

The evaporation consists of a four-effects, four-body cascade system with forced liquor circulation in the last two effects (i.e. the effects with high liquor concentration).

Though conventional evaporators are used, it was necessary to select the proper types of evaporators to comply with the characteristics of the liquor concerning silica content and viscosity.

We eventually decided to use the falling film type for two effects and the rising film type for the other two, which proved to be a good solution.

Cyclone Evaporator, Recovery Furnace and Waste Heat Boiler

The arrangement and material flow is shown in Table 4.

Further evaporation from abt. 35 to 37 % d.s. to abt. 50 % d.s. concentration is effected through direct contact with the boiler flue gases in a cyclone evaporator.

Experience from existing conventional installations for similar liquors taught that this type proved to be the most suitable one compared to other systems like venturi scrubber or cascade evaporator.

The cyclone evaporator fulfils a second function which is the flue gas washing to prevent too high salt losses through the boiler stack.

Discharging of the cyclone evaporator resp. charging of the black liquor to the liquor furnace is effected by a specially selected screw pump.

The concentrated black liquor is burnt in a rotary kiln.

The burning operation involves considerable experience and know-how since it is influenced by a lot of factors:

- method and position of liquor charging
- burning temperature
- arrangement of fuel oil burner lance
- primary air addition and temperature control
- rotation speed of kiln
- etc.

Last but not least the design of the kiln, i.e. diameter in relation to kiln length, is an important factor.

The main criteria for kiln operation is to burn black liquor into soda ash and to avoid burning temperatures and conditions which lead to the forming of smelt.

This is another point where the silica problems need to be dealt with due to the influence on the smelting point of the ash.

The waste heat boiler connected to the rotary furnace is a standard three draft water tube boiler designed for 12 atm. steam pressure.

Recausticizing

The arrangement and material flow is shown in Table 5.

The soda ash discharged from the rotary furnace is dissolved into green liquor by addition of weak liquor in a dissolving tank and is then transferred to the subsequent recausticizing.

A system is used which - on account of the low settling rates caused again by the silica content - has forced white liquor clarification by means of a rotary belt filter.

Another belt filter is used for lime mud washing and thickening, whereas clarification of green liquor is effected by sedimentation clarifier.

The arrangement is conventional with, however, the necessary adaptations to the unusual conditions in various important areas.

The lime mud after the washer is discarded.

Reburning would not be advisable due to the low capacity but even more because of the silica which would be partly kept in the system with the re-burnt lime.

General Arrangement

As you can see from the General Lay-Out of the plant (Table 6) the complete CRS requires comparatively little space.

It forms a very compact unit which after the operators have gained enough experience in its operation requires only very few operating staff.

(5) Experience Gained During Start-up and Initial Operation

5.1 General:

Though as mentioned already all available know-how and experience was used for the design of this prototype it was quite natural that during start-up quite a number of minor and a few major corrections and adaptations were to be made, to bring the system to a continuous operating level at reduced production rates.

But it has to be mentioned that especially such specific corrections at vital points, which no outsider will be aware of, eventually contribute to the comprehensive know-how required for our further activities in this field.

Unfortunately the start-up was disturbed by very frequent power cuts caused by force majeur (no rain over months and thus no power).

5.2 Specific Experience

- Initial problems in the evaporation plant could be solved by making special arrangements in liquor flow and temperature adjustments.

- A larger problem appeared to be the operation of the cyclone evaporator. Especially at the beginning of the operation at lower capacities the low amount of heat as well as lower temperatures of the flue gases led to frequent disturbances.
  Even at present, after several modifications, this item still creates some problems but we are confident that these can be settled in the near future.
  In spite of these problems, overall operation was possible by pushing the consistency of black liquor after the evaporation to abt. 45 to 47 % and burning with increased fuel oil addition. This - of course - does not form the ideal way, but it is intended with increased operating experience to step by step bring in the cyclone evaporator and reduce fuel oil consumption to the minimum.

- Recovery Furnace
  The essential criteria have been mentioned before, and to comply with them required above all a certain period of continuous operating experience. After some changes it was possible to produce soda ash at a production rate meeting the pulp mill requirements. Some additional modifications will be required to operate the kiln at rated capacity and at highest possible burning efficiency.

The criteria to burn into ash instead of smelt need, after all, specific experience, which can to the largest extent be gained in practical operation only.
It happened at the beginning that a certain amount was not properly burnt which has created increased salt losses as well as disturbances in the recausticizing.

- Recausticizing was mainly disturbed by the low quality of hydrated lime. It should preferably be quick lime which allows higher causticizing efficiency.
The available lime caused high amounts of lime sludge and higher chemical losses accordingly. Arrangements have, however, been made or are under way to adjust causticizing in such a way that even at low lime quality the expected results will be gained.

(6) Present Operating Conditions and Outlook

In spite of the fact that the installation must be considered as a prototype and in spite of difficult operating conditions and disturbances especially during the first period of start-up it can be stated that the CRS at Embilipitiya after abt. 4 months of initial operation has achieved satisfying operating conditions and results.

The system is operating continuously and is at present production rates in the pulp mill able to process the full amount of black liquor from the pulp mill. NPC and BKMI are right now starting an optimization program which aims to increase the capacity but especially to improve the overall recovery efficiency.

After this optimization program the CRS will fully meet the objectives put up by NPC and BKMI when signing the contract.

It must again be stated that a very substantial factor in the eventual results achieved from this plant will be the operating experience gained step by step by the NPC operators. Indications are that especially recently the operation has more and more benefited from this fact.

BKMI are already now in a position to further promote the marketing of this system. The now available operating data, design and operating experience are so comprehensive that the next plant on this basis could be built by BKMI without risk.

(7) Objectives of the BKMI-CRS for Small Pulp Mills

The BKMI chemical recovery system was designed in order to serve numerous existing as well as new pulp mills to be installed in the future with pulp production capacities of 20 to 50 tpd with regard to

- recovery of the expensive cooking chemicals and thus considerably improving the economy of these mills

- solving to the largest extent the effluent problems due to the elimination of black liquor effluents.

These small pulp millls were, in the past, suffering from these problems simply because

- the minimum capacities of available conventional recovery systems or their individual process units were still by far too large for these small pulp mills

- the available systems were not adapted to the specific characteristics and behaviour of black liquors from non-wood plant fibers

- the investment cost for such mostly oversized recovery units did not allow economically viable installations.

The BKMI-CRS is - at present - applicable only for pulp mills using the straight CAUSTIC SODA cooking process.

Most of the existing as well as new small-scale pulp mills in the world are based on non-wood fibers as raw material and are using the soda cooking process. The BKMI-CRS, therefore, provides the ideal solution for certainly more than 80 % of all small-scale pulp mills.

(8) Appreciation

BKMI would like to express their appreciation and thanks to the National Paper Corporation / Sri Lanka for their confidence in BKMI and their cooperation and engagement shown in the execution of this project.

Though the implementation of this project was disturbed and delayed by a number of unforeseen events NPC has always invested considerable efforts to comply with their obligations as well as trust in BKMI's capability.

Only due to such positive attitude were the partners able to jointly achieve the expected results.

Table 1

CRS - Embilipitiya Sri Lanka

Technical & Design Data

1.	**Pulp Mill**	
1.1	Production Capacity (bleached pulp):	35 BDMT/24 hrs.
1.2	Raw Material:	Rice Straw
1.3	Cooking Process:	Caustic Soda
1.4	Pulp Quality Produced:	Bleachable grade chemical pulp
2.	**Evaporation Plant + Cyclone Evaporator**	
2.1	Amount of weak black liquor from pulp mill:	580 t/24 h
2.2	Concentration of WBL (total solids):	13 %
2.3	Silica content in WBL:	up to 15 % referred to dry substance
2.4	Amount of water evaporation:	378 t/24 h
2.5	Amount of strong black liquor to Cyclone Evaporator:	207 t/24 h
2.6	Concentration of SBL to Cyclone Evaporator:	35 - 37 % total solids

Table 1 - page 2

3. Recovery Furnace and W.H. Boiler

3.1	Amount of SBL to Recovery Furnace:	50 % total solids
3.2	Concentration of SBL to Recovery Furnace:	50 %
3.3	Heating value of dry solids:	3100 Kcal/kg = 5580 BTU/lb
3.4	Fuel oil addition to Recovery Furnace:	160 kg/h
3.5	Production of Steam in W.H. Boiler:	11 t/h
3.6	Steam Pressure:	15 kg/cm² gauge

4. Recausticizing

4.1	Production of White Liquor:	87 m³/24 h
4.2	Concentration of White Liquor:	110 g/l NaOH

5. Overall Recovery Efficiency (without brown stock washing plant): 75 %

SMALL SCALE CRS EMBILIPITIYA

Table 2

BASIC FLOW DIAGRAM

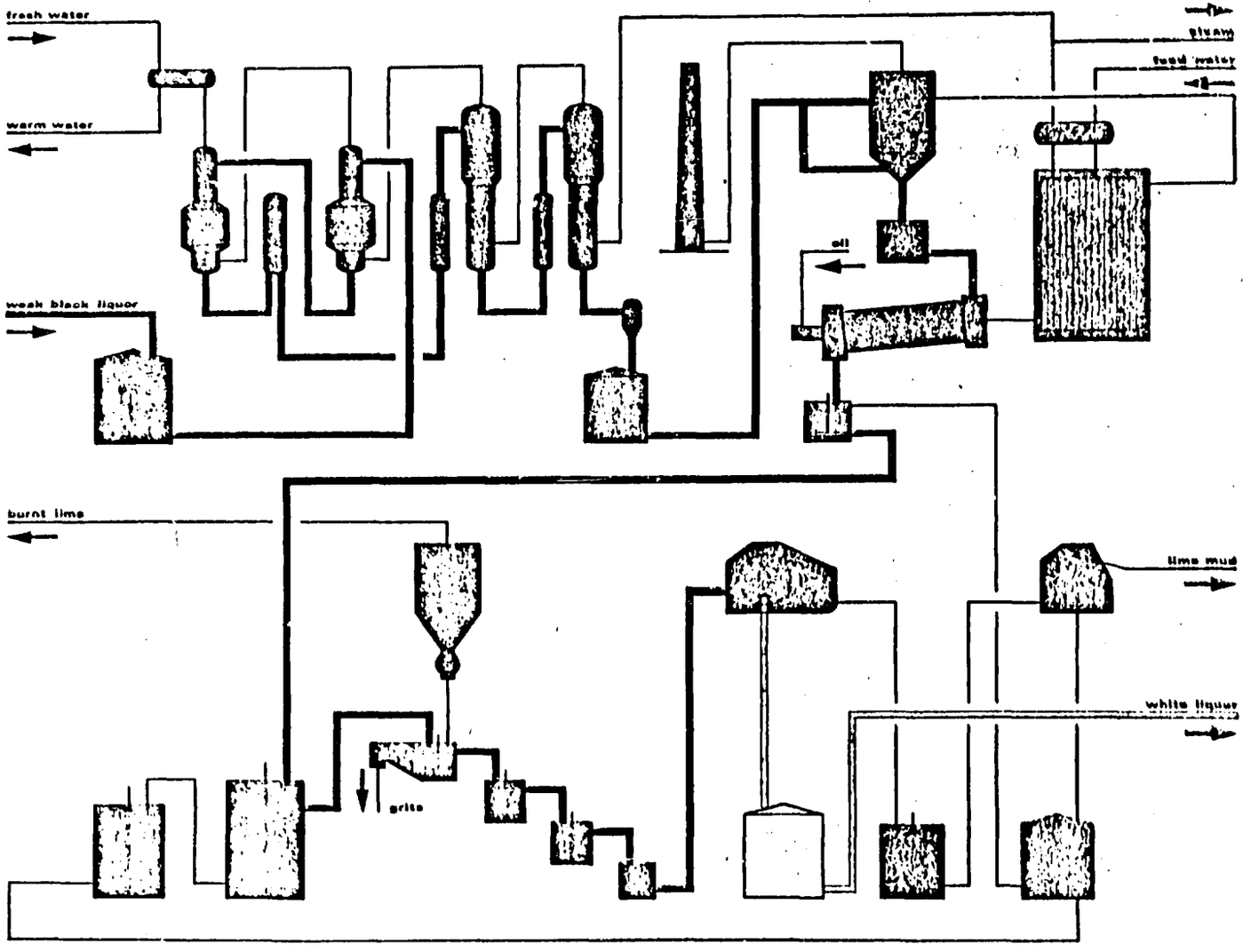

Table 3

SMALL SCALE CRS EMBILIPITIYA

BLACK LIQUOR EVAPORATION PLANT

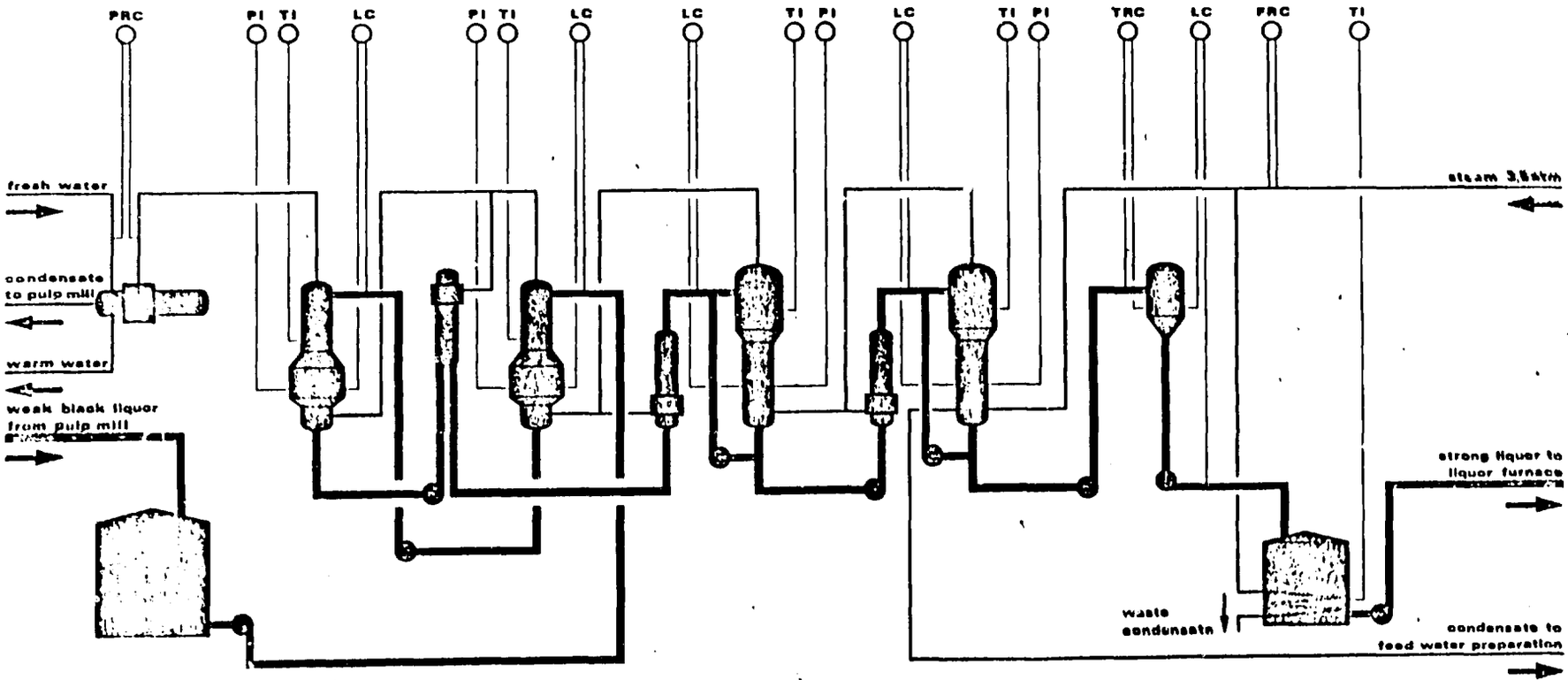

Table 4

SMALL SCALE CRS EMBILIPITIYA

CYCLONE EVAPORATOR AND LIQUOR FURNACE

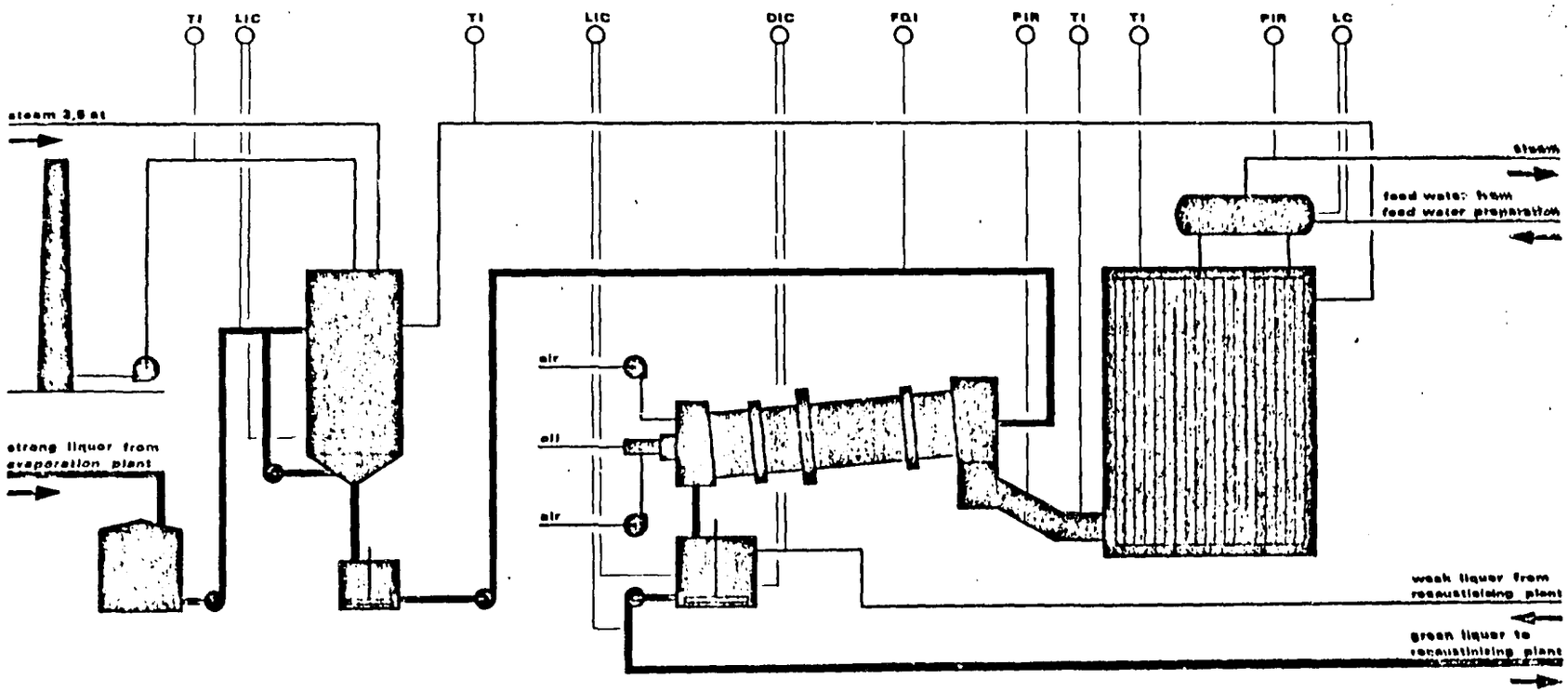

Table 5

SMALL SCALE CRS EMBILIPITIYA

RECAUSTICIZING PLANT

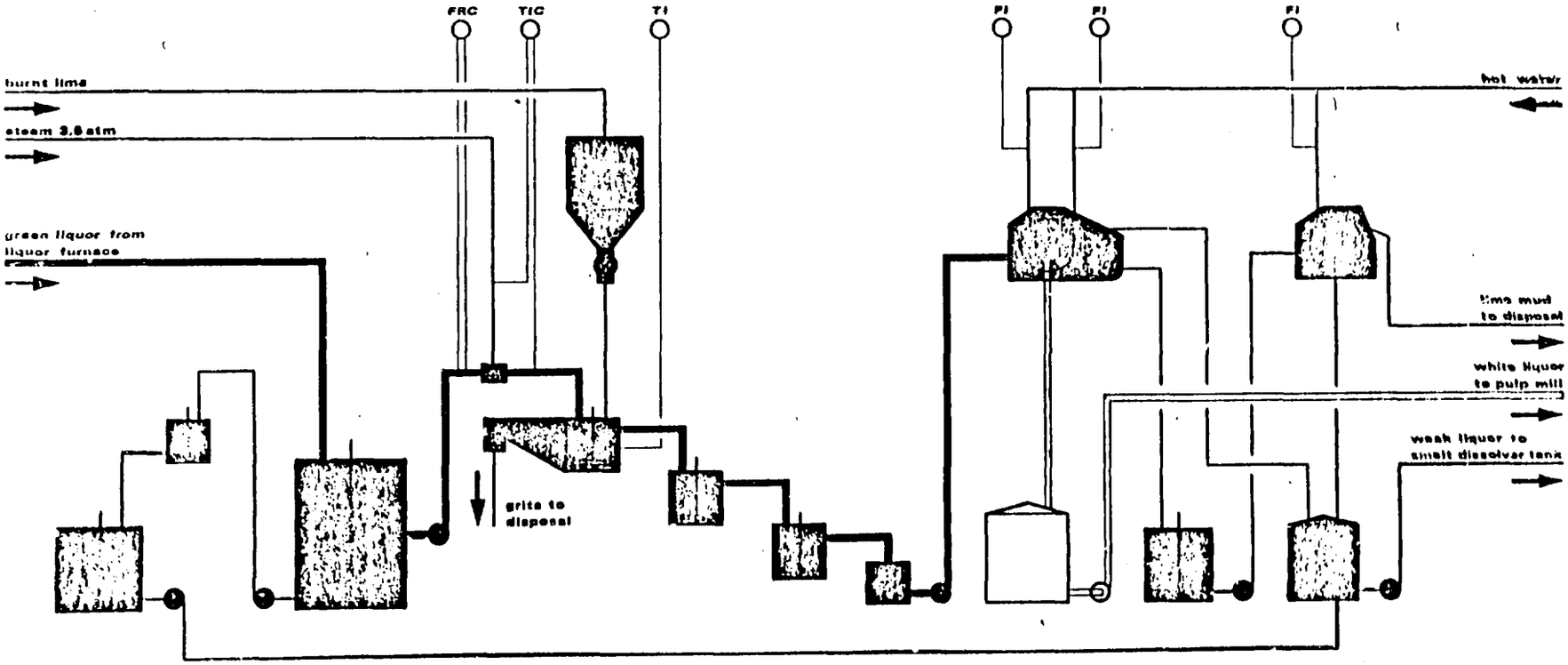

Table 6

SMALL SCALE CRS EMBILIPITIYA

GENERAL LAY-OUT

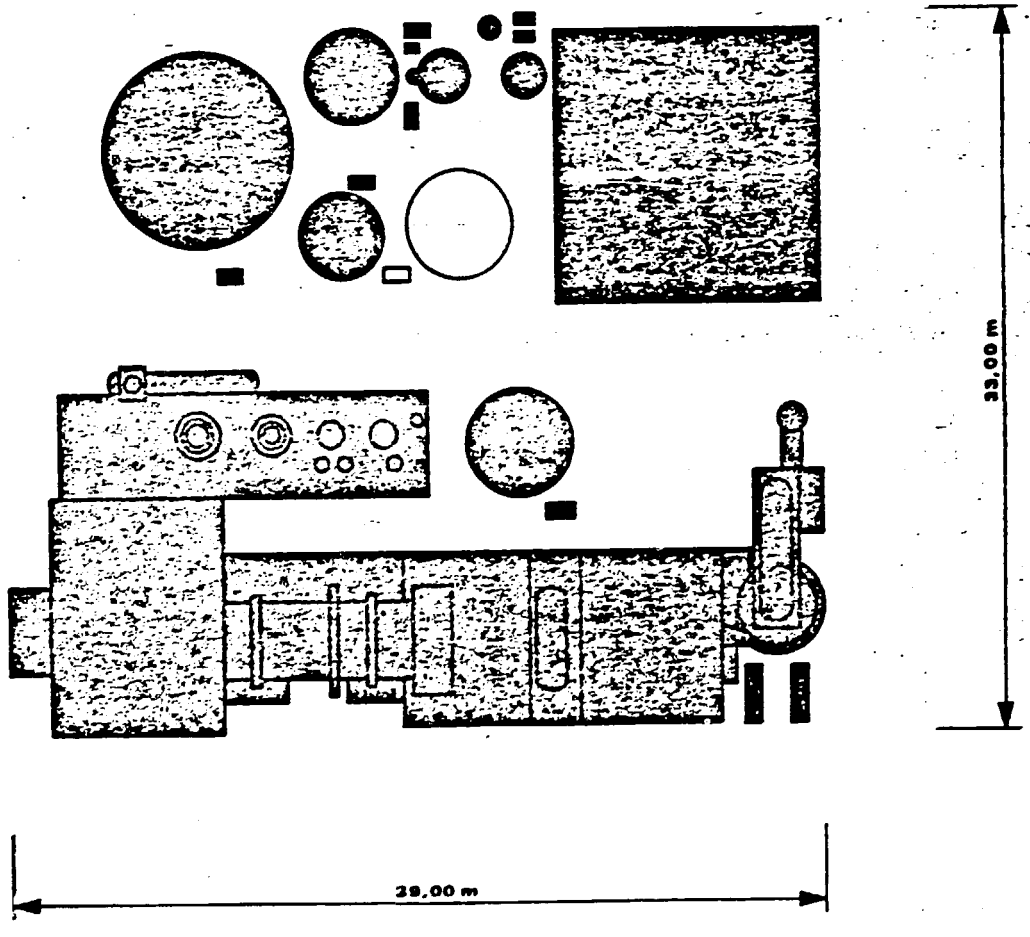

Table 7

SMALL SCALE CRS EMBILIPITIYA

ARRANGEMENT OF EVAPORATION PLANT

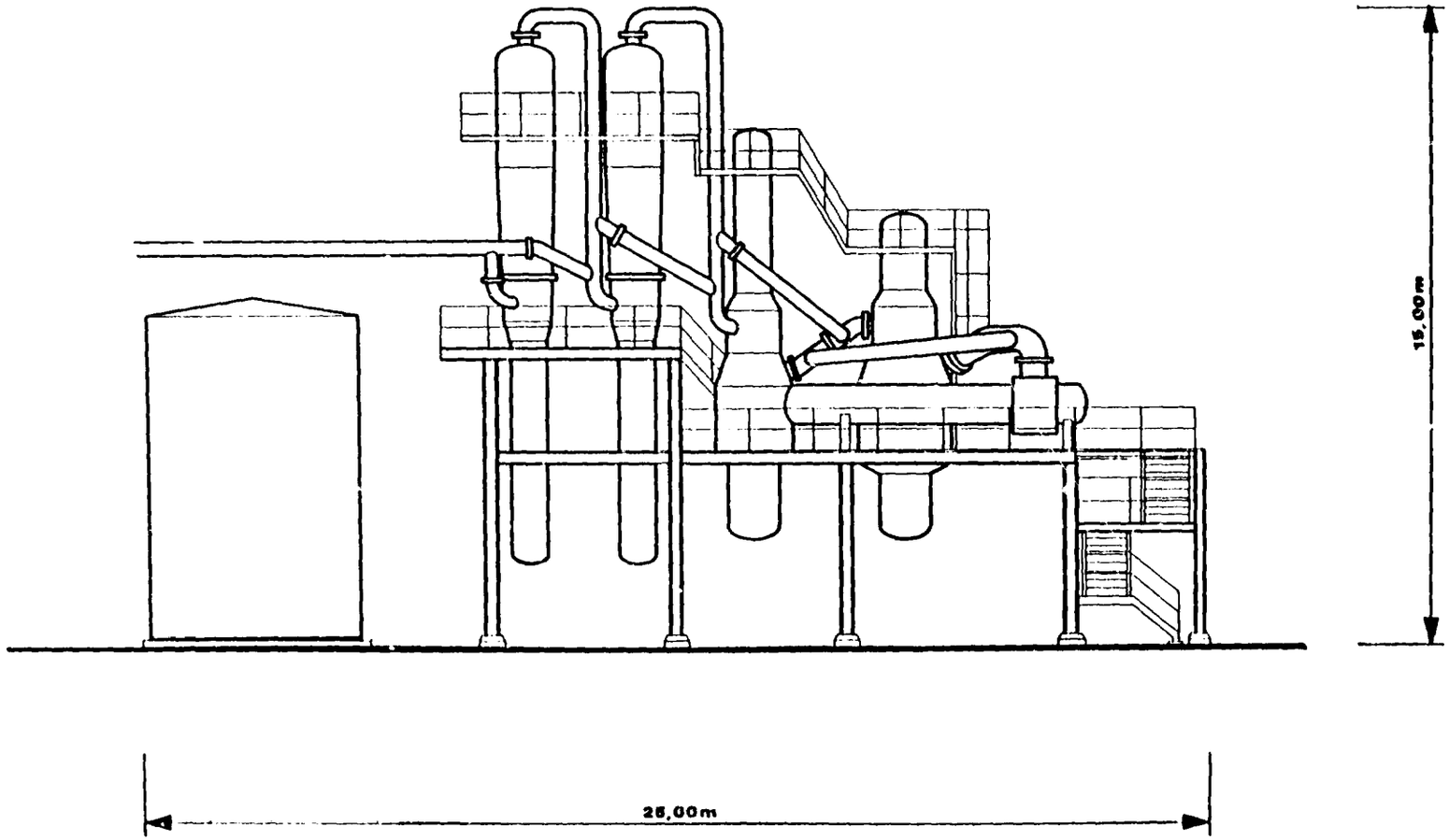

Table B

SMALL SCALE CRS EMBILIPITIYA

ARRANGEMENT OF CYCLONE EVAPORATOR

LIQUOR FURNACE AND WASTE HEAT BOILER