SODA ASH

May 2022

Safety First

SODA ASH

- SODA ASH is the inorganic compound with the formula Na_2CO_3 and its various hydrates.
- All forms are white, odorless, water-soluble salts that yield moderately alkaline solutions in water.
- Before the advent of industrial processes, sodium carbonate, often-called soda ash, came from natural sources, either vegetable or mineral.
- Soda made from ashes of certain plants or seaweed has been known since antiquity.
- At the end of the 18th century, available production was far below the growing demand due to the soap and glass market.
- The French Academy of Science offered an award for the invention of a practical process to manufacture soda ash.
- Sodium carbonate Soda Ash is either synthetic produced or naturally existing with further treatment.

SODA ASH

- **Different Synthetic processes :**
  1. Leblanc process.
  2. Solvay‘s ammonia soda process.
  3. Dual process (modified Solvay‘s process)
  4. Electrolytic process.
- **Different Natural Soda Ash :**
  1. Trona

     Trona minerals can be found underground or in dry lakes

     All processes are based on ore treatment from which impurities (i.e. organics and insoluble)
  2. Nahcolite

     A Nahcolite deposit has been found in Piceance Creek in Colorado - USA and an industrial soda ash plant has been put into operation at the end of the year 2000. Little practical experience of this process is therefore available.

Synthetic

1. Leblanc process :

- Nicolas Leblanc proposed a process for producing sodium carbonate from salt, sulfuric acid, limestone, and coal.
  - called as Leblanc or “black ash” process was developed in the period 1825 till 1890. The major drawback of this process was its environmental impact with the emission of large quantities of HCl gas and the production of calcium sulfide solid waste which not only lost valuable sulfur but also produced poisonous gases.

2. Solvay‘s ammonia soda process :

- In 1861, Ernest Solvay rediscovered and perfected the process based on common salt, limestone as raw materials and Ammonia which is also used in the process, and almost totally regenerated and recycled.
  - *The main advantage of this process is the availability of the raw materials, which can be found almost everywhere in the world and therefore allows operating production units relatively close to the market*.

Synthetic

3. Dual process :

- The proposed process basically combines two decades old processes (Solvay and Dow Magnesium) for the manufacture of soda ash and magnesium, respectively into a single process that also produces “partially-desalinated” water.

4. Electrolytic process :

- Electrolysis of sodium chloride can lead to chlorine and either sodium hydroxide (if the NaCl was in solution) or metallic sodium (if the NaCl was fused). Sodium hydroxide, an alkali like sodium carbonate, in some cases competes with it for the same applications, and in any case the two are interconvertible by rather simple processes. Sodium chloride can be made into an alkali by either of the two processes, the difference between them being that the ammonia-soda process gives the chlorine in the form of calcium chloride, a compound of small economic value, while the electrolytic processes produce elemental chlorine, which has nearly innumerable uses in the chemical industry, including the manufacture of plastic polyvinyl chloride, the plastic material produced in the largest volume. For this reason the ammonia-soda process, having displaced the Leblanc process, has found itself being displaced, the older ammonia-soda plants continuing to operate very efficiently but no new ammonia-soda plants being built.

Uses in industrial Sectors

1. **Glass industry**

   Soda ash is used in the manufacturing of flat and container glass. Acting as a network modifier or fluxing agent, it allows lowering the melting temperature of sand and therefore reduces the energy consumption. ➔ Main Consumer (≈ 45 %)

2. **Detergent industry**

   Soda ash is used in a large number of prepared domestic products: soaps, scouring powders, soaking and washing powders containing varying proportions of sodium carbonate, where the soda ash acts primarily as a builder or water softener.

3. **Steel industry**

   Soda ash is used as a flux, a desulfurizer, dephosphorizer and denitrider

Uses in Chemical Industies

1. **Sodium bicarbonate**
   animal feeds
   paper industry for paper sizing
   plastic foaming
   water treatment
   leather treatment
   detergent and cleaning products such as washing powders and liquids, dishwashing products, etc… -
2. **Chemically pure sodium carbonate**
   pharmaceuticals industry, cosmetics, food industry and fine chemicals
3. **Sodium Bichromate**
4. **Sodium Per-carbonate**
   bleaching agent for various fabrics and constituent of domestic detergent powders - cosmetology
5. **Sodium phosphates**
6. **Sodium silicates**
7. **Sodium sulfites**
8. **Other applications**
   - production of various chemical fertilizers -
   - manufacture of synthetic detergents -
   - enameling industry
   - fats, glue and gelatin industry, etc.
   - production of artificial sodium bentonites or activated bentonites
   - organic and inorganic coloring industry –
   - petroleum industry

SOLVAY PROCESS

Solvay Process

Basic reaction

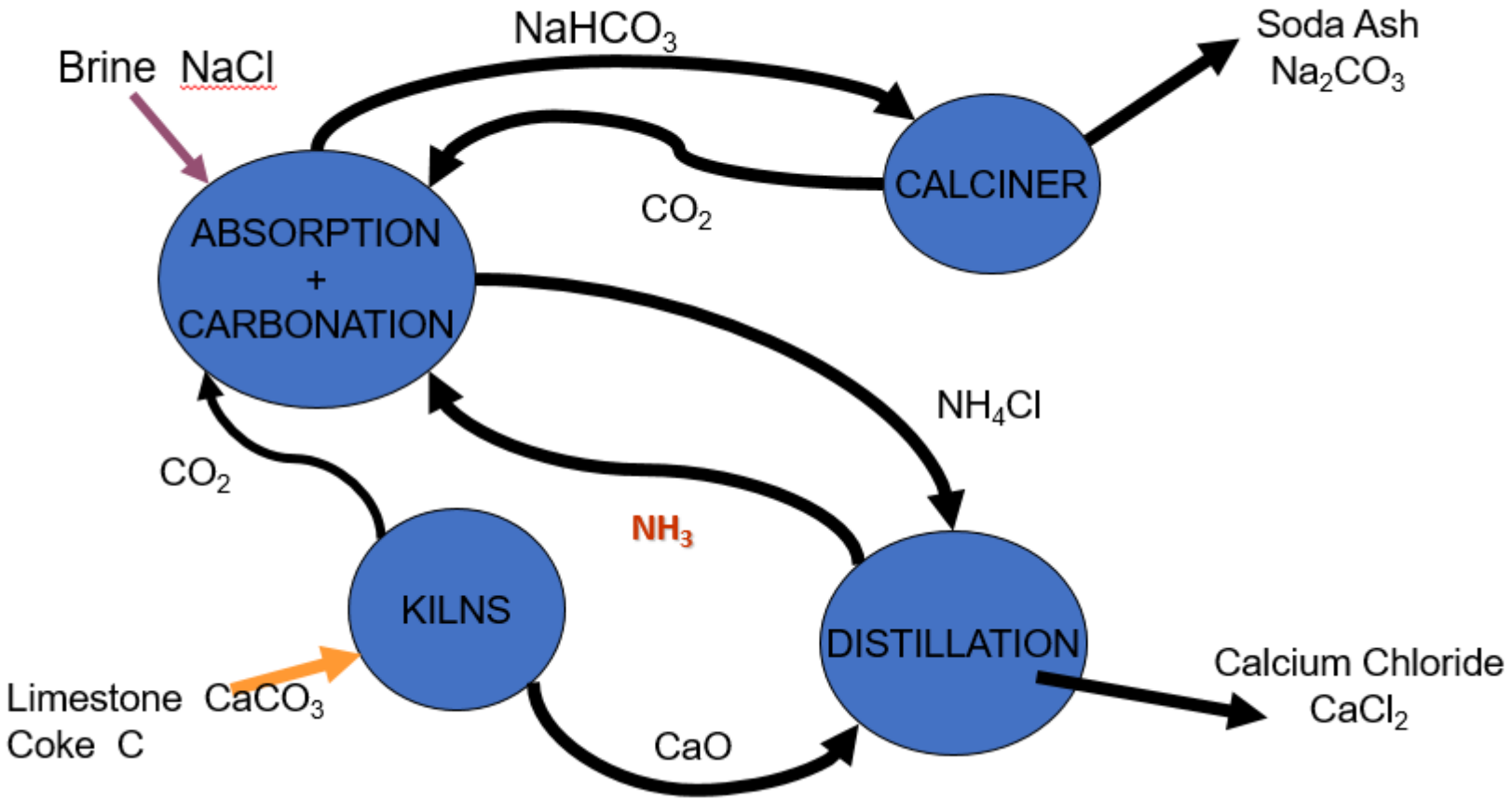
Chemical Formula Na_2CO_3

Sodium
Source NaCl - Salt

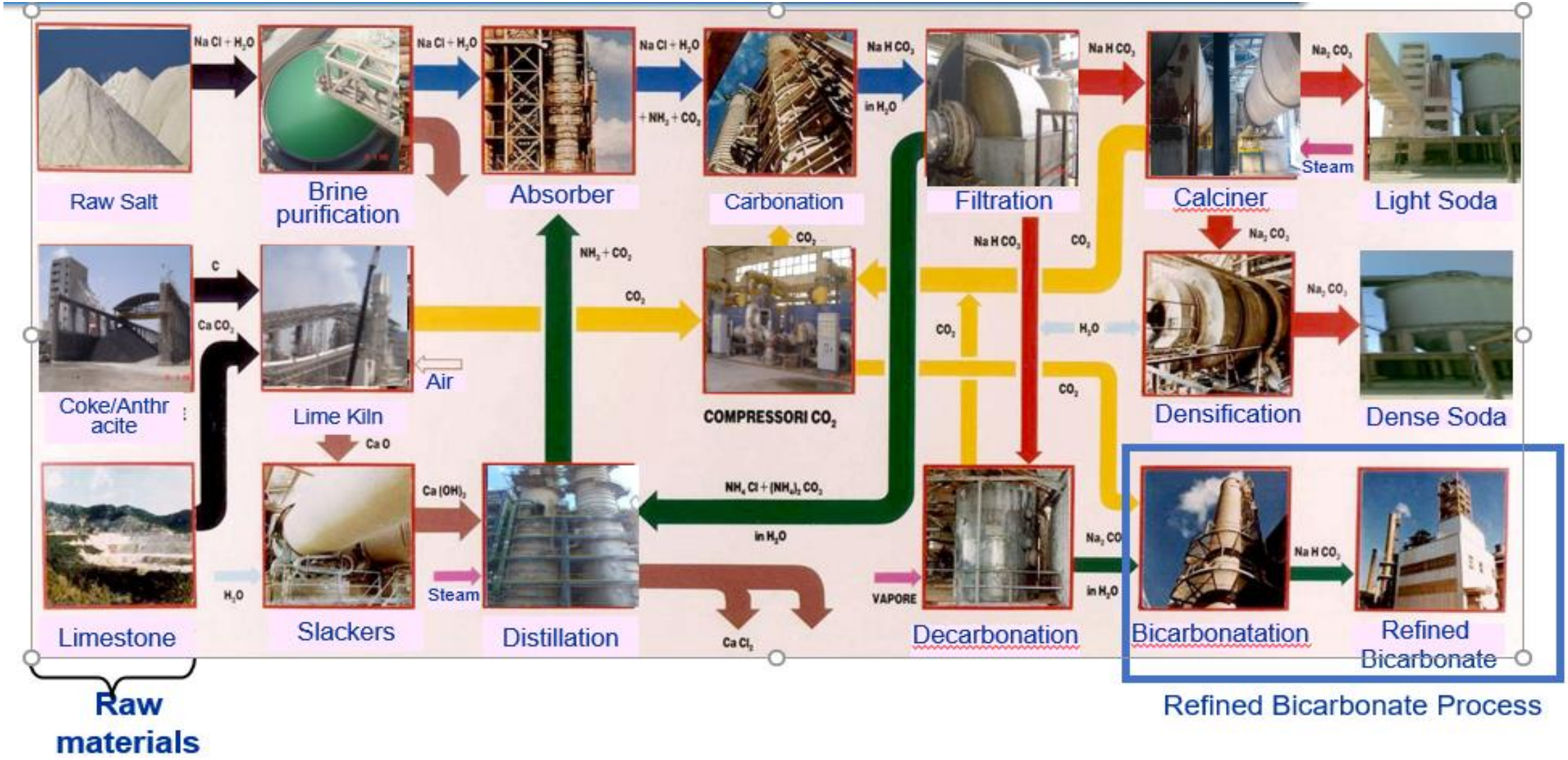
Carbonate
Source $CaCO_3$ - limestone

$$2\,NaCl + CaCO_3 \longrightarrow Na_2CO_3 + CaCl_2$$

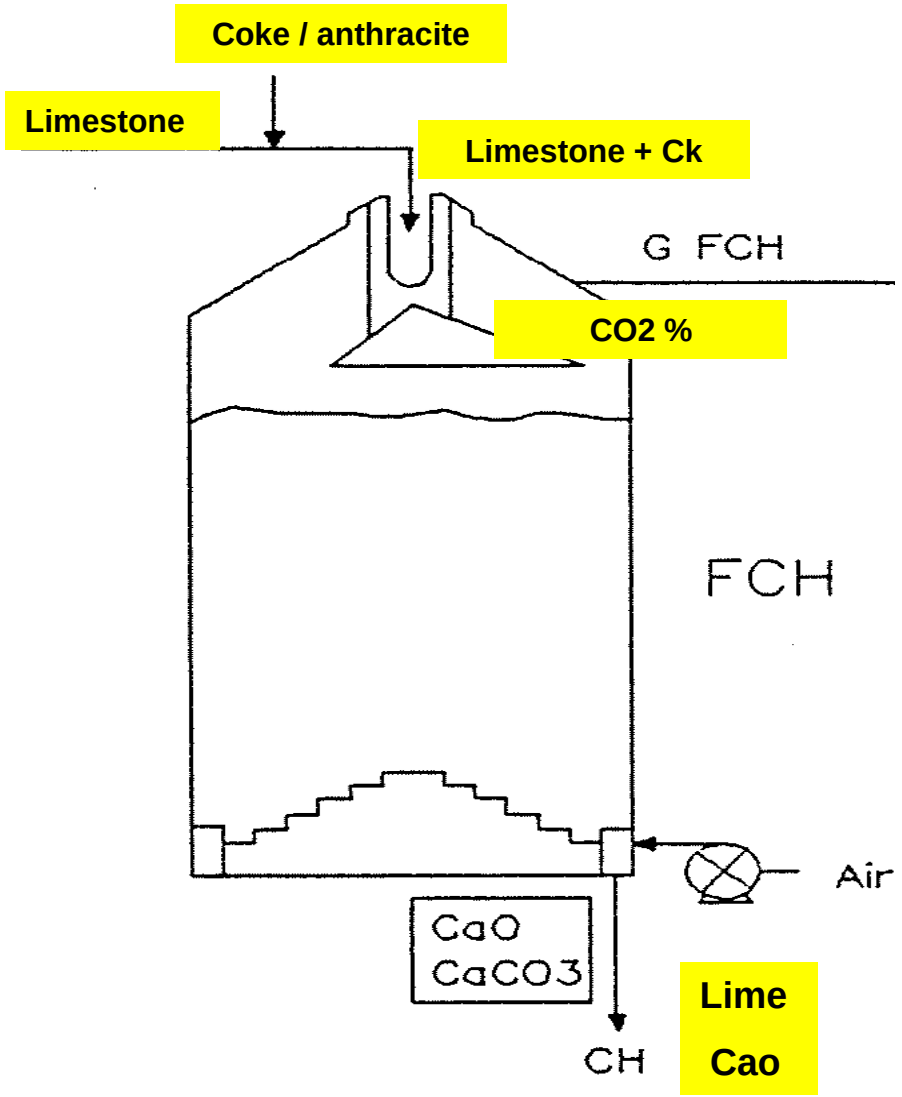
Solvay Process



Solvay Process



Lime Kilns



Role of FCH:

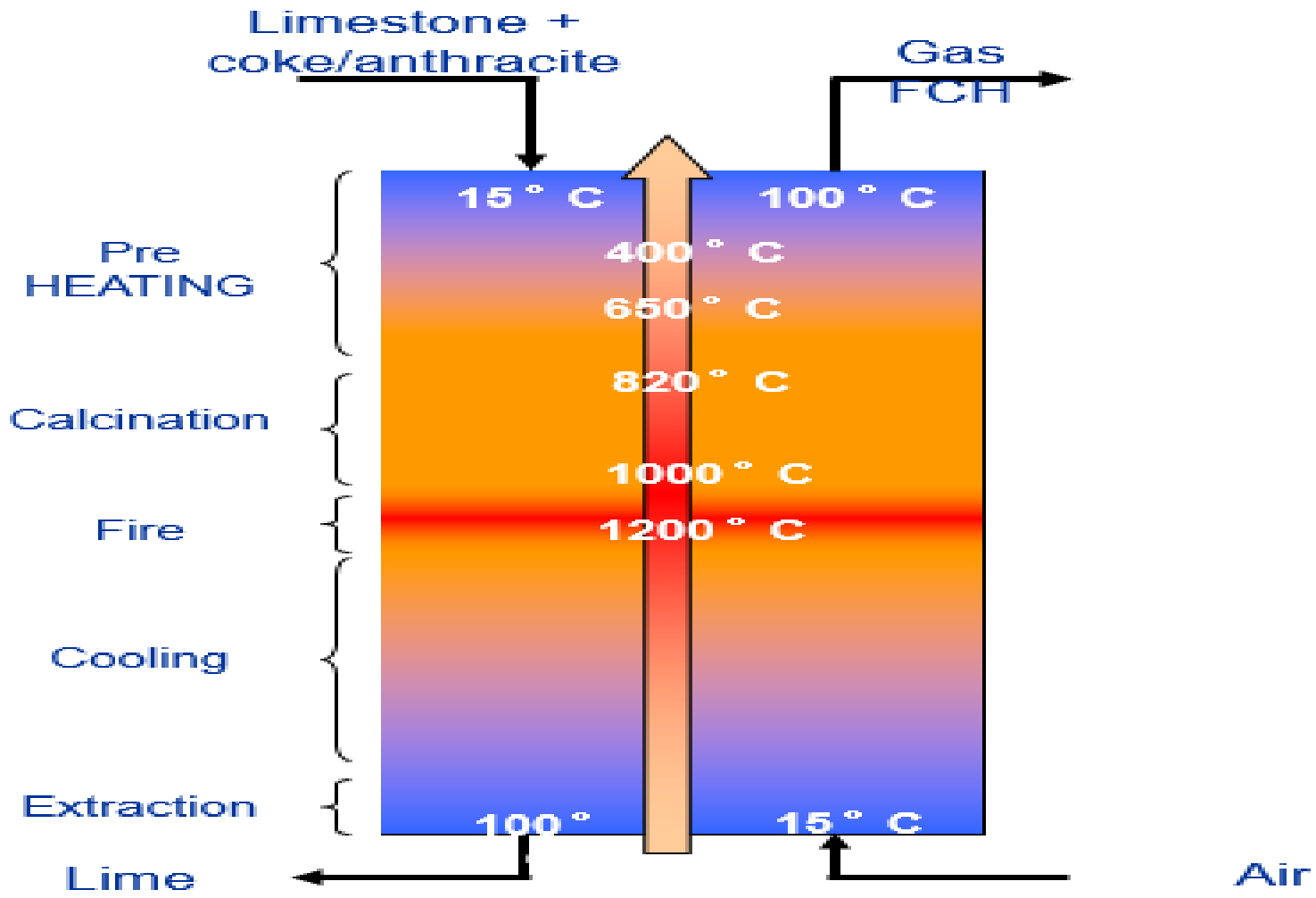
production of carbon dioxide and lime

Principal reactions:

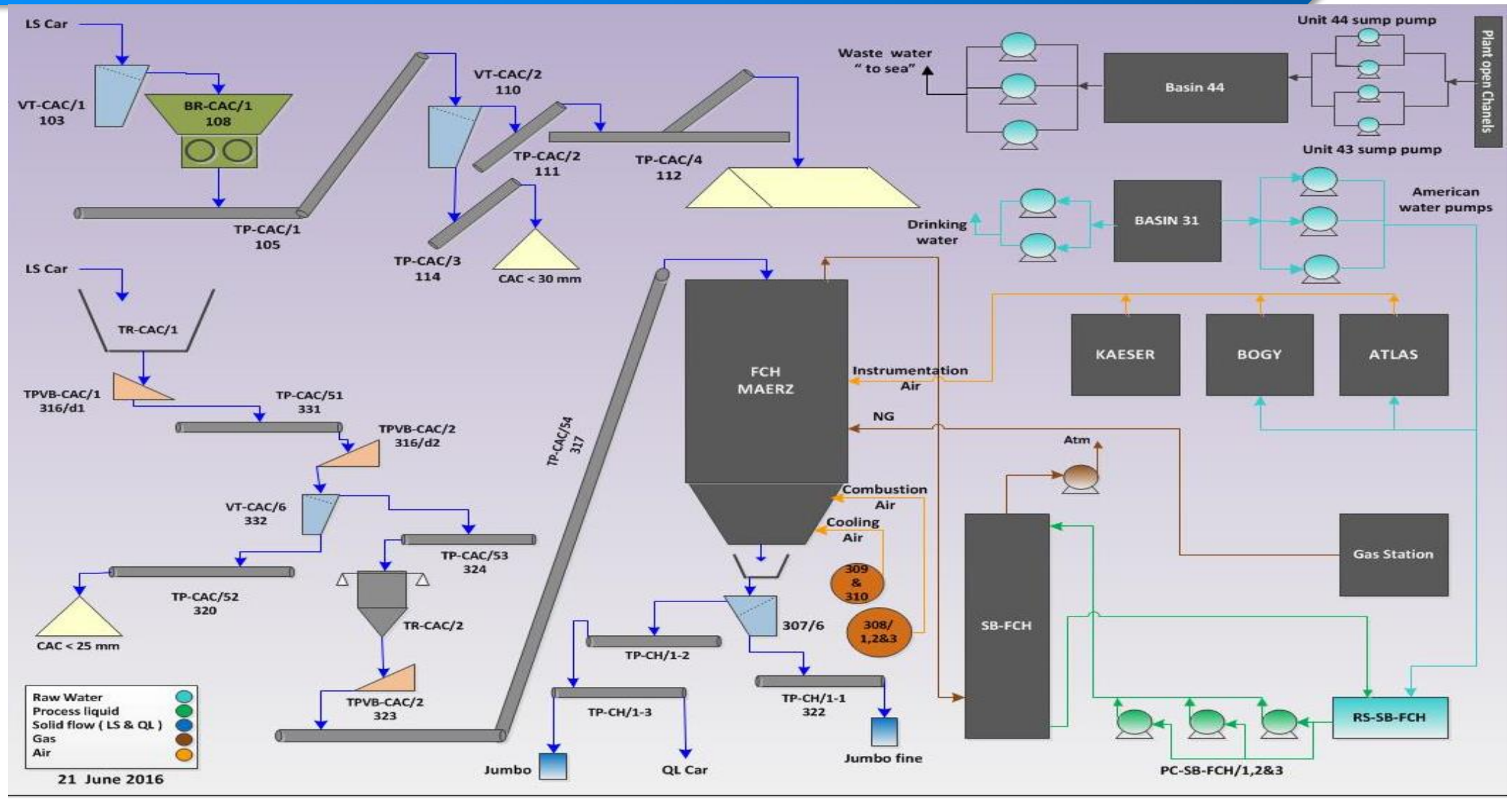
$C + O_2 \rightarrow CO_2 + heat$

$CaCO_3 + heat \rightarrow CO_2 + CaO$

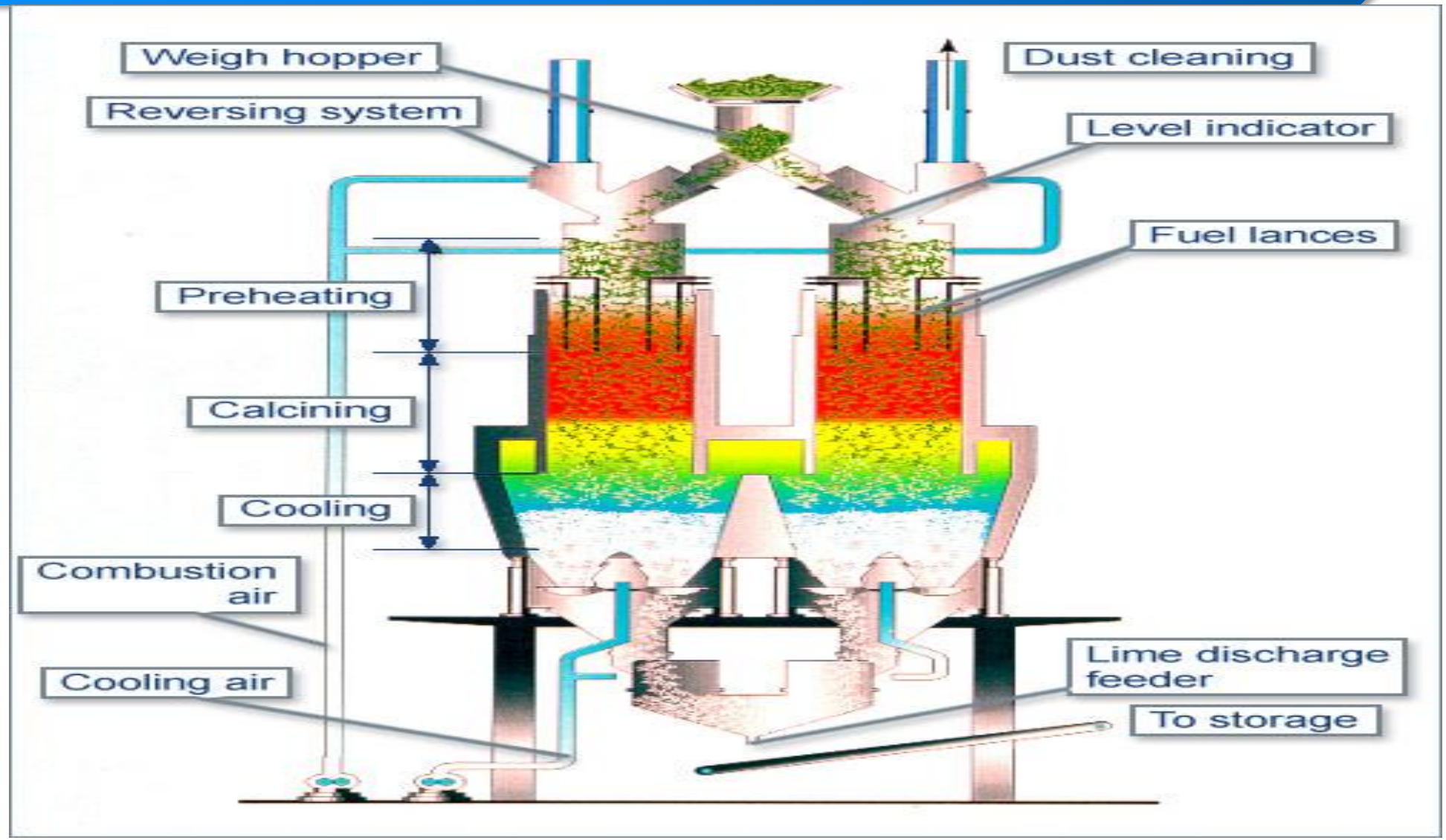
Lime Kilns


Limestone +
coke/anthracite
Gas
FCH
15 ° C
100 ° C
400 ° C
650 ° C
820 ° C
1000 ° C
1200 ° C
100 °
15 ° C
Pre
HEATING
Calcination
Fire
Cooling
Extraction
Lime
Air

Lime Kilns (MAERZ)



Lime Kilns (MAERZ)



Lime Kilns

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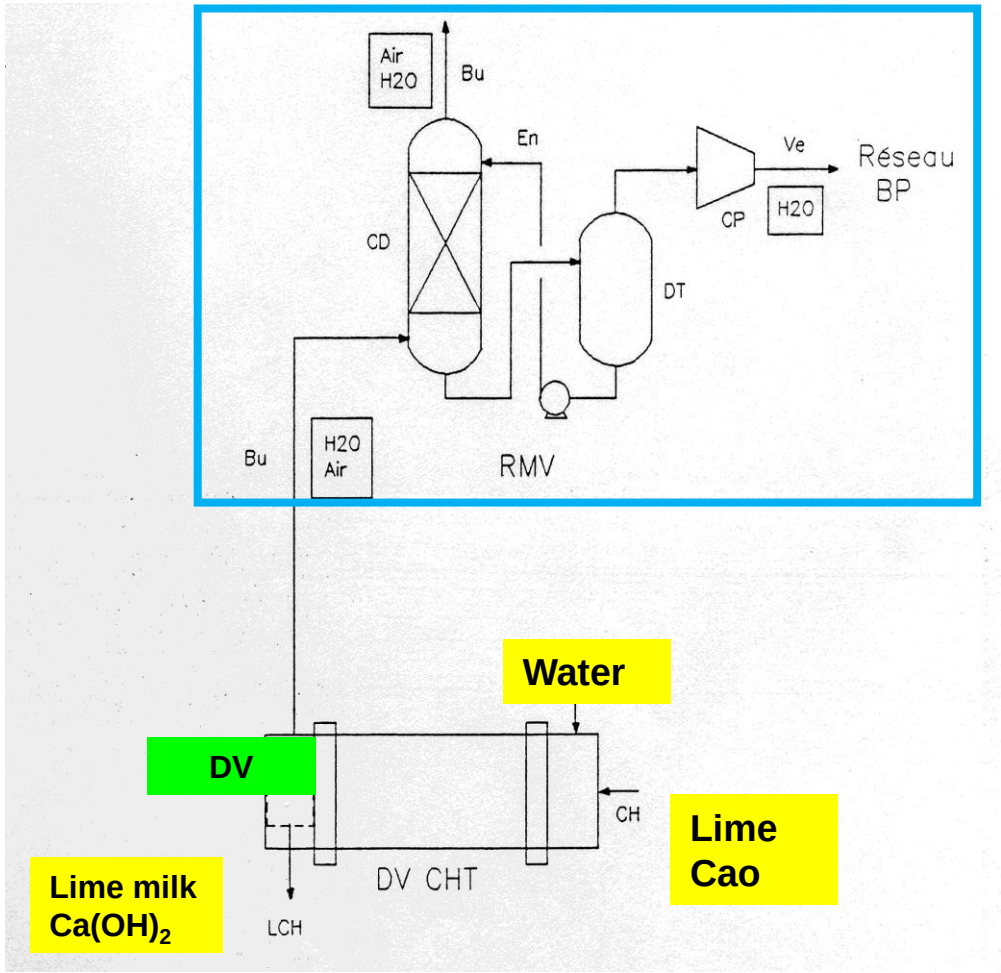
Lime Slackers



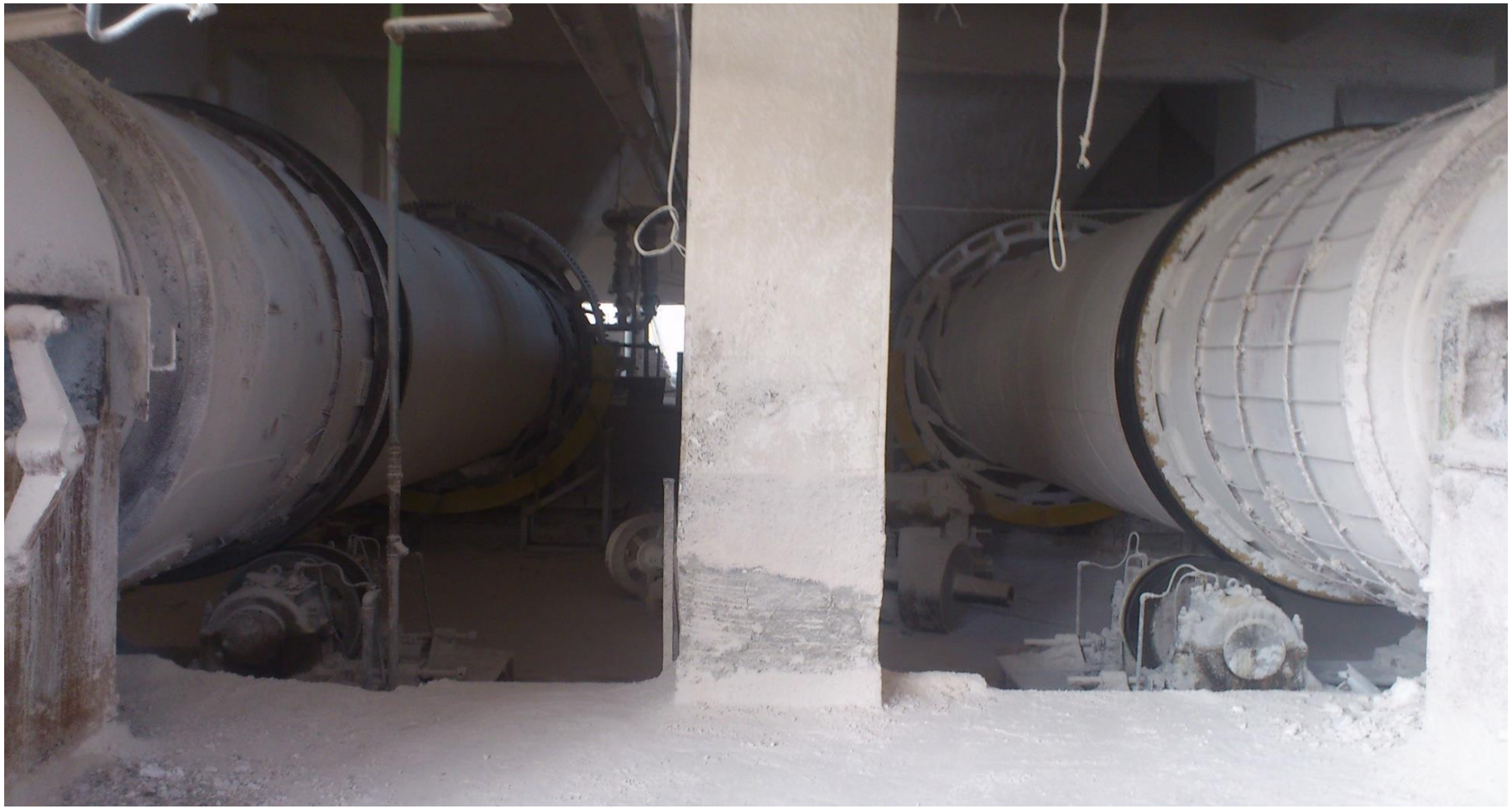
Role of DV :

- Hydration of lime to produce lime milk (LCH) using hot water …

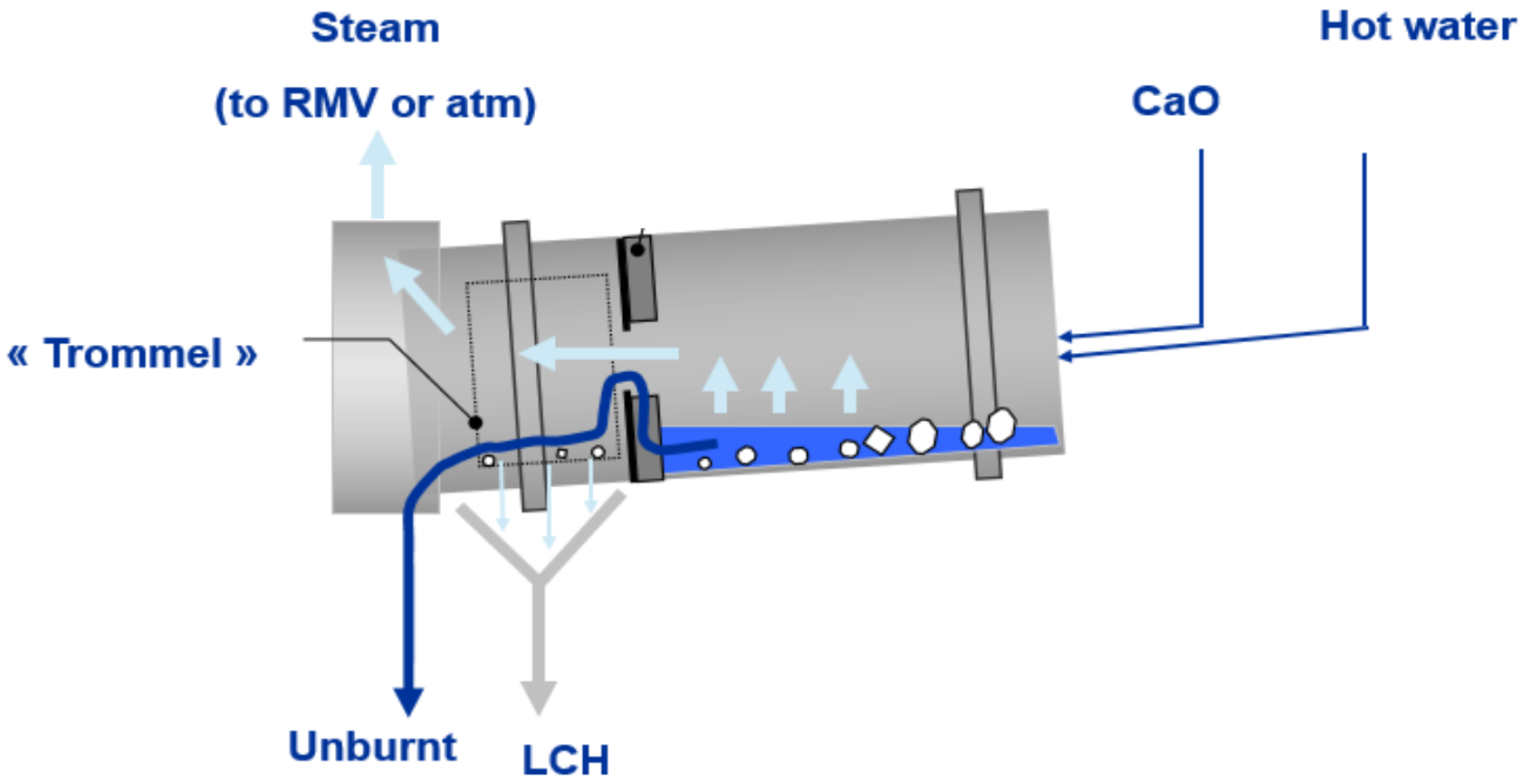
$$CaO + H_2O \rightarrow Ca(OH)_2 + \text{steam}$$

- The produced lime milk is used in the distillation unit to react with fixed ammonia.

Lime Slackers



Lime Slackers



Brine Purification

Goal

Remove Impurities present in the received raw brine mainly

Calcium Ca^{++}

Magnesium Mg^{++}

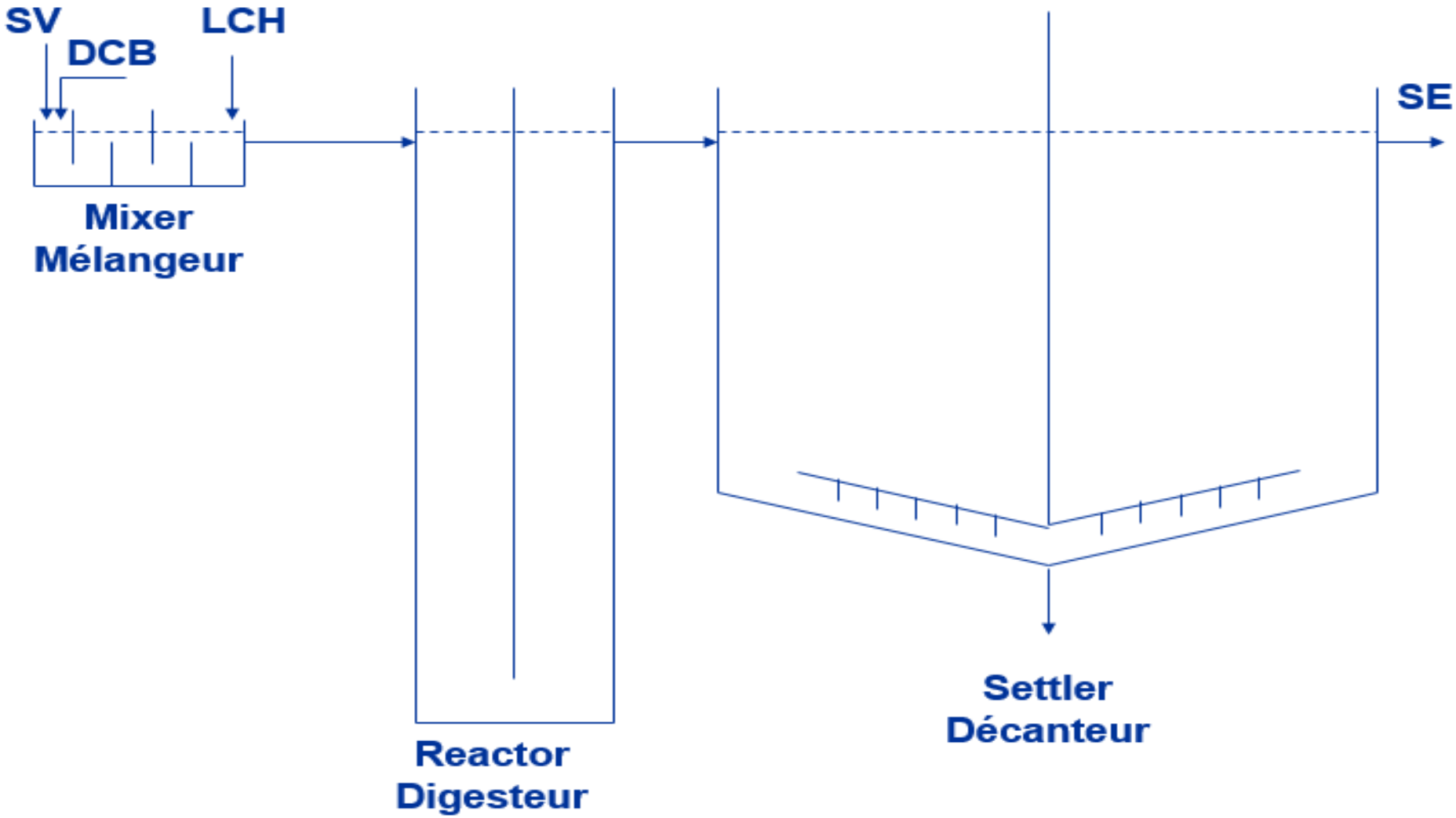
$$Mg^{++} + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + Ca^{++}$$

(Lime milk)

$$Ca^{++} + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2Na^{+}$$

(Soda Ash)

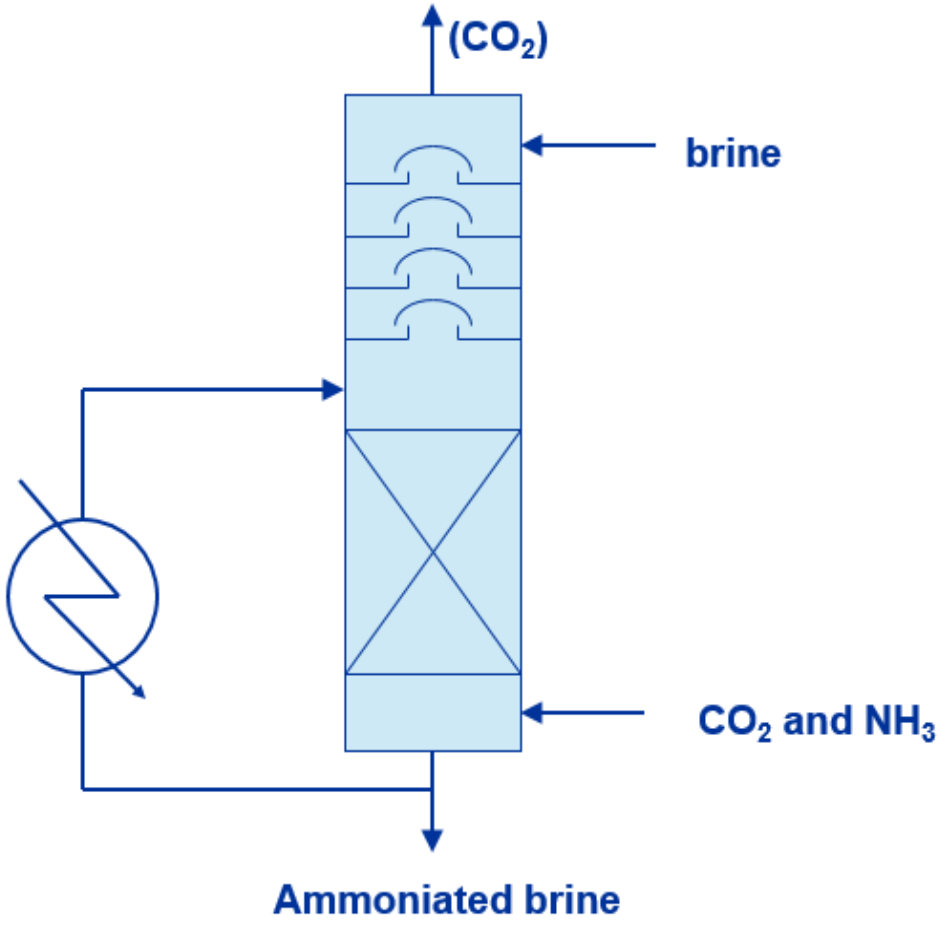
Brine Purification



Brine Purification

Brine Purification

Absorption :



Role :

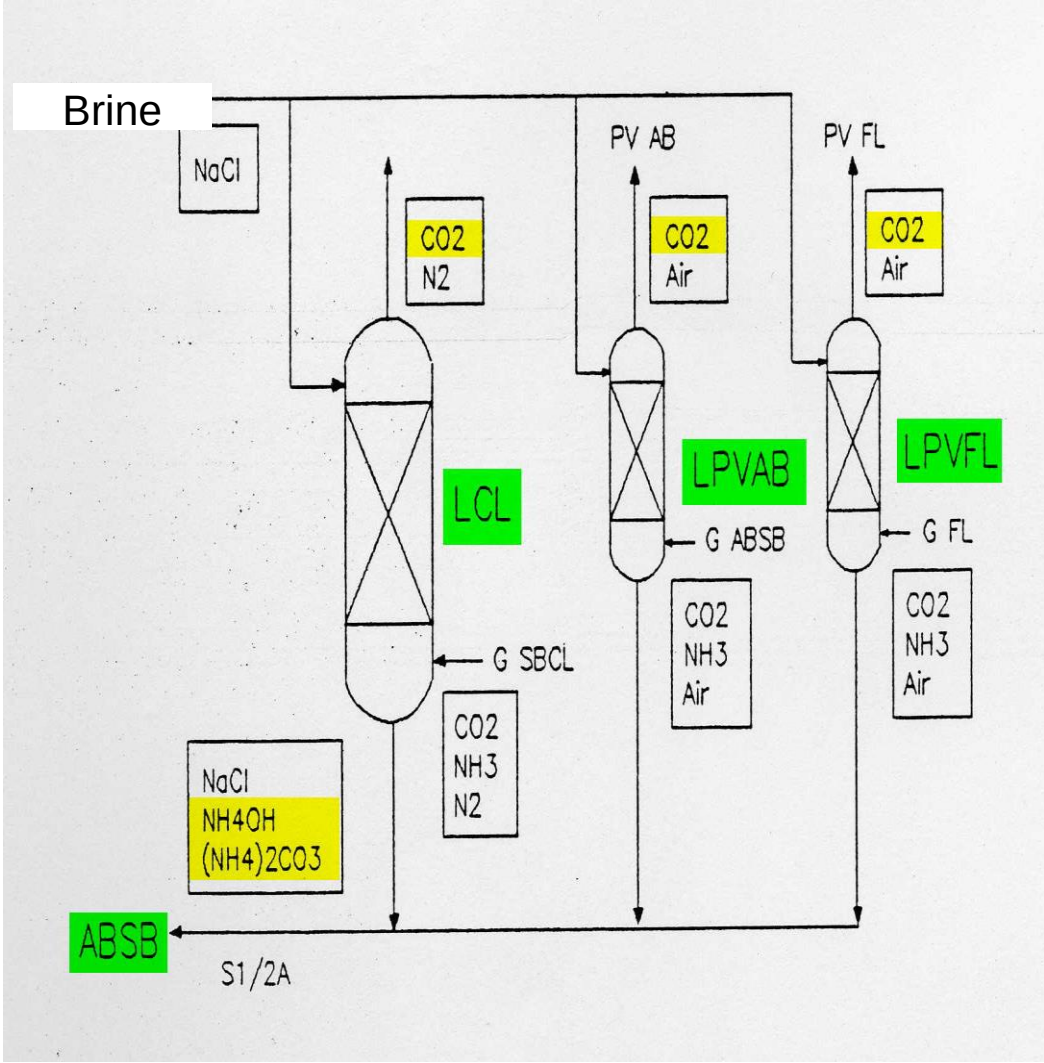
- Absorption of gas coming from distillation (NH_3 and CO_2) by using the prepared brine .

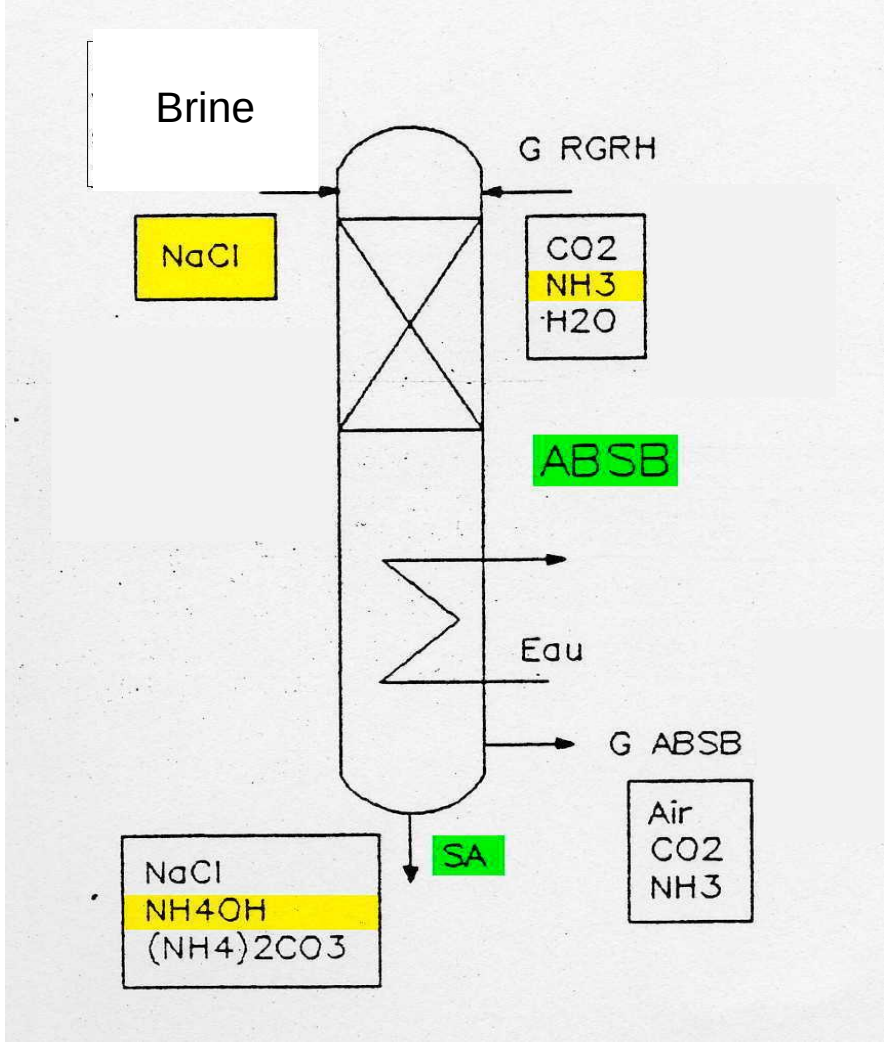
Principal reaction:

$$NH_3 + H_2O \rightarrow NH_4OH$$

- NH_3 and CO_2 must be absorbed simultaneously
- Ammoniated brine is produced .

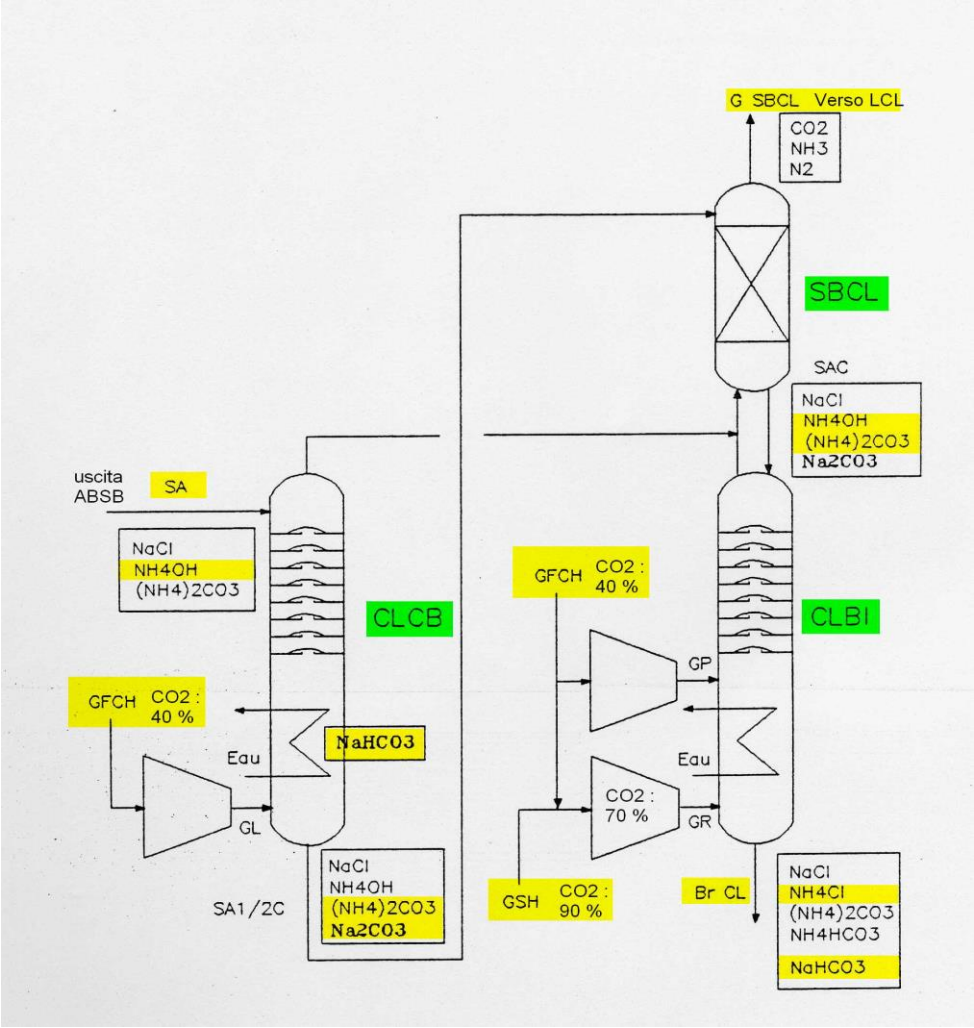
Absorption :


Brine
NaCl
CO2
N2
PV AB
CO2
Air
PV FL
CO2
Air
LCL
LPVAB
LPVFL
G SBCL
G ABSB
G FL
CO2
NH3
N2
CO2
NH3
Air
CO2
NH3
Air
NaCl
NH4OH
(NH4)2CO3
ABSB
S1/2A


Brine
G RGRH
NaCl
CO2
NH3
H2O
ABSB
Eau
G ABSB
Air
CO2
NH3
SA
NaCl
NH4OH
(NH4)2CO3

CO_2 Compressors :

Carbonation :



Role :

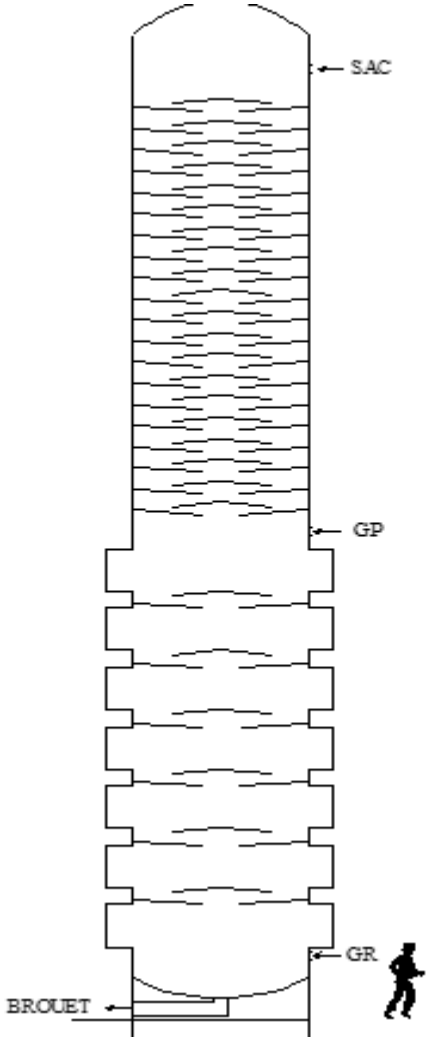
- Precipitation of raw bicarbonate ($NaHCO_3$)

➔ due to the reaction between formed ammoniated brine + CO2 produced from Kiln (after compressed in compressors)

Principal reaction:

$$NaCl + CO_2 + NH_4OH \rightarrow NH_4Cl + NaHCO_3$$

Carbonation :



Slurry

CARBONATATION ZONE :

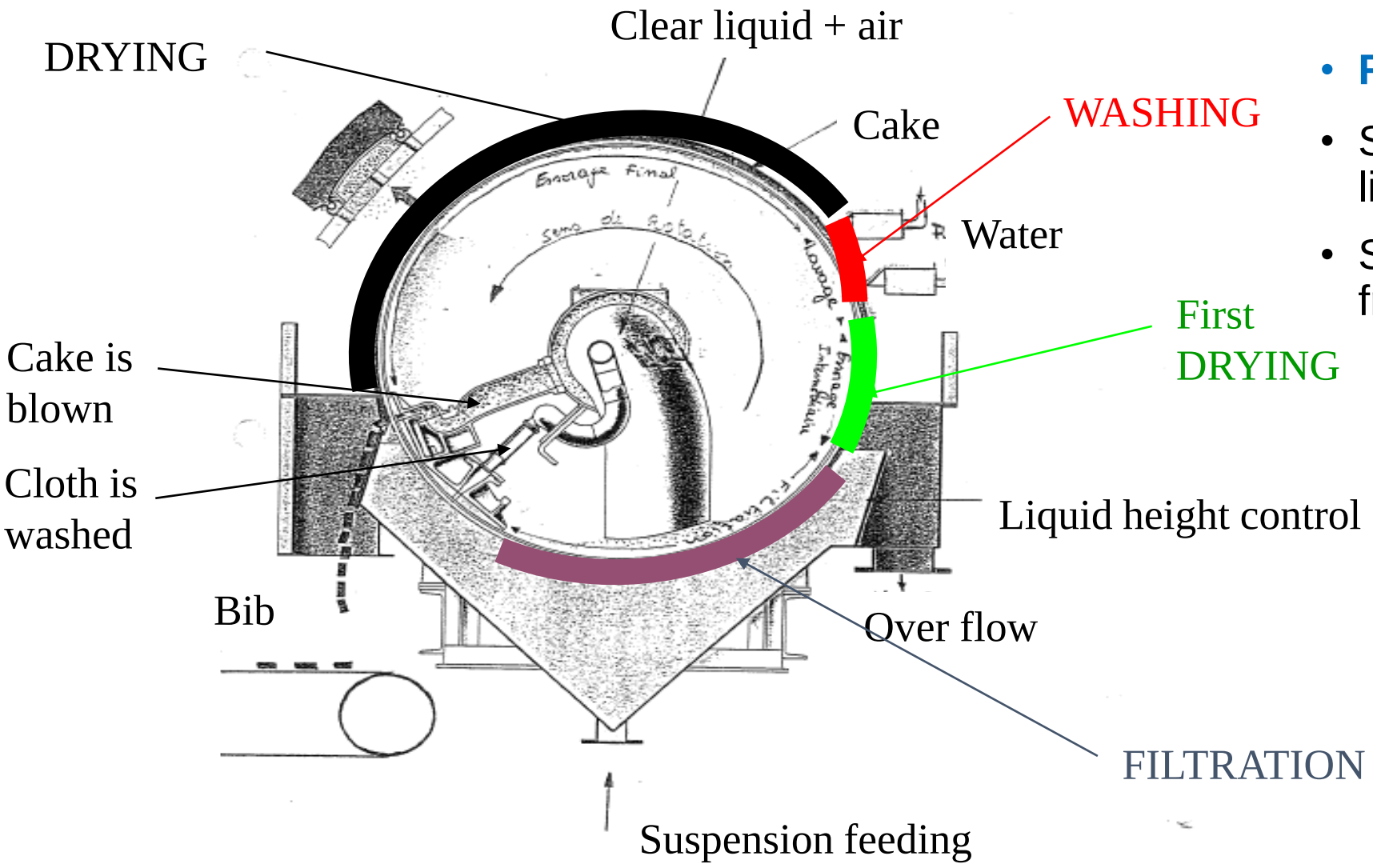
- Carbonatation – exothermic reaction
- Cristal formation with high T

- **Carbonatation**
- **Cooling**
- **Cristallisation**

COOLING ZONE :

- Conversion of NaCl to $NaHCO_3$ with low T

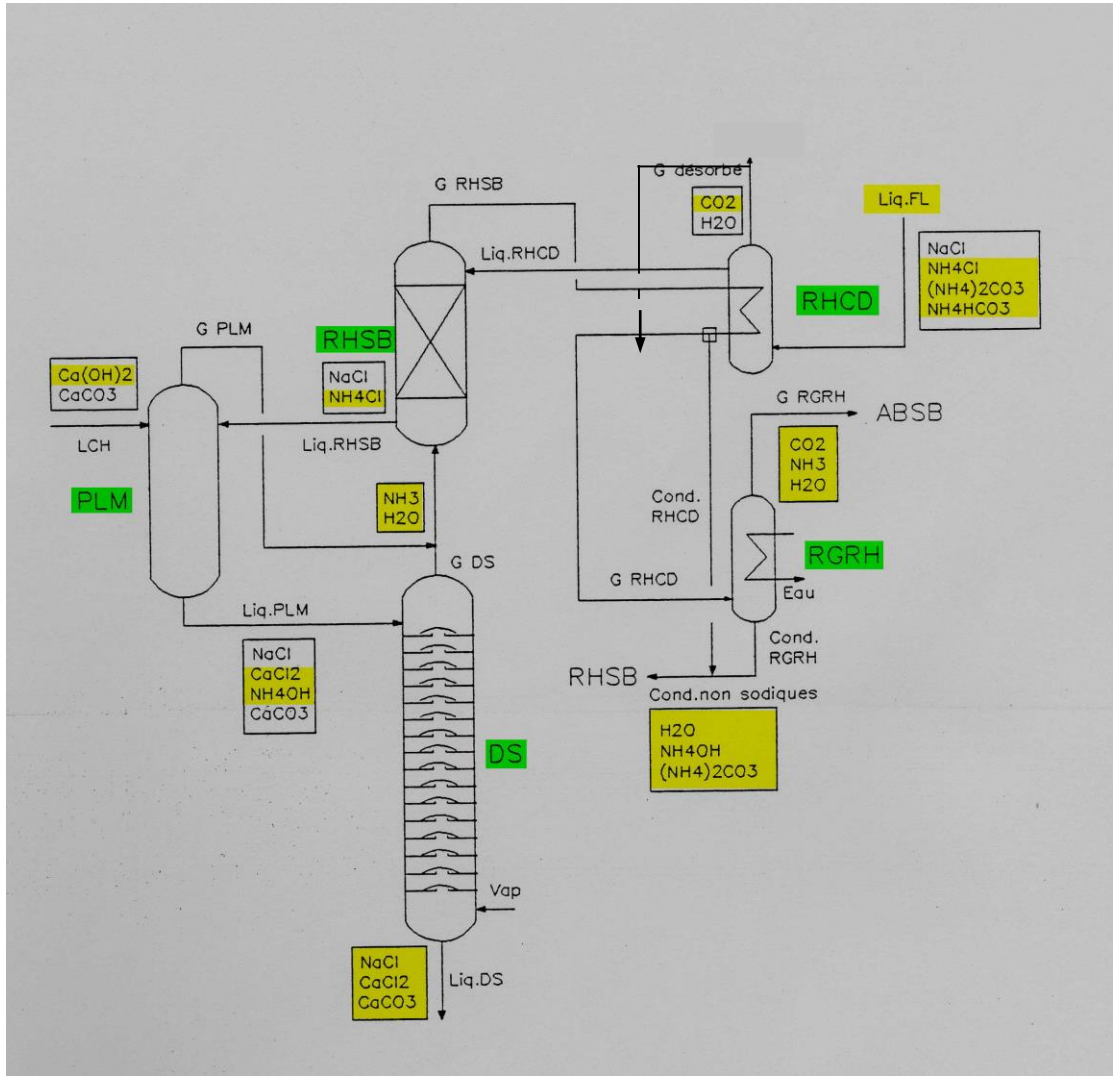
Filtration :



- **Role:**
- Separate solid ($NaHCO_3$) from liquid
- Solid wash to eliminate chlorine from brine

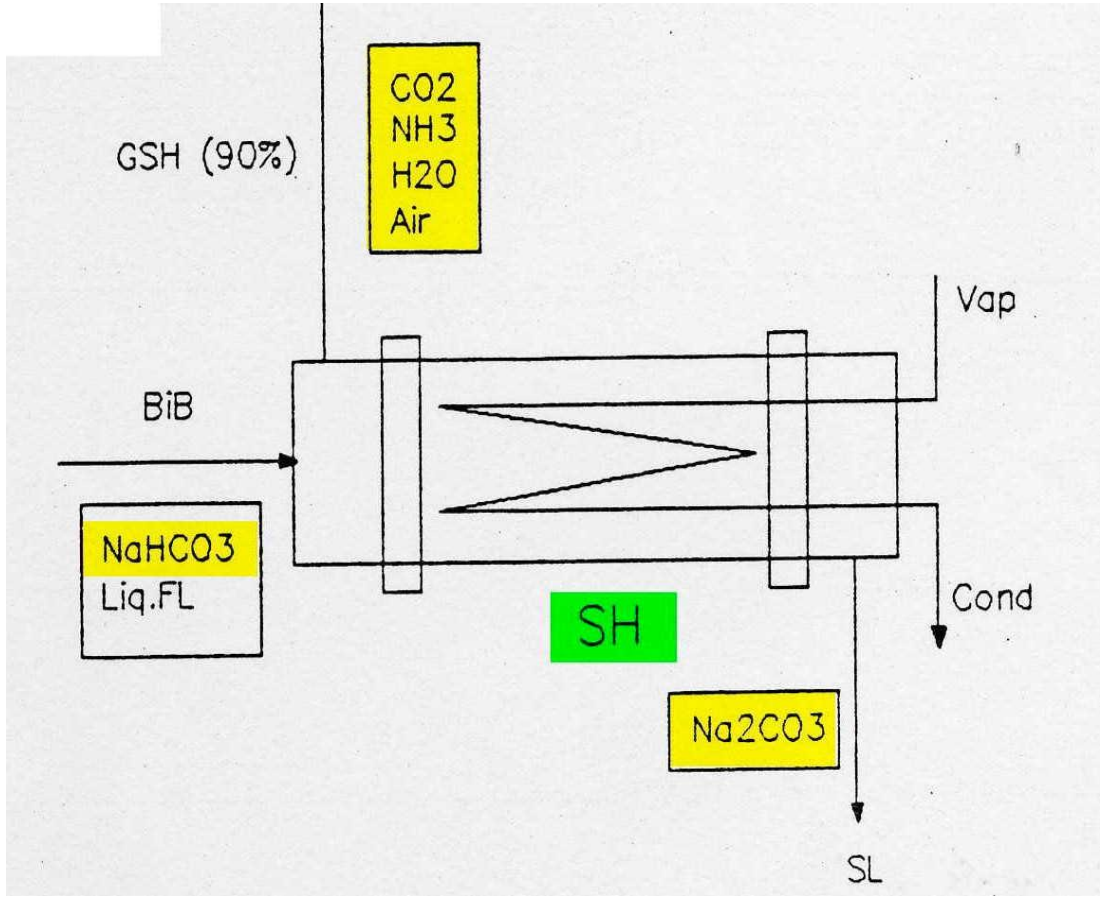
Filtration :

Distillation :



- **Role:**
- Recover of ammonia from filter lye (mother liquid of the filters (FLR liquid)) produced in filtration sector
- Also FLR liquid contains some CO2, which also has to be recovered during this operation.
- The ammonia is generally classed into two categories:
  - **Free / Volatile ammonia** (NH4OH,NH4HCO3, (NH4)2CO3)that is thermally dissociated and released through distillation.
  - **Fixed ammonia** (NH4Cl) that is chemically dissociated by using lime milk (produced in lime slackers)

Calciner :



- **Role:**
- Dry the product
- Decompose bicarbonate into Soda Ash

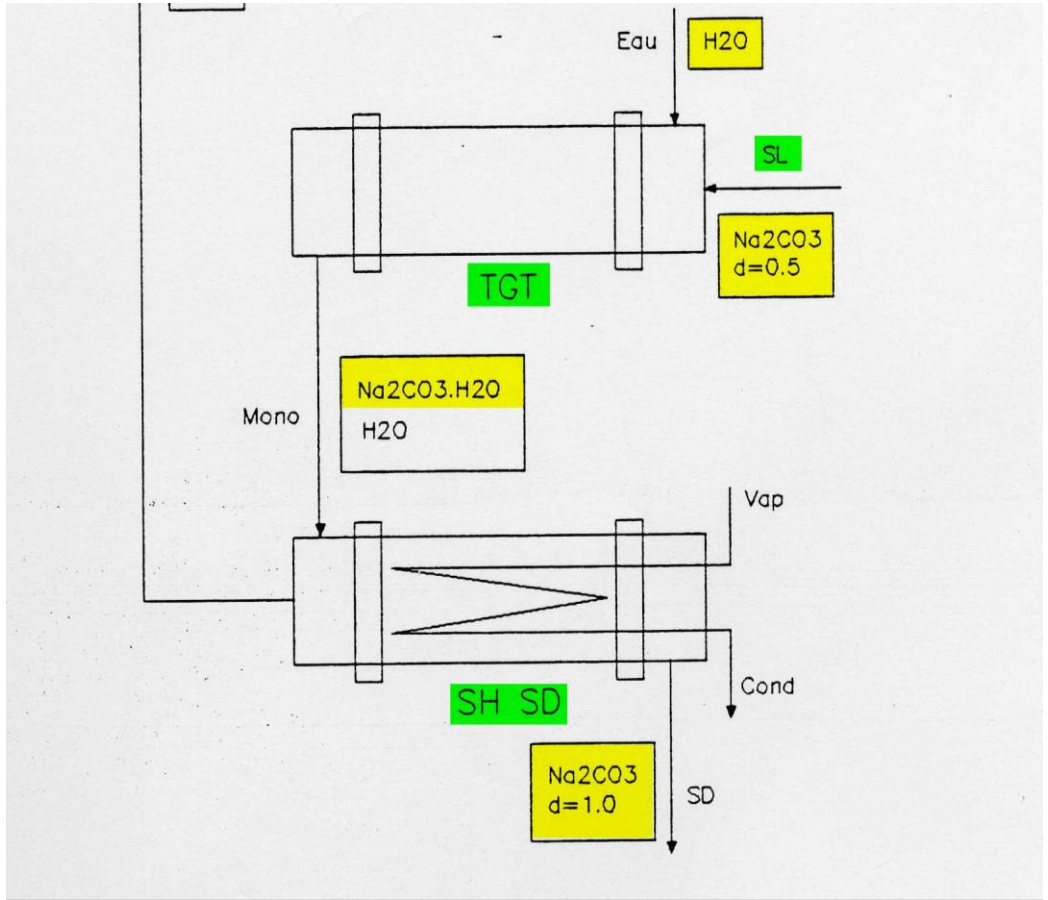
$$2\ NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

(Light Soda Ash)

- Gas produced (Rich gas ≅ 90%) used in carbonation

Calciner : LSA

Densification: DSA



- **Role:**
- At calciner outlet Light Soda has a specific weight of 0.5 t/m3
- To have Dense Soda with a specific weight of 1 t/m3, re-crystallization is needed.
- We use Demin. water to make dense soda

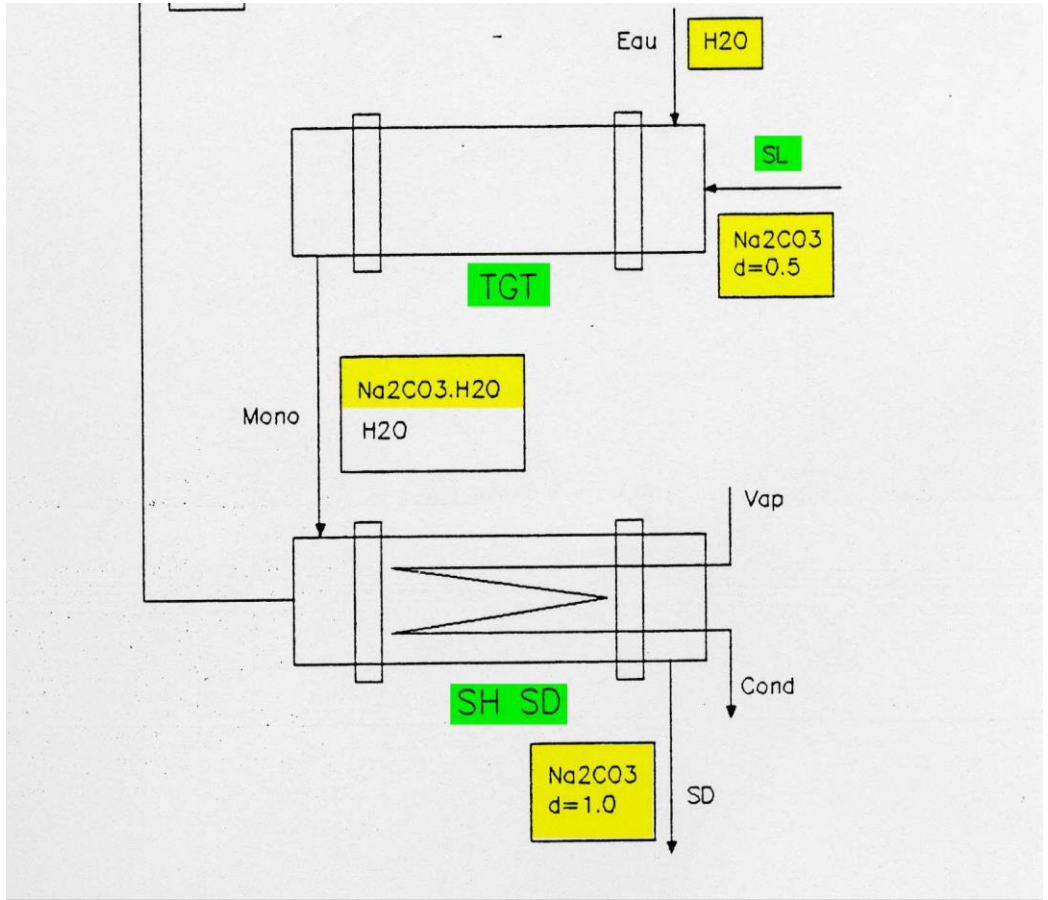
Mix water and SL to obtain monohydrate

$$Na_2CO_3 + H_2O \rightarrow Na_2CO_3.H_2O$$

Heating:

$$Na_2CO_3.H_2O + H \rightarrow Na_2CO_3 + H_2O$$

Densification: DSA



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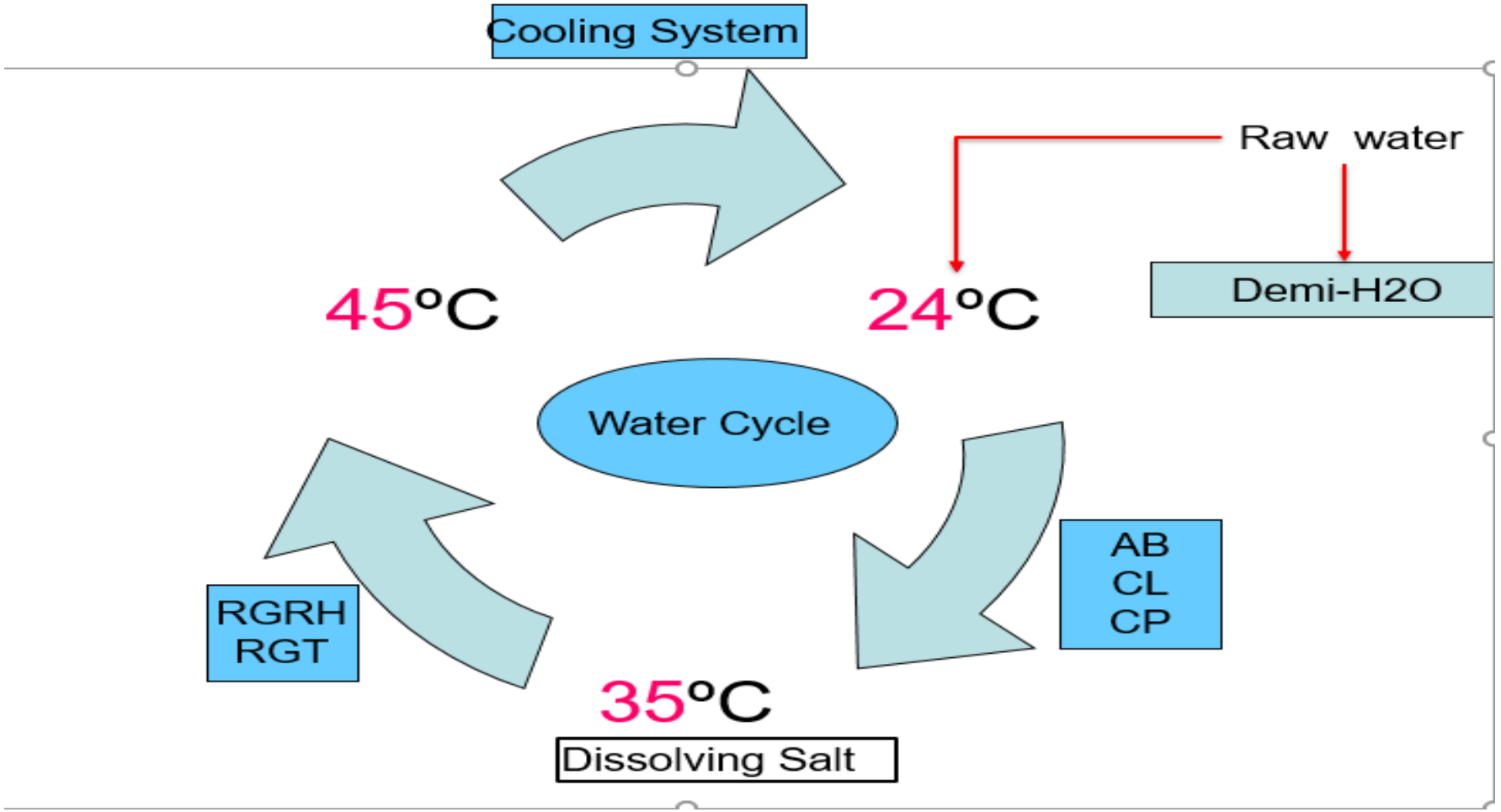
Utilities:

- **Steam Production ➔ BOILERS**
  - Driving turbine at CO_2 compressors.
  - Distillation
  - Calciner
  - Densification
- **Demineralized water :**
  - Boiler
  - Densification
  - Compressors
  - Vacuum pumps

Utilities:

- **Cooling system :**
  -




Thank you