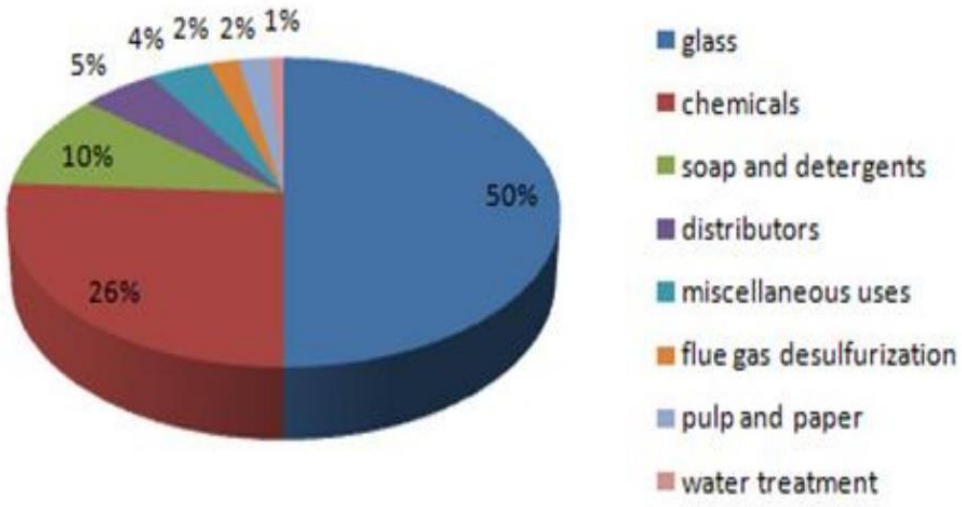
PEMBUATAN SODIUM KARBONAT

Sodium Karbonat

- Rumus kimia Na_2CO_3
- Dikenal dengan nama soda ash, soda crystal, dan washing soda



Uses

- fluxing agent in **glass manufacture**
- alkali in many **soap** and **detergent** applications.
- flue gas **desulfurization**
- **sulfite paper pulp process**
- **green liquor recovery section** of the Kraft pulping process
- production of **sodium hydroxide** by the **lime soda process**
- production of **baking powder**
- as a dry-powder **fire extinguisher**

Proses pembuatan sodium karbonat

- Ada beberapa metode
  - Le blanc Process
  - Solvay Process
  - Dual process (modifikasi Solvay Process)
  - Electrolyte process

Leblanc Process

- Bahan baku :
  - Garam laut (NaCl)
  - Batu kapur
  - Asam sulfat
  - Kokas

Leblanc process

- Common salt is first mixed with the conc. H_2SO_4 in equivalent quantities and heated in a cast iron salt cake furnace by flue gases from adjacent coal of fire.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

- HCl is passed to tower packed with coke and is absorbed through a spray of water.
- The paste of $NaHSO_4$ is taken out and heated to a high temperature on the hearth of a furnace along with some more common salt.

$$NaHSO_4 + NaCl \rightarrow Na_2SO_4 + HCl$$

Leblanc process

- The salt cake is broken or pulverized, mixed with coke and limestone and charged into black ash rotary furnace consisting of refractory lined steel shells.
- The mass is heated by hot combustion gases entering at one end and leaving at the others.
- The molten porous gray mass thus formed known as black ash is separated from the calcium sludge and then crushed and leached with water in absence of air in a series of iron tank.

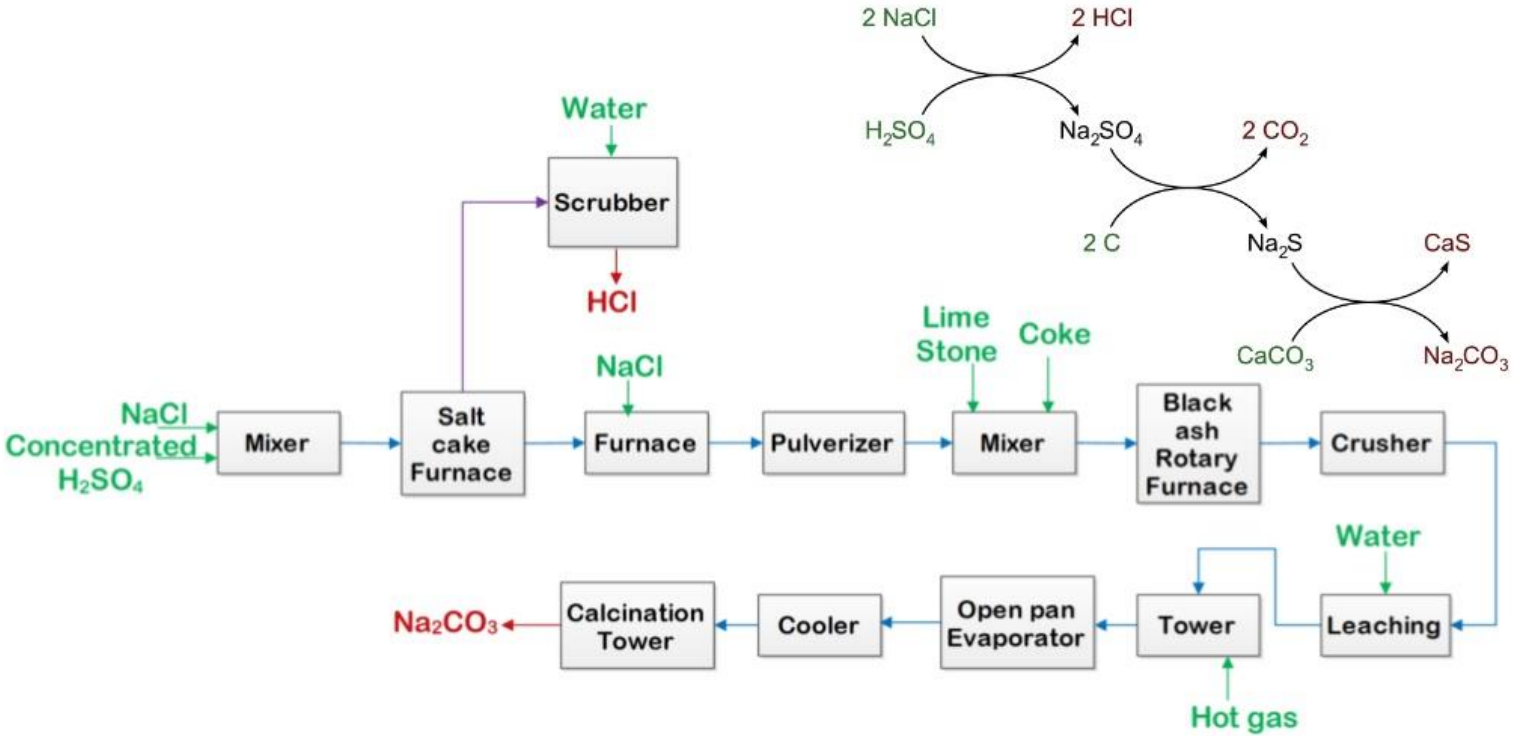
$$Na_2SO_4 + 2C \rightarrow Na_2S + 2CO_2$$

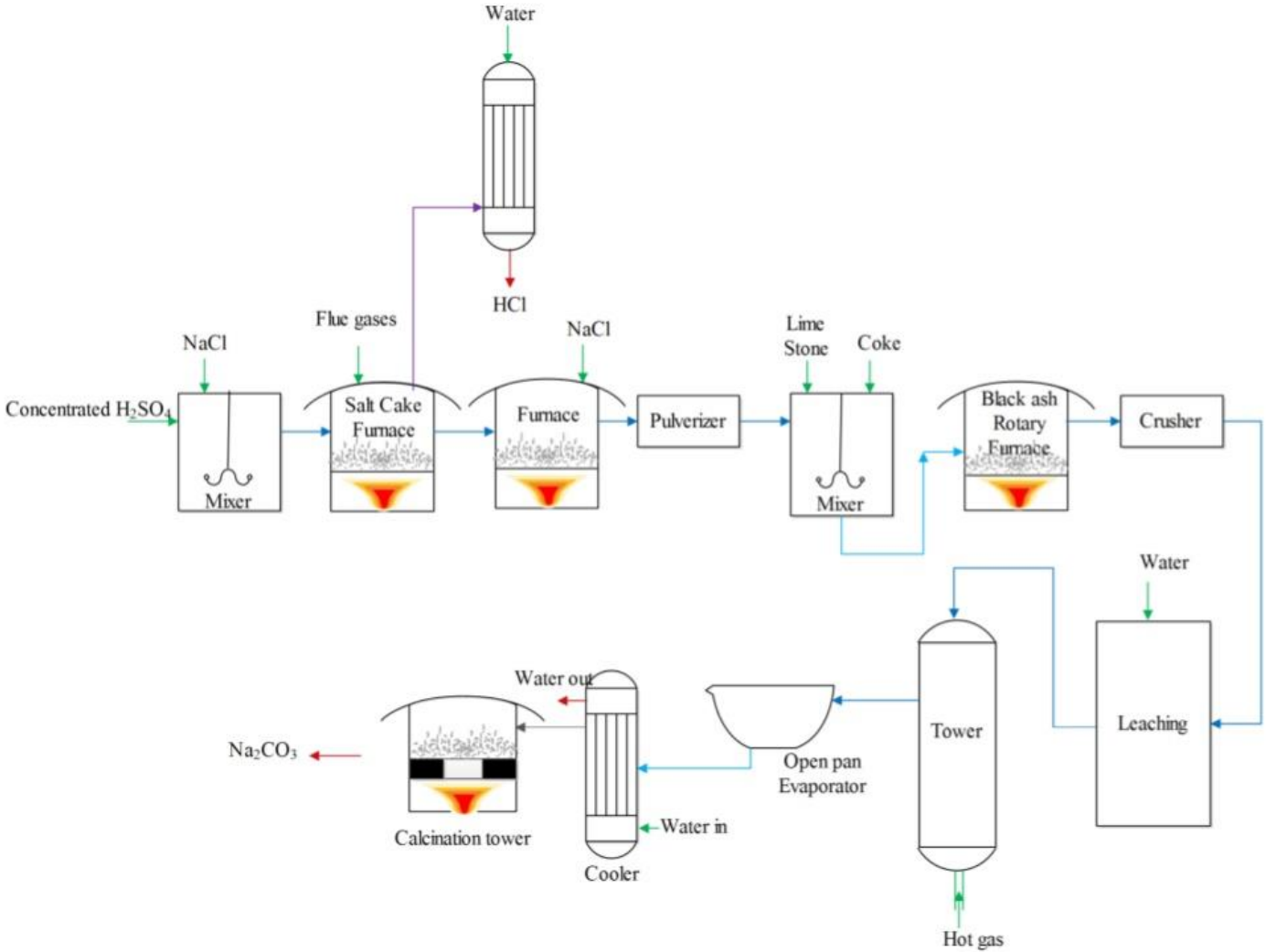
$$Na_2S + CaCO_3 \rightarrow Na_2CO_3 + CaS$$

Leblanc process

- The extract containing Na_2CO_3 , NaOH and other impurities is sprayed in counter current to the flow of hot gases from the black ash furnace in a tower.
- The sodium carbonate thus obtained is concentrated in open pans and then cooled to get sodium carbonate.
- The product is calcined to get soda ash which is re-crystallized to $Na_2CO_3.10H_2O$.
- The sludge containing mostly CaS is left behind as alkali waste.
- The liquor remaining after removal of first batch of soda ash crystals is purified and then causticized with lime to produce caustic soda.

Leblanc process




Water
HCl
Flue gases
NaCl
NaCl
Lime Stone
Coke
Concentrated H_2SO_4
Mixer
Salt Cake Furnace
Furnace
Pulverizer
Mixer
Black ash Rotary Furnace
Crusher
Water
Water out
Na_2CO_3
Calcination tower
Cooler
Water in
Open pan Evaporator
Tower
Leaching
Hot gas

- Poor economics and excessive pollution caused by the hydrochloric acid and calcium sulfide by-product led to the eventual demise of the Leblanc process.

Solvay Process

- Bahan baku :
  - Garam
  - Batu kapur
  - Amonia
  - Kokas

Solvay's ammonia soda process

Preparation and purification of brine

- Crude sodium chloride brine is first purified to prevent scaling of downstream process equipment and to prevent contamination of the final product.
- Magnesium ions are precipitated with milk of line, $Ca(OH)_2$, and the calcium ions are precipitated with soda ash.

Ammoniation of brine:

- $NH_3(aq) + H_2O(l) \rightarrow NH_4OH(aq) + 34900\ kJ$

Most of the ammonia is recycled from downstream steps, although some make-up is required.

Solvay's ammonia soda process

Precipitation of Bicarbonate

- The ammoniated brine is then sent to the carbonating columns where sodium bicarbonate is precipitated by contacting the brine with carbon dioxide

$$2NH_4OH + CO_2 \rightarrow (NH_4)_2CO_3 + H_2O + \text{heat}$$

$$(NH_4)_2CO_3 + CO_2 + H_2O \rightarrow 2NH_4HCO_3$$

$$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$$

ammonium chloride is a marketable fertilizer product

Solvay's ammonia soda process

- $NaHCO_3$ is less soluble and precipitates on the internals of the carbonating column.
- At the end of the make cycle, the slurry is drained and the solid $NaHCO_3$ is filtered. However, considerable amounts of $NaHCO_3$ remain in the column after the slurry is drained.
- A series of five or more columns with appropriate piping interconnections are used for continuous operation.
- The carbonation is favored by higher pressures and low temperature.

Solvay's ammonia soda process

Filtration of bicarbonate

- The slurry from the carbonating columns is fed to continuous vacuum filters or centrifuges where $NaHCO_3$ crystals are recovered.
- The filter cake is carefully washed to control residual chloride while maintaining acceptable yield.
- Yield losses on washing are on the order of 10%.

Calcining the Bicarbonate to Soda Ash

- The filtrate is then calcined at 175–225◦C to produce sodium carbonate, carbon dioxide and water vapor:
- $2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$
- CO_2 is recovered, compressed and recycled back to the carbonating columns as needed.

Solvay's ammonia soda process

Recovery of Ammonia

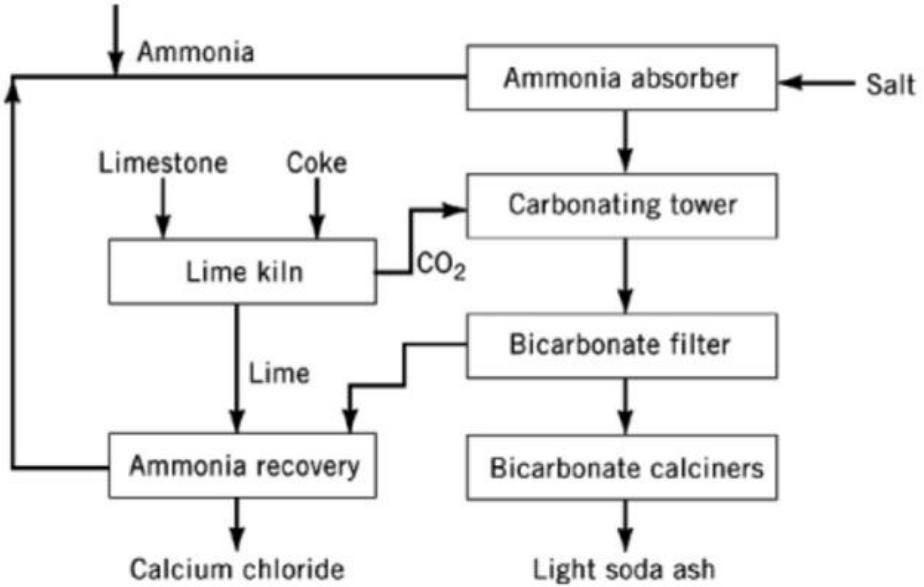
- The traditional Solvay process recovers ammonia by reacting the ammonium chloride in the filtrate liquor with milk of lime
- $2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + 2H_2O$

Solvay's ammonia soda process

Production of milk of lime

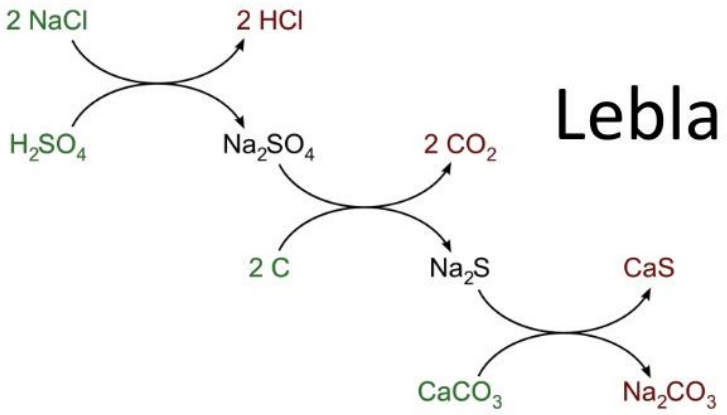
- The milk of lime and much of the carbon dioxide needed in the Solvay process are produced from limestone. The reaction is carried out in a kiln at 950–1100◦C.
- $CaCO_3 \rightarrow CaO + CO_2$
- $C(s) + O_2(g) \rightarrow CO_2(g)$
- Usually metallurgical grade coke is mixed with the limestone as a fuel.
- CO_2 is recovered from the exhaust by filtration to remove entrained dust, compressed and sent to the carbonization columns. The lime is cooled and slaked with water.
- $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2$

Solvay's ammonia soda process

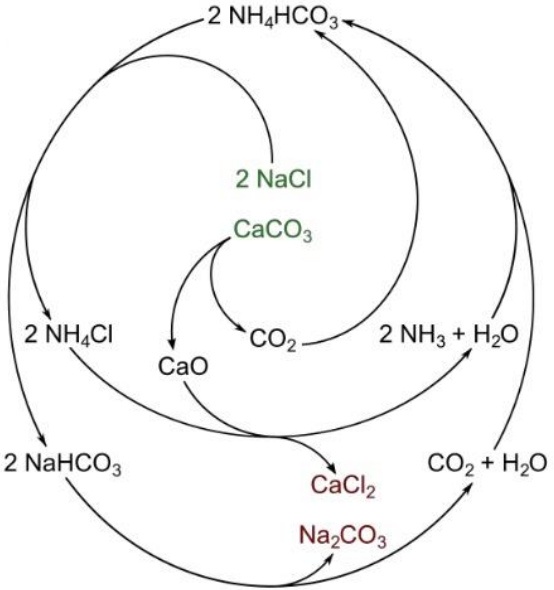


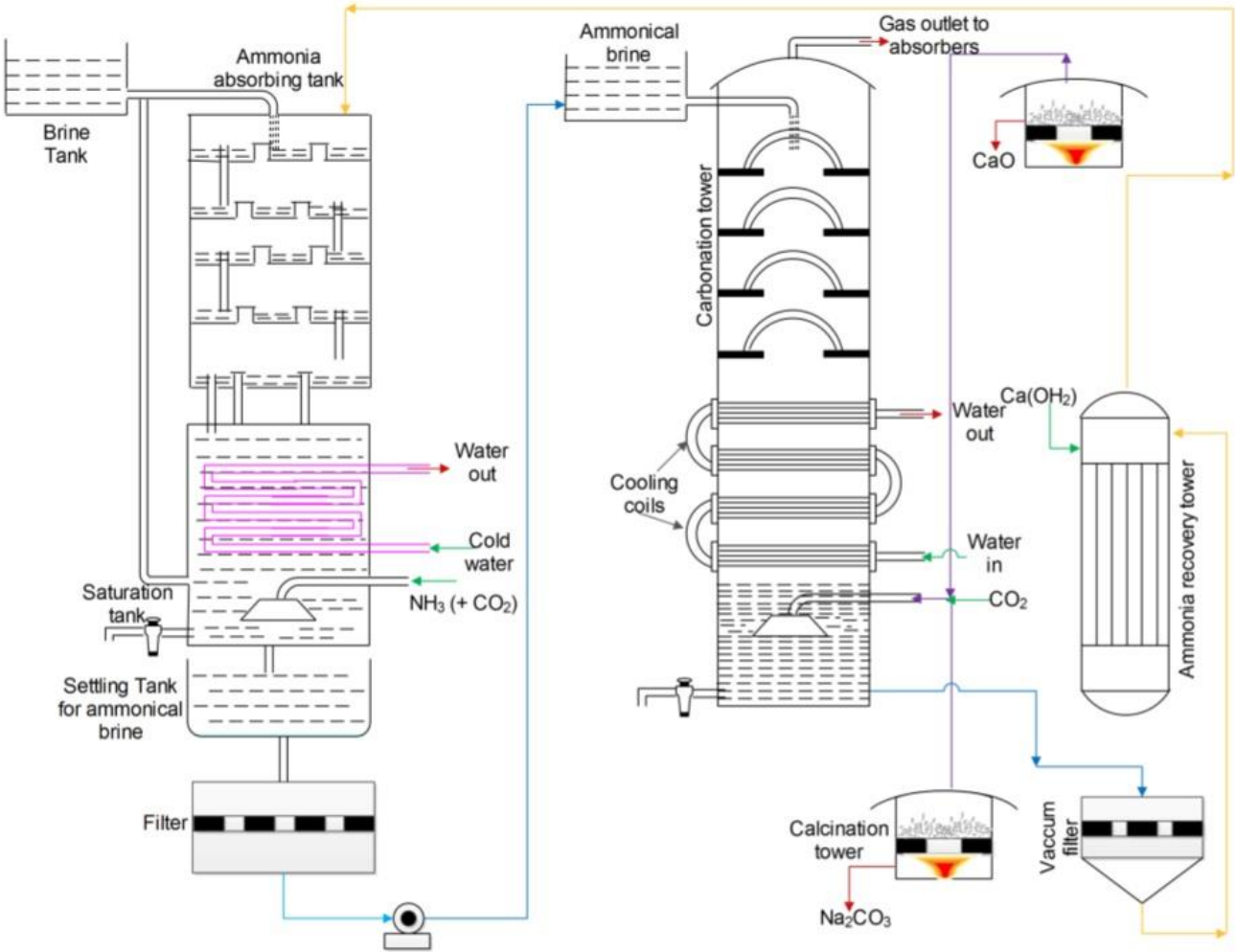
$CaCO_3 + 2NaCl \rightarrow Na_2CO_3 + CaCl_2$

Leblanc Process



Solvay's Process




Ammonia absorbing tank
Brine Tank
Water out
Cold water
NH_3 (+ CO_2)
Saturation tank
Settling Tank for ammonical brine
Filter
Ammonical brine
Gas outlet to absorbers
CaO
Carbonation tower
Cooling coils
Water out
Water in
CO_2
$Ca(OH_2)$
Ammonia recovery tower
Calcination tower
Na_2CO_3
Vaccum filter

Advantage of Solvay process

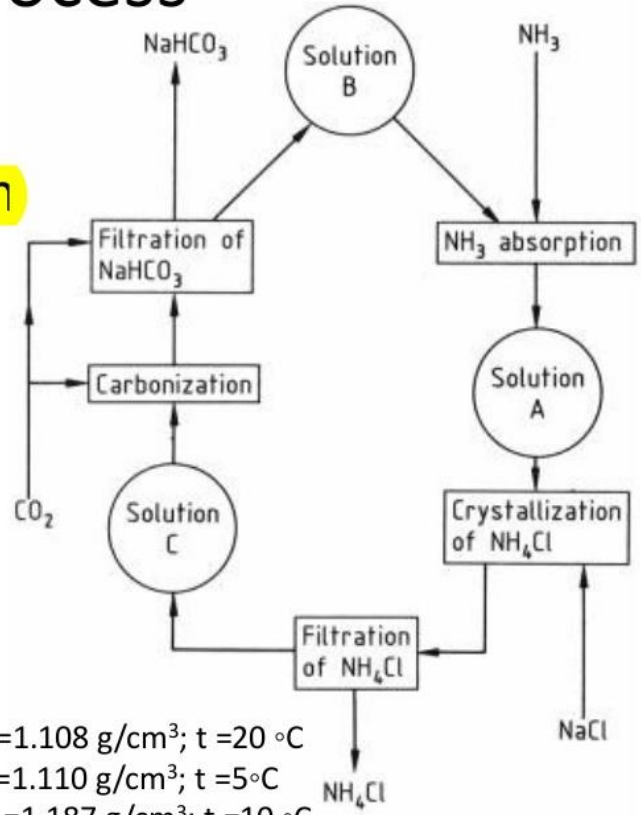
- Less electric power
- Less corrosion problem
- Use of low grade brine
- Not a problem of disposal of co-product
- Does not require ammonia plant

Disadvantage of Solvay process

- Higher salt consumption
- Waste disposal of $CaCl_2$-brine stream
- Higher investment in ammonia recovery units than crystallization unit of NH_4Cl
- Higher capacity plant set up require for economic break even operation

Dual Process

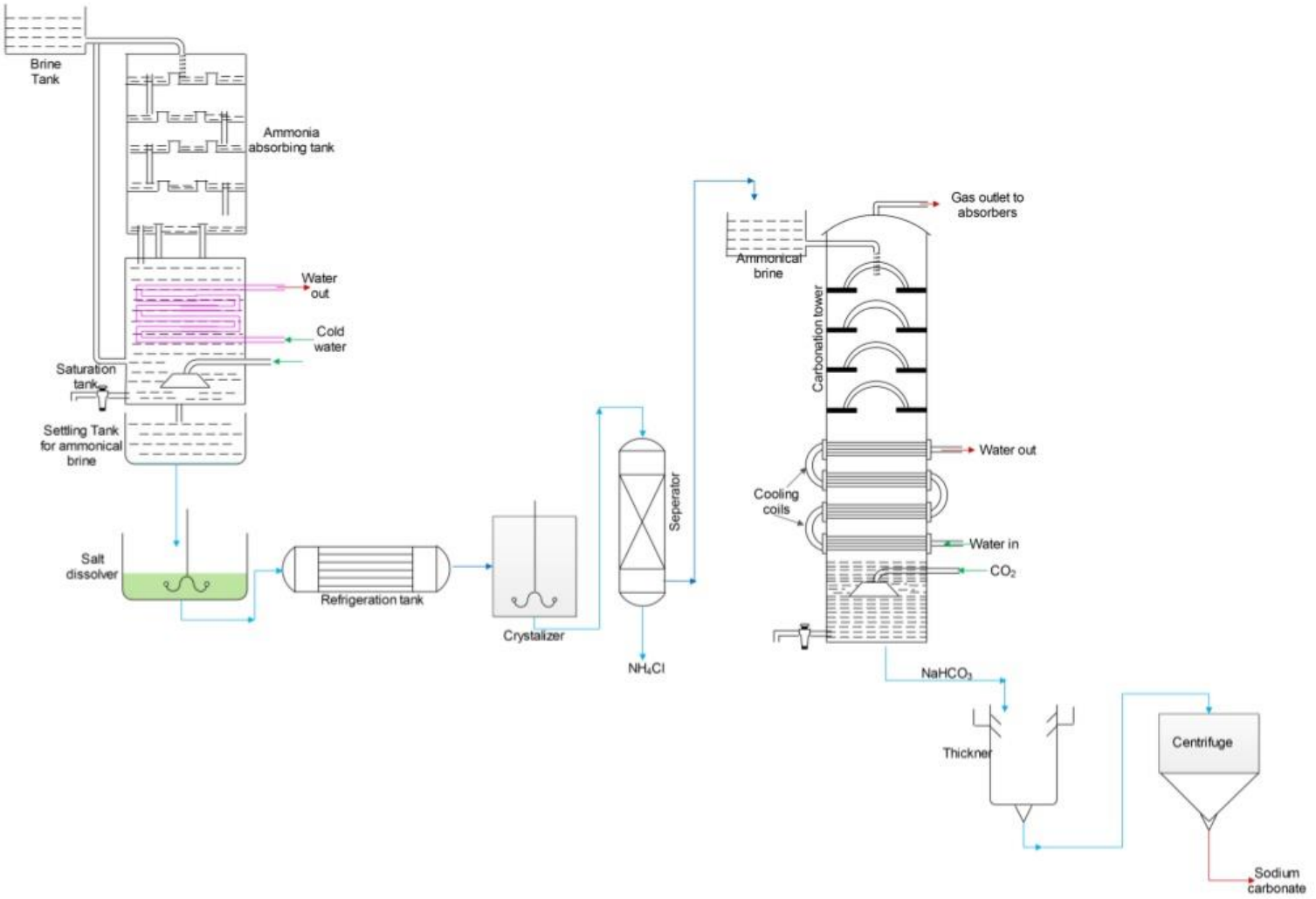
- This process combines Na_2CO_3 production with NH_4Cl production.



Solution A: 4.1 mol/L NH_4Cl + 1.05 mol/L NaCl; ρ=1.108 g/cm^3; t =20 ◦C
Solution B: 3.45 mol/L NH_4Cl + 1.1 mol/L NaCl; ρ =1.110 g/cm^3; t =5◦C
Solution C: 1.86mol/L NH_4Cl + 3.73 mol/L NaCl; ρ =1.187 g/cm^3; t =10 ◦C

Dual Process

- NH_3 is absorbed by the $NaHCO_3$ mother liquor, and solid NaCl is added.
- On cooling, NH_4Cl separates, is recovered in centrifuges, and is then dried in rotary dryers with air at 150 ◦C.
- The mother liquor is recycled to the carbonation towers where sodium $NaHCO_3$ is precipitated.


Brine Tank
Ammonia absorbing tank
Water out
Cold water
Saturation tank
Settling Tank for ammonical brine
Salt dissolver
Refrigeration tank
Crystalizer
Seperator
NH_4Cl
Ammonical brine
Gas outlet to absorbers
Carbonation tower
Water out
Cooling coils
Water in
CO_2
$NaHCO_3$
Thickner
Centrifuge
Sodium carbonate

Dual Process

Difference compared to Solvay's process

- In the dual process, NH_3 is not recovered; hence **no NH_3 recovery tower** (distillation equipment)t is required.
- Also, **lime kilns are not required** if other sources of CO_2 are available.
- As the **mother liquor is recycled**, special attention must be paid to the water balance of the system.
- The amount of water introduced into the system (e.g., for washing $NaHCO_3$ and NH_4Cl) must be controlled continuously to **maintain the correct quantity and composition**.