Manufacturing-I (Process of Raw Sugar Refining & Decolourisation)

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Function of sugar refining:-

Sugar refining involves purification of sugar to meet food safety requirements and customers' demand. There are six groups of non-sugar: suspended matters, colour, ash, macromolecules (turbidity), microbes, and heavy metals. Food safety requirements is mandatory that microbes and heavy metals in the final sugar products must meet food grade quality. Turbidity, mostly consists of macromolecules such as polysaccharides, dextrans, starch, waxes, gum, need to be removed for customers' quality control. Microbes, turbidity and suspended matters can be removed by carbonation and phosphatation during the processes of decolourization and finally by tight filtration via filter presses with diatomaceous earth (DE). Colour and ash removal are optional, depending on customers requirements.

UNIT OPERATIONS IN SUGAR REFINERY

- Raw Sugar Storage / Handling
- Affination
- Melting
- Clarification
- Decolourisation
- Filtration
- Crystallization & Centrifuging
- Drying, Cooling & Packing
- Recovery

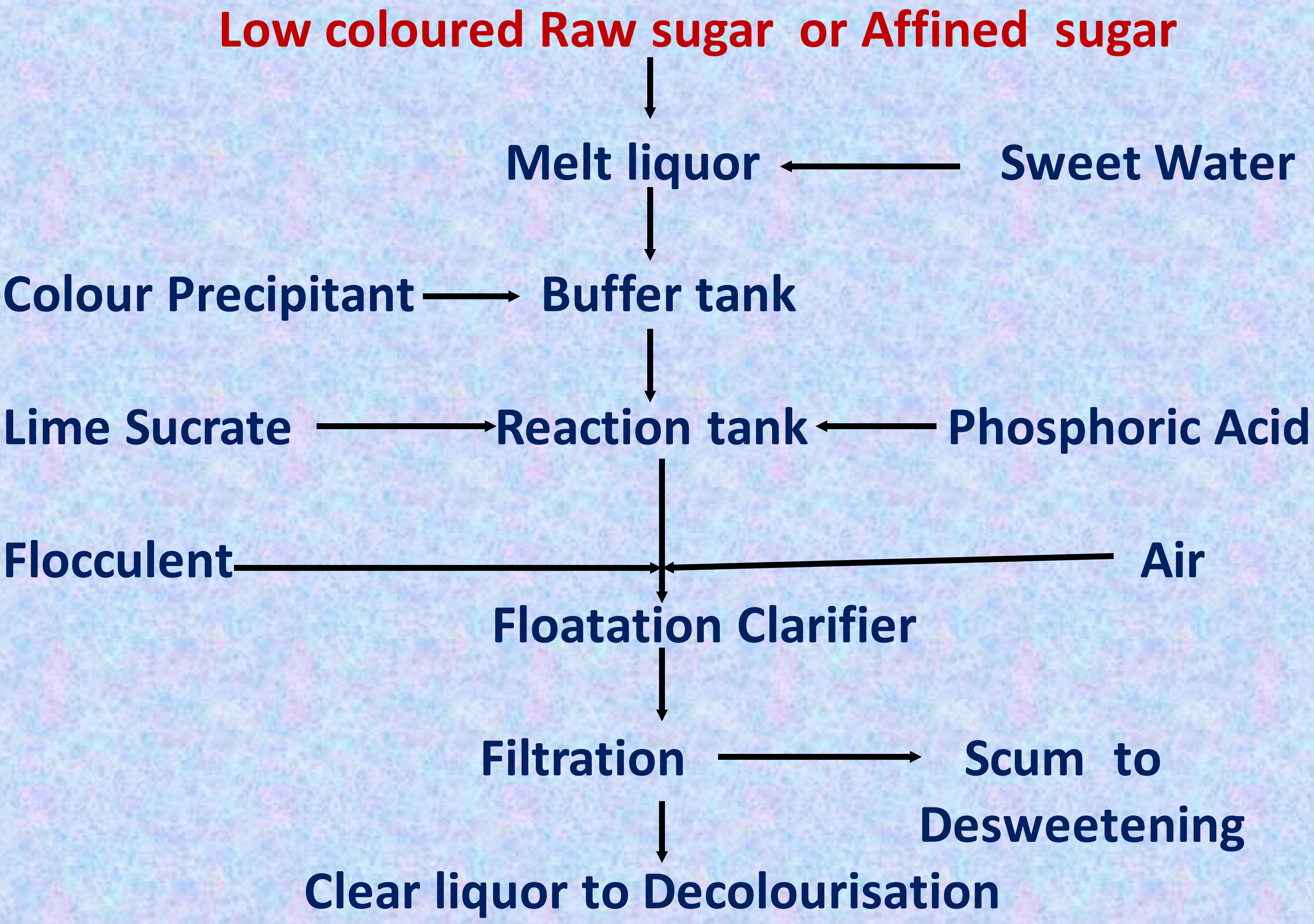
Melt treatment

❖ Melt clarification process can be done by two different techniques:-

1) Phospho-Floatation Process.
2) Carbonation Process.

1) Phospho-Floatation Process:-..................................

Melt Phosphatation

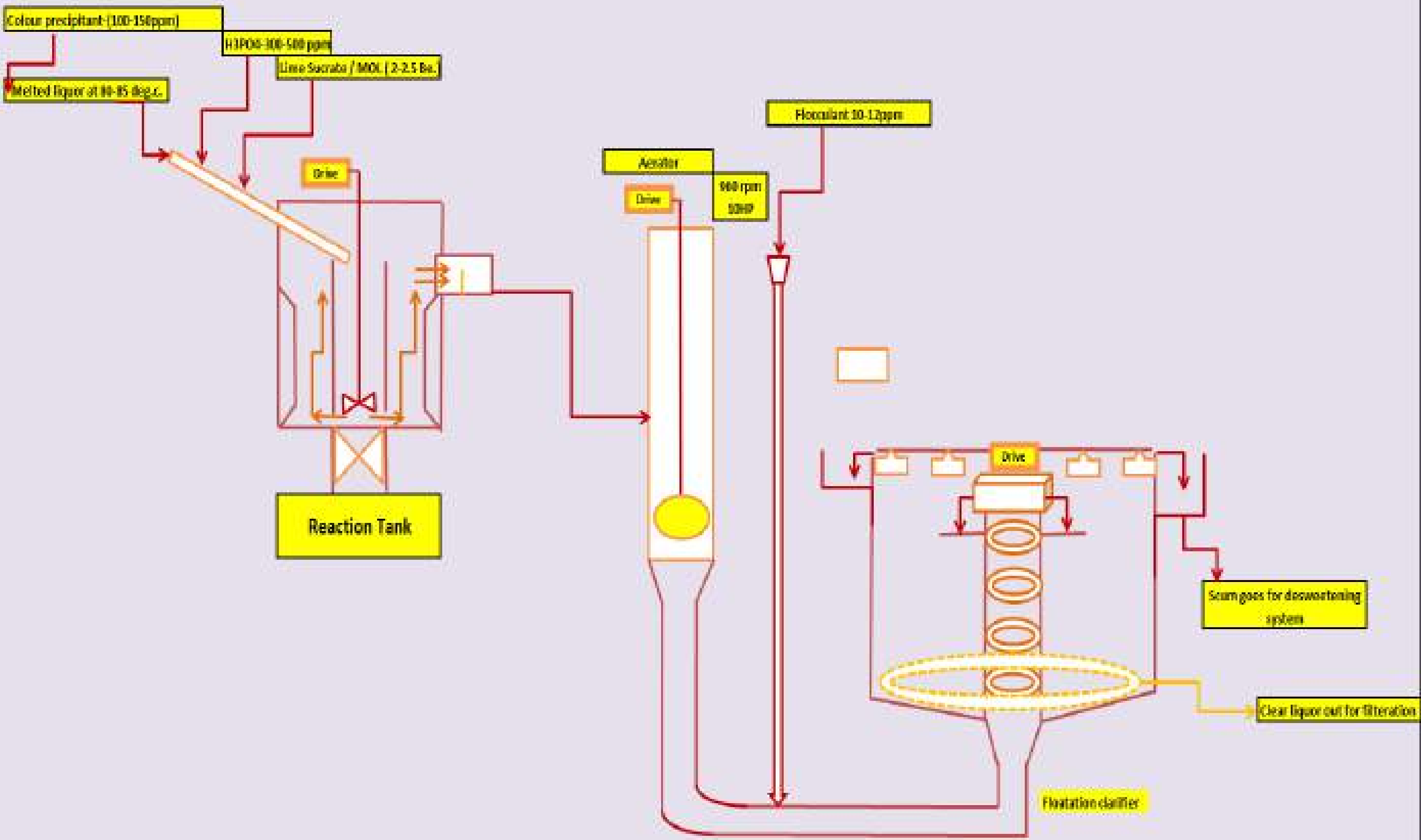


- **Affination:-** Treatment of raw sugar crystals with a concentrated Light molasses to remove the film of adhering molasses. This is achieved by mixing sugar with light molasses and then centrifuging the magma with or without water washing.
- **Affined sugar:-** Sugar which is produced after centrifugation/purging in affination process.

Description of the Phosphatation Process

- The mechanism of Phosphatation is primarily the flocculation of impurity particles (Bennett). The majority of colouring matter & colloids by nature are negatively charged and so the addition of cations such as calcium neutralises these charges and allows flocculation to take place. The anionic colour bodies are therefore most effectively removed by this process, and some soluble colours are absorbed by the tri-calcium phosphate. The open and bulky nature of the precipitate allows micro-flocs to be enmeshed in the precipitate mass. Larger particles must be screened because they do not float in the flotation clarifier.

View of melt treatment by phosphatation method.



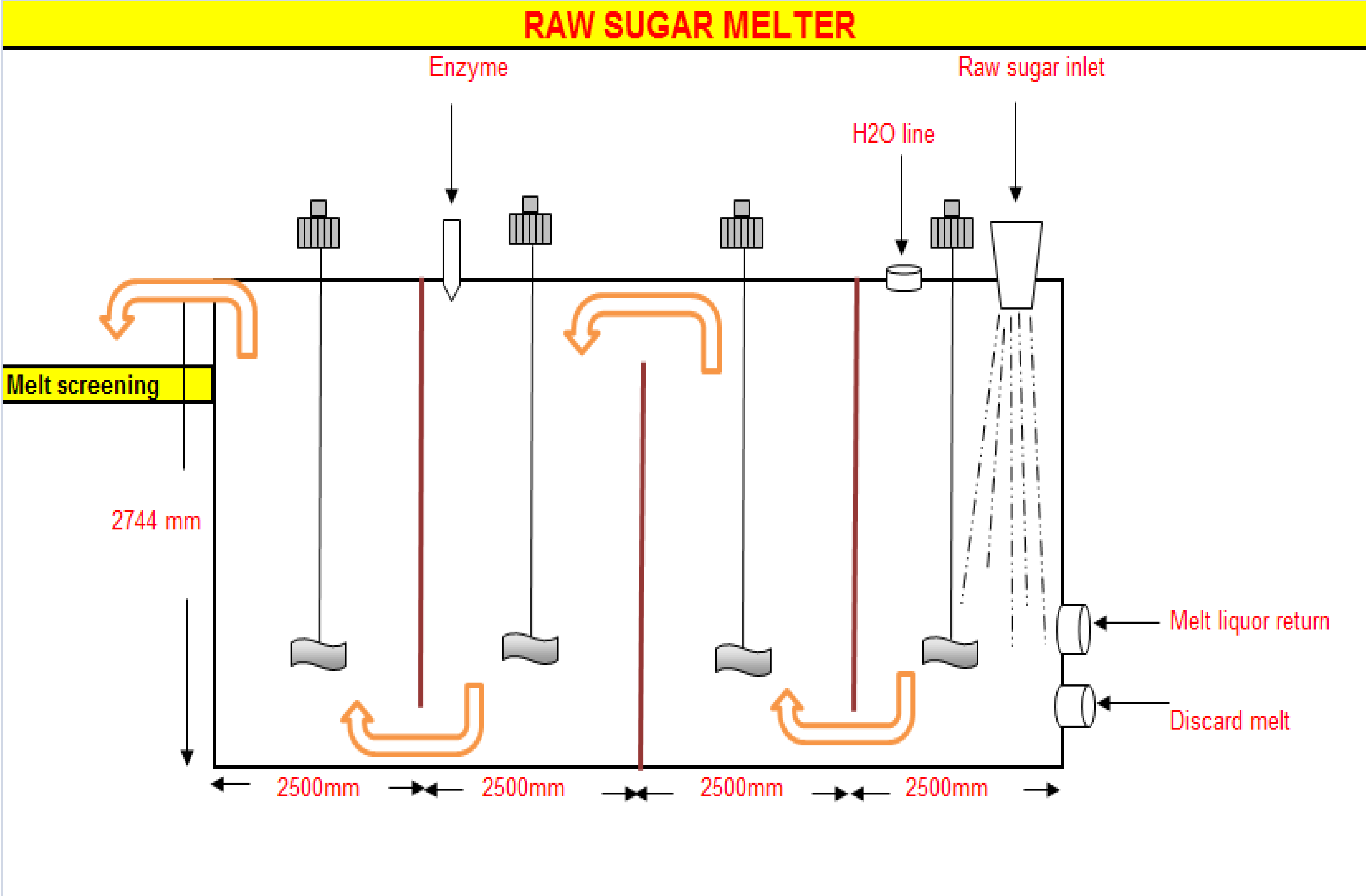
Description of the Phosphatation Process Contd…

This process consists of adding phosphoric acid to hot raw melt (80-85 deg.c) at 0.02 – 0.05% P_2O_5 on brix depending on the sugar quality, i.e. colour and suspended solids. Lime in the form of lime sucrate/ low brix (2.0-2.5 be) lime slurry is added almost simultaneously. The reaction produces a precipitate of tricalcium phosphate, to which is added a flocculent to coagulate it.

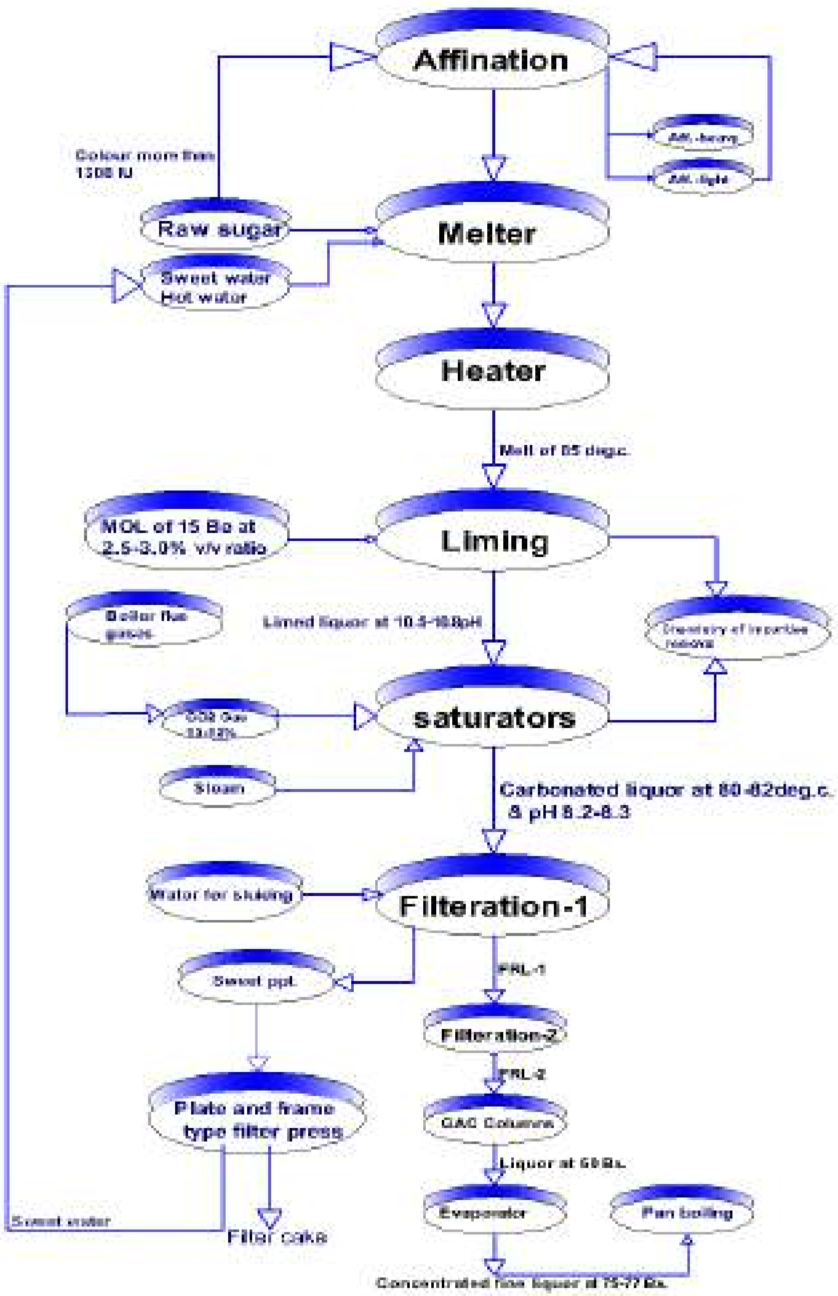
$$3Ca(OH)_2 + 2\,H_3PO_4 = Ca_3(PO_4)_2 + 6H_2O$$

The precipitate is very fine and cannot be easily filtered; therefore, the liquor is aerated by dispersed air and subject to flotation in a clarifier. The precipitate and other debris are scraped/skimmed off as a scum. The scum is de-sweetened in several ways, the most popular of which is a series of two or three counter current clarifiers. The clear liquor underflow is led to one or two filtration processes where any carry over is removed.

View of Horizontal raw sugar melter



Process Flow diagram



CLARIFICATION STEPS IN THE PHOSPHATATION PROCESS

The process of floatation can be divided in three main steps:-

- Phosphate flocculation.
- Air floatation.
- Scum production.

❖ **Phosphate flocculation:**

The objective of first step is to form a floccules that would occlude, adsorb and absorb the greatest possible portion of impurities. This process is further classified in to three steps.

- Reaction of phosphoric acid and lime.
- Primary flocculation.
- Secondary flocculation.

Continued......

- The reaction between lime and H_3PO_4 produces a precipitate of tricalcium phosphate, to which is added a flocculent to coagulate it.

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- The clear liquor underflow is led to one or two filtration processes where any carry over is removed.

Measurement of effectiveness of reaction

- Residual phosphate in the clarified liquor is most important parameter to measure the completion of reaction. Hence frequent measurement of phosphate content will give the indication about the performance of the reaction / system.
- **Aeration:** The aim of this stage is to achieve complete floatation of the floccules formed in the first stage.

  With the aeration we introduce the greatest possible population of minute air bubble uniformly distributed in the liquor. The performance of floatation is largely depends upon the sufficient no. Of suitable size of air bubbles.

Air bubble parameters

- As air bubbles provides the lifting force for floatation of the solid floccules, there size and no. Have great influence on the stability and velocity of floatation.

following equation will help in knowing this phenomenon.

Force F1 casing a body to float in the liquid is

$F1 = v.(d2-d1)$

Where v = Volume of the body.

d1=Density of the body.

d2=Density of the liquid.

The resistance F2 to a body to float is given by-

$F2 = c.d2.A.V2/2g$

Where c is the coeff. Of motion resistance and is further defined as c = 24/Re, (Re= Reynolds no.), A= Sectional area of the body, V=moving velocity of the body.

RAW SUGAR SPECIFICATIONS

The raw sugar manufacturer focuses on the following criteria to deliver an acceptable final product.

	LP	VHP	VVHP
Pol %	98.00	99.25	99.60
Colour (I.U.)	3500	1500	450
Ash %	0.35	0.20	0.12
Invert %	0.50	0.15	0.10
Starch- mg/l	300	250	110
Dextran -mg/l	285	230	<50
Insoluble's- mg/l	NA	250	150

Raw Material Specification

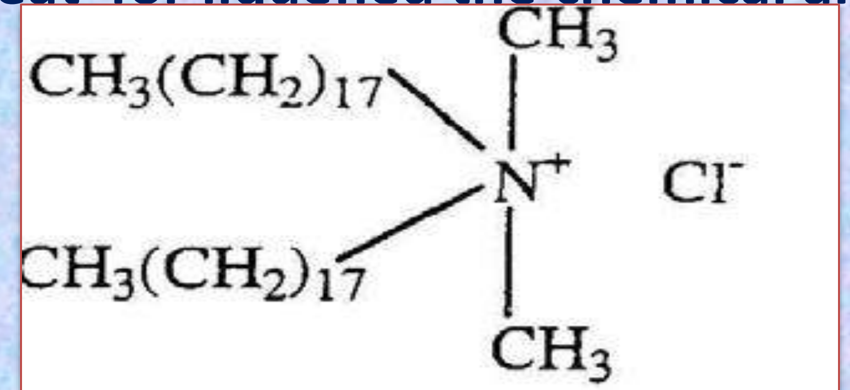
RAW SUGAR SPECIFICATIONS :-

	VHP	VVHP
POLARISATION (%) Min.	99.20 -99.40	99.45-99.70
TOTAL DRY SOLIDS %	99.94	99.96
MOISTURE (%) Max.	0.06	0.04
COLOUR (IU) MAX.	800-1500	425-650
TOTAL R.S.(%) MAX.	0.13	0.07
CONDUCTIVITY ASH (%)	0.12	0.07
GRAIN SIZE		
MA / CV (mm / %)	0.70–0.80 / 38–40	0.70–0.80 /38-40
INSO. MATTER (mg/ kg)	250	150
MICROBIOLOGICAL COUNTS (CFU /10 gm)	-------	---------
Total Mesophilic Bacteria (Max.)	-------	--------
Yeast (Max.)		
Mould (Max.)	--- ---	--------
Starch (mg/ kg)	250	150
Dextran (mg/ kg)	237	<50
Sulphite (mg/ kg)	NA	NA

Chemical used in Phosphatation process

- **Colour precipitant:-** It is a high-molecular-weight materials bearing a positively charged strong base site, which can form an adduct with colorants, most of which are negatively charged at processing pH values. High molecular weight, produces a hydrophobic insoluble precipitate that can be removed with the clarifier scum. There are three type of colour precipitant which is used in melt clarification system.

1. **dimethyl ditallow ammonium chloride (Talofloc),** a waxy material developed by Bennett at Tate & Lyle Ltd. Talofloc is a semisolid at ambient temperatures and a solid under cold conditions. Hence, it is required to heat for liquefied the chemical and then to use it.



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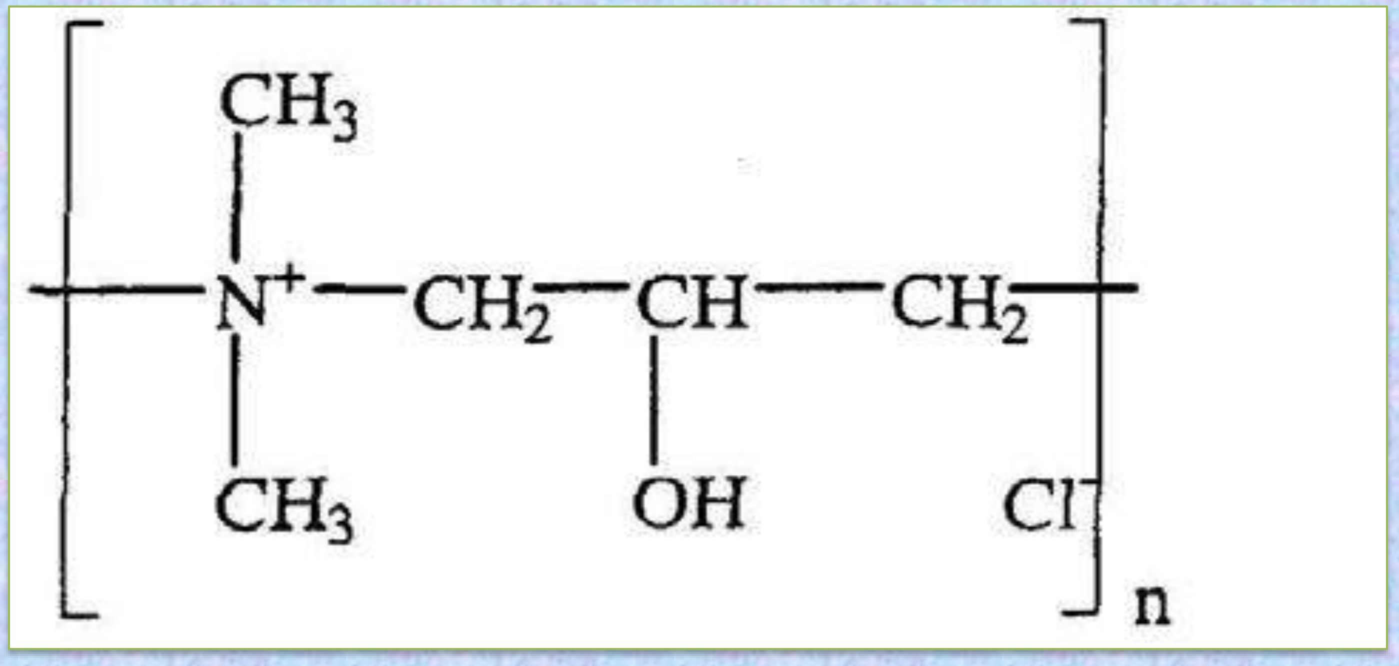
2. The 2nd colour precipitant is developed by American Cyanamid is an epichlorohydrin-methylamine Co-polymer. This substance is prepared as 50 % aqueous solution and hence it is more easily handled than Talofloc.



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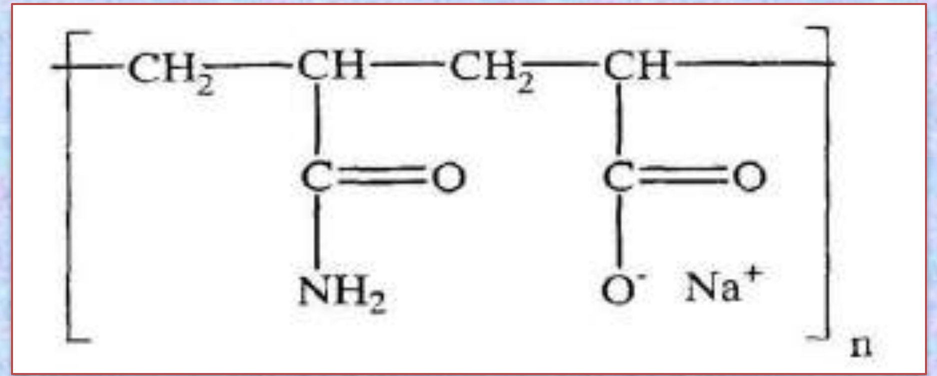
3. The 3rd colour precipitant is a cyclic polymer and is known as Diallyldimethyl ammonium chloride,Talomel.

- Phosphoric Acid (H3PO4).
- Milk of lime used for neutralization.
- **Flocculent :-** It is a Polyacrylamide flocculants of high molecular weight co-polymers of sodium acryl ate and acryl amide. It is very long linear molecular chain containing high concentration of mobile anionic charges.



Colour Removal:-

What is colour? Colour is evaluated by measuring absorbency at 420nm following the ICUMSA method which specifies the pH at 7.0.

There are basically four types of colour :-

- Plant pigments
- Melanoidins
- Caramels
- Alkaline Degradation Products of Fructose (ADF)

The first originates from the sugar cane while the last three are created in factories and prove to be more difficult to remove in a refinery.

Contd.....

1. Plant pigments:-

- The plant pigments are principally phenolics and flavonoids, which make up about two third of the colour in the raw sugar. Phenolics are generally uncoloured, but are oxidised or react with amines or iron to form colorants during processing.
- Flavonoids are polyphenols that exist in the cane plant and are involved in enzymic browning reactions. Plant pigments tend to have low to medium molecular weights (M.W.<1000), but are highly ionised, particularly at high pH values. Hence they have high indicator values (IV = colour at pH 9 divided by colour at pH 4), but are generally readily removed in the refinery. However , they are readily incorporated in to the sucrose crystal in the refinery.

Contd.....

2- Melanoidins:-

- It is a factory produced pigments that result from Maillard type reactions of amino acids with reducing sugars (non-enzymic browning).

- They are only produced with the application of heat at high brix and low purity, but can also form with low heat over long periods.

- They are slightly negatively charged at neutral PH, but positive under acidic conditions.

- A sub division of Melanoidins is melanin's and it is produced from phenol-amine reactions. These have a medium MW(>2500) and are difficult to remove in processing.

- Melanoidins are insensitive to pH and hence have low Ivs.

Contd.....

3- Caramels:- It is form as thermal degradation products of sucrose, with high molecular weights that increase with time and temperature as a result of increasing polymerization. They have only a slight charge and are not pH sensitive.

4- Alkaline degradation products of fructose (ADFs.):-

- It is formed from thermal decomposition of fructose mainly, and glucose to a lesser extent, under alkaline conditions.
- The reaction product are brown in coloured and acidic in nature, leading to inversion of sucrose and further colour formation. These compounds are usually uncharged and of medium to high MWs.

Contd.....

5-Colour precursors:- These are the compound which is not coloured themselves, undergoes reactions that form colour during processing. They includes amino acids, simple phenolics compounds, and 5- hydroxy-2-methylfurfural (HMF), The last being formed from acidic decomposition of fructose.

Melt treatment by carbonation process

Carbonation is a process used in sugar refinery to purify and clarify the sugar liquor. It involves the precipitation of calcium carbonate through the addition of lime and gassing with a gas containing carbon dioxide. The crystallization mass so formed removes the impurities by incorporation in the crystals and constitutes a filter aid for the pressure filtration process. Carbonation is generally applied to melt liquor in the refinery ahead of any decolourising process.

Contd.....

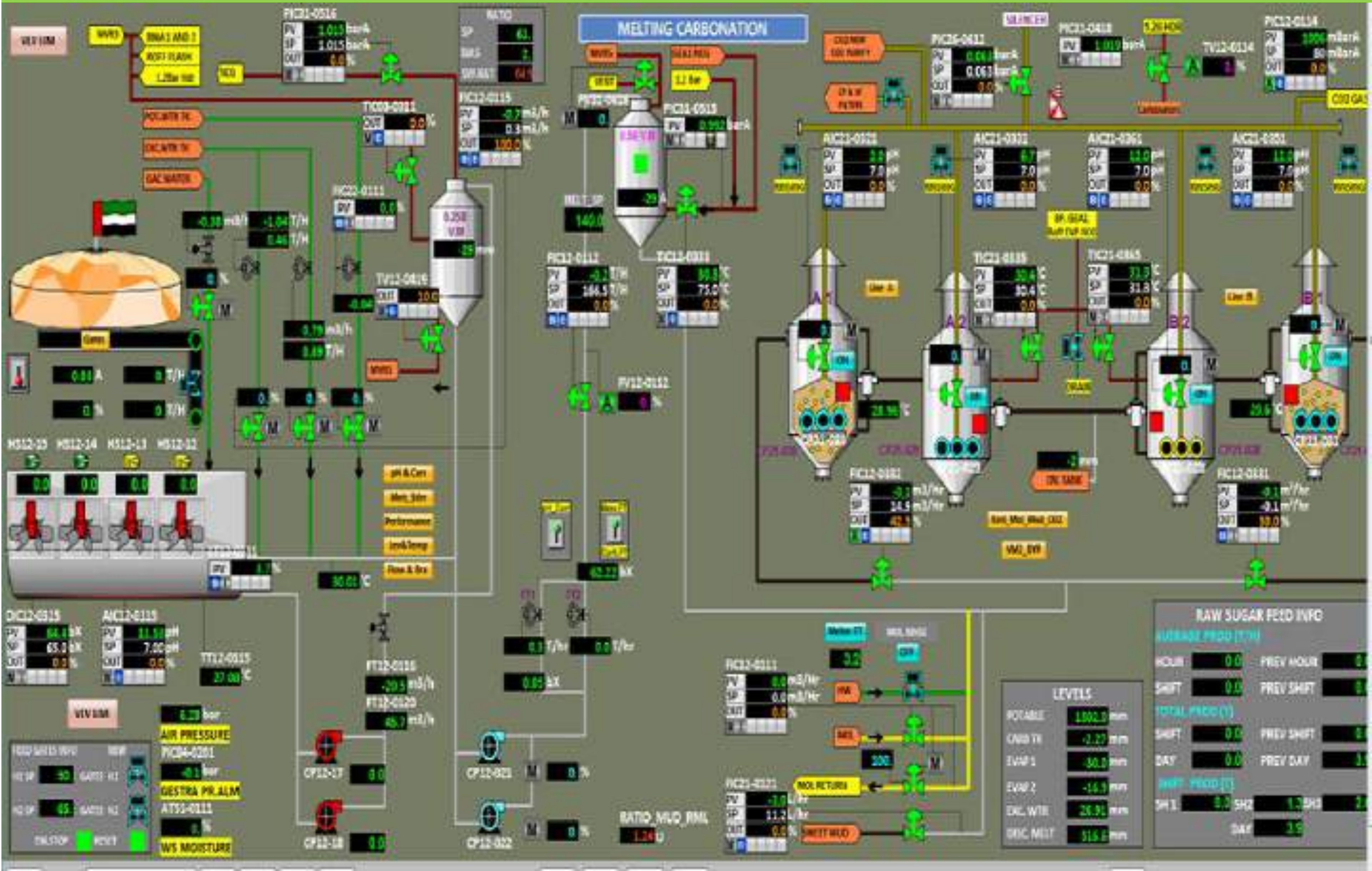
Carbonation has a good effect on sugar liquors. It is also purification process, enabling a colour reduction of about 50 % to 60 % together with a reduction in ash content of about 20-25 %. The carbonation processes incorporate a number of physical and chemical processes.

1- First there is a chemical reaction between lime and carbon dioxide to form a calcium carbonate ppt.

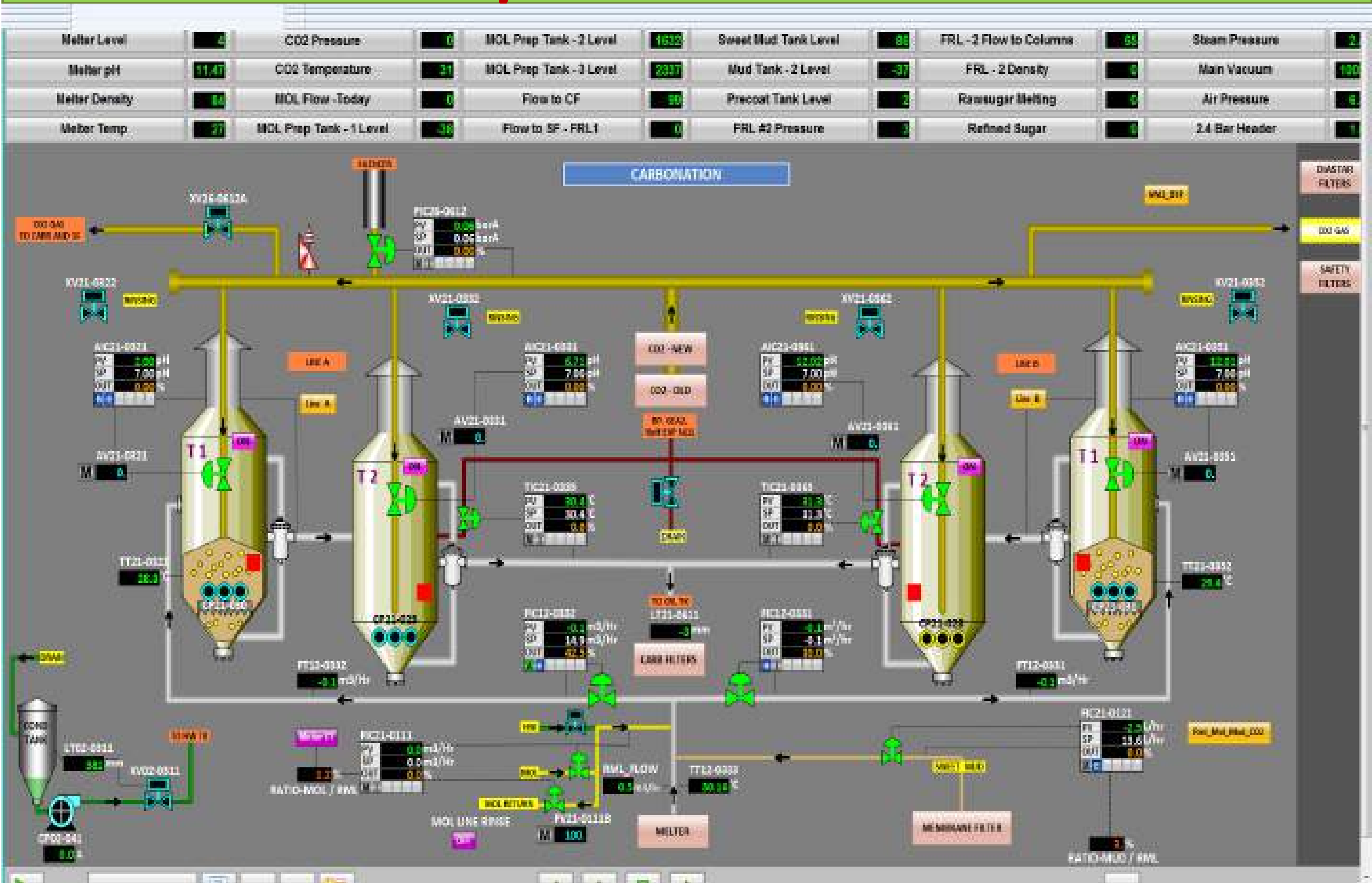
2- second a process of crystallization takes place and required to produce a mass of calcium carbonate crystals, which are of the right size, size distribution and degree of conglomeration to facilitate the subsequent filtration step.

3- Third, the condition of pH and temp dictate the extent to which inorganic species are ppt. this effecting ash removal, where the destruction of sucrose , monosaccharide and filterability of the carbonate cake are also affected by pH and temp conditions.

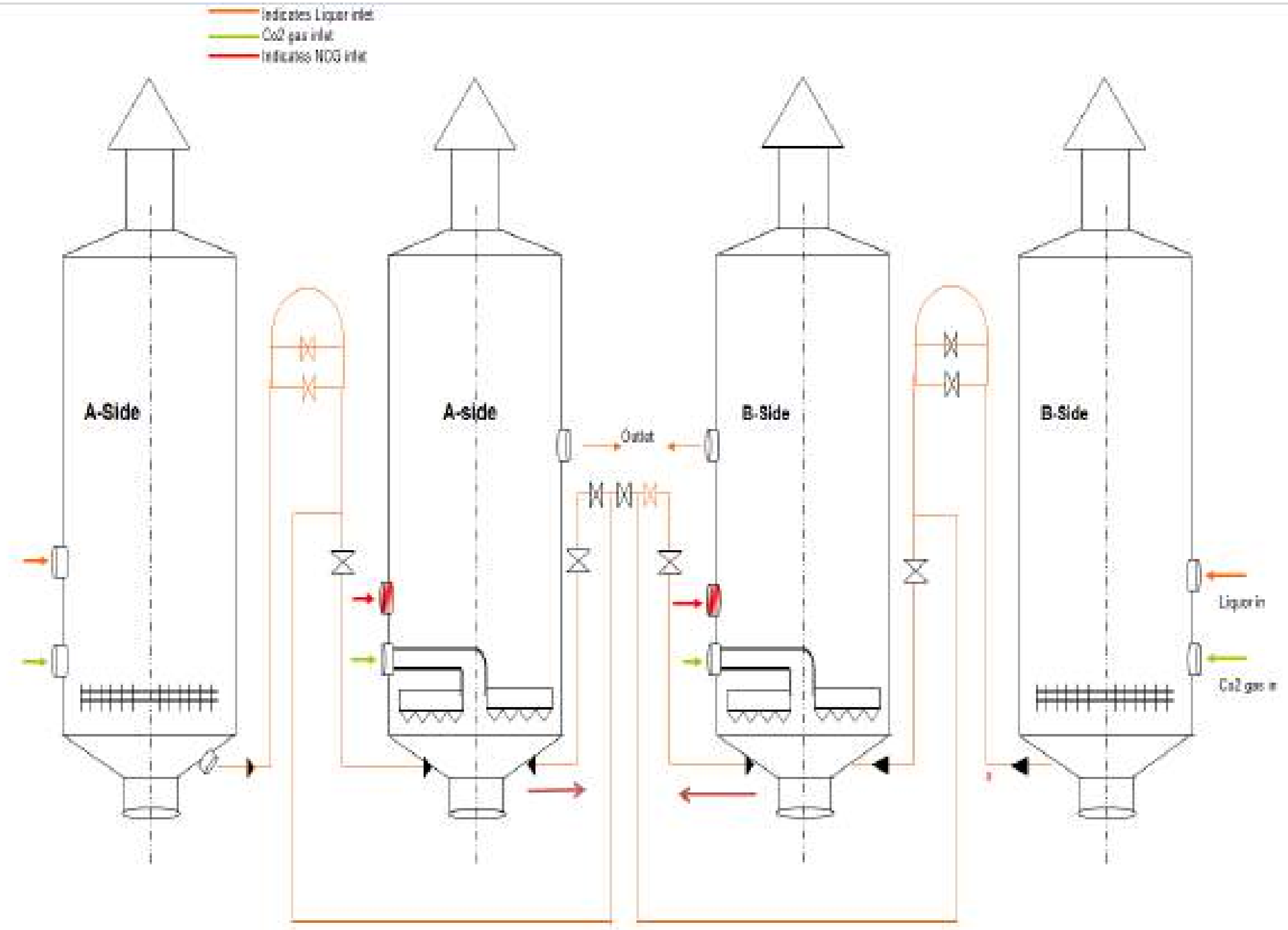
Melting and carbonation:



Saturators with the arrangement of CO2, MOL & Steam



Saturators / Carbonators



Clarification Steps in carbonation process

- Process involves precipitation of Calcium Carbonate with addition of Lime & Carbon Dioxide.
- Carbon dioxide can be scrubbed from Flue gas & then compressed to fed to Carbonators.
- Proper & effective distribution of CO_2 gas for better precipitation.
- Carbonation can be followed in three stages & in some refineries within two stages.
- Carbonator -1, pH drops from 10.6 to 9.6 & Retention time in all saturators – 50 to 60 minutes.
- Carbonator -2, pH drops up to 8.4-8.5
- Carbonator-3, pH drops to 8.0 – 8.2 at 80-85^{0}C.

CARBONATORS ARRANGEMENT

To ensure the completion of reaction, it is normal practice to use two saturators in series. About 85% of the reaction is completed in Ist vessel & remaining 15 % in second vessel.

The arrangements are made as per the capacity & reaction condition requires.

- Line A only (A1& A2)
- Line B only (B1& B2)
- Line A and B
- Line AI,AII and BI only
- Line BI,BII and AI only

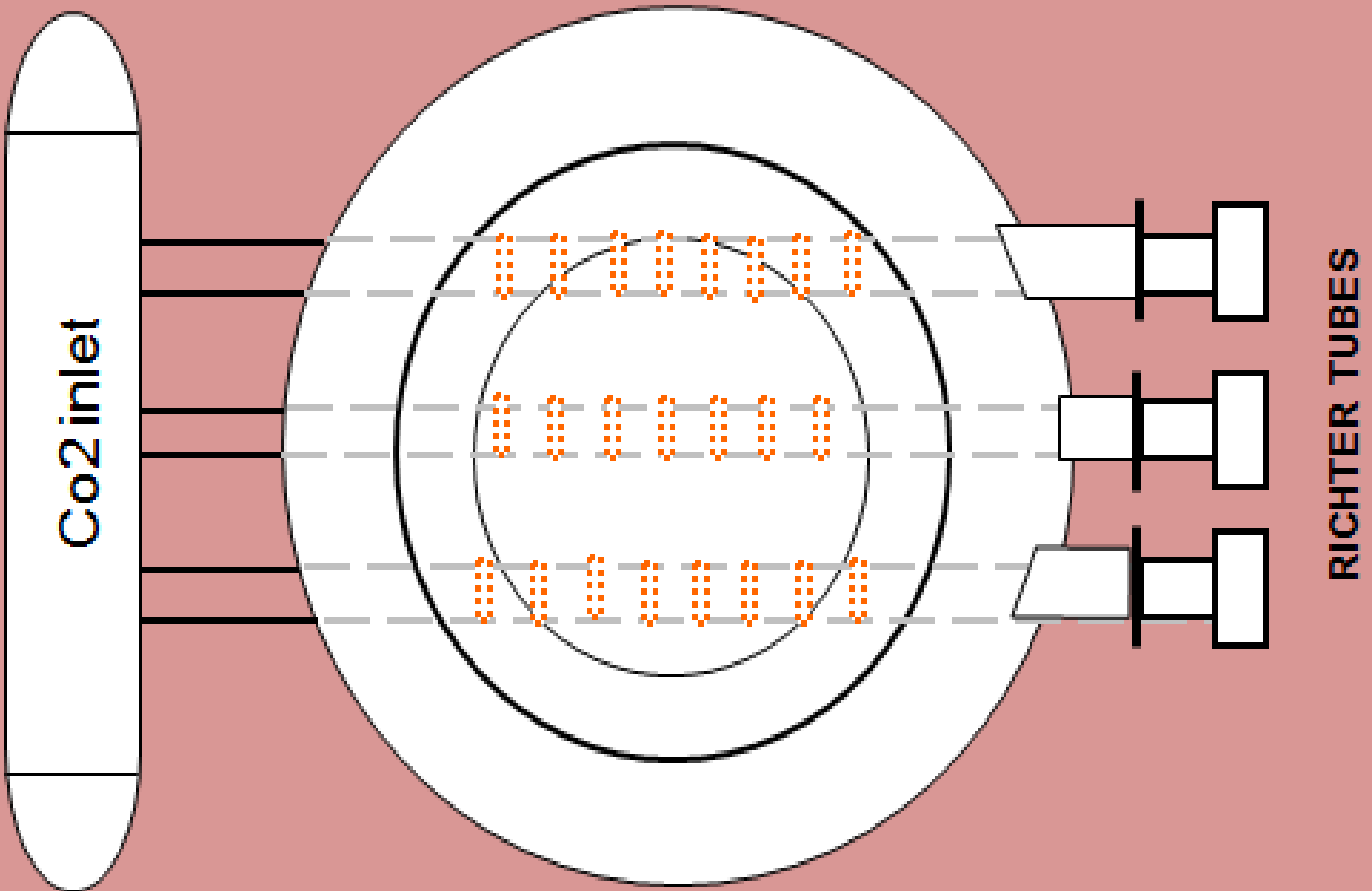
The first vessel operates at out let pH of 9.5-9.6 & second vessel at 8.1 to 8.2. The higher pH leads to higher Cao in liquor & it is observed that the soluble bicarbonates are formed below pH 8.0, which is not only increase the ash % but also detrimental to the filtration.

GAS DISTRIBUTION

The proper mixing of the CO_2 gas & limed liquor is the very essential need of the reaction. So the good gas distributor (Richter tube) must fulfil the following conditions.

- Distribute the gas uniformly over the cross-sectional area of the saturators.
- Distribute gas in the form of very small size bubbles & more nos. since the smaller the size of the bubble larger area for mass transfer.
- Sufficient agitation in the vessel is to be provided to ensure the uniform condition in the vessel & to keep the boundary layer between gas bubble & liquid as thin as

View of Richter Tube



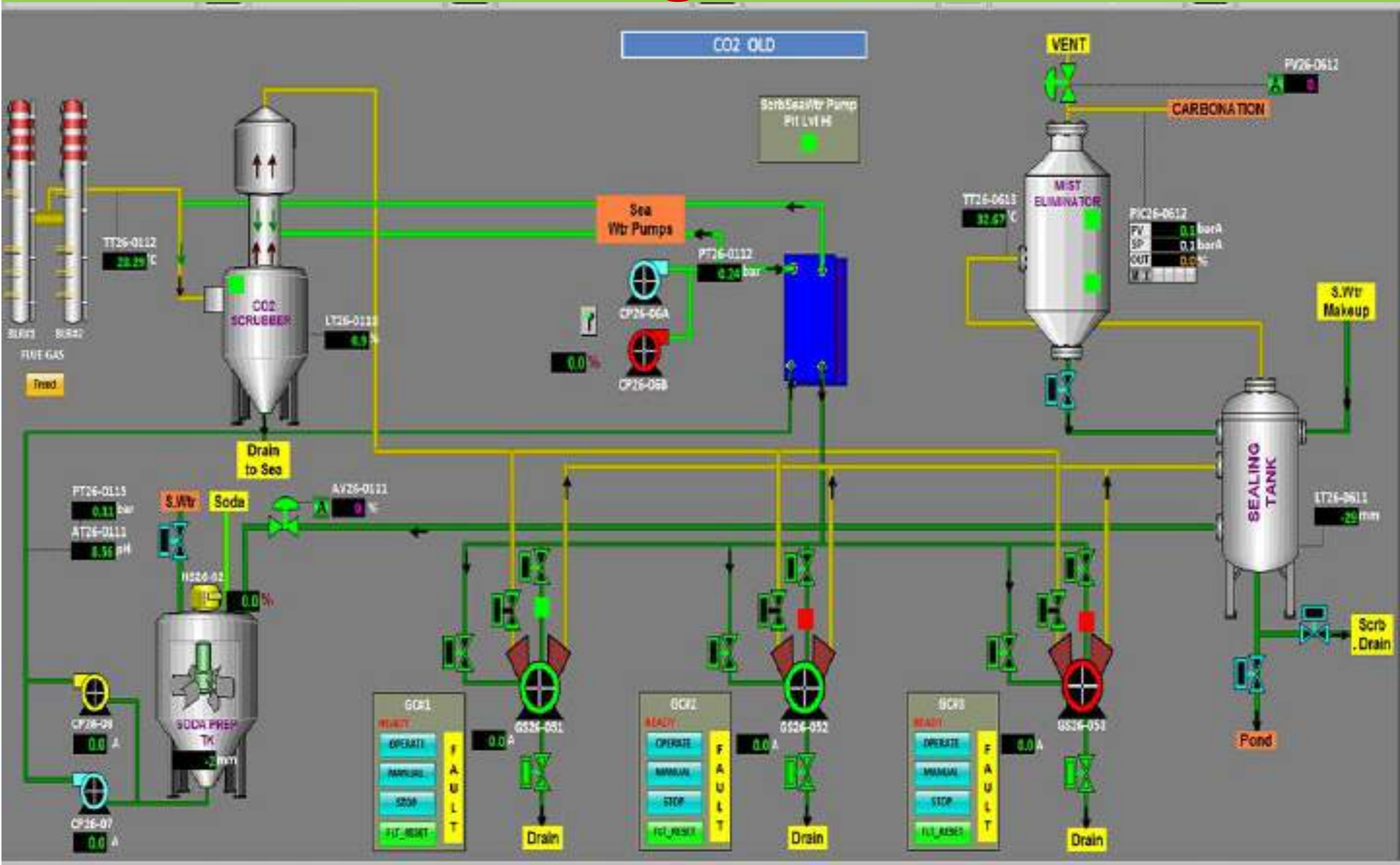
$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

- ❖ Lime is added to melt liquor immediately ahead of the saturator.
- ❖ Boiler flue gas is used as source of CO_2 required for the reaction to form calcium carbonate.
- ❖ The concentration CO_2 gas is about 12-14% in scrubbed flue gases.

General Observation on Impurity Removal from Melt during Carbonation

Colour	55
Turbidity	90
Starch	93
Gums	29
Sulphates	86
Phosphates	100
Magnesium	67

CO_2 Scrubbing system from boiler flue gases:



Step Wise Colour & Turbidity Removal in Carbonation Process:

Particular	Brix	% Pol	Purity	pH	Color (IU)	Turbidity (NTU)	Alkalinity (ppm, as CaO)
Raw Sugar Melted Liquor	64.2	63.62	99.10	6.9	1250	50	
	63.3	62.72	99.08	6.9	1380	55	
	64.3	63.82	99.25	7.3	1360	54	
Limed Liquor (MOL Ratio - 2.8 % V/V)	61.9			10.4			
	61.9			10.4			
	64.8			10.3			
Carbonated Liquor	60.7			8.1			
	60.0			8.2			
	61.3			8.2			
Filtered Melted Liquor 1	59.6	59.22	99.36	8.0	445	4	
	61.1	60.66	99.28	8.0	485	4	
	62.9	62.46	99.30	8.2	480	3	
Filtered Melted Liquor 2	60.3	59.92	99.37	7.8	428	2	180
	61.1	60.64	99.25	8.0	470	2	203
	60.0	59.58	99.30	8.0	402	2	190
Decolorized Liquor	60.8			7.8	220	1	
	60.3			7.7	215	1	
	60.1			7.9	205	1	

PRECIPITATE & CO_2 CALCULATION BY ALKALINITY METHOD

Raw sugar melting	250.00	T/Hr.		
Raw sugar Bx.%	99.94			
Melted liquor Bx.%	64.00			
Melted liquor density	1.30			
Melted liquor QTY.	390.40	T/Hr.		
	300.31	M3/Hr.		
Vilk of lime addition %	3			
VIOL. Qty used	9.01	M3/Hr.		
.imed liquor qty.	309.32	M3/Hr.		
.imed liquor alkalinity	5.20	gm./ltr.		
·ine liquor alkalinity	0.17	gm./ltr.		
Available CaO at 15 degree baume	150	gm./ltr.		
)ensity of 15 Degree Baume MOL.	1150	gm./ltr.		
	1.15	kg/m3		
)ty. of CaO used in clarification	1555873.46	Gram/hr.		
	1555.87	Kg/hr.		
ìty. of $Ca(OH)_2$	2055.98	Kg/hr.		
ìty. of $CaCO_3$ Precipitate	2778.35	Kg/hr.		
loisture % of filter cake	30			
/eighted moisture in filter cake	833.50	Kg/hr.		
·ix % of the filter cake	3.00			
/eighted Solids in filter cake	83.35	Kg/hr.	0.083	Tons/hr.
ɛsultent qty. of precipitate	3695.20	Kg/hr.		
	3.70	Tons/hr.		
ɹantity of precipitae % on raw sugar	1.48			
)2 gas pressure	1.00	Barg		
)2 gas temperature	50.00	Deg.cent.		
ɛnsity of CO_2	1.96	Kg/m3		
of CO_2 in flue gas	10.00			
of Absorption efficiency of CO_2	42.00			
ıantity of CO_2 required	1222.47	Kg/hr.		
	14850.243	Nm3/hr.		
	18031.122	M3/Hr.		

$$CaO + H_2O == Ca(OH)_2$$
56 18 74

$$Ca(OH)_2 + CO_2 == CaCO_3 + H_2O$$
74 44 100

Precipitate qty. Calculation by precipitation method

Raw sugar melting rate	2628000	M.T.			
	7200.00	T/day			
	300.00	T/Hr.			
Raw sugar Bx.%	99.94				
Melted liquor Bx.%	64.53				
Melted liquor QTY.	464.64	T/Hr.			
	357.41	M3/Hr.			
Milk of lime addition %	3				
MOL. Qty used	10.72	M3/Hr.			
Limed liquor qty.	368.13	M3/Hr.			
Available CaO at 15 degree baume	150	gm./ltr.			
Density of 15 Degree Baume MOL.	1150	gm./ltr.			
	1.15	kg/m3			
Qty. of CaO used in clarification	1608352.11	Gram/hr.			
	1608.35	Kg/hr.			
Qty. of Ca(OH)2	2125.32	Kg/hr.			
Qty. of CaCO3 Precipitate	2872.06	Kg/hr.			
Moisture % of filter cake	29.73				
Weighted moisture in filter cake	853.86	Kg/hr.			
Brix % of the filter cake	3.92				
Weighted Solids in filter cake	112.58	Kg/hr.	0.113	Tons/hr.	
Resultent qty. of precipitate	3838.50	Kg/hr.			
	3.84	Tons/hr.		*Calculated Precipitate qty. % on Raw sugar*	1.28

$$CaO + H_2O == Ca(OH)_2$$

$$56 \quad 18 \quad 74$$

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

$$74 \quad 44 \quad 100$$

Filtration:-

- The separation of the clear liquor and the calcium carbonate is done by pressure filtration.

✓Carbonated liquor pressure filters.
✓Daistar or candle filters.
✓Safety filter.

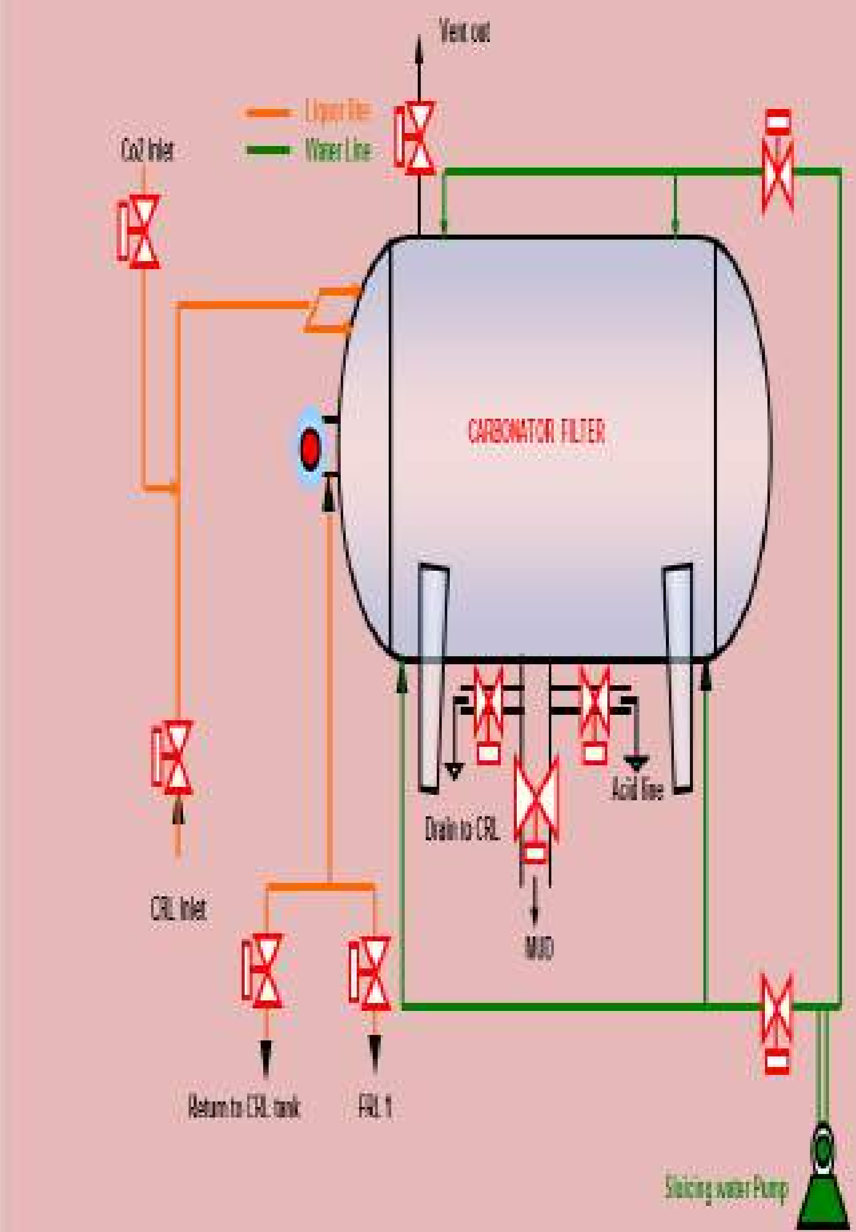
- Filtering elements are generally made up of polypropylene cloth. Monofilament polypropylene woven fabric cloth are used universally.

- Periodic cleaning of cloth with sulphamic acid with inhibitor is generally followed.

- Installed capacity of filters is designed so as to handle worst quality of raw sugar liquor.

- Considering the minimum filterability of raw sugar, filter area requirement of 15 m^2 filtering area per tone of melt per hour is considered to be standard.

- On volumetric basis, filtration rate of 0.1 m^3/m^2 / hour is acceptable.



Flux calculation in filters

FLUX CAL. IN CARNONATED LIQUOR FILTER

melting rate = 125 t/h

DATE	CYCLE NO	Filteration time /Cycle in hr	Total flow /Cycle in m3	Flow/hr in m3
	1	1.79	82.80	46.25
	2	1.87	63.70	34.06
	3	2.00	70.80	35.40
	4	2.00	69.20	34.60
	5	2.00	67.00	33.50
	6	2.10	71.40	34.00
	7	2.21	73.30	33.16
Total	7.00	13.97	498.20	
Average		2.00	71.17	35.66

Flux = (flow/hr) / area of filter

0.16 m3/m2/hr

Flux calculation in safety/ filter aid filters

		SAFETY FILTER NO. 3		
Melting rate 125 t/hr				
DATE	CYCLE NO	Filteration time /Cycle in hr	TOT FLOW/CY in m3	FLOW/HR in m3
	1	11.50	1250.00	108.70
	2	10.00	1230.00	123.00
TOTAL	2	21.50	2480.00	
AVERAGE		10.75	1240.00	115.85
		Flux = (flow/hr) / area of filter		
	=	0.53	m3/m2/hr	

FILTERATION

To obtain high quality refined sugar it is important to remove all suspended matter from the sugar liquor and the liquor to be crystallized must be brilliant and sparkling for this reason, sugar liquor are filtered at different stages of the refining operation.

Types of filters used in carbonation process.

- Carbonated liquor pressure filters.
- Daistar or candle filters.
- Safety filter.

SELECTION OF FILTERS:

When selecting a filter, consideration must be given to details and practical features of design, such as ease and efficiency of operation and maintenance.

CONSTRUCTION OF FILTER:

carbonated filter having filtering area 220m2 each. It has 55-56 ring and also nozzles on top side provided for filling filter with liquor. No of nozzles are 102 both sides. For sluicing purpose 55(spray nozzles). Central shaft having 55 holes for drain the liquor.

WORKING

Carbonated liquor is pumped to each filter from pumps. The filtering period consist of three processes.

1. Maximum flow rate at low pressure.
2. Decreasing flow rate at constant pressure.
3. Decreasing flow rate at increasing pressure.

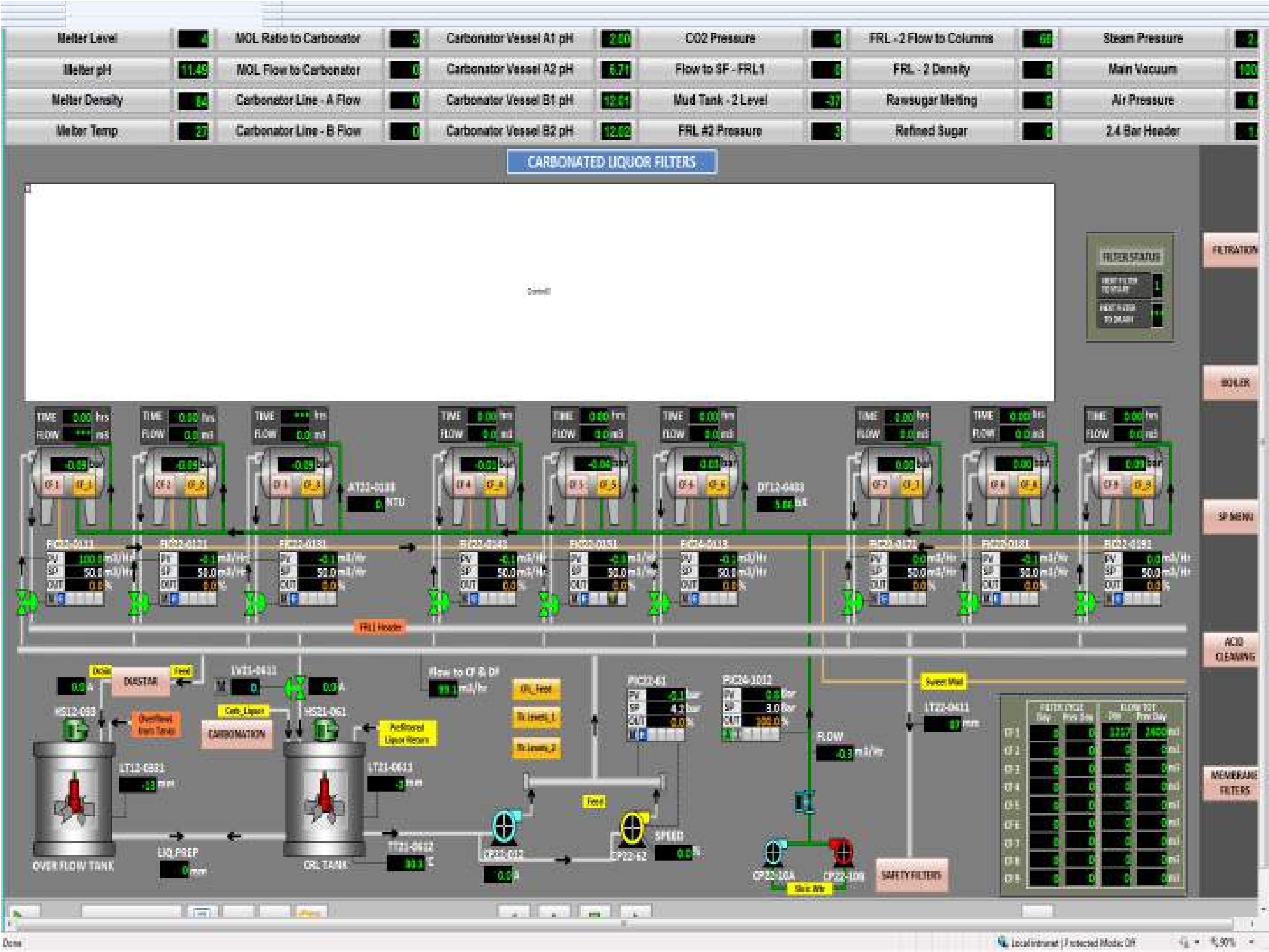
Before carbonated liquor entering the filter temperature of liquor is maintained at about 82 – 85 ^{o} C for better filterability, As per Muller & Rungas Scientist.

Each filter having inlet from top through nozzles and distribution plate are avail below nozzles. Liquor filling up to 15m3 volume. after this pre-filtration start up to liquor becomes limpid in this period liquor goes back to CRL tank. The pressure filter cycle maintain 3.5 bar and flow rate 30 -50 m3/hr. The filtration cycle ends when the filtration rate dropped to a low level and pressure also. When more cake thickness is developed on the filter elements then mud is sluiced off through sluicing device which is through water over the entire surface side of filter leaf and ensure that cloth can be thoroughly cleaned. The sweet sludge from the filter returns to sweet sludge tank.

CARB.FILTER OPERATION SEQUENCE

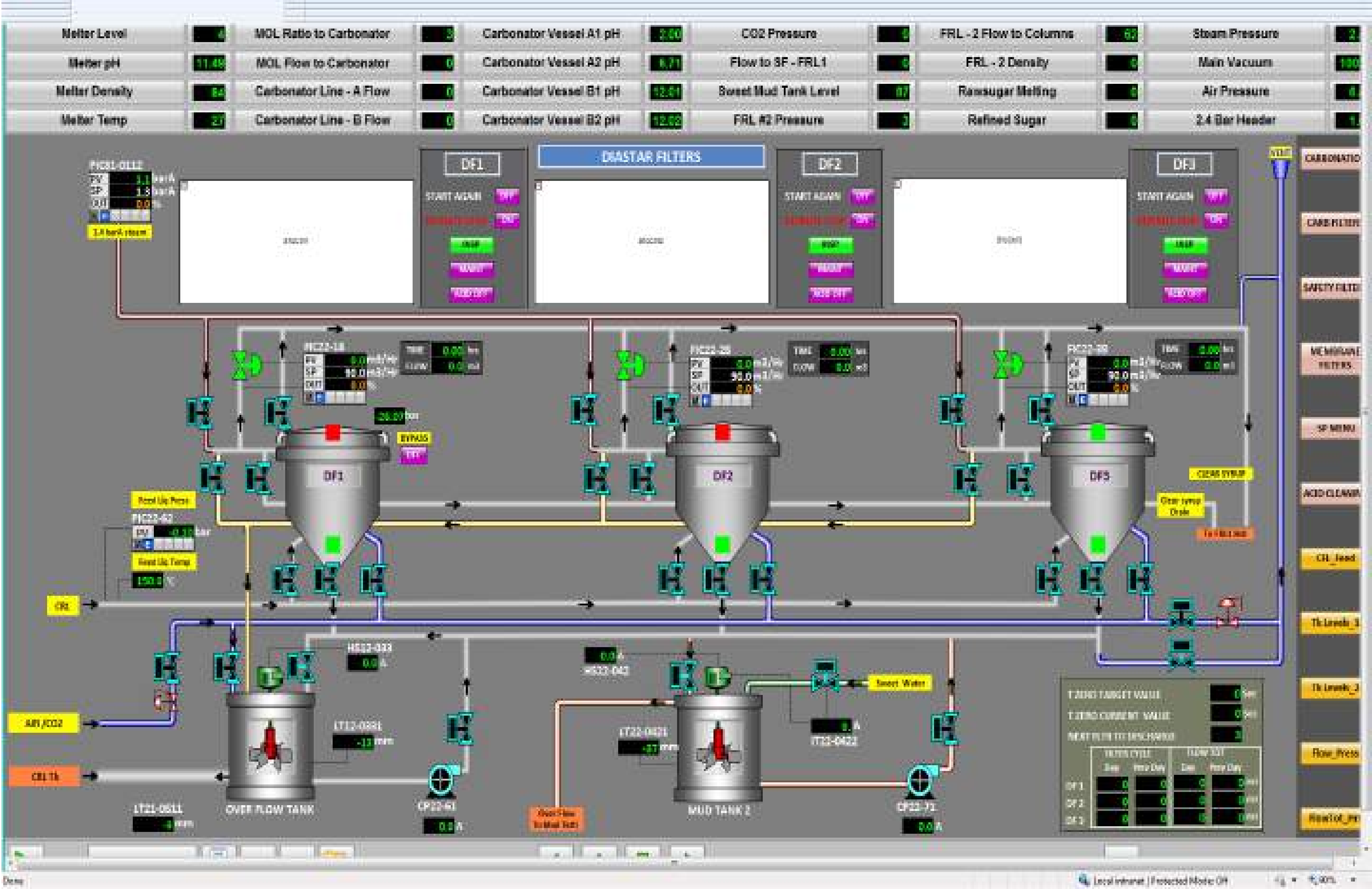
STEP #	NAME	DURATION	
1	Filling	442sec	(7min, 22sec)
2	Pre-filtration	792sec	(13min, 12sec)
3	Filtration	7200sec	(120min)
4	Draining Vent	630sec	(10min, 30sec)
5	Top Sluicing	133sec	(2min, 13sec)
6	Bottom Sluicing	76sec	(1min, 16sec)

TOTAL CYCLE TIME (DRAINING VENT) 9274sec (154min)



Melter Level
MOL Ratio to Carbonator
Carbonator Vessel A1 pH
CO2 Pressure
FRL - 2 Flow to Columns
Steam Pressure
Melter pH
MOL Flow to Carbonator
Carbonator Vessel A2 pH
Flow to SF - FRL1
FRL - 2 Density
Main Vacuum
Melter Density
Carbonator Line - A Flow
Carbonator Vessel B1 pH
Mud Tank - 2 Level
Rawsugar Melting
Air Pressure
Melter Temp
Carbonator Line - B Flow
Carbonator Vessel B2 pH
FRL #2 Pressure
Refined Sugar
2.4 Bar Header
CARBONATED LIQUOR FILTERS
FILTER STATUS
FILTRATION
BOILER
SP MENU
ACID CLEANING
MEMBRANE FILTERS
TIME
FLOW
AT22-0133
NTU
DT12-0403
PV
SP
OUT
FRL1 Header
DUSTAR
CARBONATION
Flow to CF & DF
CRL TANK
OVER FLOW TANK
LIQ.PREP
SPEED
FLOW
SAFETY FILTERS

DIASTAR/ Candle FILTERS



D.F. OPERATION SEQUENCES

STEP	NAME	DURATION
1	Total cycle time	5760sec (96min)
2	Discharge collector empty time	25sec
3	Steam blowing time (D, full)	10sec
4	Steam blowing time (D, empty)	10sec
5	Air matters reforming time	25sec
6	Cloudy filtration time	320sec (5min, 20sec)
7	Wait time before fill circuit Closing	60sec (1min)

- Discharge collector empty and Sight glass vent time — 55sec

Total cycle time 6255sec (104min, 15sec)

FILTER AID USE IN FILTRATION

Filter aid filtration:

Filtration is the process by which particles are separated from a fluid by passing the fluid through a permeable material.

HOW FILTER AID WORKS

Filtration using filter aid is a two step operation. First, a thin layer of filter aid, called a precoat, is built up on the filter septum by recirculation of filter aid slurry through the filter. After precoating small amounts of filter aid are regularly added to the liquid to be filtered. As filtering progresses, the filter aid, mixed with the suspended solids from the unfiltered liquid, is deposited on the precoat. Thus a new filtering surface is formed continuously; the minute filter aid particles provide countless microscopic channels that entrap suspended impurities but allow clear liquid to pass through without clogging.

An efficient, economical filter aid must

- Have rigid, porous, individual particles
- Form a highly permeable, stable filter cake.
- Remove even the fine solids at high rate flow.
- Chemically inert and essentially insoluble in the liquid being filtered.

The purpose of precoating:-

To prevent the filter septum from become clogging by impurities.

- To give immediate clarity, and
- To facilitate cleaning of the septum at the end of the cycle..

Precoat quantity should be from 0.1 to 0.2 lb of filter aid per square foot of

Calculation for Optimum Filter aid Thickness in Leaf Filters

Basis : Filter aid Thickness should be about 2.00 mm on filtering discs used in the filters.

Example : Leaf type Filter having 38 Nos.

A filter Disc with 1.5 mt dia. will have filtering area (both sides) = 3.53 m2.

Calculation : Total area available = 38 X 3.53 = 134.14 m2

Qty. of F. A. added for one cycle = 100 kgs (4 Bags)

Volume of Filter Aid in Filter = 100 / 380 = 0.263 m3

Filter aid Thickness in filter = 0.263 / 134.14

= 0.00196 mt

= 1.96 mm

Plate and frame type filter press

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- Filtration unit
- Membrane Filter Press

➢ Single stage filtration involves filtering of carbonated liquor or desweetening of carbonated cake and discharge of dry cake @ about 30 % moisture.

➢ Very high filtration rate when compare with conventional filters. (0.4-0.5 M3/m2/hr whereas other filters are 0.1 - 0.2 M3/m2/hr.)

➢ Operates at higher pressure 5.5 bar 6.0 bar and facilitates good filtration for even higher viscous liquor and handle low temperature.

➢ Doesn't require any pre-coat.

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discussion to liquid – solid filtration continued

The liquid–solid filtration is often called "cake–filtration", because the separation of solids from the slurry by the filtering medium is effective during the initial stages of filtration. Later, the 'cakes' or deposits collected over the medium act as the filter. Therefore, cake thickness increases during filtration and the resistance (hydraulic) offered by the cake–material is larger than that by the filtering medium.

There are two types of operation:

a. Constant-pressure

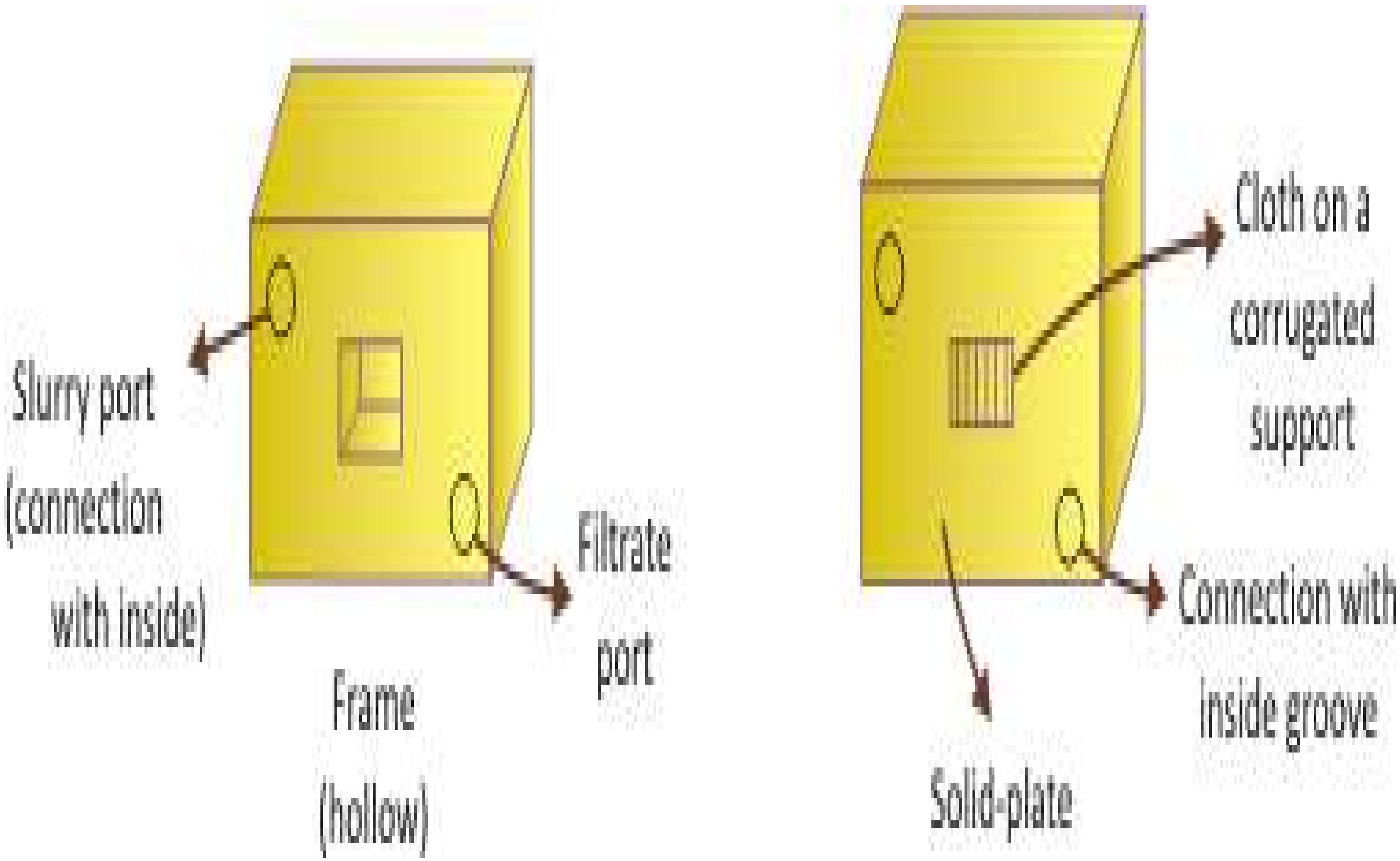
b. Constant filtering rate

In the 1st case, filtering rate varies with time, whereas in the 2nd case, pressure–drop increases with time.
For ideal cake filtration, cake should be stable and large porosity. There are two common types of filters:

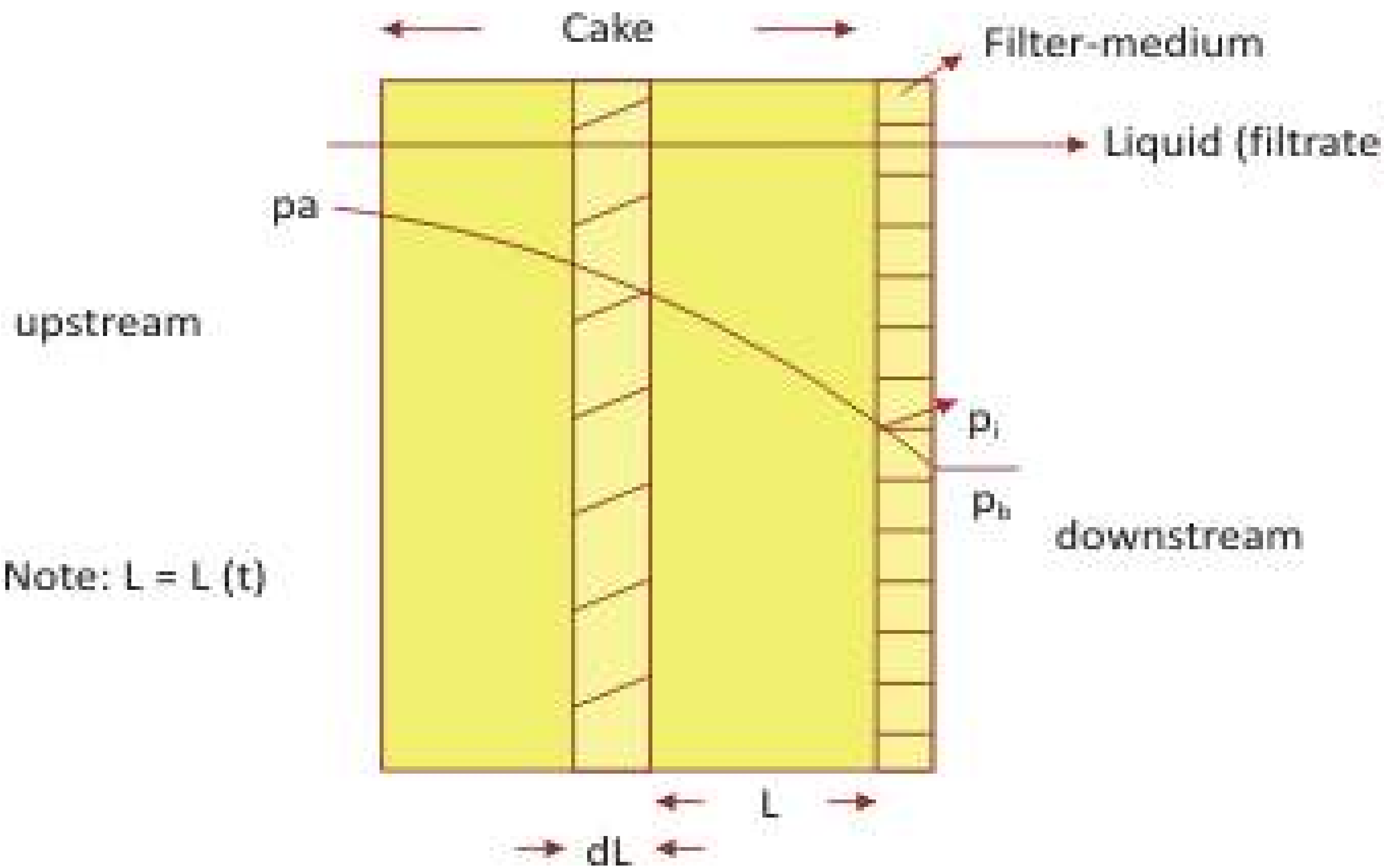
a. The plate and frame type filter press
b. Rotary-drum filter
c. Pressure filtration by using candle/ leaf filters.

The plate and frame press filter

Consists of series of plates and frames sand witched alternatively; cakes are built-up inside the frame–chamber. Cloth, filtering medium, is supported on a corrugated material. There are


Slurry port
(connection
with inside)
Filtrate
port
Frame
(hollow)
Cloth on a
corrugated
support
Connection with
inside groove
Solid-plate

Principles of Filtration (cake)



Pressure–drop is applied across the filter: $Pa > Pb$

Assuming that the flow of filtrate is under laminar conditions (low Re and viscous flow), one can apply the Ergun's equation, neglecting the inertial forms:

$$\Delta P \text{ is directly proportional to } \frac{\mu v_0}{r_w}$$

Consider a differential thickness of cake = dL at a distance of L from the filter-medium.

$$dP/dL = \frac{k_1 \mu_f v_0 (1-€)2}{€ 3} *(Sp/Vp)2$$

where, μ_f is the viscosity of the filtrate

€ is the bed-porosity or porosity of the cake.

Sp, Vp is the surface area and volume of the cake-particles, respectively (Important to note is the time–change of pressure and cake–thickness) and v is the superficial velocity of filtrate.

A calcium–carbonate slurry is to be filtered in a press having a total area of 200 m2 and operated at a constant pressure drop of 2 atm. The frames are 25 mm thick. Assume that the filter medium resistance is 1.50*10-4 per ft. Calculate filtration time and the volume of filtrate obtained in one cycle. Cake density 65 lb / ft3 . The specific cake resistance,
Concentration of slurry