Global Presence With Local Commitment

International Sugar and Sugarcane Conference 2019
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FINE LIQUOR COLOR: HOW DOES IT AFFECT ENERGY, CAPACITY, & SUGAR LOSSES?

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ABSTRACT

In today's competitive sugar refining environment, refiners are spending more time and attention to improve their conversion costs.

This means energy, maintenance and chemical usage are constantly being measured and improved upon.

As sugar refining consists of a series of separation processes, any inefficiency has a knock-on effect on operating costs.





ABSTRACT

This paper studies the main separation processes, namely clarification, decolorization, and crystallization to demonstrate where poor separation contributes to excessive costs of processing.

The results of various tests are analyzed, and conclusions are made for refiners to manage their chemical and fuel costs.





INTRODUCTION

The major conversion cost of raw sugar to refined sugar includes the following:

- Manpower
- Repairs and Maintenance
- Utilities
- Packaging
- Sugar Losses
- Depreciation

INTRODUCTION

By far the most important aspect is the understanding that in order to control cost, one must measure it.

This means that full control of every production detail from raw goods to final product, is now vital to the profitability of the business.

INTRODUCTION

For the refinery manager, there are certain important items under his control which if left unchecked, can eat up substantial profits and, occasionally, turn profits into losses.

The most important item on this list is process control.

INTRODUCTION

It is the process control, or the lack of it, which will determine the amount of fuel consumed and the tonnage of sugar lost.

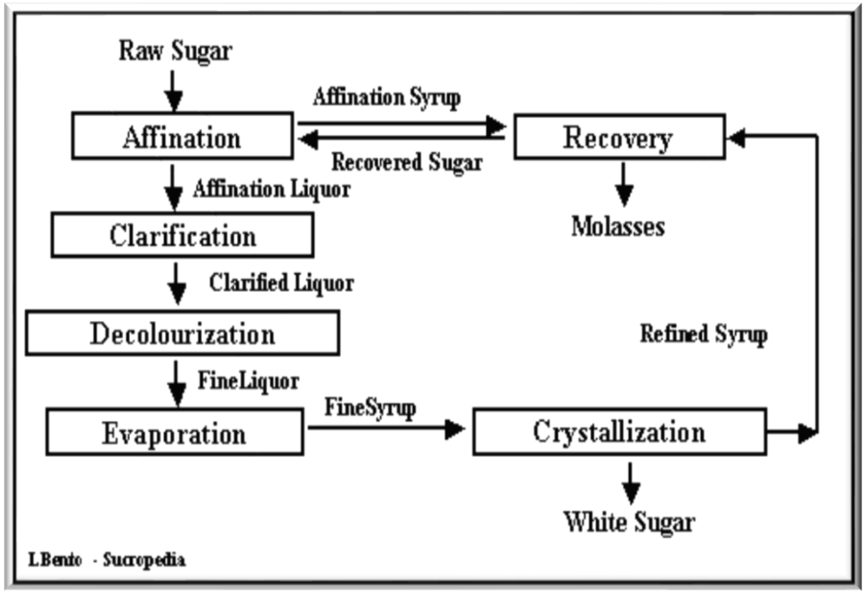




INTRODUCTION

The following areas will be discussed with respect to process control efficiency and the corresponding financial gain or loss:

- **Affination**
- **Clarification**
- **Decolorization**
- **Crystallization**
- **Centrifugation**







AFFINATION

Affination, where practiced, is the first separation process in the sugar refining process.

It is commonly applied to low pol raw sugar with a color higher than 1800 ICUMSA. (International Commission for Uniform Methods of Sugar Analysis).

It entails the mingling of raw sugar with warm syrup, which dilutes the molasses coating around the sugar crystal to form magma.



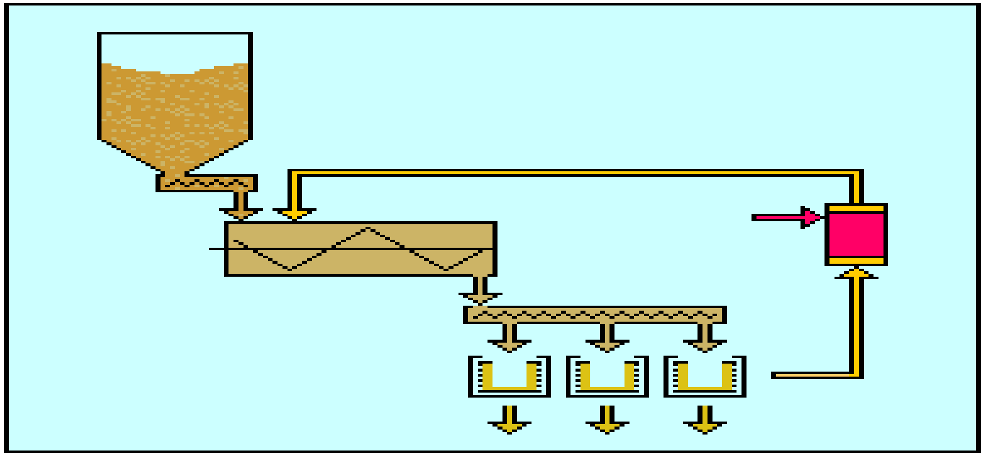


AFFINATION

This magma is centrifuged to separate the crystals from the syrup thus removing the greater part of the impurities from the input raw sugar and leaving the crystals ready for the next stage, melting.

AFFINATION

Typically, about 50 – 60% color removal is achieved across affination and a significant amount of ash and suspended matter removal is achieved.



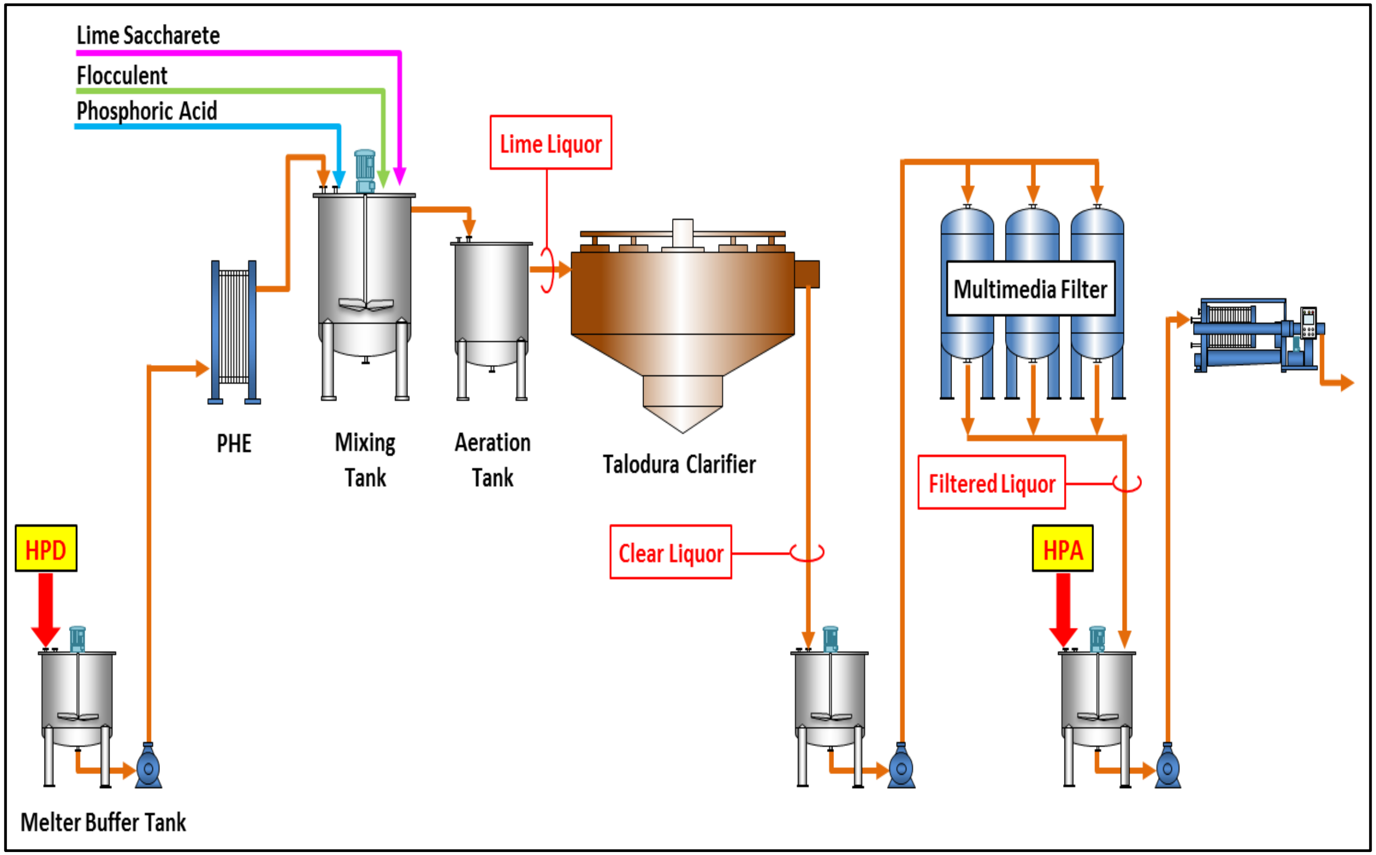
CLARIFICATION

Liquor clarification is essentially a pre-treatment for the decolorization stage of sugar refining.

The overall refining objective is the removal of turbidity, color, and ash.

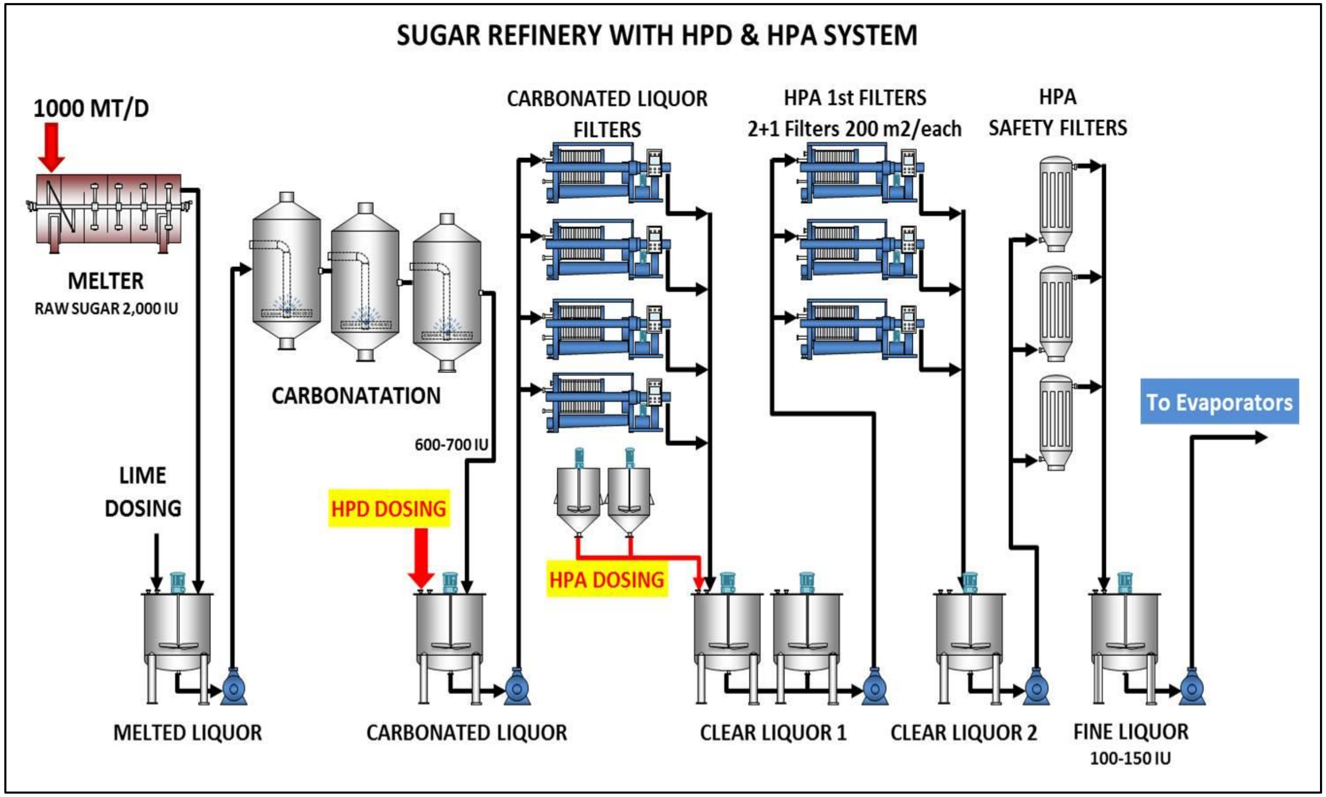
CLARIFICATION: TWO MAJOR PROCESSES

1. PHOSPHOTATION



CLARIFICATION: TWO MAJOR PROCESSES

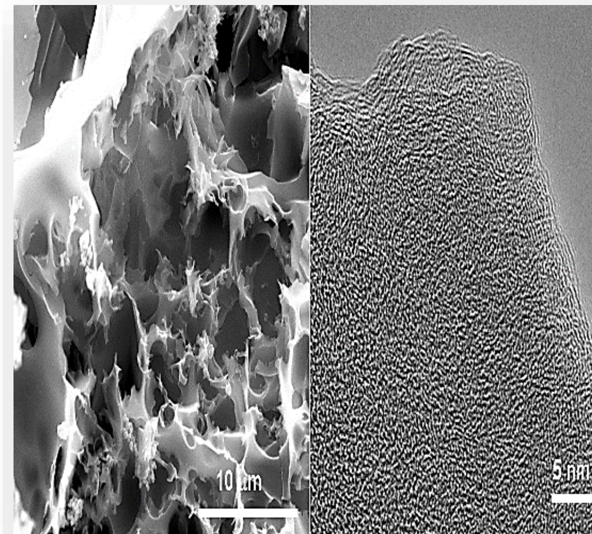
2. CARBONATATION



DECOLORIZATION

There are basically four types of decolorization systems:

1. **Granular Activated Carbon**
2. **Ion Exchange Resin**
3. **High Performance Adsorbents**
4. **Bone Char**



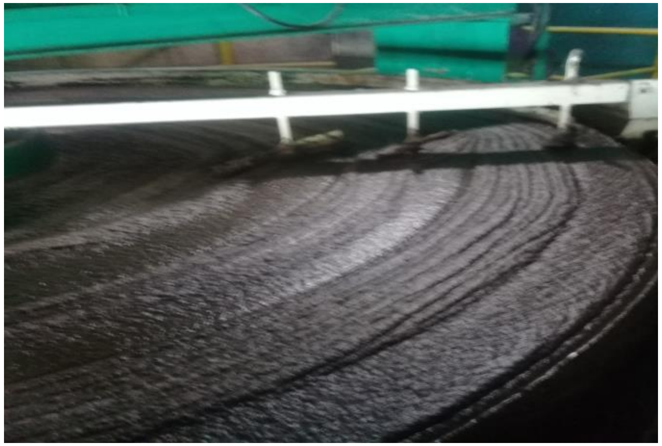
DISCUSSION

The Cost of Poor Color Removal

The previous paragraphs have covered two processes, clarification and decolorization.

Both processes have certain decolorization efficiencies.

The final color of fine liquor has a financial implication, i.e. the cost of processing a fine liquor of ICU 500 color will be much more expensive compared to a fine liquor of 100 ICU color.



DISCUSSION

Experimental Procedure to Determine Sugar Color at Different Wash % Massecuite.

Most of the work was conducted at a large sugar refinery in the Middle East and some of the data was collected from two other refineries, where high fine liquor colors were available.

DISCUSSION

From a set of nine Silver Weibull 1500 centrifugals, sugar was discharged into a screw conveyor arranged to move sugar in two directions towards two inclined screw conveyors.

Wet sugar samples were extracted at strategic points.

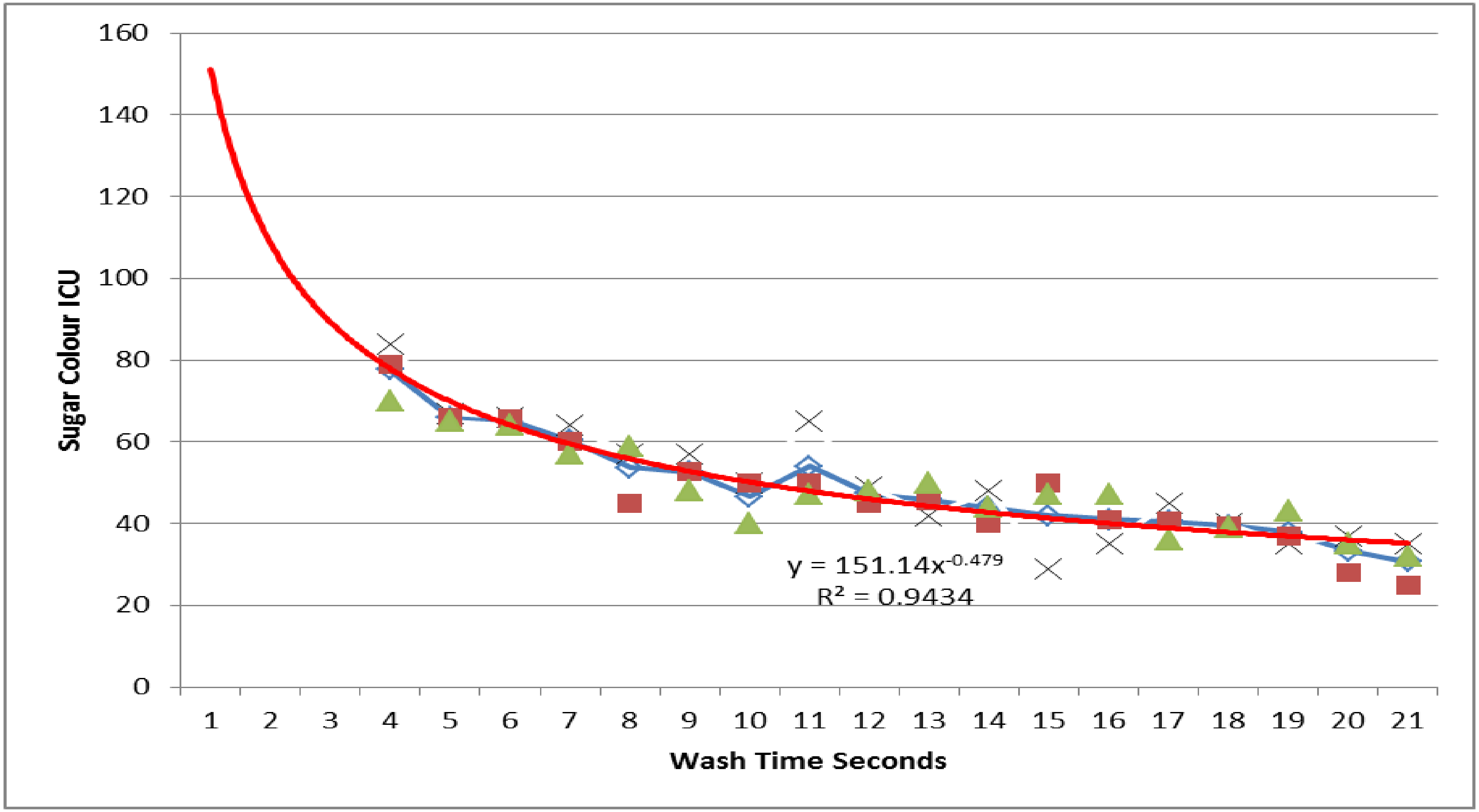
The samples were taken corresponding to pre-set wash water setting.

The samples were analyzed for ICUMSA color.





DISCUSSION



Sugar color vs Wash for Massecuite between 450 and 550 ICU

DISCUSSION

The wash times were converted to volumes based on the centrifugal manufacturer's nozzle data.

The various refineries had different massecuite colors and the wash water consumption data was collected noting the massecuite colors.

The refineries were all targeting EEC color specification between 35 – 45 ICUMSA color units.

COMPARING
100 ICU VS 500 ICU

Dissolving of sugar:

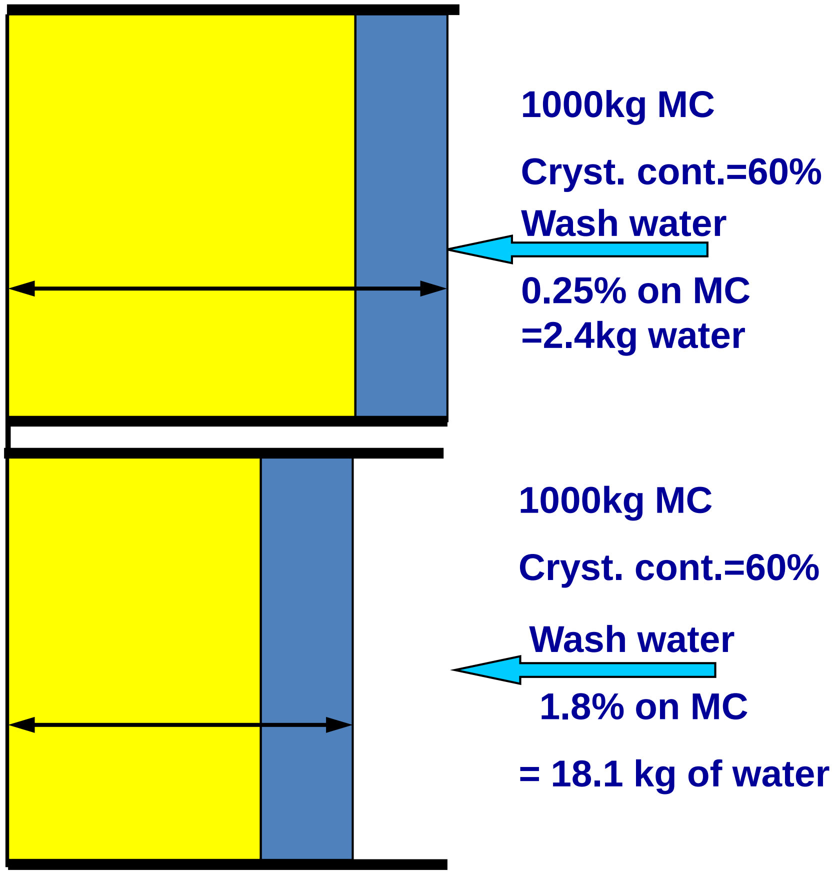
1kg water dissolves approx. 3kg sugar

Case 100ICU

: 591 kg sugar remaining
= 59.1% crystal recovery

Case 500ICU
: 536 kg sugar remaining
= 53.6% crystal recovery

Centrifugal Basket



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DISCUSSION

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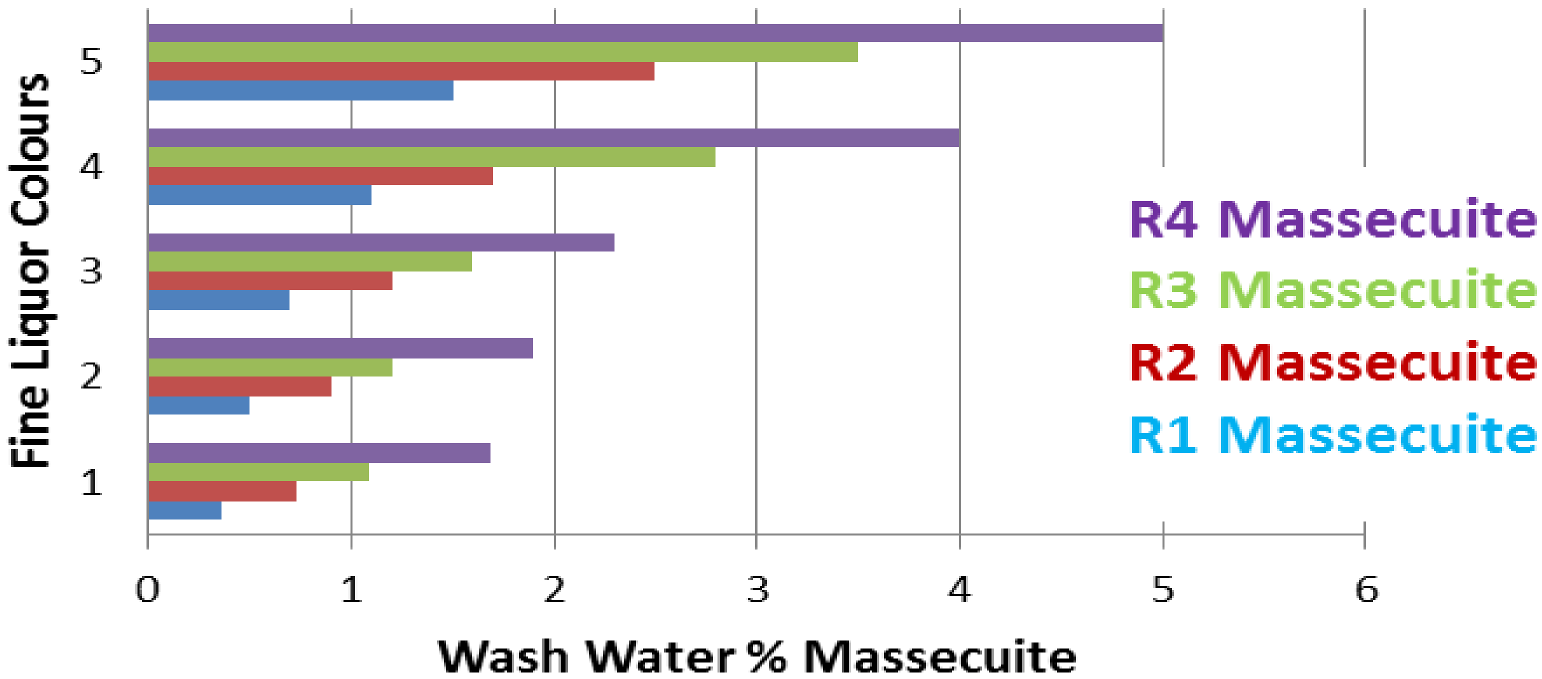


Wash time required for different massecuite colors.

DISCUSSION

The negative impact of high color and high washing inside the centrifugal.

While crystallization is a very efficient separation process, over-washing can undo the good work done in the pans.

The color is basically distributed in three different regions of the crystal:





DISCUSSION

When the surface layer of mother liquor is washed off the crystals the color will decrease and asymptotically

Crystal Surface. **Here the color does not change much. Once the surface layer has been washed off, further washing will change the color very slightly.**

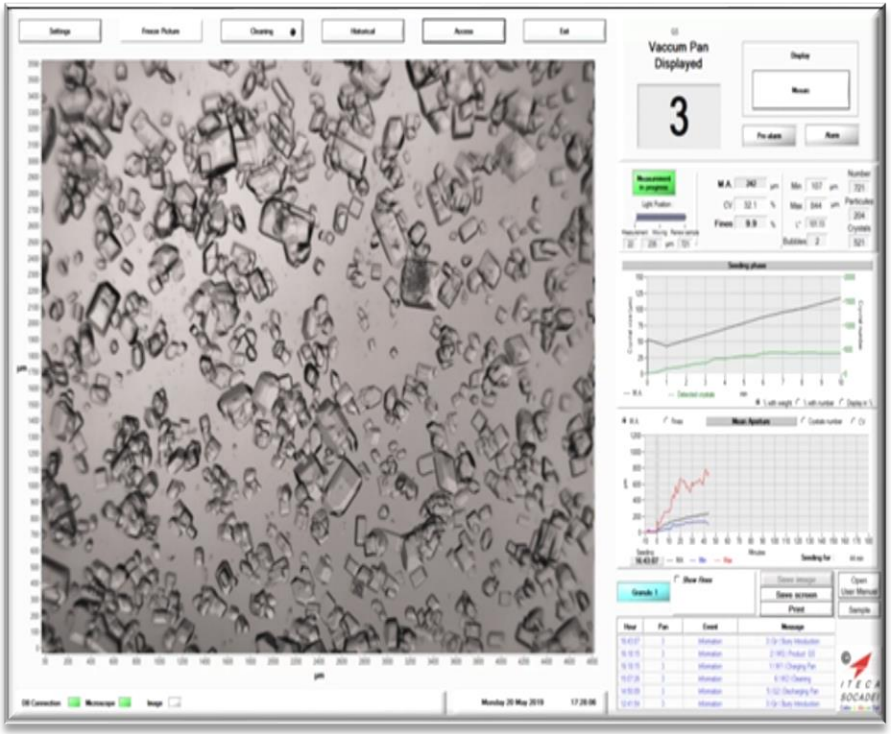
Kernel. **Here there is a smaller or larger amount of colorants, depending on the seeding and start of crystallization.**

DISCUSSION

So how did we compute the sugar dissolved in the basket?

Sucrose is highly soluble in water, and the solubility increases with temperature.

Many researchers, Bubnik, Holven, Peacock, Herzfeld, etc. have determined the values of solubility of sucrose in pure saturated solutions.



DISCUSSION

The figures obtained by Herzfeld were used for this report.

The following equation is a smoothed curve obtained from these experimental results.

$C = 64.18 + 0.1348T + 0.000531T2$
C = % sucrose in the saturated solution
T = temperature °C.



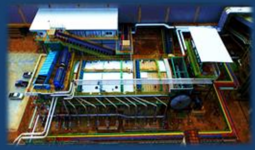


DISCUSSION

This equation was used to compute the sucrose dissolved in wash water at actual temperatures measured at the molasses receiving tank located below the centrifugal station.

Using the volume of wash water consumed, a spreadsheet was created to compute the water usage, the sucrose dissolved, and the energy required for evaporating the water.




DISCUSSION

Item	Value
Refinery capacity tpd	1000
Sugar color ICUMSA	40
Steam cost per metric ton	USD 15
Water cost per m^3	USD 1.1
Sugar per metric ton	USD 500
Number of White Boilings	4
Refinery Overall Yield	97%
Centrifugal Capacity kg	1750

Assumptions for this model

DISCUSSION

Fine Liquor Color ICU		100	200	300	400	500
Wash % Massecuite*	%	3.9	4.5	5.8	9.6	12.5
Water Usage	m^3	2 603	3 871	5 173	8 198	11 061
Sucrose Dissolved	tons	9 206	13 694	18 298	29 000	39 127
Cost of Steam	$/ton	40 856	60 773	81 201	128 696	173 638
Cost of Water	$/m³	2 863	4 258	5 690	9 018	12 167
Cost of Sucrose Loss**	$	138 094	205 415	274 462	434 997	586 901
Total Cost	$	181 813	270 447	361 353	572 711	772 706

'* Total of all centrifugal wash water on R1, R2, R3 and R4 Massecuites.
'**Based on the assumption that the total crystallization process yields 97%

DISCUSSION

All conventional color removal processes have different:

- ✓ Operating cost
- ✓ Capital costs
- ✓ Process effectiveness
- ✓ Ease or complexity of operation
- ✓ Environmental issues.

There are two areas where color removal can be enhanced: CLARIFICATION & DECOLORIZATION

DISCUSSION

Typical color removal:

STATIONS	COLOR REMOVAL
CLARIFICATION	25 – 50 %
DECOLORIZATION	65 – 85 %

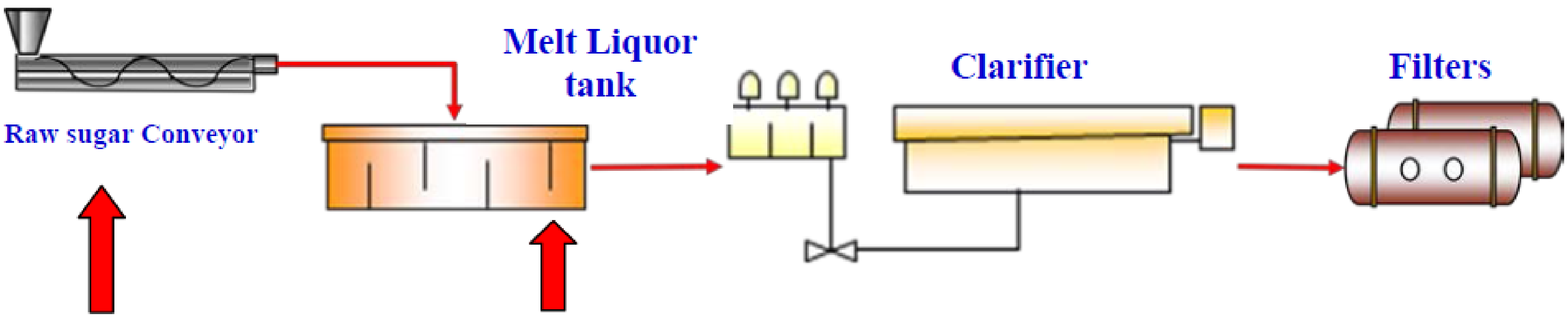
Both these numbers can be improved upon using high performance adsorbent technology.

In the case of improving color removal in phosphatation processes, there are several High Performance Adsorbents (HPA) available to add to the liquor stream.





DISCUSSION

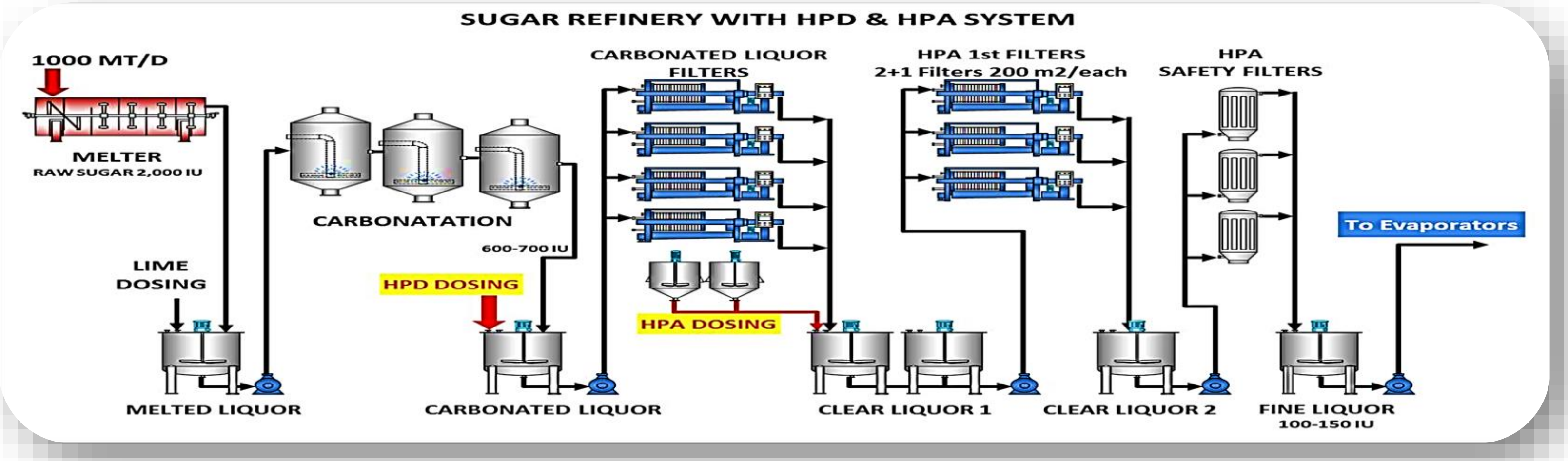


High performance Adsorbent
(In the raw sugar conveyor **OR** melt liquor tank **OR** just previous clarification)

Some of these are added at the melt stage to enhance phosphatation color removal, while others are added after the clarifier.

DISCUSSION

In the case of improving color removal in the carbonatation process, there are also several specially engineered high performance adsorbents that may be added to the post carbonatation liquor, i.e. at the filter supply tank.



DISCUSSION

High Performance Adsorbents (HPA) can lower the color of fine liquor better than IER and GAC.

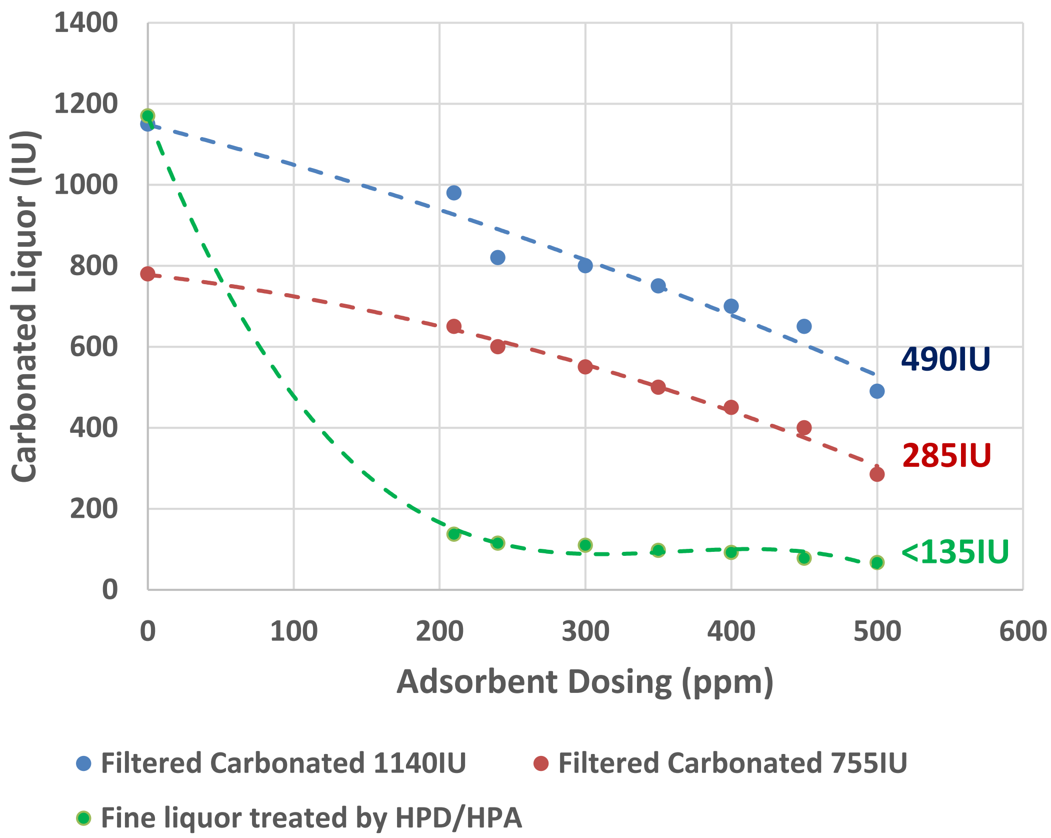
An example of color removal conducted in the lab is shown on the next slide.

A sample of filtered carbonated liquor was subjected to progressive dosages of HPA to reach fine liquor lower than 200IU.

DISCUSSION

It can be seen that starting with filtered carbonated liquor of 1140 and 755 IU, the liquors colors reduced to 490 and 285 IU respectively with GAC & IER, while 135 IU for HPA.

It can also be seen that there is a good correlation between the dosage of adsorbent and the corresponding liquor color.



DISCUSSION

THAILAND SUGAR REFINERY

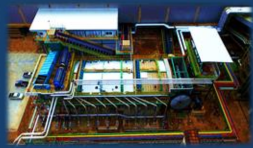
		HPD (300ppm) + HPA (500ppm)			HPD (200ppm) + HPA (500ppm)					HPD (200ppm) + HPA (300ppm)		HPA (500ppm)	
COLOR	Carbonated Liquor (IU)	1796	2008	1903	1899	1108	888	998	996	1712	1029	1074	1009
	Liquor with HPD (IU)	807	1577	1236	1396	832	665	729	740	1170	889		
	% Removal - HPD	55.07	21.46	35.05	26.49	24.91	25.11	26.95	25.70	31.66	13.61		
	Liquor with HPA (Batch) IU	659	880	923	889	555	442	481	458	867	675	634	591
	HPA PRE-COAT Dosage	0.5Kg/m2			0.5 Kg/m2					0.5Kg/m2			
	HPA Fine Liquor	70	95	137	67	78	92	115	135	76	88	110	135
	% TOTAL Removal	96.10	95.27	92.80	96.47	92.96	89.70	88.53	86.45	95.59	91.50	89.76	86.62

COLOR	HPA Fine Liquor	70	95	137	67	78	92	115	135	76	88	110	135
	IER Fine Liquor (IU)	205	218	165	140	151	155	143	141	198	128	129	136

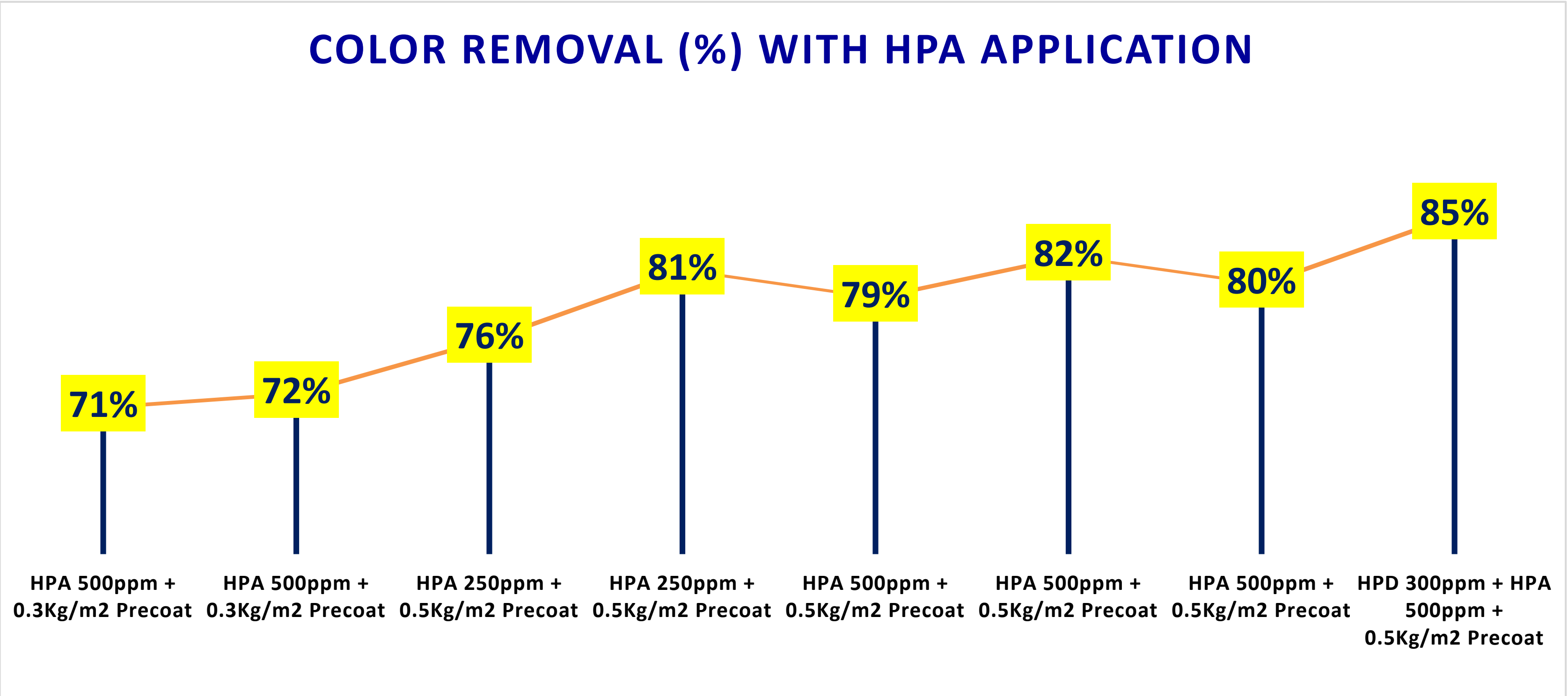
- **HPA produced consistently fine liquor colors below 135 IU.**

DISCUSSION




DISCUSSION

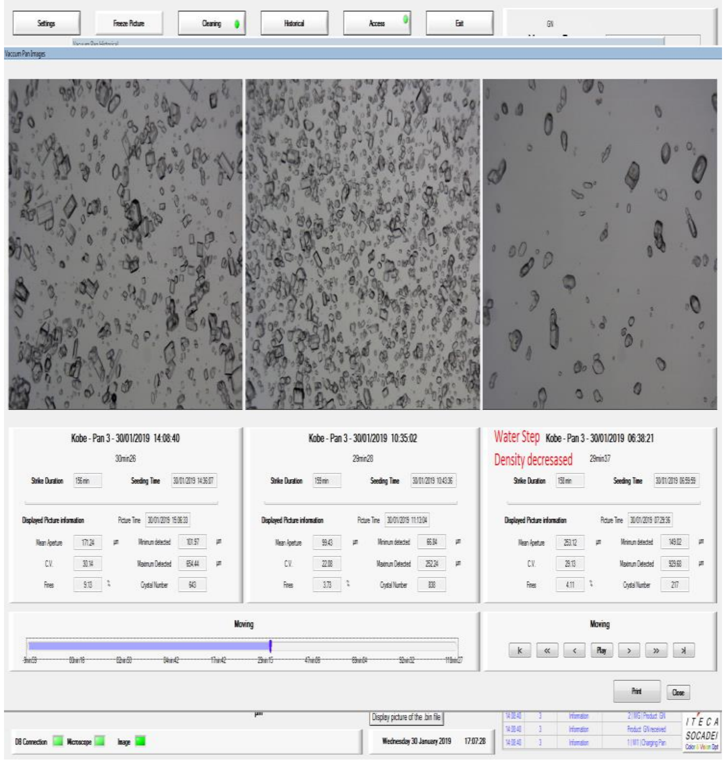


Increasing HPA dosage = increases percentage color removal.

DISCUSSION

Excessive washing in centrifugals is the cause of the following problems:

- Less sugar directly to the silo
- Smaller crystals due to dissolution
- Loss of sugar to molasses due to repeated re-crystallization
- Loss of sugar to inversion due to recycling of sucrose.
- Increased energy consumption due to reprocessing and evaporation.
- Loss of process capacity due to high recycle.



DISCUSSION

Using the spreadsheet, data was computed for a 1000 tpd refinery comparing the utilities required for fine liquor at 100 ICUMSA against 500 ICUMSA.

The results are summarized:

DISCUSSION

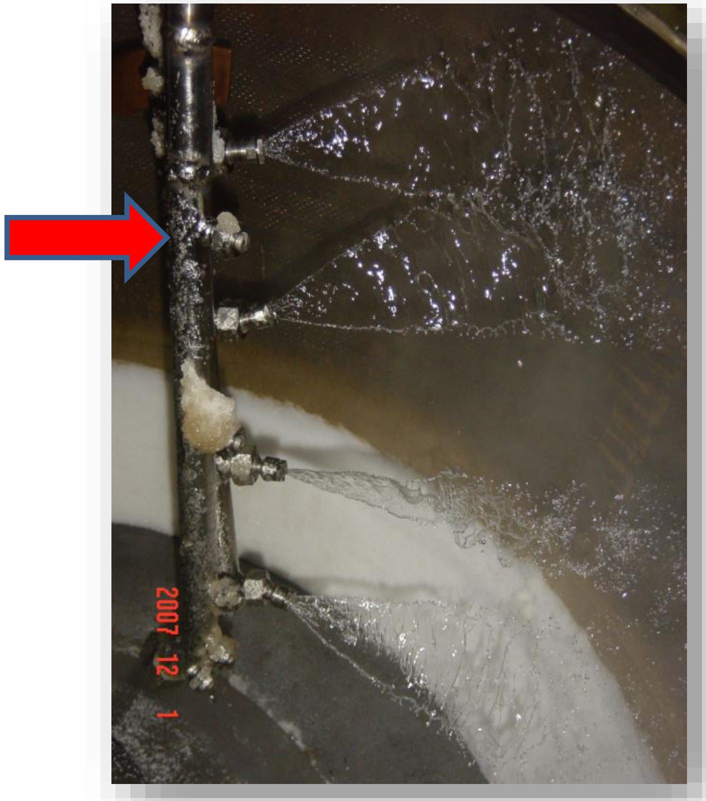
One day:

- **85 metric tons of sugar is dissolved daily, which could have been sent to the silo.**
- **24 m3 additional water is used daily.**
- **24 metric tons of additional steam is used daily.**
- **2.1 metric ton of additional sugar lost into molasses daily.**

CONCLUSION

This paper has shown that poor decolorization comes at a significant cost by demanding excessive amount of centrifugal wash water.

An attempt has been made to show the economic impact of high wash water consumption.



RECOMMENDATIONS

Refineries should strive to maximize their color removal processes and use process aids where justifiable.

A study should be conducted where the sugar loss is measured at different wash water % massecuite by actual weighing of the sugar discharged from the drier.

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