IN THE NAME OF ALLAH, THE MOST BENEFICENT, THE MOST MERCIFUL

RATED: OVER ALL BEST PAPER OF 48TH CONVENTION

RASOOL NAWAZ SUGAR MILLS PVT LTD.,
(SHAMIM SUGAR MILLS)
(A Project of Gourmet Pakistan)

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T O P I C

Improved Performance of Robert Type Evaporators in combination with a set of 2 Nos. Pre-Heaters in Heater battery in series.

ABSTRACT

The Sugar manufacturing process can be made more cost effective with significant improvement in plant performance by using 2 Nos. Pre-Heater in series in Heater battery before entering the clarified Juice in Robert Type Vapour Cell.
By this arrangement a small ΔT could be easily achieved (Temperature difference of Juice and the exhaust steam).
As result maximum vapour bleeding is made possible which ultimately resulted in achievement in enhancement in crushing rate, sugar production, increase in recovery % and bagasse saving.

INTRODUCTION

We all are well aware of existing energy crisis of our country. It is the fact that Pakistan is blessed by the nature with huge and sufficient natural resources of all kind. Need of the time is to make research and developments in every walk of life to utilize these resources wisely, dedicatedly and fruitfully.
The nature has especially blessed the sugar industry with more than self sufficient fuel in shape of bagasse. Therefore, the sugar industry has potential to be helpful by use of this nature blessed source to overcome the energy crisis.
The engineers and the scientists of the sugar industry are consistently striving best to make research and developments and by adopting new advance techniques to make the sugar manufacturing process easy, smooth and more cost effective.
An experiment has been conducted at Gourmet Shamim Sugar Mills Ltd; Faisalabad in the same scenario.

In this paper concentration has been focused on methods adopted, results, discussions and the recommendations.

METHOD

In the existing Heater battery, 02Nos. Juice heaters are utilized in series as pre-heater. The 1st pre-heater in series is bled with 1st vapour from vapour cell, raising clarified juice temperature up to 110 – 112C°. The 2nd pre-heater in series is heated up by exhaust steam raising clarified juice temperature in range of 120 –122 C°.
The defecated juice, clarified juice and syrup have been analyzed in laboratory hourly and recorded for the determination of temperature, pH, Brix %, RS % and the purity respectively. The clarified juice is also analyzed hourly for clarity.
All the methods are adopted in laboratory according to "The Manual for Uniform Method of Sugar Analysis".

References are as under:-

- ***Brix % Determination (Page No. 35)***
- ***Pol % Determination (Page No. 45)***
- ***Reducing Sugar % Determination (Page No. 59)***
- ***Clarified Juice Clarity Determination (Page No. 72)***
- ***pH Determination (Page No. 73)***
- ***Sugar ICUMSA Determination (Page No. 131)***

The temperature of 1st, 2nd and the 3rd vapours generated from vapour cell, 1st, 2nd and the 3rd effect are hourly monitored/recorded from gauges fitted at the shell & calandrias (duly calibrated). The temperature of 2nd vapours is monitored /recorded from gauges fitted at shell & calandria of the pans. The temperatures of 3rd and 4th vapours are recorded from gauges displayed at primary and secondary vapour headers of Juice heaters. The massecuite boiling time of Refine/A/B&C massecuites and B/C grains are monitored and recorded on pans graphs.
The purity drop of respective molasses i-e; Run off, A-heavy, B-heavy & Final Molasses are analyzed and recorded.
The temperature and the pH of condensate removed from calandria of the vapour cell, juice heaters, evaporators and pans are hourly analyzed and recorded. Similarly the temperatures of 1st/2nd condensates supplied to boilers are hourly analyzed and recorded. The temperature of boiler condensate is checked by the Lasser gun periodically (once in a week) and recorded.

- **The crushing rate is hourly monitored and recorded. The imbibitions % cane, pol % bagasse is hourly analyzed/ monitored and recorded.**
- **The clarity of juice from SRI clarifier is hourly analyzed and recorded.**
- **Purity of clear juice and syrup is regularly monitored by analysis in Laboratory hourly.**
- **The scale formation in vapour cell/ evaporators tubes is monitored and measured in mm at each periodic cleaning of the vessel. The cleaning schedule of vapour cell/ evaporators and pans has been regularly monitored and recorded during the season.**

- **The exhaust / vapour pressure in calandria and shell of vapour cell are recorded hourly from the calibrated gauges. The performance of each evaporator is monitor/ recorded with emphasis on syrup brix obtained from the last effect.**

RESULTS

The clarified juice having temperature 100-102° C, coming out from SRI- Clarifier after passing through the set of 2 Nos Pre-heaters, attains temperature in range 120 – 122C°. ***(Annexure _ 3a)***
The temperature of 1st vapours generated by vapour cell is achieved in the range of 119-120 C°. ***(Annexure _3b)***
The temperature of 2nd vapours generated by 1st effect is achieved in range of 108-110 C°. ***(Annexure _3b)***
The temperature of 3rd vapours generated by 2nd effect is achieved in the range of 92-94C°. ***(Annexure _3b)***
The temperature of 4th vapours generated by 3rd effect is achieved in the range of 80-82 C°. ***(Annexure _3b)***
The temperature of vapours generated by 4th effect (2nd last effect) is achieved in the range of 70-72° C. ***(Annexure_3b)***
The temperature of vapours generated by last effect to condenser is achieved in the range of 64-65° C. ***(Annexure_3b)***
The average temperature of condensate supplied to the boilers is achieved in the range of 108-110 C°. ***(Annexure_3c)***

The imbibitions % cane at mills is achieved in the range of 28-30%. The temperature of imbibitions water used is in the range of 60-65°C. ***(Annexure_3c)***
A minor scale formation at vapour cell tubes is recorded at each cleaning. The deposition of scale in the last effect is in the average range of 1.5-2.0 mm thickness, (it is recorded during each cleaning, the scale is found hard in texture.).
The periodic cleaning schedule of vapour cell and quadruplicate effects is enhanced about average 24-30 hours/ cleaning.
The exhaust steam pressure at vapour cell calandria is attained in the range of 0.9-1.0 Kg/cm² regularly without any major fluctuation. **(Annexure-4)**
The vapour pressure in shell of vapour cell is recorded in the range of 0.5-0.6 Kg/cm² regularly. **(Annexure-4)**
No considerable entrainment is recorded from Evaporators and the pans.

DISCUSSION

The improved performance of Robert Type Evaporator can be achieved by the provision of a set of 2 Nos Pre-heaters in juice heaters battery, raising the clarified juice temperature up to its maximum before entering the vapour cell. By this arrangement small ΔT (ɨe; temperature difference between Juice and the Exhaust Steam) is achieved. The higher temperature vapours generated are immediately flashed out as soon as the juice enters the shell of vapour cell.

Due to higher temperature, the maximum vapour bleeding has become possible in the process (at heaters, evaporators and the pans). ***(Annexure_8)***

Due to these facts, the performance of the plant has significantly improved as under:-

1. Reduced Steam Consumption:-

Due to generation of higher temperature vapours from vapour cell, it could be possible to utilize vapour bleeding as maximum as possible as under:- ***(Annexure_8)***

(i) The clarified juice passing in 1st Pre-heater is heated up with 1st vapours having temperature 119-120°C, raising clarified temperature in the range of 110-112 ° C. ***(Annexure_3b & 3a)***

(ii) 2nd pre-heater in the series is heated up with exhaust steam having temperature 128-130°C raising clarified juice temperature in the range of 120-122° C. ***(Annexure_3b &3a)***

(iii) The 1st vapours having temperature 119-120°C are utilized at dryer without any major fluctuation and the problem of drying of the sugar crystals.

(Annexure_3b)

(iv) The 2nd vapours having temperature 108-110°C are utilized for Refine, A/B massecuites & B/C grain Pans boiling.

(Annexure_3b)

(v) The 2nd vapours having temperature 108-110°C are utilized for secondary juice heating temperature, in the range of 105-106° C.

(Annexure_3b &3a)

(vi) The 3rd vapours having temperature 92-94°C are utilized for C-Massecuite boiling at C-Conti Pan.

(Annexure_3b)

(vii) Due to these arrangements, the steam consumption has reduced upto average 7 %.

2. Clarity of Clear Juice

Due to consistent achievement in temperature of defecated juice in range of 105-106°C, the shinning clear juice from SRI-Clarifier is obtained with improved clarity in the range of 96+, with formation of compact nature filter cake at vacuum filter.

(The deposition of scale in tubes of vapour cell/ Evaporators is measured in range of average 0.1-0.2 mm). ***(Annexure_3a)***

3. Improvement in Evaporators Efficiency

Due to higher temperature vapours, the performance of evaporators has improved. As a result, the syrup of higher brix in range of 62°-65° with golden luster is consistently obtained from the last effect. ***(Annexure-9)***

4. Performance of Pan Boiling

Due to consistent supply of good quality thick syrup from the last effect and as well as the supply of higher temperature vapours from the vapour cell/ evaporators, the efficiency of pans has improved with significant reduction in boiling times of the respectives massecuites. ***(Annexure-7)***

5. Control of entrainment at Evaporators/ Pans

Due to consistently sustained back pressure at vapour cell in the range of 0.9-1.0Kg/cm² and improved performance of the evaporators/ pans, the losses of entrainment are significantly controlled in the process. ***(Annexure_4&9)***

6. Improvement in Centrifugal Machines Performance

With production of well exhausted massecuite, the purging at centrifugals has significantly improved with production of the best quality sugar of higher purity. The lesser quantity of washing water at the centrifugals is used. The maximum purity drop is achieved with minimum recycling of sugar in molasses. ***(Annexure-5)***

7. Improvement in Boiler Performance

Due to consistent supply of best quality feed water (free of contamination having higher temperature in range of 108°-110°C and pH 8.0-8.2), the boiler performance has significantly improved. ***(Annexure_3c / 1)***

8. Impact on Sugar Quality

Due to improved clarity of the juices, the well exhaustion of massecuites at pans and improved purging at centrifugals, resulted in significant impact on colours of liquors and the sugars. Ultimately the best quality sugar is produced. ***(Annexure_6)***

9. Achievement in Mills Performance

Due to rapid consumption of higher brix syrup at pans, the crushing rate has significantly improved with consistency. Due to the higher imbibitions % at mills with higher temperature water, it could be possible to reduce the losses of sugar in bagasse (Bagasse Pol %). **(Annexure_3c&9)**

10. Cleaning Schedule

Due to improved clarification, the scale formation in evaporator tubes has become significantly lesser and periodic cleaning schedule of vapour cell/ evaporators has prolonged approximate 24-30 hours/cleaning.

11. No Caramalization:

No sugar caramalization is observed/ recorded at evaporators and Pans. The syrup of good quality with matching purity of clarified juice is obtained. ***(Annexure_9)***

12. Enhancement in Recovery %age

Due to the combined impact of improvements in performance of Boiler, Mills, Evaporators, Pans and centrifugals resulted in significant achievement in Sugar recovery %age (in range of 0.3-0.4 % on Cane).

13. Fuel Saving

Due to improved factors as mentioned in No. 12 resulted reduction in steam consumption up to average 7 % on cane. The significant saving of bagasse is achieved approximately 3 % 0n Cane.

14. *No Power Involvement*

There is no requirement of regular recirculation of juices back to the vapour cell, therefore no additional power for recycling of juice is required.

15. *Normal Civil Foundation*

Normal civil foundation for heater structure and plate form is required.

RECOMMENDATION

The performance of Robert Type evaporators can be significantly improved by the provision of a set of 2 Nos Pre-heaters in series in the heater battery. The 1^{st} Pre-Heater in the series is heated up by higher temperature vapours generated from vapour cell and the 2^{nd} Pre-Heater is heated up with exhaust steam attaining small ΔT (Temperature difference between clarified juice and exhaust steam).

By this arrangement, heat transfer co-efficient of Robert Type vap. cell become significantly improved. Maximum vapour bleeding become possible at Heaters, Pans, Evaporators, Sugar Dryer etc. The Mills performance , Boiler performance Pan boiling time, centrifugation and evaporation is significantly improved. As result steam consumption is reduced approx. 7% on cane with approx. 3% fuel saving is achieved.

It is therefore recommended that arrangements may be provided for a set of 2 Nos Pre-heaters in the heater battery to make the process cost effective, beneficial and with trouble free operation as experienced at Gourmet Shamim Sugar Mills Ltd, Samundari, District Faisalabad during season 2013-14.

Cost / Benefit Ratio (Financial Impact)

Expenditure:

Addition of Pre-Heater in the heater battery	Nos.	=	2
Capacity/Pre-heater	M^2	=	350
Cost/Pre-Heater	Rs.	=	3000000 x 2
	Rs.	=	6000000
Cost of (Pipelines & Allied Valves)	Rs.	=	2500000
Cost of Structure Material/Civil Work	Rs.	=	100000
Total Cost	**Rs.**	**=**	**8600000**

BENEFITS

A:-

1. Average Increase in Crushing rate	%	=	17
2. Avg. Increase in Production through put	%	=	16.66
3. Crushing rate	TCD	=	4000
4. Season Period	Days	=	120
5. Total crushing /Season	Tons	=	480000
6. Achievement in Recovery	%	=	0.32
7. Average Steam Reduce % on cane	%	=	7
8. Average Bagasse saving % cane	%	=	3
9. The loss of sugar due to entrainment		=	Negligible
10. Total increase in Production/Season	Tons	=	1536
11. Price of Sugar Per Kg	Rs.	=	50/-
12. Total price of Sugar	Rs.	=	76,800,000/-
13. Government Prevailing FED	%	=	8
14. Amount of Tax	Rs.	=	6,144,000/-
15. **Net sugar Cost**	**Rs.**	**=**	**70,656,000/-**

BENEFITS

B:-

1.	Bagasse saved on cane	%	=	3
2.	Bagasse Saved	Ton	=	14400
3.	Price/ Ton Bagasse	Rs.	=	3000/-
4.	Total Price of Bagasse	Rs.	=	43,200,000/-

C:

1. Total saving	***(A+B)***	**Rs.**	=	**11,3856,000/-**

D:

Cost Benefit Ratio		=	1:10.8

Annexure—1

pH

JUICES/ LIQUOR/ FEED WATER

Sr. No.	***Description***	***pH***	***Remarks***
1.	Mix Juice	5.5-5.7	
2.	Defecated Juice	7.8-8.2	
3.	Clear Juice	6.8-7.0	
4.	Syrup	6.0-6.2	
5.	Clear Liquor	6.7-6.8	
6.	Fine Liquor	6.2-6.3	
6.	Boiler Feed Water	8.0-8.2	

Annexure—2

PURITY

JUICES & SYRUP

Sr. No.	***Description***	***Purity***	***Remarks***
1.	Mix Juice	76.12	
2.	Defecated Juice	76.20	
3.	Clear Juice	77.62	
4.	Syrup	77.70	

Annexure—3 A
TEMPERATURE °C
JUICES

Sr. No	**Description**	**Avg. Temperature °C**	**Remarks**
1.	Primary Juice	62-65° C	
2.	Secondary Juice	105-106° C	
3.	Clarified Juice	100-102° C	
4.	Pre Heated Juice (1st stage)	110-112° C	
5.	Pre Heated Juice (2nd Stage)	120-122° C	

Annexure—3 B
TEMPERATURE °C
EXHAUST STEAM/VAPOURS

Sr. No	Description	Avg. Temperature °C	Remarks
1.	Exhaust Steam	128-130° C	
2.	1st Vapour	119-120° C	
3.	2nd Vapour	108-110° C	
4.	3rd Vapour	92-94° C	
5.	4th Vapour	80-82° C	
6.	5th Vapour	70-72 ° C	
7.	Last Effect vapour	64-65° C	

Annexure—3 C
TEMPERATURE °C
FEED WATER & CONDENSATES

Sr. No	Description	Avg. Temperature °C	Remarks
1.	1st Condensate	114-115° C	
2.	2nd Condensate	104-106° C	
3.	3rd Condensate	80-85° C	
4.	4rth Condensate	70-75° C	
5.	Last effect Condensate	64-65° C	
6.	Pan Condensate	104-106° C	
7.	Boiler Feed Water	108-110° C	
8.	Imbibition Water	60-65 ° C	

Annexure—4
PRESSURE – Kg/cm²
EXHAUST STEAM/VAPOUR

Sr. No	Description	Ex.Steam Pressure Kg/cm²	Vapour Pressure Kg/ cm²
1.	Vapour cell Calandria	0.9-1.0	
2.	Vapour cell shell		0.5-0.6
3.	Pan Calandria		0.3-0.4

Annexure—5
PURITY DROP
MASSECUITES/MOLASSES

Sr. No	Type of Massecuite	Massecuite Purity	Type Of Molasses	Molasses Purity	Average Purity Drop
1.	A-Massecuite	81.64°	A-Heavy	65.90°	15.74°
2.	B-Massecuite	68.35°	B-Heavy	47.41°	20.94°
3.	C-Massecuite	53.10°	Final Molasses	32.12°	20.98°
4.	Refine Massecuite	98.49°	Run off	94.32 °	4.17 °

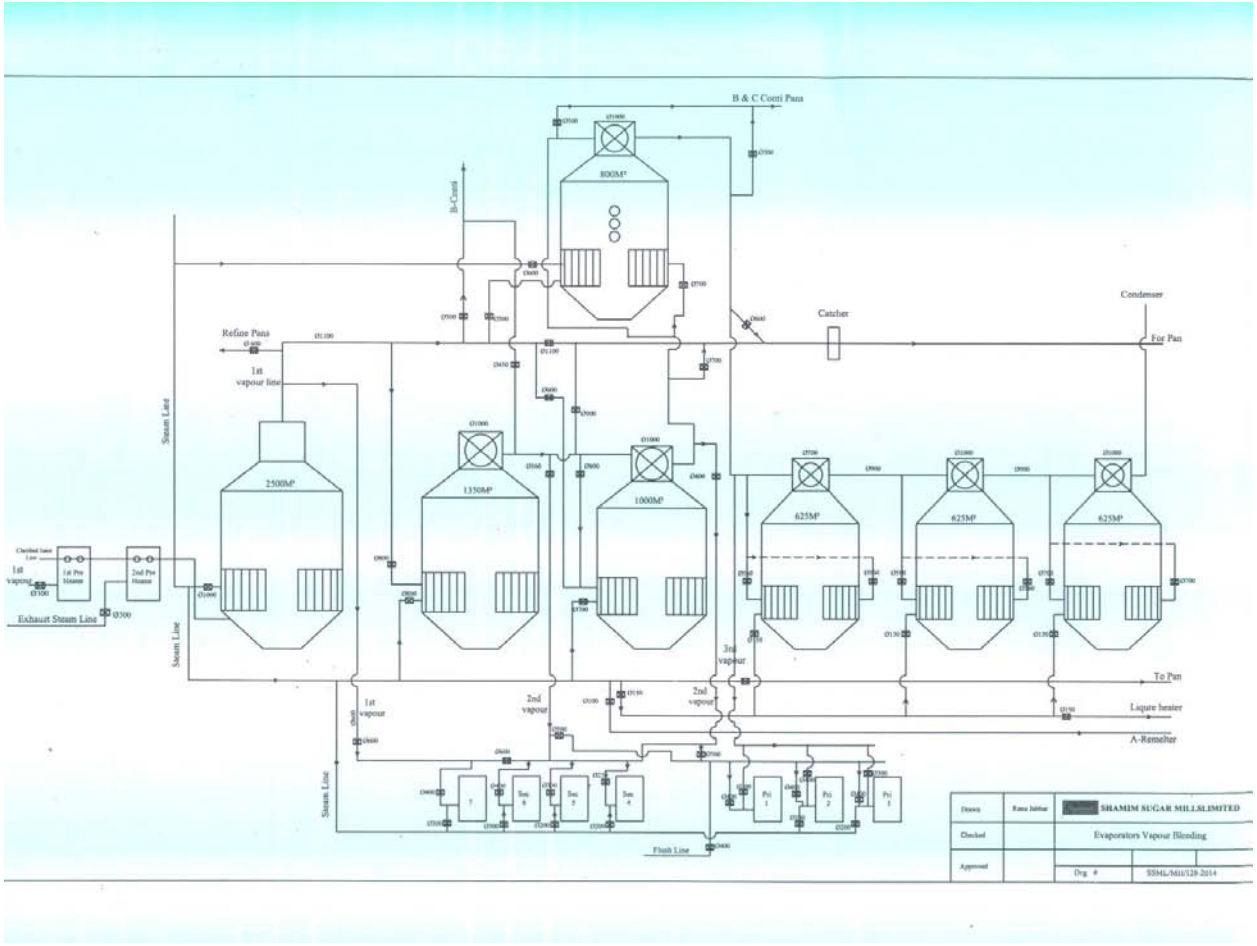
Annexure—6
ICUMSA (ma)
SUGAR GRADES

Sr. No.	Sugar Grade	ICUMSA (ma)	Remarks
1	R 1	35-40	
2	R 2	40-50	
3	R 3	50-62	

Annexure—7
MASSECUITE BOILING TIMES

Sr. No	Description	Avg. Normal Massecuite Boiling Time	Average Boiling Time of Massecuite with Double set of Pre-heater	Boiling time difference/ strike
1.	Refine Massecuite	1.50 Hrs	1.15 Hrs	0.35 Hrs
2.	A-Massecuite	2.25 Hrs	2.00 hrs	0.25 Hrs
3.	A´-Massecuite	1.30 Hrs.	1.10 Hrs	0.20 Hrs
4.	B -Grain	3.40 Hrs	3.10 Hrs	0.30 Hrs
5.	C-Grain	5.40 Hrs	5.00 Hrs	0.40 Hrs

Annexure—8
VAPOUR BLEEDING DIAGRAM



Annexure—9
AVERAGE BRIX%, POL% & PURITY

Sr. No	Description	Average Brix%	Average Pol%	Average Purity
1.	Mix Juice	14.57	11.35	77.90
2.	Clear Juice	14.20	11.20	78.87
3.	Syrup	63.47	50.11	78.95
4.	Spray Pond Pol	-	Tracess	-
5.	Bagasse Pol %	-	2.09	-

Annexure—10
HEAT TRANSFER CO-EFFICIENT (HTC)
K=0.465 x Temp. Clear Juice/Brix Clear Juice

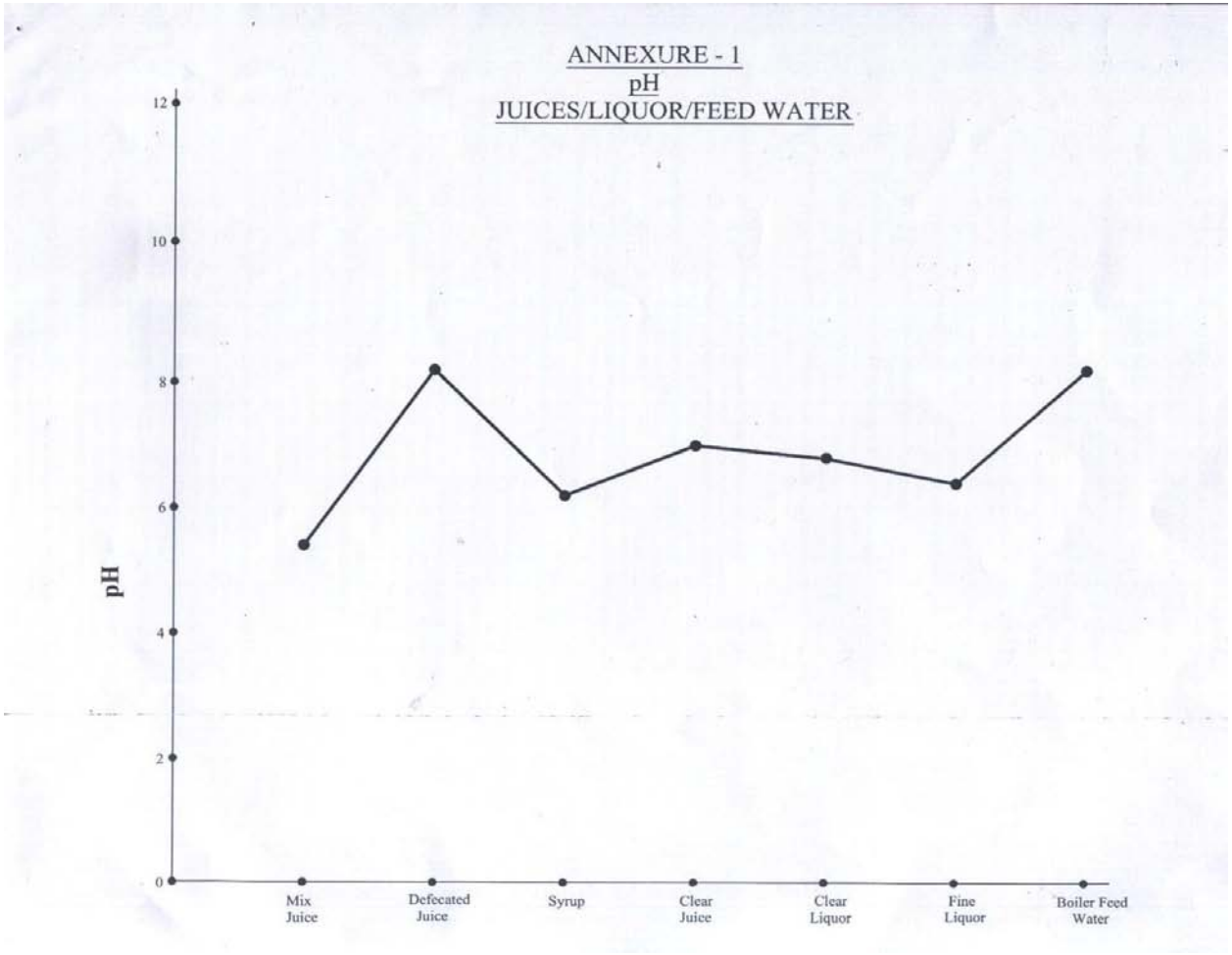
Reference:- PG WRIGHT, Heat Transfer Co-efficient Correlations for Robert Juice Evaporators
Proc Aust Soc Sugar Cane Technol Vol 30 2008, Page No. 553

Sr.	Description	Temp. Clear Juice	Brix Clear Juice	HTC KW/M²/Hr	Difference KW/M²/Hr	Achievement Lb/Ft²/Hr	Remarks
1.	Single Pre-Heater	108 °C	14.20	3.53	0.40	1.38	Improvement achieved in HTC
2.	Double Pre-Heater	120 °C	14.20	3.93			

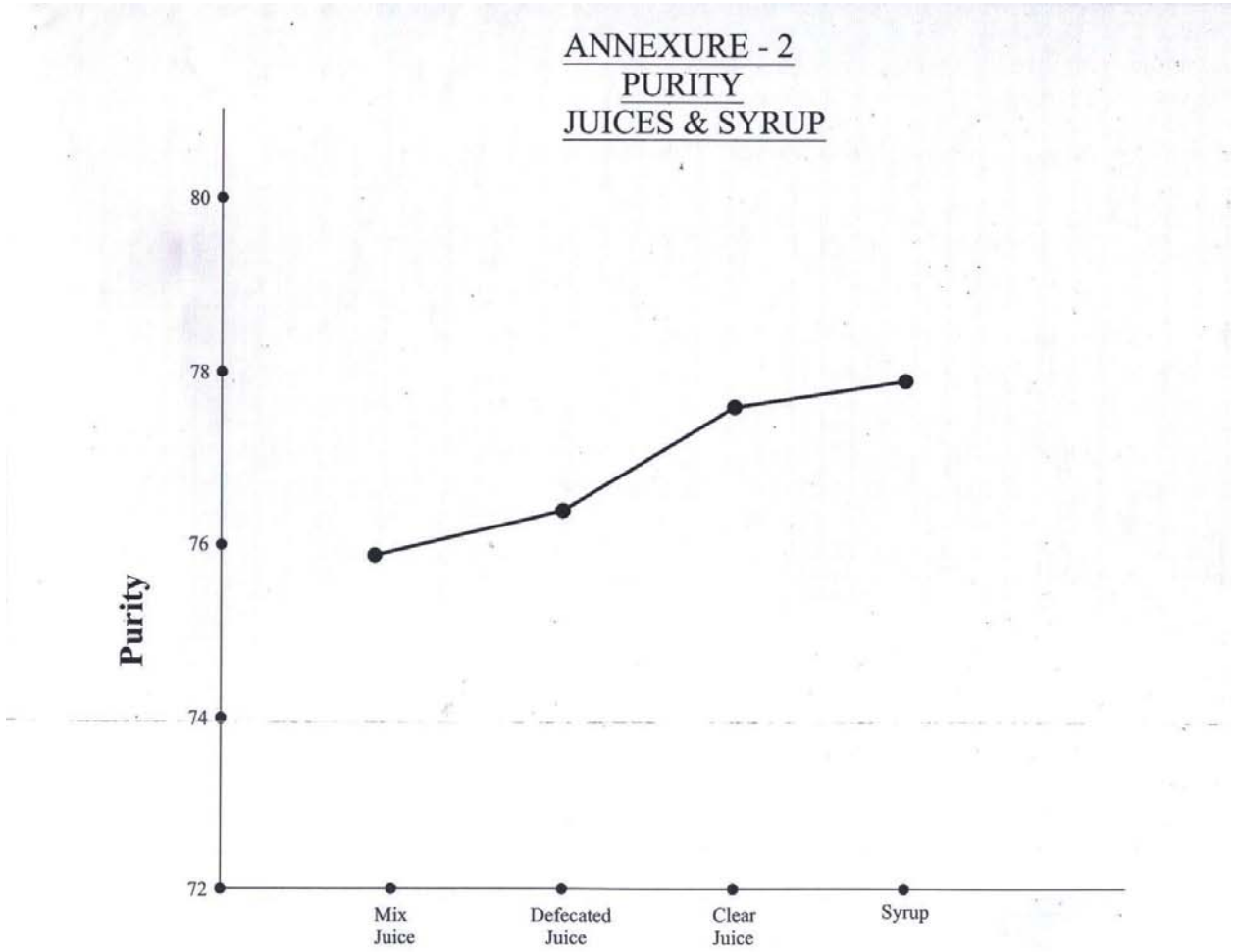
Annexure—11
Average Reducing Sugar %
Clear Juice & Syrup

Sr. No	Month	Clear Juice RS%	Syrup RS%	Remarks
1.	Nov - 13	0.76	0.795	
2.	Dec - 13	0.80	0.82	
3.	Jan- 14	0.79	0.845	
4.	Feb - 14	0.81	0.83	
5.	Mar - 14	0.77	0.80	

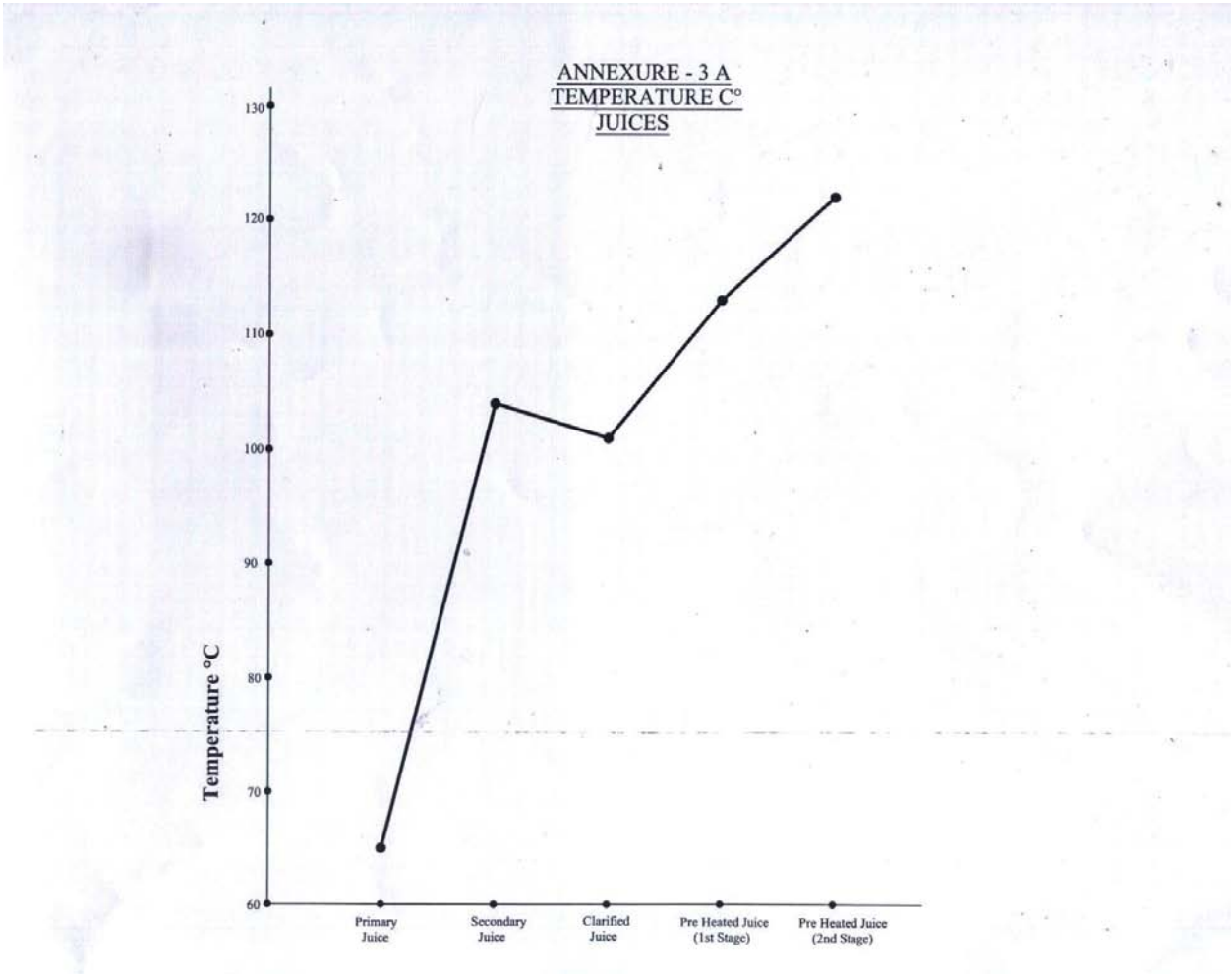
Graph Annexure—1



Graph Annexure—2



Graph Annexure—3 A



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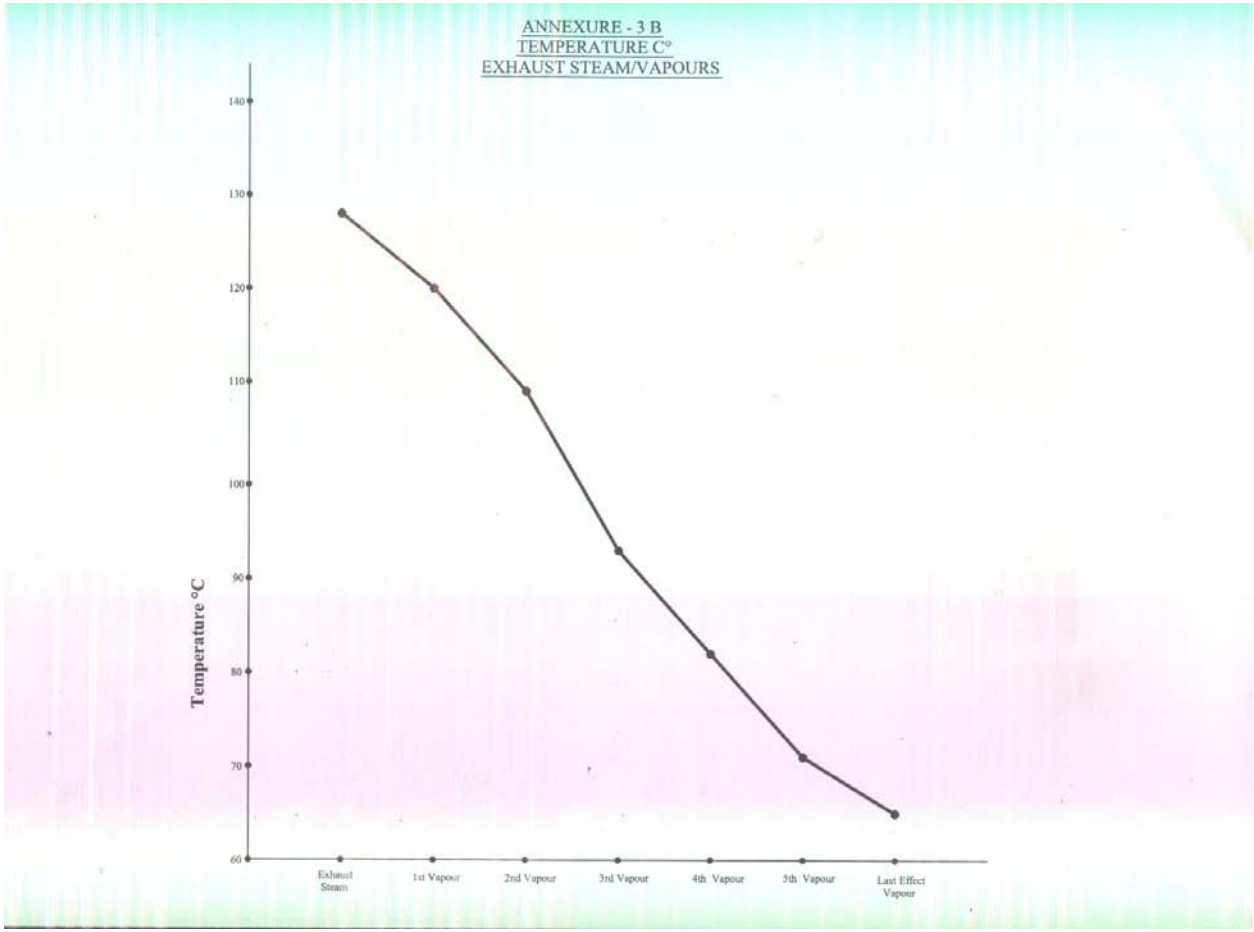
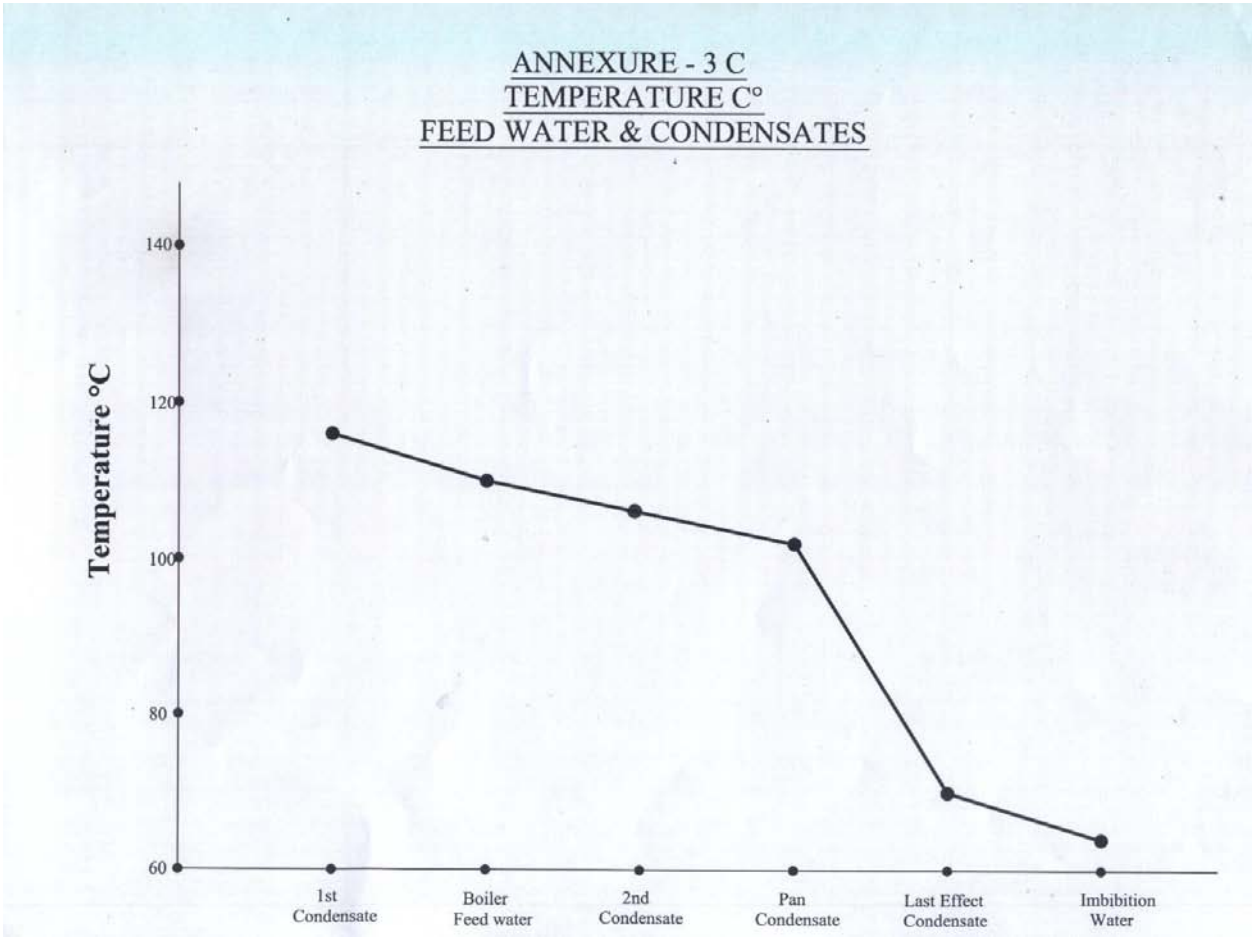


Graph Annexure—3 C



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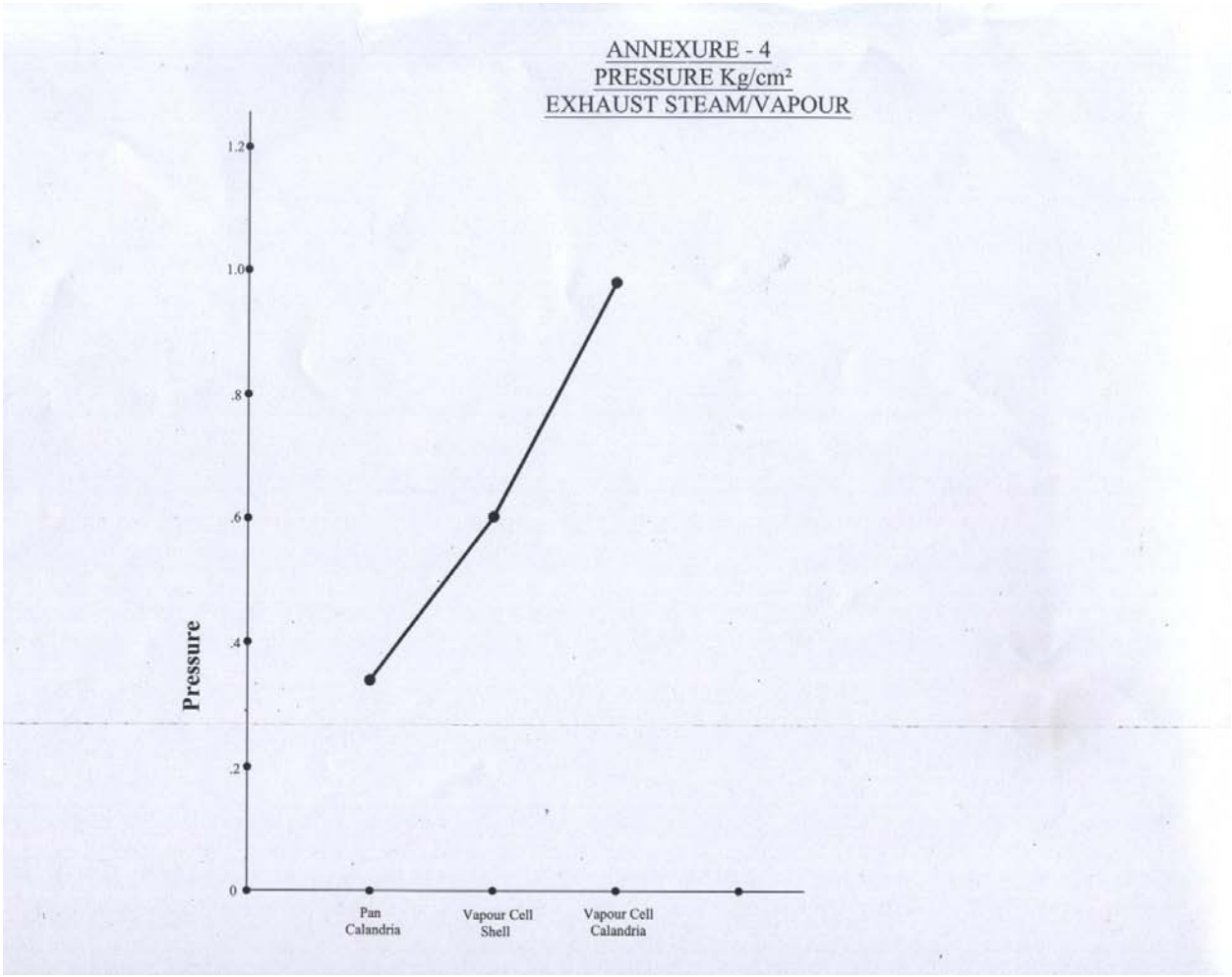

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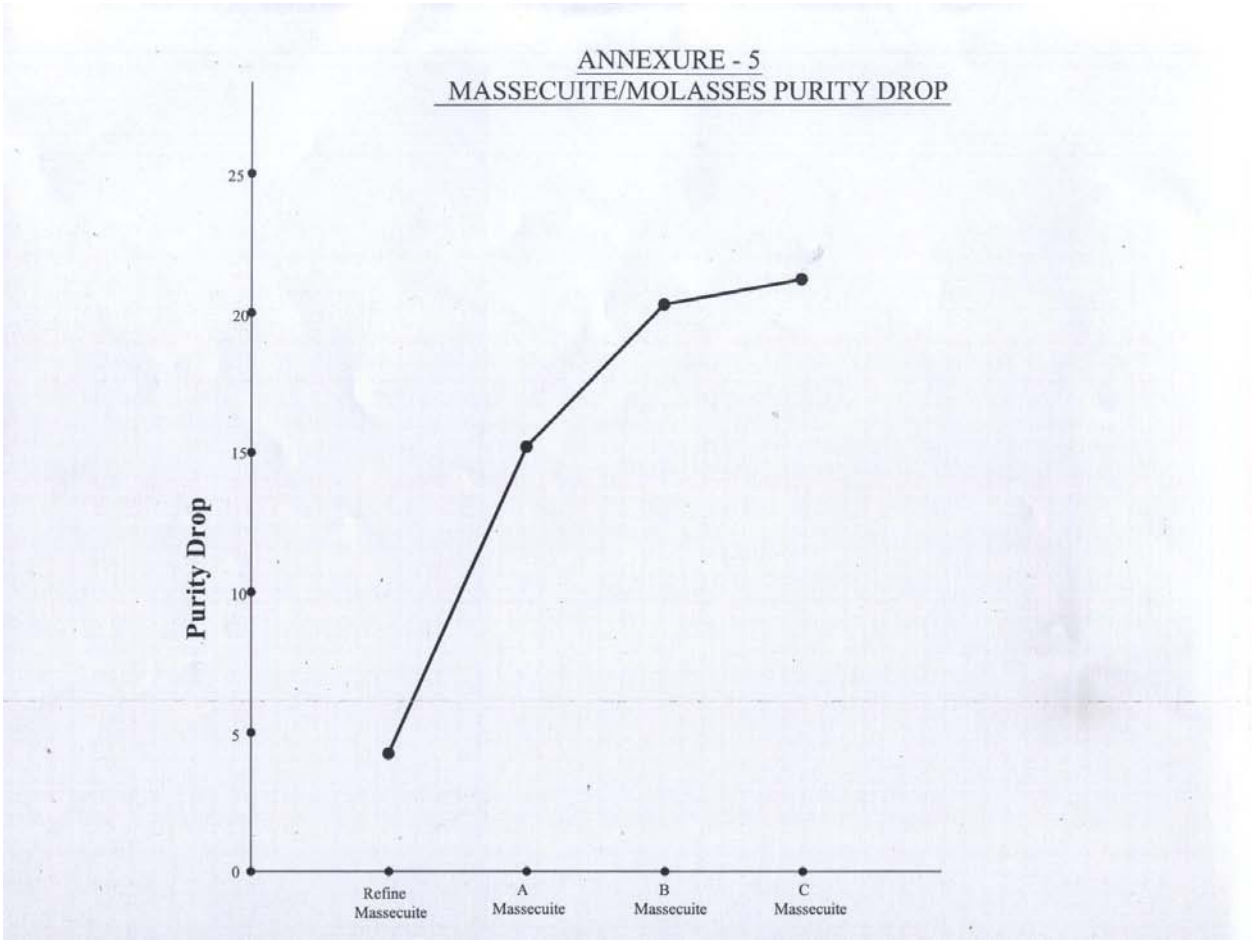

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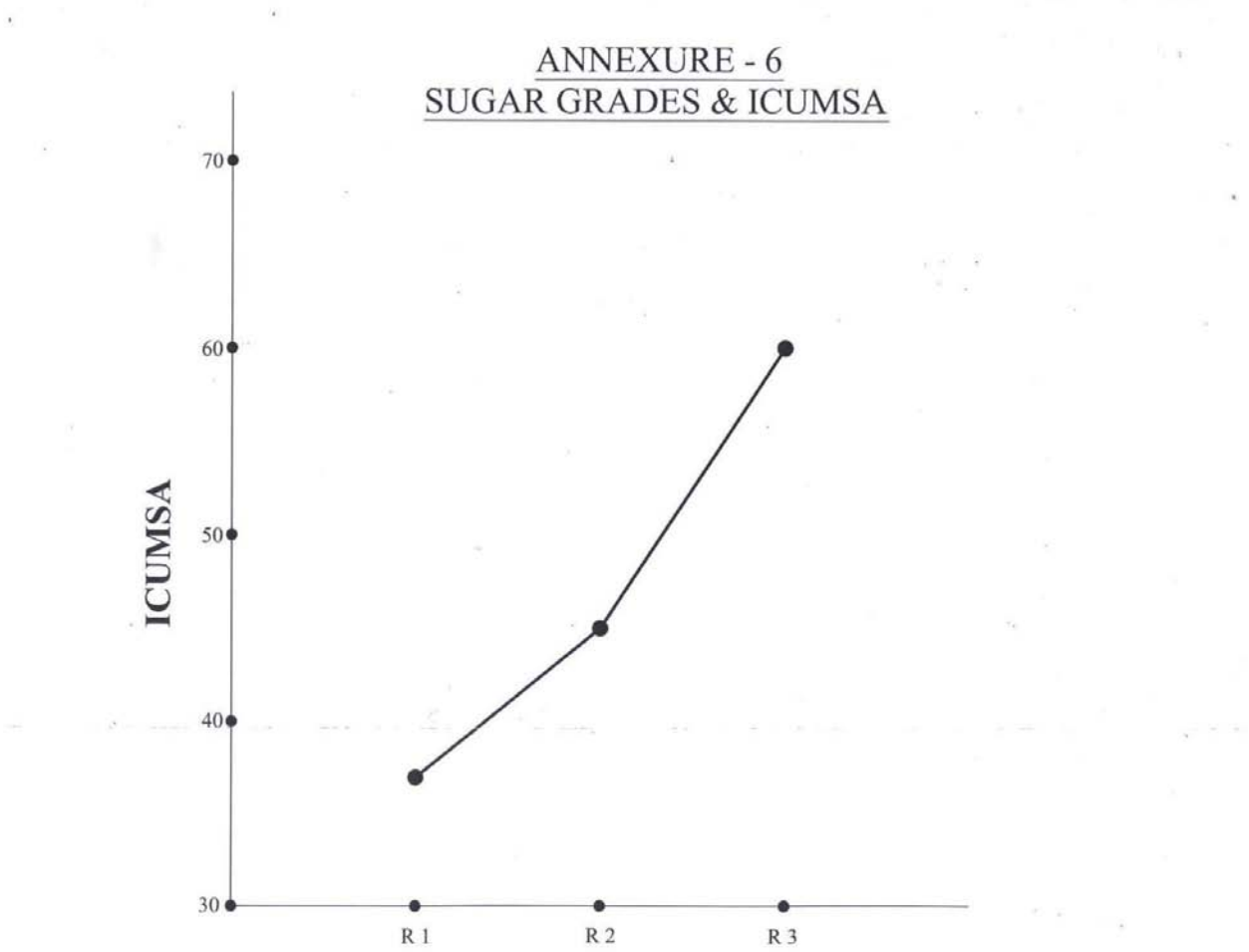

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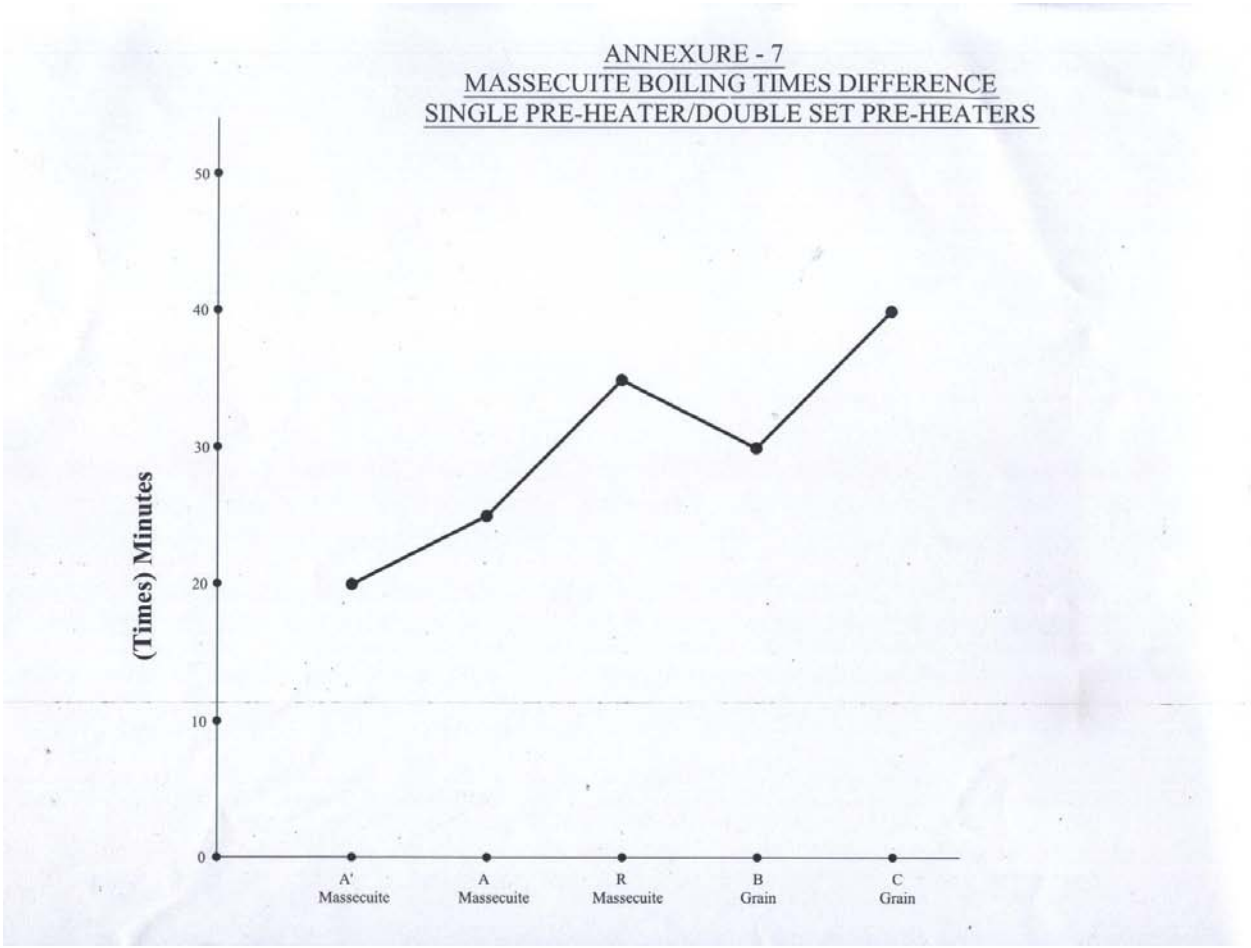

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T H A N K S