Modification In NCG Removal & Clandria Equalizing System To Improve Continuous Pan Efficiency

(A Case Study At Mirpurkhas Sugar Mills)

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ABSTRACT

The function of vacuum pan is to initiate the process of crystallization in sugar mother liquor under vacuum. The crystallization in vacuum pans involves simultaneously two processes i.e. mass transfer and evaporation. The process is carried out in both batch and continuous system.

The pan design should be such that it efficiently meets the requirement of energy conservation, better mass transfer (exhaustion) and improved circulation.

This presentation covers the basic requirements of better design of continuous pan which includes circulation ratio, hydrostatic head, heating surface to volume ratio, graining volume ratio etc.

Further advantages of continuous pans over batch pans are also discussed. The factors which influence operation of vacuum pans have also been identified.

To improve the evaporation, heat transfer and mass transfer, the very important parameter is the proper distribution of mass/vapor in the calandria. This factor is specially significant while operating pans on low steam/vapor pressure.

This paper is a case study regarding the improving upon in operation of continuous pan in Mirpurkhas Sugar Mills. We observed that boiling in central chambers of continuous pans was sluggish. After detailed monitoring of pans operation, it was found that it was mainly due to the fact that the non-condensable gases were not removed efficiently and calandria is not properly equalized and vapors do not reach to the farthest point from the steam entry.

Some modifications were done in the non-condensable gases removal and equalizing system of calandria. This modification has resulted in improved boiling efficiency in pan and we achieved optimum utilization of the capacity and better exhaustion of the mother liquor.

INTRODUCTION

Mirpurkhas sugar mills was came in operation during season 1965 initially its capacity was of 1500 TCD. Time to time steps were taken, Alhamdulillah now its running on 7200 TCD with appropriate results.

First continuous pan was installed in MSM in the year 1985. supplied by Fletcher and Stewart Ltd England used for C-massecuite duty. later converted it for A-boiling in the year 2010.. Before conversion from C- to A, Two CVPs were added for B and C masscuite boiling of 102 M3 each capacity, in the year 2006 and 2010 respectively.

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This modification has resulted in improved boiling efficiency in pan and we achieved optimum utilization of the capacity with better exhaustion of the mother liquor.

The pan design should be such that it efficiently meets the requirement of energy conservation, better mass transfer (exhaustion) and improved circulation.

This presentation covers and reviews some basic parameters and requirements for good design continuous pan which includes:

1. Advantages of continuous pan over batch pans.
2. Strike level, Hydro static head.

3. Circulation ratio, Need of circulation.
4. Heating surface to volume ratio.
5. Graining volume / ratio.
6. NCG quantity and removal.
7. Steam distribution in Calandria, NCG removal system of continuous pan in MSM
8. Modification done in MSM
9. Benefits achieved in MSM.

Advantages of continuous pan over batch pans.

Good circulation with well exhausted massecuite of higher dry solid content resulting improved raw sugar recovery.

- Enhanced efficiency due to minimal vapors consumption and the ability to use low pressure vapors.
- Minimum supervision requirement.
- Narrow size distribution in the crystal product so that good purging performance and the extent of sugar dissolution by washing is reduced.
- Uniformnes in the composition of the product massecuite.
- Large increase in crystal mean size from seed to massecuite.
- Down time for striking and steaming out is saved, this improves the volumetric efficiency, approximately 1.8 times that of batch pan ,hence cost effective. (P. Rein 1992)
- High productivity due to high crystal growth rates without the formation of fine grain.
- Maximum temperature reached by the massecuite considerably lower.
- No risk of re-melting crystal and possibility of feeding the pan with syrup and molasses, only slightly under saturated.

- Significant reduction in the color, about 16% lesser than massecuite produced in batch pan. (P.Rein 1982)
- Sharp and regular crystallization.

Only the encrustation is the disadvantage. That does occur and breaks in layers, after some days of operation. But Saving in time for the strike.

Some Basic factors for good design conti. pan

A. STRIKE LEVEL / HYDRO STATIC HEAD.

- The maximum level of massecuite above the top tube plate, to avoid resolution of crystals.
- As the masscuite level increases, the hydrostatic pressure on the masscuite increases as a result available temperature difference between vapor in the calandria and masscuite becomes smaller reducing evaporation rate and masscuite circulation. Specially at the end of the strike or in 12th chamber of continuous pans.(P.Rein)

Lower height helps to promote, a strong circulation rolling action of massecuite from above the calandria into the down takes.

- Level must be as small as possible to prevent excessive hydrostatic head and hence boiling point elevation.
- For maximum evaporation In batch pan level must not to exceed 1.8 M to be maintained 1.5-1.6 M for natural circulation. With mechanical circulation 1.8 to 2.0 M. (Tippens 1972)
- For continuous pans masscuite level to be kept 0.55-0.6, 0.4- 0.5, and 0.35- 0.4 M respectively for A/B/C boiling at 98 kPa calanderia pressure. (Broad foot 2005)
- SRI measured velocity across the width of the down take of continuous pan using a hot film anemometer was typically 0.07 m/s to 0.12 m/s. If the level is about 0.4 M above the top tube plate.

B. B.CIRCULATION RATIO / NEED OF CIRCULATION.

Most important parameter and fundamental to design, is to produce a strong circulation.

- Natural Circulation is promoted by the bubbles of vapour due to heating in the tube these bubbles tend to rise, growing as they do so, and agitate the mass and lift it towards the surface. If heating is stopped, circulation also ceases.
- Heat transfer is strongly inter related with masscuite velocity of circulation, faster the heat transfer rate the more vapor is generated and the better circulation.
- The circulation ratio is the total tube cross sectional area to down take cross sectional area, for adequate circulation ratio is 1.5 -2.0 i.e. between 1.5 and 2.5 for good circulation(Peter Rein 1999).
- Difficult to measure massecuite circulation in a pan directly but heat transfer rate can be used to gauge the degree of circulation achieved.
- Average values of heat transfer co-efficient is about 413, 212 and 115 W/ m^2 ºk for "A" "B" and "C" continuous pan respectively, with bled vapor boiling.
- Strong circulation movement allows for tighter control on the operating super saturation and production of massecuite at high brix hence exhaustion performance improve.
- Heating steam pressure, vacuum and purities raise the evaporation rate while longer tube, higher strike level, high brix and viscosity reduces it.
- Formulae for specific Rate of evaporation Kg(h.m2) calculation as for A masscuite= $0.28.\Delta t$ ºC+11.3, for B= $0.06.\Delta t$ºC+5.6 for C =$0.48.\Delta t$ºC-19.1 (Msimanga & P.Rein)
- Bosworth (1959) indicates the following mean circulation velocities without circulator.
- **Refine massecuite** 20 cm/s (8 in/s)

- **A massecuite** 10 cm/s (4 in/s)
- **B massecuite** 4 cm/s (1.6 in/s)
- **C massecuite** 2 cm/s (0.8 in/s)
- With Mechanical circulators good heat transfer is achieved with lower temperature difference, also increase circulation in order to reduce the boiling time, a reduction in sugar color and an increase in pan yield.
- Steam assisted circulation (jigger steam) increase rate of heat transfer hence increase in circulation and enables to boil at higher strike height also reduce boiling time.

C. HEATING SURFACE TO VOLUME RATIO: (S/V ratio)

- Another important factor for pan design is Area per unit volume , sometimes referred to as "specific surface"
- The exchange area is normally around 6 m^2/m^3, but for high strike grades, where evaporation rates are higher, it can be increased to 9 m^2/m^3 (van der Poel et al., 1998).
- S/V Ratio depends upon
- (a) Steam used for heating
- (b) Massecuite to be handled

RATIO OF HEATING SURFACE TO VOLUME By Austmeyer (Table 1)

Type of H.S	**Steam used °C**	**Steam pressure** (Kpa abs.)	**Optimum S/V ratio** (m^2 / m^3)
Batch Pan Calandria	Exhaust (120-125)	190-200	4.9 – 6.6

Batch Pan Calandria	Bled Vapor (110-112)	135-145	6.6 – 7.2
Continuous pan Calandria	Bled vapor (98-102)	90- 100	8 – 10

D. GRAINING VOLUME RATIO:

- Level of pan up to the tube plate, for the minimum volume of strike.
- The graining volume ratio (for batch pan) is the volume of grain contained in the calandria upper tube plate to the total volume of pan at strike. It should be as small as possible to limit the number of cuttings required to achieve the desire grain size and in order to permit the maximum exhaustion with minimum volume.
- In batch pans necessary to cover entirely pan calandria before steam is turned on. Otherwise, the ebullition would through sugar solution on the exposed portions of heated metal; this would cause losses by caramelisation and would increase the color of sugar.
- Preferable not to exceed 30 -35 % the graining volume, or 40 % as an extreme value.(varies due to seed crystal size and required masscuite crystal size).

E.NCG QUANTITY AND REMOVAL.

- A gas from condensation/evaporation that is not easily condensed by cooling; consists mostly of nitrogen, light hydrocarbons, carbon dioxide, or other gaseous materials
- When state (liquid to vapour) changes takes place in boiler water, non condensable gases are released and carried with the steam into the plant. Steam releases the latent heat to the process and condense down

to condensate in the heating area but the non condensable gas do not condense.

- Air and non-condensable gases can reduce the heat transfer efficiencies by 21% are more depending on the air concentration.(W.P.Rein)
- Incondensable quantity is estimated as about 100 mg/kg of steam. Thus quantity of NCG to be vented is about 1% of the steam flow at the calandria. (webre).
- Now a days More effective use of the incondensable gases from the calandria to the base of the pan for jigging. (Vermeulen and Pillay, 2000).

A/B/C CONTI: PAN Specification of MSM			
Parameter	**A conti**	**B conti.**	**C conti**
Total length	13.80 M	14.57 M	14.5 M
Total width	4.3 M	4.83 M	4.83 M
No of compartment	12	12	12
Tube Dia	0.101 M	0.101 M	0.101 M
Tube length	1.22 M	1.34 M	1.32 M
No of tube/chamber	142	185	185
Tube to tube center	120MM	120MM	120MM

Vapor in pipe line	500MM	300MM	300MM
Vapor out line	900MM	1000MM	950MM
NCG(before modification)	50MM*2=8	50MM*2=8	50MM*2=8
NCG(after modification)	25MM*3=12	25MM*3=12	25MM*3=12
Total no of Tube	1697	2216	2220
Heating Surface	657m²	942m²	930m²

F. STEAM DISTRIBUTION IN CALANDRIA AND PROBLEM FACED IN MSM.

To ameliorate the evaporation, heat convey and mass transfer, the another important parameter is the balanced distribution of mass/vapor in the calandria, specially significant while operating pans on low steam/vapor pressure.

It had been noticed that boiling in A/B/C-continuous pan is not what it should be, especially in central chamber. particularly in A-Conti pan. Steam pressure, condensate removal, leakages, vacuum and other parameters were checked. Vapor line Dia of A-Conti pan was changed from 0.3 M to 0.5 M due to shifting from C-masscuite to A-masscuite duty. This change gave some positive results but still boiling of central chamber was not up to the mark, Consequently it was decided to modify NCG removal system.

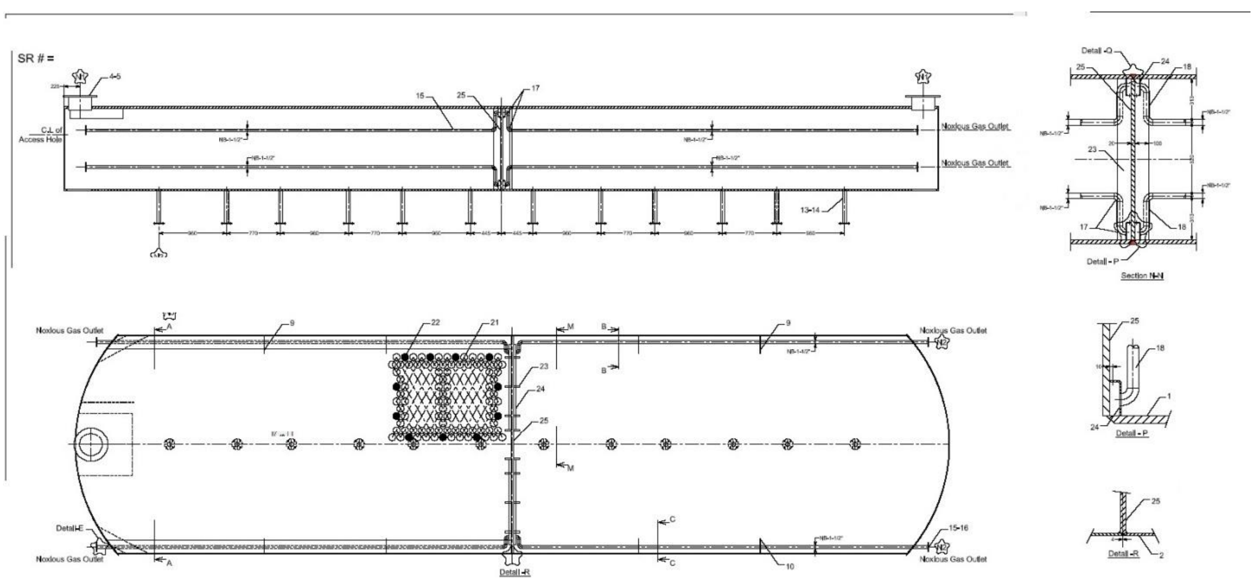
	Before Modification		After Modification	
Material	Brix	Purity	Brix	Purity
A-Massicute	94.3 0	83.41	95.10	83.52
B-Massicute	97.8 5	69.77	98.10	68.92
A-H	78.98	66.95	79.91	66.17
B-H	85.70	46.90	86.59	46.40
A-Sugar	98.30	98.32	98.34	98.37
B-Sugar	89.72	92.80	89.85	92.95

Modification done in MSM

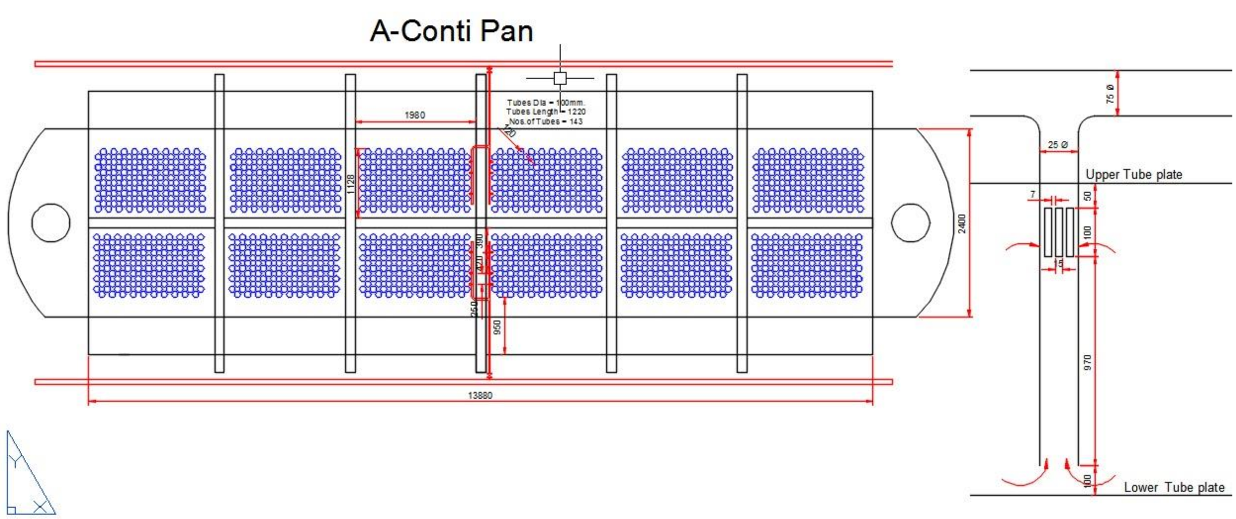
After long time operation NCG venting out pipe lines become corroded and weak, can short circuits, or if not properly designed for NCG removal. It is difficult to see and observe what is the actual condition. No technologist want to cut calanderia shell to see what's happening inside it, hence problem could be faced in down efficiency of pan. So from the farthest point (near chamber no. 3,4 and 9,10) of steam entrance new holes for NCG removal were drilled each 25 mm and three in each cell with 75mm outlet pipe connected with these 25mm pipe, further connected with equalizing lines. (As shown in pics and drawings).

This was decisive, that brought betterment in pan boiling and a couple of advantages attained.

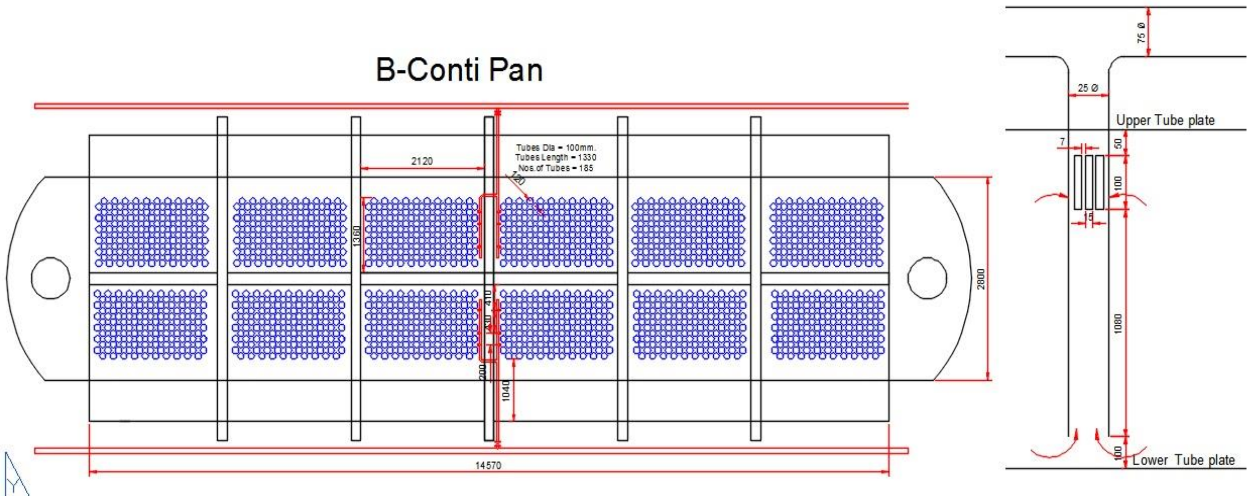
B/C Conti Pan Original Drawing



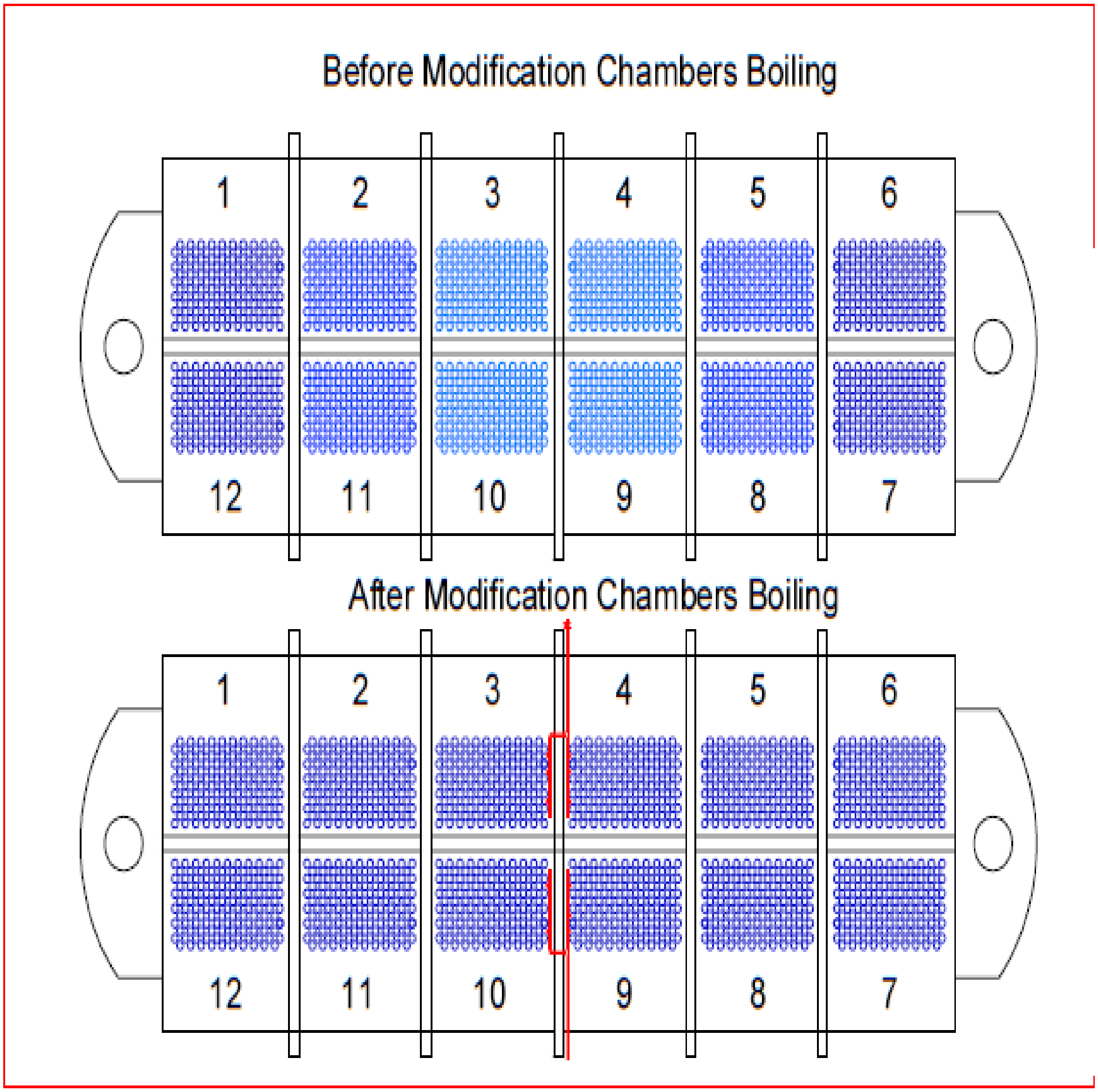
A-Conti pan Calandria After Modification



B-Conti pan Calandria After Modification



Before and After Modification Central Chambers oiling



Calandria Marked for Holes

Calandria being Drilled

Calandria after Drilling

Calandria after new NCG Connections

Advantages of Modification coming out from this modification

- Extremely uniform distribution of steam over the entire calandria,hence 20-25% better utilization of Heating area.

- Implicit and effective non condensable gasses elimination.
- Almost equal and Good circulation in all cells, that made possible to use vapors at lower pressure and thus reduces some steam consumption.
- Additional exhaustion achieved.(As in table 3).
- More uniform crystals and quality of massecuite.
- An improvement in sugar color, although small was noticeable and the operators were able to reduce the wash water on centrifugal .(As in table 3).
- Before modification A. CVP was handling 57 t/hr masscuite after that 66+ t/hr.
- Brixes of A/B massecuite meliorate, hence better exhaustion, purity drops, grain size of massecuite and sugar color were achieved (as shown in table 3).
- Substantial Increase in evaporation rate in both A/B continuous pan. (as shown in table 3)
- B/C CVP were already able to handle exiting crushing rate but their performance improved. In future they can able to handle more crushing rate. (as shown in tab 3).
- Going to modify C-continuous pan this year.

Conclusion

Number of factors which influence the operation of pans discussed. NCG removal is one of the most important factor effecting performance. Adequate arrangements for the removal of condensate and incondensable gases must be made. It is crucial and vital that these details are given proper attention, as they can be the cause of under-performance if not properly evaluated and designed. Few comparatively small changes can be made to boost capacity and performance as did in MSM.

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REFERENCE

1. Energy Efficient design and operation of continuous pan : (*Broad foot 1999*).
2. Advantage of continuous pan (*Journet G. 1994*)
3. Heating surface arrangement and circulation in vacuum pan. (*Jekins , G.H, 1958*)
4. Heat transfer during sugar boiling (*International sugar journal*).
5. Performance of continuous low grade pan.. (*Broadfoot .R, Millser K.F. Mclean SASTA 1983*)
6. Cane sugar Engineering (Pet*er Rein 2006*)
7. Circulation in Vacuum pan.. (*P.Rein, Lius E. F.cheverri*)
8. Working of FCB continuous pan in south Africa (*Graham & Radford 1997*)
9. Hand Book of cane sugar Engineering..(E.Hugot…)