**DECANTER SYSTEM FOR TREATMENT OF CLARIFIER UNDERFLOW MUDDY JUICE AT DAUND SUGAR PVT. LTD., DAUND (M.S.)**

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## Abstract:

Improvements in most of the technologies represent small but significant advantages, and it is necessary to look for additional ways by which revenue can be squeezed from the sugar crop. Decanter system is one of such technologies used in sugar industries for de-sugarization of juice clarifier underflow muddy juice.

Decanter technology has successfully proved its performance in all respect at many sugar factories in India. In the crushing season of 2014-15 at Daund Sugar Ltd., Daund, “Suviron” has installed and successfully commissioned fully automatic decanter system using 5 nos. decanters provided with BCC automation. Obtained parameters and results were quiet encouraging which are discussed in this article.



## Key word:

Decanter, rotary vacuum filter**,** juice clarifier underflow muddy juice, centrate, flocculent.


## Analytical method used data collection:

| | |
|---|---|
| Method GS7 – 7 | The Determination of the Pol content of Filter cake and Reject Cake |
| Method GS7 – 9 | The Determination of Moisture content of filter cake and Reject cake by Oven Drying |
| Method GS7 – 11 | The Determination of the mud solids in juice, clarifier underflow muddy juice, Filter cake and Reject cake by Gravimetric method |
| Method GS7 – 13 (1994) | The Determination of the mud solids in juice, clarifier underflow muddy juice, Filter cake and Reject cake by filtration method |

## Introduction:

Daund Sugar Pvt.Ltd; is a sugar complex commissioned in the season 2009 with initial capacity of 3500 TCD. Subsequent to expansion of plant during the year 2014 the expanded plant capacity is increased to 6000 TCD with 18 MW power co-generation and 90 KLPD distillery. The new technologies like, AC-VFD drive for mill with cascade system, high pressure boilers, modern steam saving devices like flash heat recovery system, DCH, continuous pans, batch pans with circulator, hot condensate for sugar drying, condensate polishing unit, efficient ETP plant etc. are installed and all are working satisfactorily.

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To increase the economical viability of co-generation project, saving of steam is of vital importance. In view of achieving bagasse saving and to reduce the losses of sugar through filter cake the factory decided to install fully automatic decanter for clarifier underflow muddy juice treatment. Accordingly total decanter system having capacity suitable for 6000 TCD with five numbers decanter machines are installed by discarding existing 1 no. RVF. Out of these five machines two nos. are for 1$^{st}$ stage, two nos. for 2$^{nd}$ stage and one no. as a common standby for 1$^{st}$ or as 2$^{nd}$ stage operation. The supply, erection & commissioning of the total decanter system was completed in October 2014. During the season 2014 – 15 factory has crushed 887000 Tons of cane producing 103900 Tons of sugar having recovery 11.70 and exporting 4,60,48,000 KWH of electric power to state grid.

In the second season of decanter installation, as on today factory has crushed _______ tons of cane producing ___________ tons of sugar.

**Photograph of Decanter system**

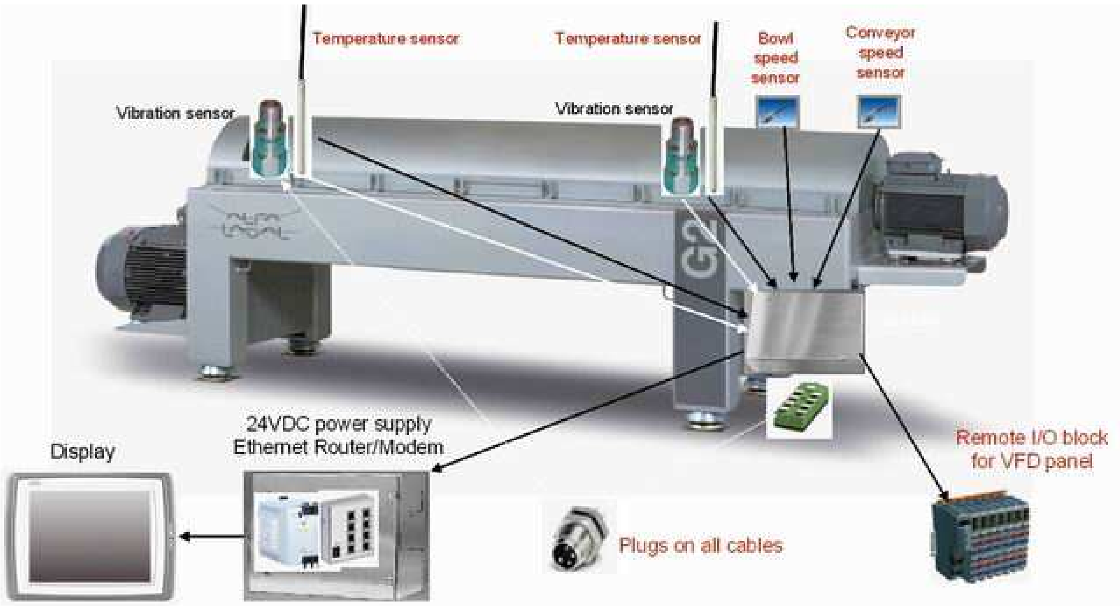
**List of equipments comprising total decanter system for 6000 TCD**

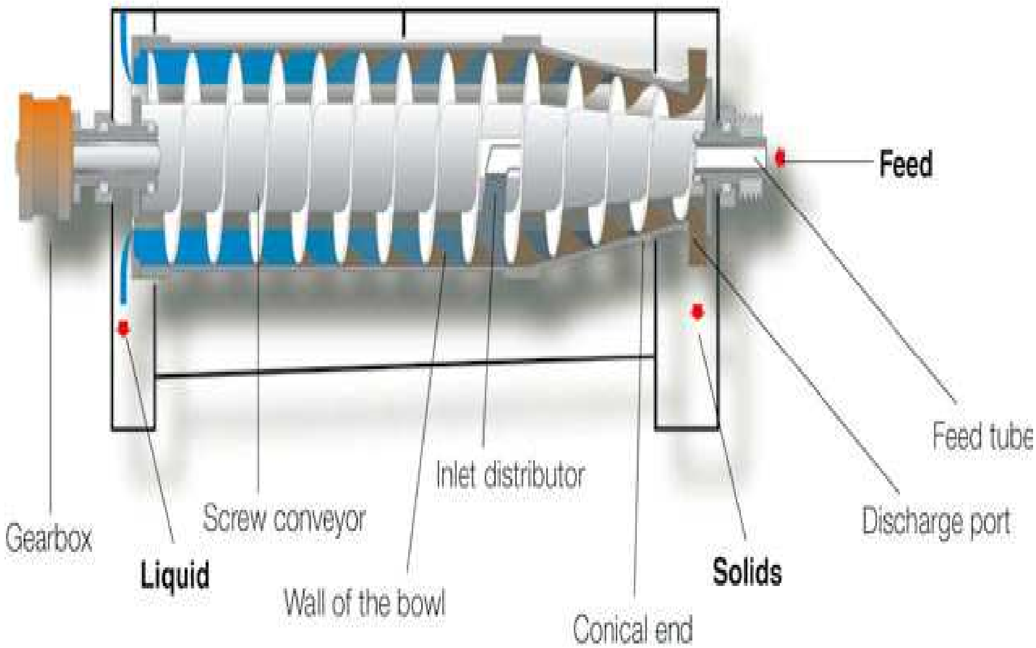
| Sr. no. | Name of equipment | Quantity |
|---|---|---|
| 1 | 1st stage Mud receiving tank | 01 No. |
| 2 | 1st Stage muddy juice transfer pumps | 03 Nos. |
| 3 | Polymer preparation and storage tank | 02 Nos. |
| 4 | Polymer dosing pumps | 06 Nos. |
| 5 | 1st stage Decanter machine<br>Sugar Dec 400 with BCC automation | 02 No. |
| 6 | 2nd stage Mud receiving tank | 01 No. |
| 7 | 2nd Stage mud slurry conditioner | 01 No. |
| 8 | 2nd Stage mud slurry transfer pumps | 03 Nos. |
| 9 | 2nd stage Decanter machine<br>Sugar Dec 400 with BCC automation | 02 Nos. |
| 10 | Centrate I flotation clarifier | 01 No |
| 11 | Centrate I receiving tank | 01 No |
| 12 | Centrate I transfer pump | 02 Nos. |
| 13 | Centrate II receiving tank | 01 No. |
| 14 | Centrate II transfer pumps | 02 Nos. |
| 15 | Decanter machine - Standby | 01 No. |
| 16 | Process automation and electrical | 1 set |
| 17 | Cake conveying system | 01 No. |
| 18 | Cake discharge bin | 01 No. |

**Specification of Decanter machine**

| | | |
|---|---|---|
| 1 | Model | Sugar Dec 400 with BCC |
| 2 | Bowl diameter | 450 mm |
| 3 | Operating main speed | 3250 rpm |
| 4 | G- Force at operating speed | 2657 G |
| 5 | Main drive | 45 kW - VFD |
| 6 | Back drive | 11 kW - VFD |
| 7 | Gear box toque | 4.5 kNm |
| 8 | Differential speed | Upto 27 rpm |
| 9 | Wear protection | |
| 9.1 | Bowl solid discharge | Wear bushing in tungsten carbide |
| 9.2 | Bowl feed zone | Tungsten carbide wear tiles |
| 9.3 | Conveyor feed zone | Tungsten carbide wear liners |

**Decanter machine with BCC automation**



**Working of decanter machine**

Insoluble solid and liquid separation is carried out in a bowl fitted with inside screw conveyor. The muddy juice i.e. feed enters into the decanter through a stationary tube where it is accelerated before discharge through openings in the feed chamber into the separating pool of the bowl. The bowl rotates at high speed and due to the high G force solids being higher in density get separated from the low density liquid to accumulate against the rotating bowl wall, while the less density liquid phase forms a concentric inner layer. The screw conveyor rotate at a slightly different speed (**differential speed**) to the bowl, with a small clearance between screw and bowl, screw conveys these separated suspended solids towards the solids outlet of decanter. The liquid is also discharged from outlet port located at other end. The part of the centrifuge where this solid/liquid separation process takes place is known as the clarifying zone.

**Two stage operation of total decanter system :**

**A) First stage operation**

Clarifier underflow i.e. muddy juice from conventional 4-4-4 clarifier is taken to first stage muddy juice receiving tank provided with stirrer to homogenously mix the muddy juice from all 4 compartments of clarifier.

This preconditioned muddy juice is transferred to first stage Decanter centrifuge through progressive cavity pumps provided with VFD drive. Muddy juice which is going to first stage is measured and indicated by a magnetic flow meter and transmitter installed in the feed line of each machine. At muddy juice entry of decanter machine polymer solution addition connection is provided. The "Anionic" grade polymer is used for improved solid liquid separation at decanter centrifuge.

The decanter machine rotates at 3250 rpm AT "G" force of 2657 G. Machine has one inlet for muddy juice feeding mixed with online addition of polymer solution and has two outlets viz. one for liquid outlet, termed as 'centrate' and another one is for solid discharge i.e. mud cake.

The conveyor of the decanter rotates at slightly lesser speed i.e. differential speed (21 to 27 rpm) than that of the bowl which allows compacting of accumulated solids towards conical end, eventually pushing the solids from discharge ports, in the form of mud cake.

The centrate-I which is coming out from first stage decanter operation before clarification is having brix and purity as like mixed juice and insoluble solids 0.35 % which are half the solids content in mixed juice. This centrate content good amount of air which is adherent to insoluble solid is then fed to Centrate I flotation clarifier. The clear centrate coming out from centrate clarifier with negligible solid content then collected at centrate I receiving tank and pumped to juice reaction vessel. Scum generated in flotation clarifier was sent to 1$^{st}$ stage muddy juice tank.

**B) Second stage operation**

Cake solids discharged from first stage decanter is mixed with hot water in second stage mud slurry preparation tank provided with mechanical stirrer for proper mixing of mud solids with added hot water. For control and proportionate addition of hot water, control valve and magnetic flow meter is provided in hot water pipeline. Mud conditioner is provided at the outlet of second stage mud slurry dilution tank for further conditioning of mud slurry. By using progressive cavity pump this homogeneous mixture of mud slurry is pumped to second stage decanter machines. Magnetic flow meter is installed in the feed line for each machine. At mud slurry entry of decanter machine polymer solution addition connection is provided. The “Anionic” grade polymer is used for improved solid liquid separation at decanter centrifuge.

The reject cake from second stage decanter is having Pol % in the range of 1.4 to 1.6 % and moisture percentage in the range of 68 to 70 %.

Centrate generated in second stage operation is having brix 3 to 5 and purity 60 to 65 is collected in centrate-II receiving tank and two nos. centrifugal pumps are provided to transfer centrate-II always for mill imbibition. Recycling of Centrate II to mills for mill imbibition purpose is further continued in current season also because there was no any adverse effect found on Pol% bagasse. Infact there was a considerable steam economy gained by corresponding to reduction in hot imbibition water. Detailed calculations of steam economy achieved through this good practice are attached at Annexure.

## OPERATING PARAMETERS AND DATA COLLECTED DURING TWO CRUSHING SEASONS

**Operating parameters of decanter system**

| Sr. no. | Parameter | Values | | Unit |
|---|---|---|---|---|
| | | First stage | Second stage | |
| 01 | Feed flow rate Decanter machine A | 14 | 15 | $M^3$/hr. |
| 02 | Feed flow rate Decanter machine B | 14 | 15 | $M^3$/hr. |
| 03 | Polymer Quantity. Decanter machine A | 1800 | 1000 | LPH |
| 04 | Polymer Quantity. Decanter machine B | 1800 | 1000 | LPH |
| 05 | Differential speed Decanter machine A | 20 - 25 | 15 -18 | rpm |
| 06 | Differential speed Decanter machine B | 20 - 25 | 15 -18 | rpm |
| 07 | Torque Decanter machine A | 0.85 to 1.0 | 1.1 to 1.3 | kNm |
| 08 | Torque Decanter machine B | 0.91 to 1.05 | 1.05 to 1.25 | kNm |
| 09 | Main motor Current Decanter machine A | 45 | 47 | Amp |
| 10 | Main motor Current Decanter machine B | 44 | 46 | Amp |
| 11 | Back drive current Decanter machine A | 5.5 | 5.8 | Amp |
| 12 | Back drive current Decanter machine B | 4.7 | 4.5 | Amp |
| 13 | Bearing temperature MDE Decanter machine A | 82.6 | 71.9 | Deg. C |
| 14 | Bearing temperature MDE Decanter machine B | 78.9 | 67.8 | Deg. C |
| 15 | Bearing temperature BDE Decanter machine A | 73.8 | 75.7 | Deg. C |
| 16 | Bearing temperature BDE Decanter machine B | 73.8 | 75.7 | Deg. C |
| 17 | Vibration Decanter machine A | 2.4 - 4.4 | 2.0 - 4.0 | mm/sec. |
| 18 | Vibration Decanter machine B | 2.7 to 3.6 | 2.4 to 4.3 | mm/sec. |
| 19 | Main drive actual power consumed Decanter machine A | 20 | 20.5 | kW |
| 20 | Main drive actual power consumed Decanter machine B | 20 | 20.5 | kW |
| 21 | Back drive actual power consumed Decanter machine A | 0.1 | -2.4 | kW |
| 22 | Back drive actual power consumed Decanter machine B | 0.1 | -2.4 | kW |
| 23 | Bowl speed Decanter machine A (RPM) | 3250 | 3250 | rpm |
| 24 | Bowl speed Decanter machine B (RPM) | 3250 | 3250 | rpm |
| 25 | Dilution water quantity | 18 to 21 | | M3/hr. |
| 26 | Centrate I quantity | 7 - 9 | | % Cane |
| 27 | Centrate II quantity | 7.5 – 8.5 | | % Cane |
| 28 | Polymer solution concentration | 0.05 | | % |

## INSOLUBLE SOLIDS AND FIBRE ANALYSIS

60 samples were collected for analysis over a period of two crushing seasons and average of the same is tabulated below:

| Sr. no. | Sample | % of w/w solids | % of fiber |
|---|---|---|---|
| 01 | Mixed juice | 0.65 | 0.16 |
| 02 | Sulphited juice | 0.62 | 0.158 |
| 03 | Muddy juice 1 | 7.8 | 1.85 |
| 04 | Muddy juice 2 | 5.51 | 1.79 |
| 05 | Centrate 1 | 0.35 | 0.03 |
| 06 | Centrate 2 | Nil | Nil |
| 07 | Clarified centrate | Nil | Nil |
| 08 | Scum from Centrate I clarifier | 5.6 | 0.13 |

## PERFORMANCE RESULTS

| Sr. no. | Parameters | Value |
|---|---|---|
| 01 | Pol % reject cake | 1.3 to 1.6 |
| 02 | Moisture % reject cake | 67 to 70 |
| 03 | Reject cake % cane | 1.8 to 1.9 |
| 04 | Suspended / insoluble solid removal efficiency across decanter station | 92 to 94% |

## DISCUSSION

**A) Filter cake % cane before installation of decanter system and relative bagasse saving after installation of decanter system**

Quantity of filter cake during operation of RVF = 3.25 % cane
Quantity of reject cake during operation of decanter system = 1.85 % cane
Reduction in reject cake is = 1.40 % cane
From the above the reduction in cake after installation of decanter system is 1.40 % cane

Quantity of mill bagasse saved is

$$= \frac{\text{Reduction in cake x moisture of mill bagasse at last mill}}{\text{Moisture \% cake}}$$

$$= \frac{1.40 \times 48}{70}$$

Quantity of bagasse saved is 0.96 % cane.

**B) Insoluble / Suspended solid separation efficiency depends upon following operating parameters.**

1. *Rated feed flow rate:* - Suspended solid separation efficiency decreases with sudden increase in feed flow rate hence constant and rated flow is recommended for better separation efficiency.
2. *Concentration of suspended solid in muddy juice*: - If the concentration of suspended solid increase then solid loading on decanter machine increases which reduces the separation efficiency. Periodic monitoring / sampling for insoluble solid is required.
3. *Differential speed of bowl and conveyor*: - Separation efficiency varies directly proportional to the differential speed. At higher differential speed moisture content of reject is found relatively higher.
4. *Pond level inside the decanter bowl*:- Separation efficiency varies directly proportional to the pond depth. At higher pond depth moisture content of reject is relatively higher.
5. Conditioning of mud slurry feed to 2$^{nd}$ stage decanter.
6. Proportionate polymer dosage.
7. Temperature of clarifier underflow muddy juice,
8. Temperature of wash water and stabilized flow.

**C) Factors affecting Pol% reject cake**

a) Quantity, quality and temperature of wash water used
b) Use of settling polymer at juice clarifier
c) Quantity of baggase / fibre content present in muddy juice
d) Pol % cane
e) Differential speed of conveyor with respect to bowl speed
f) Pond depth of 1$^{st}$ stage as well as 2$^{nd}$ stage decanter machine.
g) Flow of clarifier underflow muddy juice / mud slurry to decanter

**D) Factors affecting moisture content of final reject cake**

i. Rated flow rate to decanter
ii. Particle size distribution of insoluble solid
iii. Porosity of insoluble solid
iv. Viscosity of liquid phase
v. Dosage of polymer solution
vi. Differential speed of bowl and conveyor of decanter.
vii. Pond depth of liquid inside the bowl of decanter.
viii. Concentration of dissolve solids in clarifier underflow muddy juice / mud slurry.

**E) Addition of centrate II on mill**

The quantity on centrate II is in the rage of 8 to 9 % cane having brix in the range of 3.5 to 4.5 and purity 55 to 65 %.

At mill tandem we are having total five mills with following details

| Sr. no. | Mill no. | Size | GRPF / TRPF |
|---|---|---|---|
| 01 | Mill No. 1 | 40 x 80 | GRPF |
| 02 | Mill No. 2 | 36 x 78 | TRPF |
| 03 | Mill No. 3 | 36 x 78 | TRPF |
| 04 | Mill No. 4 | 36 x 78 | TRPF |
| 05 | Mill No. 5 | 36 x 78 | TRPF |

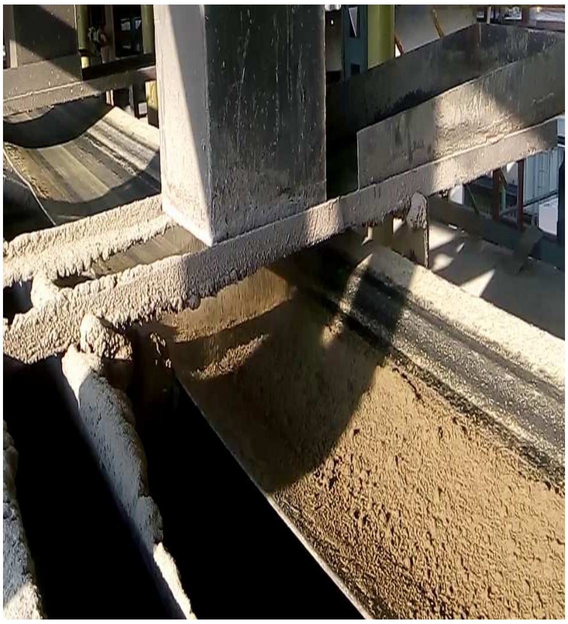
70 % Centrate II is added at the juice trough of 3$^{rd}$ mill and 30% at juice trough of fourth mill. With this combination of centrate II addition there is no any adverse effect observed on Pol % bagasse.

**F) Performance check list**

1. Decanter station shall always operate in two stages.
2. Insoluble solid removal efficiency shall be more than 92 to 94% to minimize insoluble solid recirculation through centrate juice recycling.
3. Monitoring of differential speed, feed flow rate, optimum polymer dosage, optimum quantity of wash water in order to get consistent results of Pol % reject cake and moisture % reject cake

**G) Polymer requirement**

Settling polymer required in conventional clarifier having retention time of 2 to 3 hours is normally 0.5 to 1 ppm. While at decanter where separation takes place only in a few seconds the requirement of optimum polymer dosage is established in the range of 10 to 11 ppm on cane which appears to be quite logical and negligible as against forever commercial gains achieved.



Discharge of reject cake

Scum generated at centrate I clarifier

**CONCLUSION**

1. Techno economic evaluations of the system indicate a reasonable payback period and therefore this technology will be better placed in near future.
2. With centrate II addition by adapting proper combination as described above there is no any increase in Pol% bagasse.
3. As only centrate I (around 7 to 9 % on cane) is sent back to process, there is reduction of 5 to 6 % cane juice load in the process house. Hence crushing rate can be proportionately enhanced as compared to rotary vacuum filters where combined filtrate returns to process is generally observed around 15% on cane.
4. Dry insoluble solid content in clarified centrate returns is much less (negligible) than in combined filtrate returns resulting into good reduction in solid loading factor on juice clarifier which in turn will improve solid/liquid separation efficiency at existing juice clarifier.

**ACKNOWLEDGEMENT**

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## Annexure

# Advantages of recycling centrate II to mills for mill imbibition

A) First of all, following few facts may kindly be noted,

1) 'Mills' are always designed to accept sugar cane having sugar content expressed as Pol % cane = 15.0
2) The factories having total sugar losses of more than 1.8% cane are generally not considered as a 'Healthy' or rather, as per standard accepted norms it is considered as a 'Sick' unit when total sugar losses exceed 1.8% cane. (In earlier times it was 2.5….2.2…..2.0 and now 1.8, considered as feasible/achievable as decided by the technical fraternity.)
3) Hence a sugar recovery of say 13.2 % cane (15 - 1.8) is justifiably achieved.
4) Considering average sugar recovery of say = 11.7 % cane and total sugar losses of say = 1.8 % cane, then Pol % cane works out as 13.5
5) Since mills are designed for 15 % of Pol in cane which leaves a gap of 15.00% – 13.5% = 1.5 % of Pol input to mills.
   This means the mills still have in-built potential to accept additional sugar of 1.5 % cane.

B) Pol entering in the milling station when centrate II is recycled to mills as mill imbibition.

Depending upon sugar recovery zone and decanter operational practices below mentioned figures are observed.

| | |
|---|---|
| Brix of centrate II | = 3.5 to 4.5 |
| Purity of centrate II | = 55 to 65 |
| Pol % centrate II | = 1.9 to 2.9 = 2.4 (Average for calculation) |
| Centrate II % cane | = 8.0 |

Therefore Pol in centrate II % cane = $\frac{2.4 \times 8}{100}$ = 0.192 % cane Pol goes to mills through centrate II.

This means the mills still have potential to absorb this 0.192 Pol % cane entering through centrate – II because the gap of 1.5 as mentioned above at A (5) is more than the such available allowance of 1.5 % cane i.e. by 800% !

<u>Conclusions:</u>

It can therefore be safely concluded that Mill performance with respect to Pol % bagasse does not at all gets affected after diverting centrate II to mills for 'imbibition duty'

C) Additional gains when centrate – II @ 8% cane is reused for mill imbibition.

Corresponding reduction in imbibition water by 8% cane allows additional steam economy. As per below given calculations a net additional forever gain of ₹. 77 lacs is achieved per season of 5.0 lacs tons of cane crushed.

Commercial benefits are calculated based on following considerations,

| 1.0 | **Particulars** | **Rotary Vacuum Filter** | **Decanter System** |
|---|---|---|---|
| 2.0 | Electric power Tariff | | ₹ 5.69 per kWh |
| 3.0 | Specific steam consumption of power house turbine | | 5.5 Ton per mW |
| 4.0 | Steam generation per ton of bagasse | | 2.5 Ton |

| **Additional revenue by sending Centrate II for mill imbibition** | | |
|---|---|---|
| In case of Rotary Vacuum Filter both the filtrates i.e. heavy filtrate and light filtrate are combined and sent to juice reaction vessel for further treatment. So the total quantity of filtrate normally 15% cane is recycled back to the process. | In case of decanter system for muddy juice treatment which is operated in two stages, the centrate I resulting from first stage (approximate 7% cane) is recycled to juice reaction vessel and the centrate II resulting from second stage (approximate 8% cane) is recycled to mills for mill imbibition, of course having no any adverse effect on Pol% bagasse. Hence the fresh imbibition water requirement is reduced by 8%. | Considering quintuple effect evaporator station, Steam saving % cane shall be :<br>= 8 ÷ 5<br>= 1.6 % cane, say 1.5% cane<br>= 0.015 ton of steam per Ton of Cane<br><br>Additional electricity generated<br>= (0.015 ÷ 5.5) x 1000<br>= 2.727 kWh<br><br>Additional revenue generated :<br>= 2.727 x 5.69<br>= ₹. 15.51 per Ton of Cane |
| | | **₹ 15.51** |

**Additional forever financial gain for 5 lacs tons cane = ₹15.51 x 5,00,000**
**= ₹77,55,000**

D) Practically proven facts at recent installation - Daund Sugar Ltd.

At Daund Sugar Ltd. from the very first day of commissioning centrate II is recycled to mills which is in range of 8.5 to 9 % on cane. Factory is having 5 nos. mills in a tandem.

The centrate II going to the milling station is judiciously divided into two streams.

30% of the centrate II is added in juice collection trough of fourth mill and balance 70% is added in juice collection trough of $5^{th}$ mill.

By diverting centrate II to mills factory has proportionately reduced their total fresh imbibition water requirement by 8.5 to 9% cane.

It is further confirmed that there is absolutely no any adverse effect on Pol % bagasse.

E) Disadvantages, if centrate II is recycled to clarification process.

1) Solid loading on clarification house will increase.
2) Increase in moisture and Pol content of reject cake.
3) Polymer consumption at decanter station will also get slightly increased.