TWO STAGE DECANTER SYSTEM TO PROCESS MUDDY JUICE FROM CLARIFIER*

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Abstract:
For the treatment of muddy juice from clarifier there exists technologies like rotary vacuum filter, filter press etc. There are some disadvantages of using these technologies e.g. higher sugar loss through cake, requirement of sieved bagacillo as filtering media, higher quantities of cake, less solid removal efficiency, larger footprints etc.

In chemical engineering terms the existing Rotary Vacuum Filter / filter press technology could be well described as an inefficient method of solid / liquid separation being in use for more than 80 years. The average figure of solid retention factor in the filter cake ranges between 60-70% even if best operational practice is adopted. The rest of the solids are unnecessarily re-circulated back into process causing sugar losses and seriously affecting juice clarification process.

It was therefore felt necessary to adopt such a modern but proven technology for this duty application in the sugar industry. The obvious choice therefore rests with solid bowl decanter technology which is already efficiently operating in other various industries since last 100 years allowing highest level of solid/liquid separation efficiency.

This paper highlights technical details, advantages and comparison with existing system.

Keywords:
Decanter, muddy juice, centrate, suspended solids, flocculent.

Analytical method used for data collection:
Following universally accepted ICUMSA methods were used for data collection:-

- Method GS7–11 (1994) - The determination of the mud solids in juice, mud and filter cake by a gravimetric method.
- Method GS7–13 (1994) - The determination of cane fibre in juice, mud and filter cake by a filtration method.
- Method GS7–7 (1994) - The determination of the pol (polarisation) of filter cake by polarimetry with lead subacetate.
- Method GS7–9 (1994) - The determination of moisture in filter cake by oven drying

*Global patent applied

Introduction:

The obsolete plate / frame type filter presses for full juice filtration were eventually replaced by rotary vacuum filter which long stayed in the sugar industry almost for last 80 years! inspite of various associated problems perhaps for the reason of simplicity and more importantly for the reason that no better alternative technology was then readily available.

The Solid bowl decanter technology has gained wide application in other industries like oil, dairy, chemical, water and sewage treatment etc. and is in existence for more than a century all over the world.

The growing awareness of power cogeneration for sustainable growth of sugar industry has been a major driving force to look out for alternative technologies allowing diverting more than 1.0% cane of bagasse for generation of additional electric power energy using renewable source of green fuel viz. bagasse.

Technology:

Unlike the conventional centrifugal machine used for separating sugar crystal from mother liquor either in batch or continuous where mother liquor by application of centrifugal force passes through the screen openings, the decanter although is centrifugal machine does not have any perforations over the rotating basket. The basic principle of using centrifugal force for solid/liquid separation is universally remains the same. The only difference is that the insoluble solids when subjected to centrifugal force get separated from liquid towards basket surface and are continuously pushed towards discharge end by a rotating helical scroll. The cake is continuously discharged through discharge ports fitted with tungsten carbide bushings. The decanted juice is continuously taken out through a concentric opening.

Figure no.1&2:- Details of solid bowl decanter centrifugal machine (i.e. decanter)

Wear and tear protection - a special feature

At all our installations we have given a special consideration with a major thrust on wear and tear protection at critical places and have therefore exercised utmost care by providing wear and tear protection at following places which has practically proved its importance by having achieved enhanced service life of decanter machine,

a. Tungsten Carbide Tiles weld-fitted on conveyor leading flights (Fig. No. 3)
b. Tungsten Carbide bushing (wear liners) at feed zone (Fig. No. 4)
c. Tungsten Carbide bushing inserts at solid outlet ports (Fig. No. 5)

Figure no. 1 – Cut view of decanter machine.

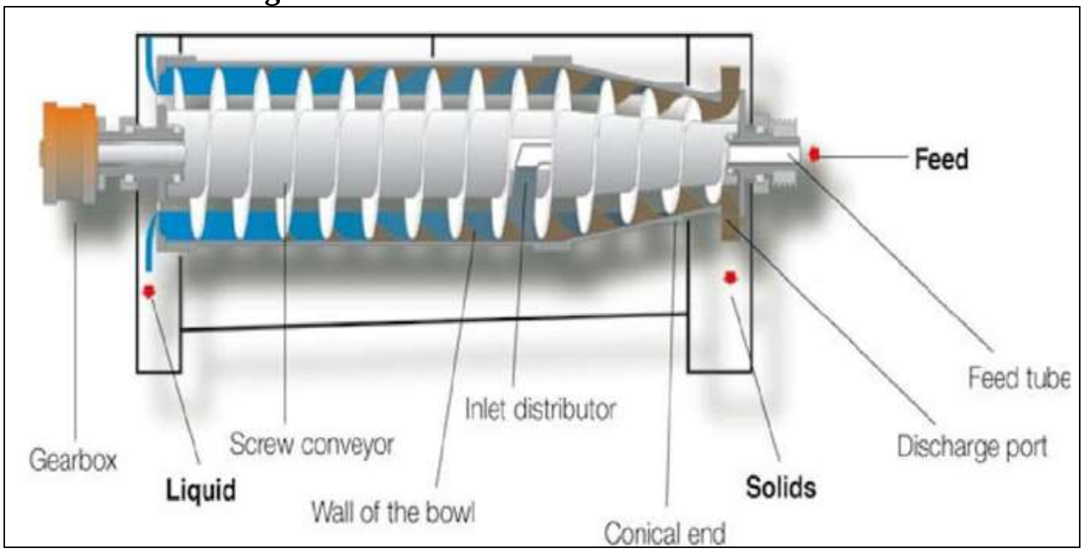


Figure no. 2 –Decanter machine.

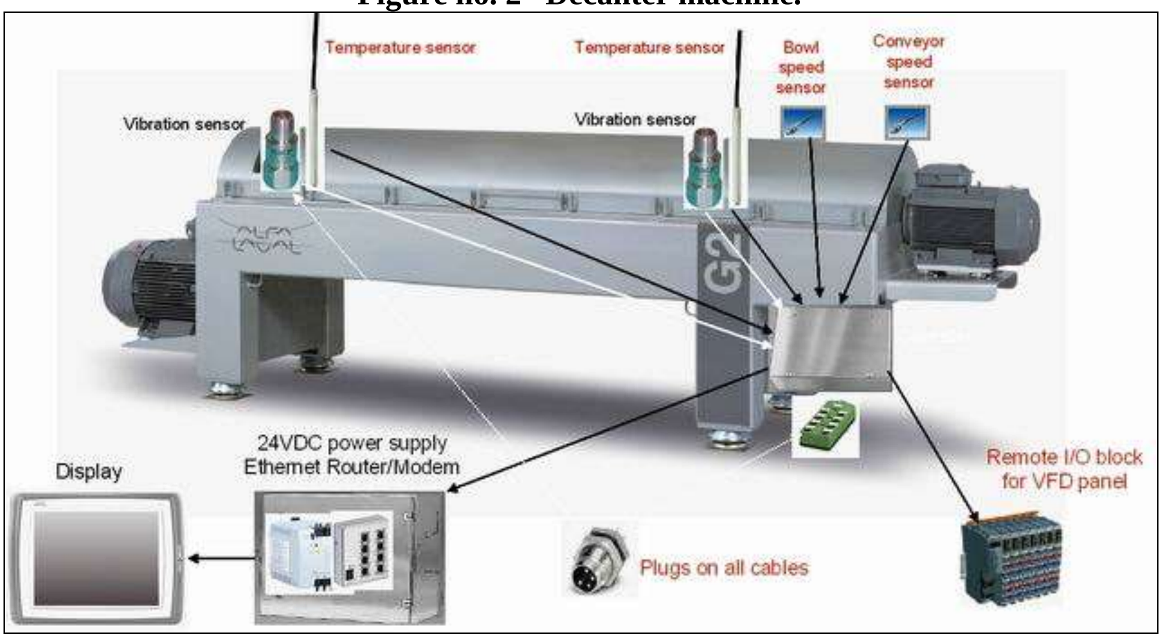


Figure no. 3 – Wear protection on conveyor leading flights.

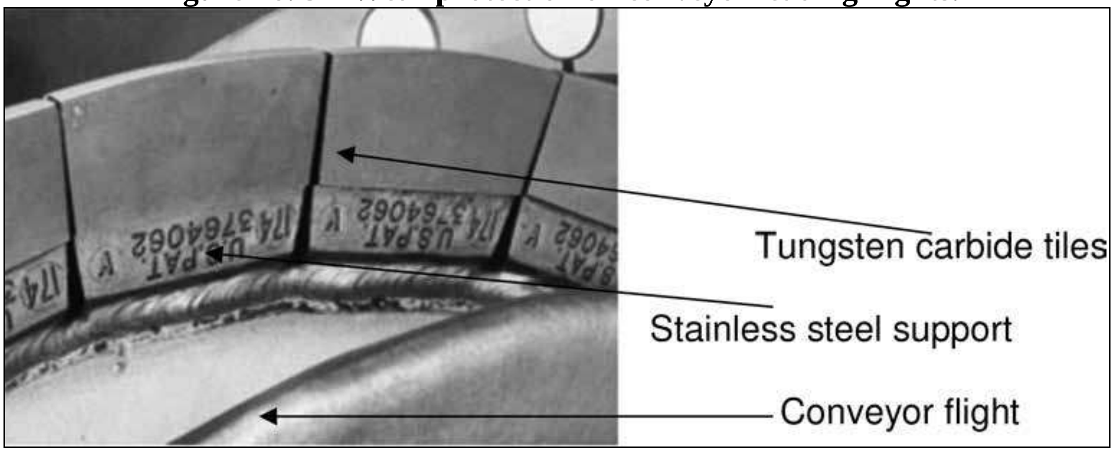


Figure no. 4 – Wear protection at feed zone.

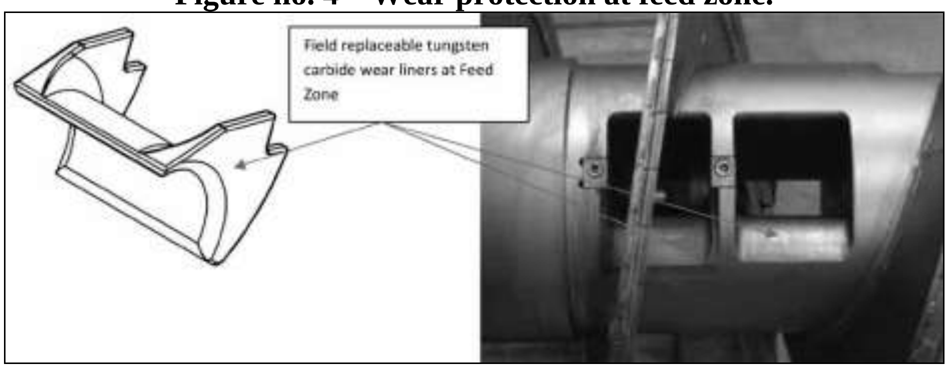


Figure no. 5 – Wear protection at solid outlet ports.

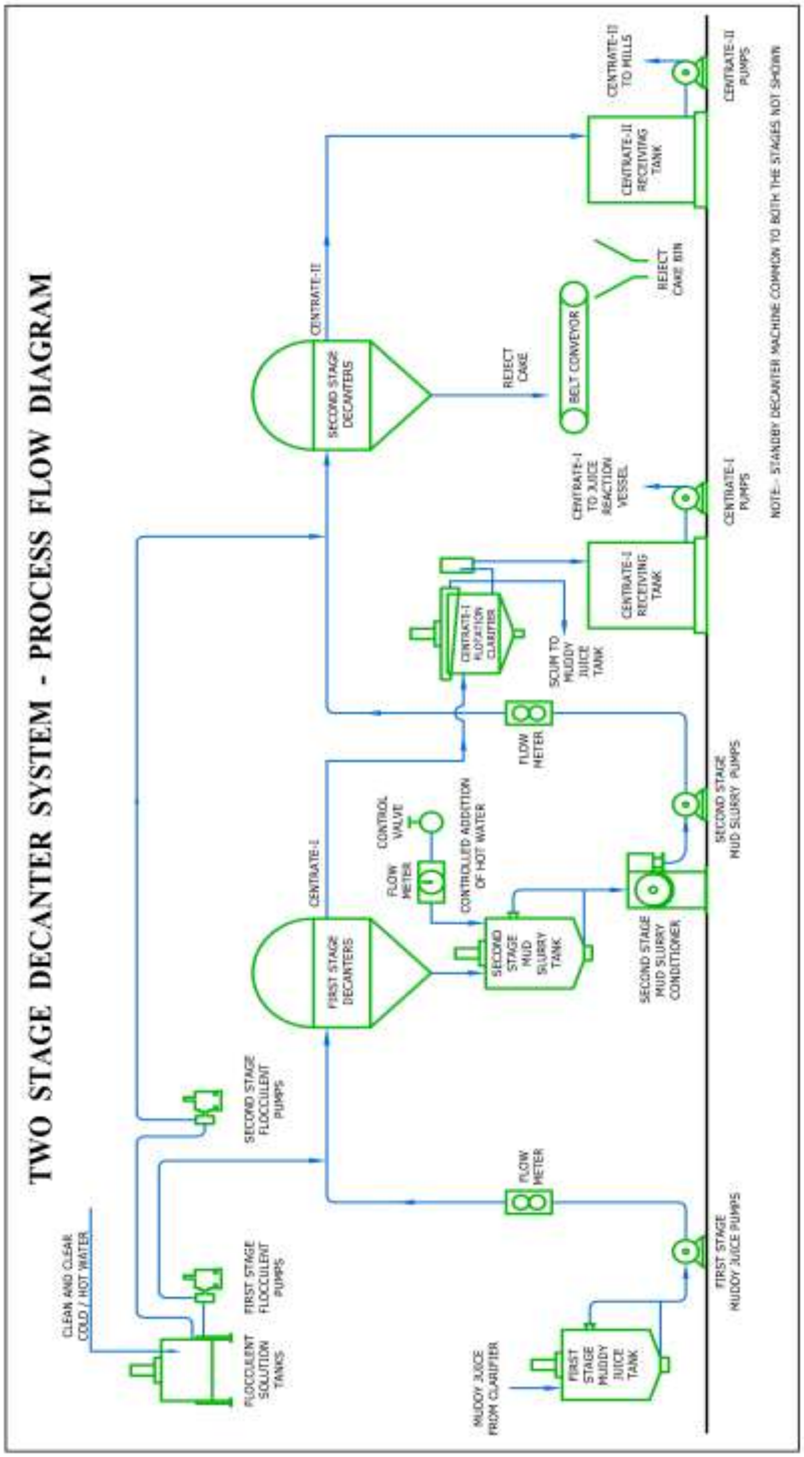
Equipment list: (Fig. No. 6 shows various equipments of the system and also the process flow)

- 1st stage Mud receiving tank
- 1st Stage muddy juice transfer pumps
- Polymer preparation and storage tank
- Polymer dosing pumps
- 1st stage Decanter machine (Sugar Dec 400 with BCC automation)
- 2nd stage Mud receiving tank
- 2nd Stage mud slurry conditioner
- 2nd Stage mud slurry transfer pumps
- 2nd stage Decanter machine (Sugar Dec 400 with BCC automation)
- Centrate I flotation clarifier
- Centrate I receiving tank
- Centrate I transfer pump
- Centrate II receiving tank
- Centrate II transfer pumps
- Decanter machine – Standby (Sugar Dec 400 with BCC automation)
- Reject Cake conveying system
- Reject Cake discharge bin
- Process automation and electrical

Specification of decanter:

Particular	Unit	Data
Flow configuration		Counter-current
Maximum design temperature	°C	100
Maximum operating speed	r/min	3250
Centrifugal G force	G	2675
Bowl diameter	mm	450
Bowl length	mm	1910
Liquid outlet type		4 plate dams
Liquid outlet radius	mm	Adjustable 131 to 134
Solid outlet type		10 bushing
Main drive motor	kW	45 with VFD
Back drive motor	kW	11 with VFD
Control panel		Basic core controller

Two stage operation of total decanter system:
Figure no. 6 – Process flow diagram.



First stage operation:

Muddy juice from existing clarifier is taken to first stage muddy juice receiving tank provided with stirrer to homogenously mix the muddy juice. This preconditioned muddy juice is transferred to first stage Decanter centrifuge through progressive cavity pumps provided with VFD. 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 decanter. At muddy juice entry of decanter polymer solution addition connection is provided. The “Anionic” grade polymer is used for improved solid liquid separation at decanter centrifuge.

The decanter rotates at 3250 rpm AT “G” force of 2657 G. Decanter 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 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. This centrate contains 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 is then collected at centrate I receiving tank and pumped to juice reaction vessel. Scum generated in flotation clarifier is sent to 1^{st} stage muddy juice tank.

Role of differential speed and pond depth:

For the first-stage operation differential speed is kept at 20-25 rpm and pond depth (liquid outlet radius) is kept as 131 mm or 132 mm. This result in a clear centrate and wetter cake; a desirable parameters for the first-stage operation.

Second stage operation:

Cake solids discharged from first stage decanter are 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 decanters. Magnetic flow meter is installed in the feed line for each machine. At mud slurry entry of decanter 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 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 for mill imbibition. After recycling of Centrate II to mills for mill imbibition purpose there is no any adverse effect on Pol% bagasse. In fact there is a considerable steam economy gained corresponding to reduction in hot imbibition water.

Role of differential speed and pond depth:
In the second stage operation differential speed is kept at 15-18 rpm and pond depth (liquid outlet radius) is kept as 133 mm or 134 mm. This results in dryer cake formation which is a desirable parameter for the second-stage operation.

Data collection at various installations:
Detailed analysis was conducted at decanter installations of **8** sugar factories with respect to various operating parameters and following table shows average of the analytical results for the period ranging from 1 to 6 crushing season as per the year of installation of individual decanter system at respective sugar factories.

Name of Factory	% Fibre Solids in muddy juice	% Mud Solids in muddy juice	Muddy juice % cane	Pol % reject cake	Moisture % reject cake	Solid removal efficiency percentage
Gangakhed Sugars	2.26	8.38	8 - 9	1.4 - 1.8	67 to 70	92 to 93
Olam (Hemarus)	2.14	8.24	8 - 9	1.3 - 1.7	68 to 71	94 to 95
VithalraoShinde	1.457	5.65	9 - 11	1.4 - 1.7	68 to 70	93 to 94
Shree Chh. Shahu	1.74	5.44	10 - 12	1.3 - 1.8	67 to 70	95 to 96
Lokmangal - Mauli	1.98	7.10	11 - 13	1.3 - 1.7	67 to 70	91 to 94
Athani Sugars	1.64	7.88	9 - 10	1.4 - 1.8	68 to 72	92 to 95
Daund Sugar	1.85	7.8	9 - 10	1.2 - 1.8	67 to 70	92 to 94
Lokmangal - Bhandarkavathe	1.96	7.23	9 - 11	1.4 - 1.8	68 to 72	93 to 95

Similar data collection at recently commissioned three nos. decanter system installation is in progress (includes two factories in Peru, South America)

Photographs:

Decanter system installed at Daund Sugar

Clarified centrate from first stage

Reject cake from second stage

Multiple Advantages:

- No bagacillo required.
- No vacuum requirement.
- Less power consumption.
- Less quantity of reject cake.
- Less sugar loss through reject cake.
- Higher solid removal efficiency more than 90%. Hence less recirculation of sugar and non sugars.
- Less moisture of reject cake. Hence easier cake handling.
- Less maintenance cost.
- Easy operation.
- Compact layout. Hence smaller foot print.

Discussion:

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

- Rated feed flow rate: - Suspended solid separation efficiency decreases with sudden increase in feed flow rate hence constant, uniform and rated flow is recommended for better separation efficiency.
- 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 of insoluble solid is required.
- Differential speed of bowl and conveyor: - Separation efficiency varies proportional to the differential speed. At higher differential speed moisture content of reject cake is found relatively higher.
- Pond level inside the decanter bowl:- Separation efficiency varies according to the pond depth. At higher pond depth moisture content of reject cake is relatively higher.
- Conditioning of mud slurry feed to 2nd stage decanter.
- Proportionate polymer dosage.
- Temperature of clarifier underflow muddy juice,
- Temperature of wash water and stabilized flow.

B) Factors influencing Pol% reject cake

- Quantity, quality and temperature of wash water used
- Use of settling polymer at juice clarifier
- Quantity of baggase / fibre content present in muddy juice
- Pol % cane
- Differential speed of conveyor with respect to bowl speed
- Pond depth of 1st stage as well as 2nd stage decanter machine.
- Flow of clarifier underflow muddy juice / mud slurry to decanter

C) Factors influencing moisture content of final reject cake

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

D) Polymer requirement

Settling polymer required in conventional multi tray clarifier having retention time of 2 to 3 hours is normally 0.5 to 1 ppm on cane. 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 gains achieved.

Conclusion:

- As only centrate I (around 7 to 9 % on cane) is sent back to process there is reduction of juice load in the process house as compared to rotary vacuum filters where combined filtrate returns to process is generally observed around 15% on cane.
- 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.
- Technical comparison and evaluations of this system with Rotary Vacuum Filter indicate an edge over the old obsolete Rotary Vacuum Filter technology and hence decanter system will be better placed in near future.

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