SUGAR MUDDY JUICE CLARIFICATION AND DEWATERING USING ALFA LAVAL DECANTERS

Amol Chinchankar
Alfa Laval India Limited

ABSTRACT

Sugar mills, throughout the World, have conventionally used Rotary Vacuum Drum Filters (RVDF) to dewater the sugar mill mud that is produced after lime treatment of the sugar juice and subsequent sedimentation in Short Retention Time Clarifiers (SRTC) or in conventional clarifiers. An alternative technology for clarification of the sugar muddy juice and dewatering of the sugar mud, using Alfa Laval Decanter Centrifuges (henceforth referred to as "Decanters") has been established with encouraging results. The advantages that we have found using Decanter Technology are:

- Increase in the recovery of sugar by maximizing mud cake dryness.
- Reduction in the power consumption required for mud dewatering.
- No bagacillo is required as a filter aid and therefore this is available for power generation.
- Easy disposal of the mud due to very low moisture content and reduced quantity, with no bagacillo.
- Lower steam consumption in the sugar juice evaporator, since there is no wash liquor to dilute the juice.
- Avoid or reduce inversion losses arising out of longer residence time in the RVDF system and bacteria associated with the addition of bagacillo as filter aid.
- Smaller foot print thereby saving space and civil expenditure compared to the RVDF.

Four major decanter installations have been commissioned with SugarDec 400 manufactured by Alfa Laval; Gangakhed Sugar & Energy Ltd in Maharashtra,

Bannari Amman Sugar Ltd. in Tamil Nadu and Vijaynagar Sugar Ltd. and Hemarus Technologies Ltd. in Karnataka. Performance of the decanters was established by sampling and analysis of the feed, de-sweetened mud and centrate. Mud cakes with very low moisture content and residual pol levels could be produced using the decanters. The centrate clarity was such that it could be recycled to the process for recovering sugar content. Substantial savings could be generated by using decanters in place of RVDFs.

INTRODUCTION

Rotary Vacuum Drum Filters are traditionally used for sugar mud de-sweetening in sugar mills. While the drum filters support a continuous process, they tend to have certain disadvantages with respect to decanters in terms of performance parameters and operating costs. These observations were made at a sugar mill in South India where the first Alfa Laval SGDM 400 decanter (henceforth referred to as **SugarDec 400**) was supplied and operated on a commercial scale for sugar mud de-sweetening in 2007. On the basis of that success, 15 more SugarDec 400 decanters were supplied in 2009-10 to four upcoming sugar mills for sugar mud de-sweetening and proper analysis was conducted at these decanter installations commissioned in early 2010.

We determined the moisture content and dissolved solids in the final mud cake to give the sugar recovery, while at the same time getting optimum quality of liquor / centrate for recycling back to the process. The study also involved economic analysis of operating Decanters vis-à-vis RVDFs.

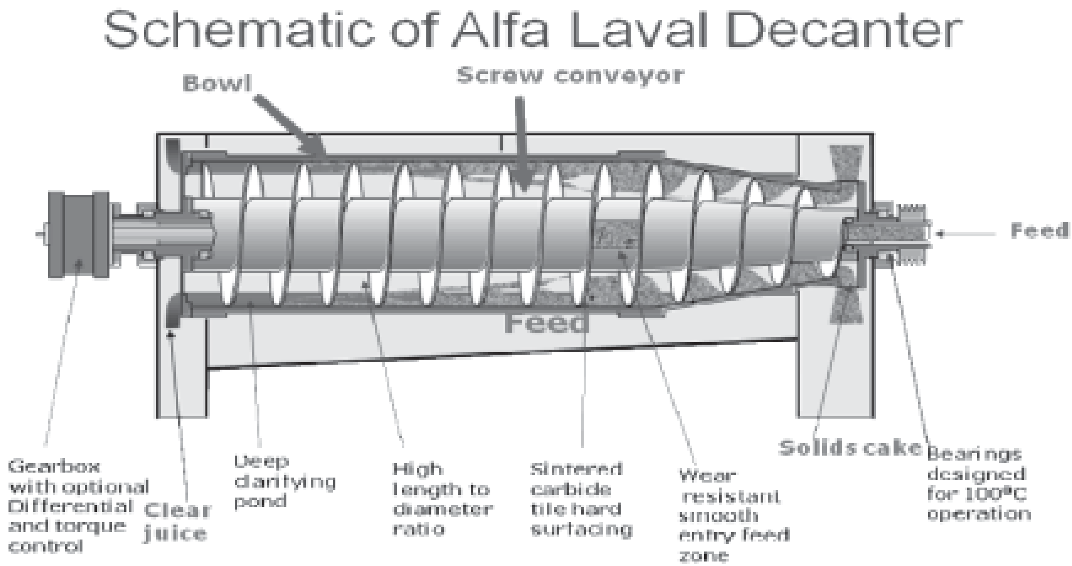
What is a Decanter centrifuge?

A decanter centrifuge or decanter is a sedimentation centrifuge for separation of suspended solids from one or two liquids. It has a cono-cylindrical rotor equipped with a conveyor for continuous unloading of sedimented solids. Separation takes place in the horizontal bowl which is equipped with a variable pitch screw conveyor. The slurry is fed into the bowl through a stationary feed tube and smoothly accelerated by the inlet distributor. Centrifugal force causes the sedimentation of the solids on the wall of the bowl. The conveyor and bowl rotate in the same direction but at different speeds with the scroll slightly slower than the bowl. The solids are lifted out of the liquid and are centrifugally dewatered before being discharged into the casing. The clarified liquid overflows into the casing through openings in the end of the bowl. An electrical motor and a V-belt transmission drive the bowl. Power is transferred to the conveyor by means of a two- or three stage planetary gearbox. The speed difference between the bowl and the conveyor may be obtained by a fully automatic back drive system that compensates for variations in the incoming solids. A compact, in-line frame carries the rotating part with main bearings at both ends. Vibration isolators are placed under the frame. The rotating part is enclosed in a casing with a cover and a bottom section in which the solids and liquid outlets are integrated. The bowl, conveyor, inlet tube, outlets and other parts in direct contact with the slurry are made of stainless steel. The discharge ports as well as the conveyor flights and feed zone are protected with highly erosion resistant sintered tungsten carbide. The frame is made of mild steel with an epoxy enamel finish.

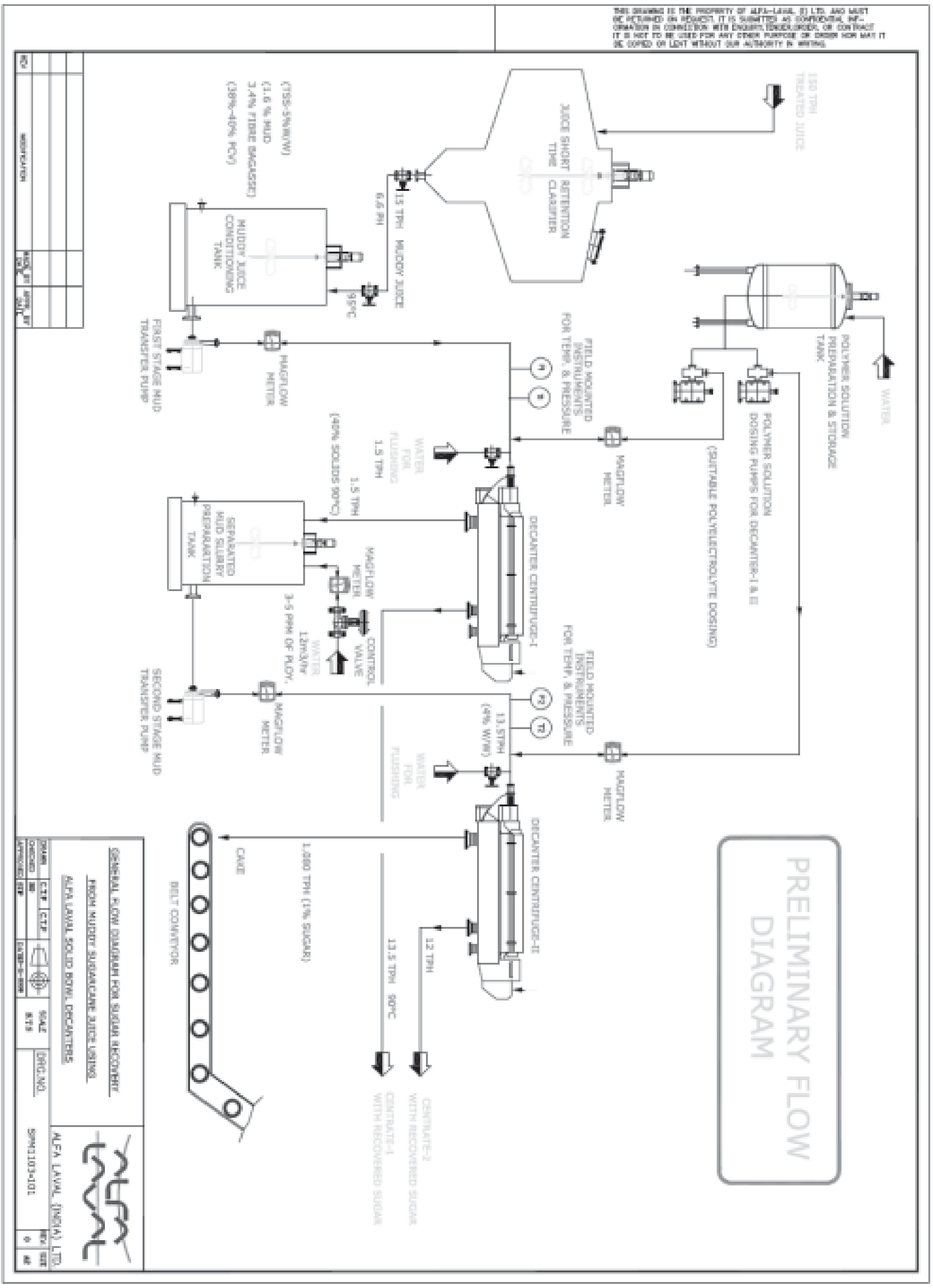
The main components of a Decanter are:

- Bowl
- Conveyor
- Gearbox
- Frame with the casing
- Feed and discharge arrangements
- Motor

Decanters are used in a wide range of applications where their ability to achieve both good clarity and low moisture in the discharged solids is appreciated.



Typical flowsheet with decanters for sugar mud de-sweetening



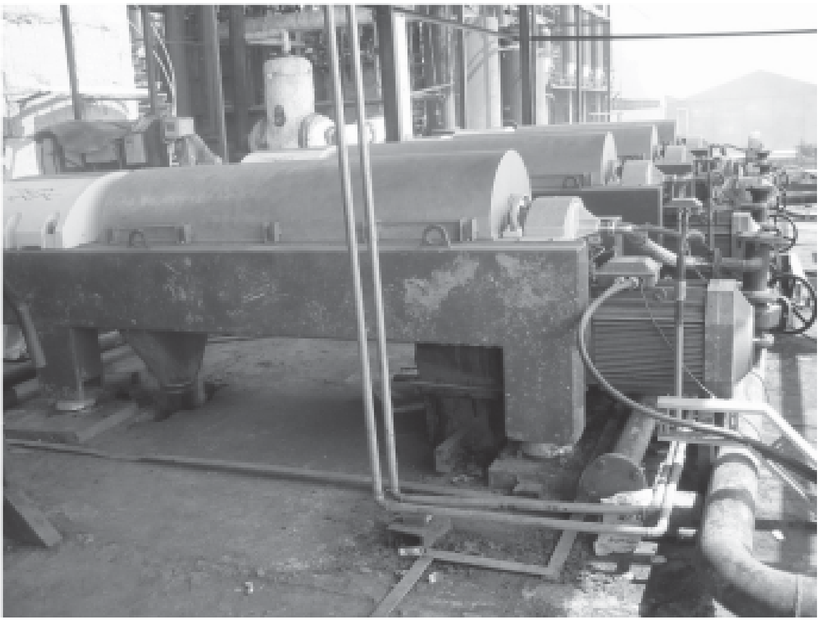
Results obtained in actual Decanter installations

1. Gangakhed Sugar & Energy Ltd., Maharashtra, have installed 4 nos. SugarDec 400 for sugar mud de-sweetening with two in the first stage and two in the second stage. Suviron Equipments have constructed Raw Juice Clarification and Sugar Mud Clarification system at Gangakhed Sugar. This mill was commissioned in the 2009-10 season. Initially they had issues with the centrate clarity but it was addressed up to their satisfaction by selecting a suitable polyelectrolyte for their application. The separation results obtained at Gangakhed Sugar are tabulated on the next page.

Separation efficiency of more than 90% was achieved on Alfa Laval decanters at Gangakhed Sugar. Total polyelectrolyte consumption was found to be around 1.25 kg/ton of dry solids for the first stage and 0.5 kg/ton of dry solids for the second stage or 6 gm/TC for the first stage and 2.4 gm/TC for the second stage.

The quantity of hot water used for re-slurrying is in the range of 4 to 5% cane. The resultant centrate from the second stage decanter is sent to imbibition. This avoids additional load on evaporation unlike in RVDF where the wash water gets added to the filtered juice thereby increasing the load on evaporation.

The pol% pressmud achieved at Gangakhed Sugars and Energy is in the range of 1.5 to 2%. The Pol is normally 85 to 90% of the dissolved solids content, due to no sucrose and sugars being included in the solid cakes.



4 nos. SugarDec 400 decanters at Gangakhed Sugar & Energy

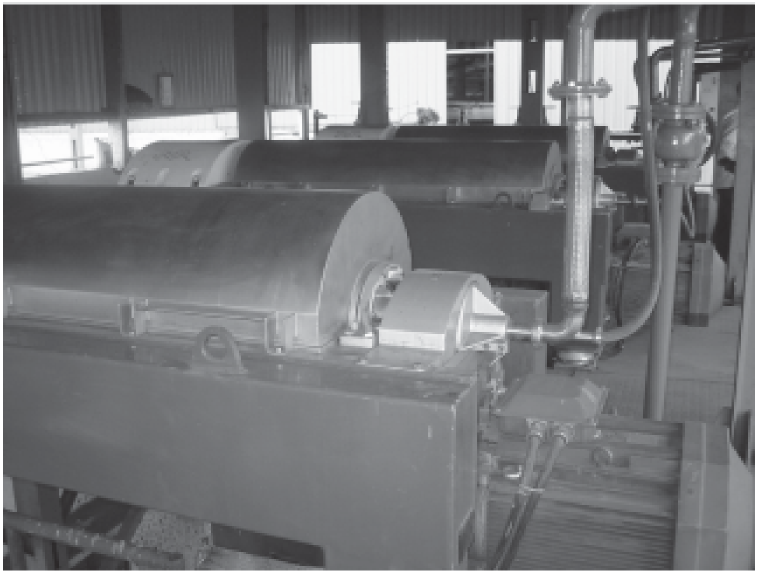
	Sugar Mud Mass Balance	Lime Sludge	2-Feb-11		
	Project Name: Gangakhed Sugar & Energy				
		Sugar Dec-400			**Sugar Dec-400**
		m/c 1		**Second Stage**	**m/c 4**
Muddy Juice	Feed Temperature Degree C	95			80
	Total m^3/hr	7.50	**Feed 2**	Dilution Water (kg/hr)	5,624
	Suspended Solids %	14.11%		Net Water In Cake (kg/hr)	2,987
	Suspended Solids (kg/hr)	1,058		Dissolved solids in cake liquid (kg/hr)	376.1
	Dissolved Solids %	13.39%		Suspended D.S. in cake (kg/hr)	1,052
	Dissolved Solids (kg/hr)	1,004		Total Feed to 2nd Decanter (m^3/hr)	10.04
	Water (kg/hr)	5,438		Suspended Solids %	10.48%
	Dissolved concentration in water only	15.59%		Suspended Solids (kg/hr)	1,052
	Total Solids in Feed %	27.50%		Dissolved Solids %	3.75%
				Dissolved Solids (kg/hr)	376.06
Feed + Poly	Total m^3/hr	10.04		Water (kg/hr)	8,612
	Suspended Solids %	10.54%		Dissolved concentration in water only	4.18%
	Suspended Solids (kg/hr)	1,058		Total Solids in Feed %	14.23%
	Dissolved Solids %	10.00%	**Feed 2+Poly**	Total m^3/hr	11.09
	Dissolved Solids (kg/hr)	1,004		Suspended Solids %	9.49%
	Water (kg/hr)	7,977		Suspended Solids (kg/hr)	1,052
	Dissolved concentration in water only	11.18%		Dissolved Solids %	3.39%
	Total Solids in Feed %	20.54%		Dissolved Solids (kg/hr)	376.06
				Water (kg/hr)	9,664
Cake	Suspended Solids Retention	99.43%		Dissolved concentration in water only	3.75%
	Suspended D.S. in cake (kg/hr)	1052.2		Total Solids in Feed %	12.88%
	Suspended dry solids in cake (%)	23.83%			

	Total cake (kg/hr)	4,416	**Mud Cake**	Suspended Solids Retention	99.75%
	Net liquid in cake (kg/hr)	3,363		Suspended D.S. in cake (kg/hr)	1,050
	Dissolved solids in cake liquid (kg/hr)	376		Suspended dry solids in cake (%)	28.40%
	Net water in cake (kg/hr)	2,987		Total cake (kg/hr)	3,696
	Total D.S. in cake (kg/hr)	1,428		Net liquid in cake (kg/hr)	2,646
	Total D.S. in cake (%)	32.35%		Dissolved solids in cake liquid (kg/hr)	99.12
	Total Moisture in cake (%)	67.65%		Net water in cake (kg/hr)	2,547
				Total D.S. in cake (kg/hr)	1,149
Sugar Juice	Suspended solids (kg/hr)	6		Total D.S. in cake (%)	31.08%
	Water and T.D.S. (kg/hr)	5,618		Total Moisture in cake (%)	68.92%
	Net dissolved solids in effluent (kg/hr)	628		Dissolved solids in Cake (%)	2.68%
	Total effluent (kg/hr)	5,624	**Imbi-bition**	Suspended solids (kg / hr)	3
	Dissolved solids in effluent (%)	11.17%		Water and T.D.S. (kg/hr)	7,396
	Suspended Dry Solids in effluent (%)	0.11%		Net dissolved solids in effluent (kg/hr)	277
	Total Solids in effluent (%)	11.28%		Total effluent (kg/hr)	7,399
				Dissolved solids in effluent (%)	3.74%
				Suspended dry solids in effluent (%)	0.04%
				Total solids in effluent (%)	3.78%

2. Hemarus Technologies Ltd., Karnataka, have installed 3 nos. SugarDec 400 for sugar muddy juice separation on their 3,500 TCD Sugar Mill. This was commissioned in the 2010 season. Their results are excellent, as reported overleaf.

Separation efficiency was 98% of suspended solids, very low polyelectrolyte consumption, a 30% wt suspended solids cake from a basic decanter and less than 1.3% wt dissolved solids in the sugar mud cake.

The clear centrate is recycled to the main juice clarifier for recovery of sugar. The centrate from the second stage decanters is pumped to the mills as imbibition water. The final mud cake from the second stage is transported on a conveyor belt to be dropped into a hopper from where it goes into a tractor trailer or truck for disposal. The mud cake is a rich source of nutrients and is therefore used as a manure for the crops by local farmers.



3 nos. SugarDec 400 decanters at Hemarus Technologies

	Sugar Mud Mass Balance	Lime Sludge	10-Apr-11		
	Project Name: Hemarus Sugar Mill	3500 TCD			
		Sugar Dec-400		Second Stage	Sugar Dec-400
Feed Mud	Total m^3/hr	8.50	**Feed 2**		
	Suspended Solids %	6.50%		Dilution Water (kg/hr)	6,971
	Suspended Solids (kg/hr)	553		Net Water In Cake (kg/hr)	1,107
	Dissolved Solids %	12.00%		Dissolved solids in cake liquid (kg/hr)	156.7
	Dissolved Solids (kg/hr)	1,020		Suspended D.S. in cake (kg/hr)	541
	Water (kg/hr)	6,928		Total Feed to 2nd Decanter (m^3/hr)	8.78
	Dissolved concentration in water only	12.83%		Suspended Solids %	6.17%
	Total Solids in Feed %	18.50%		Suspended Solids (kg/hr)	541
Feed + Poly	Total m^3/hr	8.78		Dissolved Solids %	1.79%
	Suspended Solids %	6.30%		Dissolved Solids (kg/hr)	156.70
	Suspended Solids (kg/hr)	553		Water (kg/hr)	8,078

	Dissolved Solids %	11.62%		Dissolved concentration in water only	1.90%
	Dissolved Solids (kg/hr)	1,020		Total Solids in Feed %	7.95%
	Water (kg/hr)	7,204	**Feed 2+Poly**	Total m^3/hr	9.05
	Dissolved concentration in water only	12.40%		Suspended Solids %	5.98%
	Total Solids in Feed %	17.92%		Suspended Solids (kg/hr)	541.45
				Dissolved Solids %	1.73%
Cake	Suspended Solids Retention	98.00%		Dissolved Solids (kg/hr)	156.70
	Suspended D.S. in cake (kg/hr)	541.5		Water (kg/hr)	8,349
	Suspended dry solids in cake (%)	30.00%		Dissolved concentration in water only	1.84%
	Total cake (kg/hr)	1,805		Total Solids in Feed %	7.72%
	Net liquid in cake (kg/hr)	1,263	**Cake 2**	Suspended Solids Retention	98%
	Dissolved solids in cake liquid (kg/hr)	157		Suspended D.S. in cake (kg/hr)	531
	Net water in cake (kg/hr	1,107		Suspended dry solids in cake (%)	30.00%
	Total D.S. in cake (kg/hr)	698		Total cake (kg/hr)	1,769
	Total D.S. in cake (%)	38.68%		Net liquid in cake (kg/hr)	1,238
				Dissolved solids in cake liquid (kg/hr)	22.81
Sugar Juice	Suspended solids (kg/hr)	11		Net water in cake (kg/hr)	1,215
	Water and T.D.S. (kg/hr)	6,960		Total D.S. in cake (kg/hr)	553
	Net dissolved solids in effluent (kg/hr)	863		Total D.S. in cake (%)	31.29%
	Total effluent (kg/hr)	6,971		Dissolved solids in Cake (%)	1.29%
	Dissolved solids in effluent (%)	12.38%		Dissolved solids loss from decanter feed %	2.24%
	Suspended Dry Solids in effluent (%)	0.16%	**Imbi-bition**	Suspended solids (kg/hr)	11
	Total Solids in effluent (%)	12.54%		Water and T.D.S. (kg/hr)	7,278
				Dissolved solids in effluent (kg/hr)	134
				Total effluent (kg/hr)	7,289
				Dissolved solids in effluent (%)	1.84%
				Suspended Dry Solids in effluent (%)	0.15%
				Total Solids in effluent (%)	1.99%

3. Australian results indicate that with a better differential speed control on the decanter centrifuge and more torque capability (features incorporated in Alfa Laval Decanters with automation) it is possible to get a consistent cake dryness of 35% or better, on both stages. This will reduce the sugar loss in the final cake even further, in the case of Hemarus to less than 1% wt dissolved solids/sugar in the cake. The test work also showed that a lower bagacillo content in the suspended solids improved cake dryness as well as reducing the cake quantity.

4. Bannari Amman Sugars Ltd. – Unit 4 have installed 5 nos. SugarDec 400 decanters for muddy juice de-sweetening. There are 2 decanters for the first stage, 2 for the second stage and the 5th as a standby. Clarifier underflow is taken into a mud tank from which a progressive cavity pump (1 opr + 1st.by) feeds to the first stage decanters. The polymer preparation tank discharges into a stock solution tank from where it is pumped to the decanters using VFD controlled screw pump (1 opr + 1st.by). Solid cake from the first stage decanters is mixed with hot water and the resulting slurry is pumped to the second stage decanters.

5 nos. SugarDec 400 decanters at Bannari Amman Sugars Ltd.

The pol% pressmud achieved at Bannari Amman Sugars was 1.5. However, owing to very high suspended solids concentration of 11 to 13% by weight in the feed to first stage decanters coupled with high feed flow rates of 25 to 30 cum/hr to each decanter, it was challenging to maintain good clarity of the first stage centrate. This challenge was overcome by adding defecated juice to the mud tank to bring down the suspended solids to 7-8% and maintaining a pH of 7.4 to 7.5 by addition of milk of lime. Thus, separation efficiency of more than 90% was achieved at Bannari Amman Sugars also.

Decanter Automation with 2Touch Controller

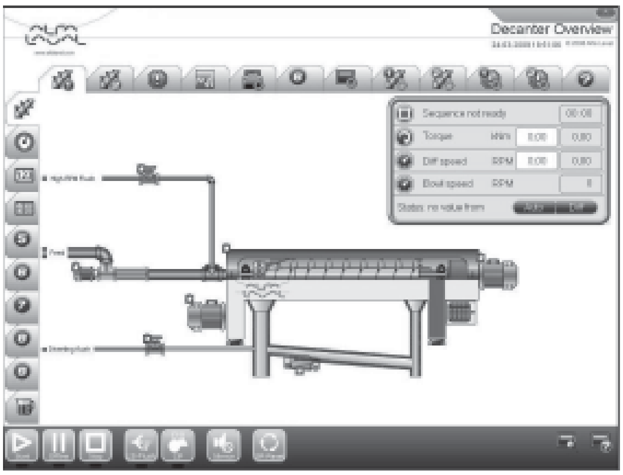
The 2Touch controls package is designed to serve as a complete system for Alfa Laval decanter centrifuges fitted with a VFD back drive in which the differential speed is controlled by varying the speed of the back drive motor. The 2Touch limits the maximum torque and excessive speed, while operating in differential speed or torque control mode. Torque control mode allows the differential speed to modulate while keeping the torque constant, thus optimising/maximising the solids dryness.

A touch screen HMI on which different parameters such as the Bowl Speed, Torque and Differential Speed can be monitored is also a part of the 2Touch controller. Additional features such as temperature sensor for main bearing and vibration sensors can also be included with this controller. Moreover the 2Touch Controller also monitors and controls flocculant consumption thereby saving on operating costs.

BACKDRIVE PANEL

It comprises of the ABB Variable Frequency Drive and switch gear for the power supply.

A picture of the 2Touch HMI screen is shown below.



Performance with rotary vacuum drum filter system

Basis: 5000 TCD sugar mill

Requirement: 2 nos. 14' dia x 24' long

Performance parameters of RVDF system in general:

Muddy juice feed flow rate: 20 to 25 m^3/hr @ 8-12% w/w suspended solids (each)

Mud solids retention: 70% (average)

Mud cake solids: 15 to 18% w/w

Bagacillo in cake: 8 to 10% w/w

Cake moisture: 72 to 77% w/w

Sugar content in mud cake: 2.5 to 4% pol

Suspended solids in filtrate: 1.5 to 3% w/w

RVDF - 2 nos. 14' dia x 24' long

Operating costs:

Basis: 200 days per sugar season

Consumed power:

Vacuum pumps	2 nos.	110 KW
Drum drive	2 nos.	15 KW
Agitator drive	2 nos.	8.0 KW
Filtrate pumps	2 nos.	37 KW
Hot water pump	1 no.	5.5 KW
Feed (mud) mixer	1 no.	15 KW
Bagacillo blower	1 no.	22 KW
Mud pump	1 no.	22 KW
Wash water pump	1 no.	5.5 KW

Total consumed energy: 240 KWH
Considering INR 4/unit of power, cost is INR 46.08 lakh/season

Bagacillo required for filtration: 1% on cane or 50 TPD
Rate of bagacillo is INR 2,000/ton
Cost of bagacillo works out to INR 200.0 lakh/season

Polyelectrolyte consumption: Not required

Wash water consumption: 200 m^3/day @ 4% on cane
Considering INR 50/m^3, cost of wash water is INR 20.0 lakh/season

Considering 1% steam equivalent to 0.5% bagasse,
Cost towards evaporation of wash water works out to INR 100.0 lakh/season

Approximate maintenance cost: INR 6.0 lakh/season

Total Operating cost: INR 372.08 lakh per season

Sugar loss @ 0.06% cane: INR 150.0 lakh per season

Area required for installation: approximately 2,800 sq. ft.

Considering 2 Drum Filters with associated auxiliaries such as vacuum pumps, moisture traps, filtrate receivers, etc.

Performance with alfa laval decanter centrifuge system

Basis: 5000 TCD sugar mill

Requirement: 4 nos. SugarDec 400 Decanters – two for 1st stage and two for 2nd stage. We also recommend one standby decanter.

Performance parameters of Decanter system in general:

Muddy juice feed flow rate: 25 m^3/hr @ 4-5% w/w suspended solids (each)

Mud solids retention: > 90%

Mud cake solids: 25 to 30% w/w

Bagacillo in cake: NIL

Cake moisture: 70 to 75% w/w

Sugar content in mud cake: 0.8 to 1.5% pol (average 1.2)

Suspended solids in filtrate: 0.5 to 1% w/w

Decanters - 5 nos. SugarDec 400 (considering one standby)

Operating costs:
Basis: 200 days per sugar season

Consumed power:

Decanter main drive	4 nos.	96 KW
Hot water pump	1 no.	5.5 KW
First stage feed (mud) mixer	1 no.	15 KW
Mud pump	1 no.	15 KW
First stage centrate pump	1 no.	15 KW
Second stage mud agitator	1 no.	15 KW
Second stage mud pump	1 no.	15 KW
Second stage centrate pump	NIL (by gravity)	
Dilution water pump	1 no.	5.5 KW
Agitator for polyelectrolyte preparation	1 no.	2.2 KW
Polyelectrolyte dosing pump	5 nos.	7.5 KW

Total consumed energy: 192 KWH
Considering INR 4/unit of power, cost is INR 36.86 lakh/season

Cost of bagacillo: NIL

Polyelectrolyte consumption: 50 kgs/day
Cost of polyelectrolyte: INR 30.0 lakh/season

Re-slurry water consumption: 300 m^3/day @ 6% on cane
Cost NIL as imbibition water is used

Approximate maintenance cost: INR 20.0 lakh/season

Total operating cost: INR 86.86 lakh per season

Sugar loss @ 0.03% cane: INR 75.0 lakh per season

Area required for installation: approximately 1,500 sq. ft.
for 5 nos. SugarDec 400 Decanters.

Cost–economics: ALFA LAVAL Decanters v/s Rotary Vacuum Drum Filters
Basis: 5000 TCD Sugar Mill

COST/SEASON	ROTARY VACUUM DRUM FILTER	ALFA LAVAL DECANTER	SAVINGS/SEASON WITH DECANTER
Operating costs	372.08	86.86	285.22
Sugar loss	150.00	75.00	75.00
Total costs	522.08	161.86	360.22

Note: All figures are in Rs. Lakh.

Extra cost for Decanter system is INR 140.0 Lakh as compared to RVDF system.

Therefore, payback period with Alfa Laval Decanters is less than 6 months!

CONCLUSIONS

On the basis of the operating data collected from our major installations, we can safely state that the Alfa Laval Decanter Centrifuges can replace conventional Rotary Vacuum Drum Filters for desweetening of sugar mud (*i.e.,* muddy juice) in sugar mills. The advantages/benefits of using Alfa Laval Decanters can be summarized as follows:

- Saving of bagasse which is not required as in the case of drum filters (as filtration aid) and can be used for power production instead.
- Higher recovery of sugar due to lower sugar losses in solids cake.
- Savings in power consumption.
- Superior juice quality (centrate) as compared to filtrate from drum filters. Wash water is not included in the juice and therefore reduces the evaporative load.
- Lower floor area requirement.
- Simplified continuous operation.
- Lower inversion losses due to very short residence time.
- No bacterial contamination and no environmental pollution as mixing of bagasse is completely eliminated.
- System can be kept clean as decanters and piping can be flushed with hot water.
- Totally closed system – leakage & splash-free.
- Decanters can handle lower consistency mud unlike drum filters.

All the above benefits amount to a shorter payback period of less than 1 sugar season.

With further work we expect to prove conclusively the financial advantage of higher torque, variable speed differential features that can easily be incorporated in our SugarDec specification and fully justify their inclusion by reducing the payback time further, with less sugar loss.

ADDITIONAL BENEFIT

In sugar mills which also operate sugar refineries, the same Alfa Laval decanters can also be used for sugar scum de-sweetening, thereby generating additional revenue and reducing the payback period further.

ACKNOWLEDGEMENTS

The author acknowledges the contributions of Mr. Bob McCarthy, Separation Specialist at Alfa Laval, for his guidance and support in making the decanter installations commercially successful. The author thanks his colleagues, namely, Mr. Dinesh Deo, Mr. GSV Subbarao and Mr. Prashant Dravid, for their valuable inputs from time-to-time. Sincere thanks are also due to the Decanter System builders, M/s. Chemical Systems and M/s. Suviron Equipments, as well as to the factory staff at the sugar mills where the Alfa Laval decanters are installed.

REFERENCES

Steindl R.J., Rainey T.J. and Plaza F. (2010). Low moisture mud from solid bowl decanters.

Amol Chinchankar and Bob McCarthy (2010). Muddy juice de-sweetening in sugar mills using Alfa Laval Decanters.

SGDM 400 and SugarDec 400 are brand names of Alfa Laval Decanters.