Recycle of spentlees as heating medium for primary column reboiler in distillation process

Abstract

Spent lees is the bottom water generated (at a volume equivalent to the ethanol volume produced) in the rectification column at a temperature of 120^{o}C – 125^{o}C. The objective of this project is to recover as much heat for primary column re-boiler heating, (an activity that normally consumes 1.5 tons of direct steam per hour as well as generate additional waste water). Spent lees may also be used as CIP water for pre-fermenters, thus minimizing waste water production. In order to accomplish these projects, re-piping and minor revisions were done. Improvement savings was 0.8 ton per hour steam in sparging or an equivalent of 11.3 tons bagasse per day, equating to a financial savings of 29,380 pesos/day at bagasse cost of 2,600 pesos/ton. There was observed reduction in spent wash generation equivalent to savings of 5,000 pesos/day (the would-have-been expense for hauling of spent wash for disposal). The reuse of spent lees as cleaning water creates savings of 10 cu. M. of soft water, at 180 pesos daily. Annually, this project is expected to generate a savings of 11.0M pesos at 317 operating days as against revision and re-piping cost of 300,000 pesos.

The Process

Distillation is the process of separating components of a liquid mixture by differences in boiling point or volatility. In chemical engineering and industrial applications, distillation has a universally important role in a wide range of applications for purified products, solvent recovery and green technologies . Common forms of industrial scale distillation include steam distillation, fractional distillation, vacuum, azeotropic, and extractive distillation. This distillation process takes place in a distillation column.

In SCBI, there are four distillation column. The mash column, the de-aldehyde column ,the rectifier column and the recovery . These four column have different purpose. Mash column is also called stripping column wherein all alcohol were separated from a mash. Condensate in this column is a called primary condensate. The purity of primary condensate ranges from 35% to 45% alcohol. De-aldehyde column is used to removed aldehyde that comes with the alcohol. This is usually separated when producing food grade ethanol, thus in SCBI, this column is not operated. The next column is the rectifier column, wherein alcohol is concentrated to 94-95%. This alcohol is called rectified spirit. The last is the recovery column. Purpose of this column is to vaporize rectifier spirit before being introduced into the Molecular Sieve for dehydration.

These columns are equipped with re-boilers for heating the column. The re-boilers either utilized saturated steam or alcohol vapor to attain is desired heating requirements. Rectifier, de-aldehyde and recovery column uses saturated steam as heating medium while primary column use alcohol vapor from rectifier column as its heating medium.

These column were design to handle fermented mash that utilize syrup as feedstock. When SCBI utilizes molasses as its feedstock, additional heat is needed to effectively separate the alcohol from mash. This is due to increase in the specific gravity of the mash which in turn increase the boiling point of the solution.

In order to supply the needed additional heat, SCBI uses steam to heat the primary column. The steam is either introduced into the small reboiler or directly into the primary column thru sparging. It consumes an additional two(2) tons/hr steam. The approached was effective, but additional steam requirements means additional fuel.

Effect on fuel requirement for ethanol production

Fuel is the 2nd highest cost component in ethanol production. It constitute 15-20% of the total cost. With the scarcity of biomass fuel nowadays, this cost will increase because of the increase of fuel price.

SCBI uses mainly bagasse, biogas and other biomass as fuel in its boiler. 50% of the fuel requirements is supplied by the mill thru its millrun bagasse. 25% is supplied by biogas and the remaining 25% will be sourced out. Sourced-out bagasse is expensive and quality is not good. This low quality bagasse drives the fuel cost high more than 20%.

Based on initial design, distillation will require 1.8 kg steam for every liter of alcohol produced and and additional 0.7 kg steam for every liter of ethanol generated in dehydration.

To optimize fuel usage in the plant, steam savings projects is encourage by the management:

- ✓ Recovery and use of condensate tank flash steam.
- ✓ Use of primary column vapor as heating for spentwash evaporator.

Another option to reduce steam usage is to recycle spentlees as a source of heat for reboiler of primary column.

Because of the high temperature of spentlees and its sufficient volume, it can replace steam at one of the reboiler of primary column which uses steam as heating medium. As computed below, spentlees can displace almost1 ton of steam per hour.

Savings on Fuel

Description	With out 4th Reboiler	With 4th Reboiler
Direct steam heating flow(tons/hr)	1.5	0.7
Equivalent bagasse (tons/hr)(1.7 tons steam/ton bagasse)	0.88	0.41
Total direct steam consumption per day	36	16.8
Equivalent tons bagasse per day	21	9.88
Equivalent Cost (Php /day) @ Php 2,600/ton	Php 54,600.00	Php 25,700
Total cost for 317 days	Php 13.3M	Php 8.15
Projected Estimated Savings (Php/year)		**Php 5.15M**

Computation on the equivalent Steam Tonnage

Computation on the Equivalent Steam to be displaced

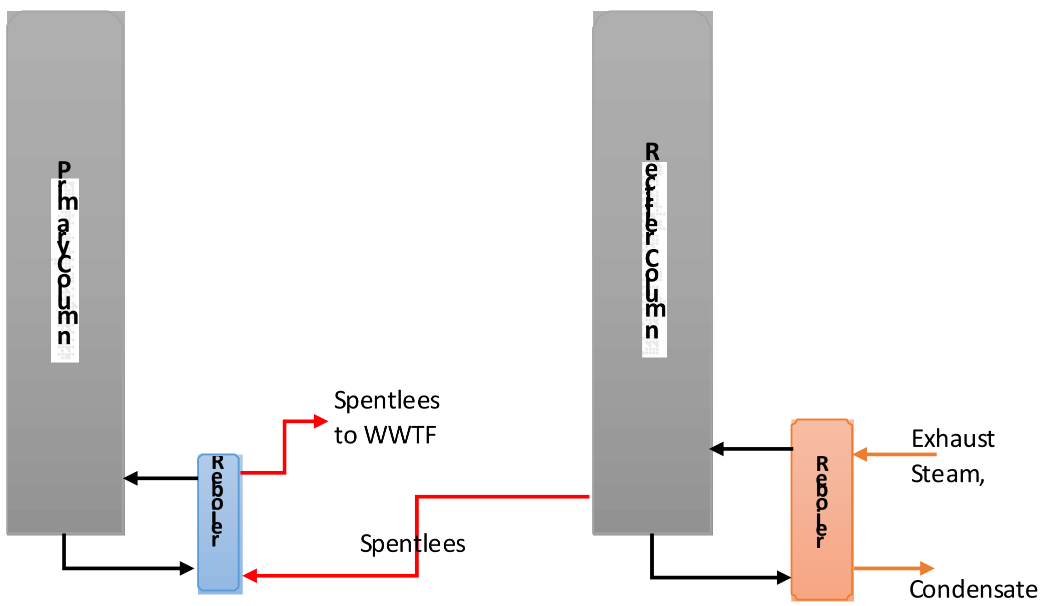
Q 0.68 MW

Spent Lees Solve

V	5 cu.m/hr							125		
P	1.5 bar (gauge)				P	bar (gauge)				
T	125 °C	Pipes			T	100 °C				
?	938.97 kg/cu.m	#of tubes	300					122.90		100
?H(liq)	524.96 kJ/kg	d2	1.125 inches	A2(sq.m) 80.79						
h	5000 BTU/hr-sqft-°F	?x	3 mm	A(lm) 76.47						76.56
h2	300 BTU/hr-sqft-°F	d	1.01 inches	A(sq.m) 72.31						
		L	3 m					?T1	2.104279	
		k(Stainle	45 W/m-k					?T2	23.44	
		Thermal E	90%					?T(lm)	8.85	

		P	T	?H(liq)	?H(vap)	?S(liq)	?S(vap)
Steam	0.81 Ton/hr						
P	401.33 kPa	361.3	140	610.61	2740.3	1.7906	6.8832
T	143.69917 °C	401.33	143.69168	626.5682	2744.813	1.828405	6.849612
?H(kJ/	2744.813	415.4	145	632.18	2746.4	1.8417	6.8378
?S(kJ/	6.8496116						
Mash							
V(cu.m/hr)		38.587	75	313.91	2635.3	1.0154	7.6824
P(barg	-0.6	41.325	76.5551517	320.4323	2637.913	1.034	7.660535
T(°C)	76.56	47.39	80	334.88	2643.7	1.0752	7.6121

Schematic Diagram



Value of Spentlees Recycling

The reuse of the spentlees has the ff. effect:

- ✓ Reduce temperature of spentlees before going into the lagoons.
- ✓ Reduce direct steam heating of about 50%(minimum).
- ✓ Reduce spentwash volume.
- ✓ Improve steam condensate recovery of boiler.
- ✓ Reduce fuel consumption of boiler.

Actual Performance

The project was installed last October 2018 and was commissioned last November 10, 2018. As of November 21, 2018, direct steam flow is zero from as high as 1.6 tons per hour at the start of Cy 2018-19. Temperature of spentlees before the reboiler is 123C while after is 92C.

Actual Monitoring(November 21- December 16)

Sparging Monitoring						Steam Savings	SW Reduction	Boiler Water Savings	
Date	Expected Sparging(Tons/day)	Actual Sparging Flow (tons/hr)	Daily Consumption (tons)	Steam savings (tons)	Equivalent Bagasse(tons)	Equivalent Savings(Php)	Equivalent Savings(Php)	Equivalent Savings(Php)	Savings(to date)
20-Nov	48	0.5	12	36	19.3	P50,053.48	P5,040.00	P864.00	P55,957.48
21-Nov	48	0.1	2.4	45.6	24.4	P63,401.07	P6,384.00	P1,094.40	P119,358.55
22-Nov	48	0.1	2.4	45.6	24.4	P63,401.07	P6,384.00	P1,094.40	P182,759.61
23-Nov	48	0.1	2.4	45.6	24.4	P63,401.07	P6,384.00	P1,094.40	P246,160.68
24-Nov	48	0.1	2.4	45.6	24.4	P63,401.07	P6,384.00	P1,094.40	P309,561.75
25-Nov	48	0.5	12	36	19.3	P50,053.48	P5,040.00	P864.00	P359,615.23
26-Nov	48	0.5	12	36	19.3	P50,053.48	P5,040.00	P864.00	P409,668.71
27-Nov	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P464,727.53
28-Nov	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P519,786.35
29-Nov	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P574,845.18
30-Nov	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P629,904.00
1-Dec	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P684,962.82
2-Dec	48	0.5	12	36	21.2	P55,058.82	P5,040.00	P864.00	P740,021.65
3-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P787,739.29
4-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P835,456.94
5-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P883,174.59
6-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P930,892.24
7-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P978,609.88
8-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P1,026,327.53
9-Dec	48	0.7	16.8	31.2	18.4	P47,717.65	P4,368.00	P748.80	P1,074,045.18
10-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,107,080.47
11-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,140,115.76
12-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,173,151.06
13-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,206,186.35
14-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,239,221.65
15-Dec	48	1.1	26.4	21.6	12.7	P33,035.29	P3,024.00	P518.40	P1,272,256.94
16-Dec	**48**	**1.1**	**26.4**	**21.6**	**12.7**	**P33,035.29**	**P3,024.00**	**P518.40**	**P1,305,292.24**

Pictures

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