ENERGY EFFICIENCY MEASURE **SVP-01**

Replacement of cyclone evaporator with a new super concentrator for black liquor in Soda Recovery Boiler

Observation

The plant owns a Soda Recovery Boiler SRB. A cyclone evaporator is installed on the SRB.
Through this evaporator the concentration of black liquor increases from 54% to 60% dry substance. Thus concentrated, the black liquor is feeded as fuel to the SRB. The higher this concentration, the lesser the heat taken away in the furnace chamber of the boiler for water evaporation, contained in the black liquor. It is envisaged the doubling of the pulp production, which is connected with an increase of the SRB capacity to 550 t of absolute dry substance for day.

Recommendation

The reconstruction of the existing SRB is connected with replacement of its bottom, installation of a new superheater, new burners for black liquor, new feed pumps, air system and air fan, alteration in the exhaust flue gases, adding of a new economizer unit to the existing economizer, replacement of flue gas suction fan, replacement of a cyclone evaporator from concentration of black liquor with super concentrator, which utilizes steam for water evaporation from the black liquor, without loading the furnace chamber and the exhaust flue gases of the boiler with the great quantities of water steam, obtained from the increased feeding volume of the black liquor to the boiler.

Estimated Saving

	Description	Value	Formula	Notes
A	**Baseline**			
B	Black liquor flow rate	34,9 *t/h*		*From engineering plan*
C	Average Calorific value of black liquor @ 60% tds	1 747 *kcal/kg*		*calculated from dry substance value*
D	Annual working hours for SRB	8 040 *hours*		*site data*
E	SRB efficiency	67% *%*		*site data*
F	Outlet steam temperature	440 *°C*		*From survey*
G	Outlet steam pressure	41 *bar*		*site data*
H	Thermal input at SRB from black liquor	70,9 *MWth*	*BxC/860*	
I	Thermal power output of steam from SRB	47,5 *MWth*	*ExH*	
J	Outlet steam enthalpy	3 304 *kJ/kg*		*from steam & water tables*
K	Inlet water enthalpy	613 *kJ/kg*		*steam & water tables 145°C and 43bar*
L	Steam produced by SRB	64 *t/h*	*Ix860/(J-K)/4.186*	
M	Steam production from SRB	382 120 *MWh/y*	*DxI*	
	Project Activity			
N	Black liquor flow rate	34,92 *t/h*		*From survey*
O	Average Calorific value of black liquor @ 72% tds	1 805 *kcal/kg*		*calculated from dry substance value*
P	Annual working hours for SRB	8 040 *hours*		*site data*
Q	SRB efficiency	78%		*from engineering plan*
R	Outlet steam temperature	440 *°C*		*From survey*
S	Outlet steam pressure	41 *bar*		*site data*
T	Thermal input at SRB from black liquor	73,3 *MWth*		*From survey*
U	Thermal power output of steam from SRB	54,3 *MWth*	*QxTxload factor*	*at 95% load*
V	Outlet steam enthalpy	3 304 *kJ/kg*	*J*	
W	Inlet water enthalpy	506 *kJ/kg*		*from steam & water tables*
X	Steam produced by SRB	70 *t/h*	*Ux860/(V-W)x4.186*	
Y	Steam production after energy efficiency measure	436 644 MWh/y	*UxP*	
	Savings			
Z	Net steam reduction compared to baseline scenario	54 524 *MWh/y*	*Y-M*	

ENERGY EFFICIENCY MEASURE **SVP-02**

Replacement of a barometric condensers with plate heat exchangers in evaporating systems for black liquor

Observation

Current Washing installation is designed to increase the concentration of the weak black liquor up to 13%, and its further increasing accomplishes in the Evaporating installation and in the Cyclone evaporator, where it reaches up to 54%.

Recommendation

A new parallel technological line with two new filters will be installed to the washing installation to increase the concentration of the weak black liquor up to 18%. In order to increase the efficiency and capacity of the Evaporating installations the two barometric condensers will be replaced with two new surface heat exchangers with indirect heat exchange. As a result of it the concentration of the weak black liquor will increase up to 60% and heat consumption will be decreased at the final step of the installation

Estimated Saving

	Description	Value	Formula	Notes
	Baseline			
A	Quantity of black liquor at 100% concentration	550 *t/day*		*from site data*
B	Annual working hours	8 040 *hours*		*from site data*
C	Black liquor concentration after WASHING	13 *%*		*measurements*
D	Quantity of black liquor after WASHING	4 231 *t/day*	*Ax100/C*	
E	Black liquor concentration after heat exchanger	54 *%*		*measurements*
F	Quantity of black liquor after heat exchanger	1 019 *t/day*	*Ax100/E*	
G	Evaporated quantity of water	3 212 *t/day*	*D-F*	
H	Steam temperature	160 ^{0}C		*from site data*
I	Steam pressure	4 *bar*		*from site data*
J	Steam enthalpy	2 775 *kJ/kg*		*water & steam tables*
K	Condensate enthalpy at T=60^{o}C P=0.78 bar	251 kJ/kg		*water & steam tables*
L	Heat for 1 kg generated steam	2 524 kJ/kg	*J-K*	
M	Steam consumption for evaporation of 1 t water	0,185 t_{steam}/t_{water}		*from site data*
N	Steam consumption for evaporation of all water	595 t_{steam}*/day*	*GxM*	
O	Steam consumption for evaporation of all water	199 279 t_{steam}*/y*	*NxB/24*	
O1	Steam consumption for evaporation of all water	139 727 *MWh/y*	*OxL/3600*	
P	***Project Activity***			
Q	Quantity of black liquor by 100% concentration	550 *t/day*		*from site data*
R	Black liquor concentration after WASHING	18 *%*		*From survey*
S	Quantity of black liquor after WASHING	3 056 *t/day*	*Qx100/R*	
T	Black liquor concentration after heat exchanger	60 *%*		*measurements*
U	Quantity of black liquor after heat exchanger	916,7 *t/day*	*Qx100/T*	
V	Evaporated quantity of water	2 139 *t/day*	*S-U*	
W	Steam temperature	160 ^{0}C		*From survey*
X	Steam pressure	4 *bar*		*From survey*
Y	Steam enthalpy	2 775 *kJ/kg*		*from steam & water tables*
Z	Condensate enthalpy at T=60^{o}C P=0.78 bar	251 kJ/kg		*from steam & water tables*
AA	Heat for 1 kg generated steam	2 524 kJ/kg	*Y-Z*	
AB	Steam consumption for evaporation of 1 t water	0,185 t_{steam}/t_{water}		*from site data*
AC	Steam consumption for evaporation of all water	396 t_{steam}*/24h*	*VxAB*	
AD	Steam consumption for evaporation of all water	132 690 t_{steam}*/y*	*ACxB/24*	
AD1	Steam consumption for evaporation of all water	93 038 *MWh/y*	*ADxL/3600*	
AE	***Savings***			
AF	Heat saved from evaporation of water from black liquor	66 588 t_{steam}*/y*	*O-AD*	
AG	Heat saved from evaporation of water from black liquor	46 689 *MWh/y*	*AFxL/3600*	

ENERGY EFFICIENCY MEASURE **SVP-03**

Installation of frequency control drives on electric motors

Observation

Electric motors assembled to the feed pumps of Soda Recovery Boiler (SRB), and cutting machine are old and poorly efficient. Pumps are over sized and running far from optimal point of their curve

Recommendation

Frequency control drives will be installed to electricity motors whith power above 130 kW.

Estimated Saving

	Description	Value	Formula	Notes
	Baseline			
	Pump type: MOM315M-4			
A	Power	132 *kW*		*from site data*
B	Nominal intensity	229 *A*		*from site data*
C	Working intensity	170 *A*	*74%*	*from site data*
D	Active power	1 121 *MWh/y*		*Schnider electric software calculation*
E	Reactive power	635 *MWh/y*		*Schnider electric software calculation*
	Pump type: MOM315S-4			
F	Power	200 *kW*		*from site data*
G	Nominal intensity	364 *A*		*from site data*
H	Working intensity	150 *A*	*41%*	*from site data*
I	Active power	1 666 *MWh/y*		*Schnider electric software calculation*
J	Reactive power	944 *MWh/y*		*Schnider electric software calculation*
	Pump type: MOM315M-4			
K	Power	200 *kW*		*from site data*
L	Nominal intensity	364 *A*		*from site data*
M	Working intensity	320 *A*	*88%*	*from site data*
N	Active power	1 604 *MWh/y*		*Schnider electric software calculation*
O	Reactive power	909 *MWh/y*		*Schnider electric software calculation*
	Pump type: MO280M-2			
P	Power	132 *kW*		*from site data*
Q	Nominal intensity	283 *A*		*from site data*
R	Working intensity	120 *A*	*42%*	*from site data*
S	Active power	927 *MWh/y*		*Schneider electric software calculation*
T	Reactive power	526 *MWh/y*		*Schneider electric software calculation*
U	Total active power	5 319 *MWh/y*	*D+I+N+S*	
V	Total reactive power	3 015 *MWh/y*	*E+J+O+T*	
	Project Activity			
W	Active power for:			
X	*Pump type: MOM315M-4*	831,3 *MWh/y*		*Schneider electric software calculation*
Y	*Pump type: MOM315S-4*	1 314 *MWh/y*		*Schneider electric software calculation*
Z	*Pump type: MOM315M-4*	1 189 *MWh/y*		*Schneider electric software calculation*
AA	*Pump type: MOM280M-2*	714 *MWh/y*		*Schneider electric software calculation*
AB	Total electricity consumption	4 049 *MWh/y*	*X+Y+Z+AA*	
	Savings			
AC	Expected saving of electrical energy	1 271 *MWh/y*	*U-AB*	

ENERGY EFFICIENCY MEASURE **SVP-04**

Installation of a back pressure steam turbine to utilize steam generated by Soda Recovery Boiler and cogeneration of electricity

Observation

SRB produces overheated steam under pressure 41 bars and a temperature 440^{o}C, after which the steam is reduced to 12 bars and 220^{o}C. Additional reduction from 12 to 5 bars follow to meet other technological needs of the plant.
The steam pressure is reduced through pressure regulating stations, which are essentially throttling valves. This represents a potential opportunity to generate some additional electricity on site.

Recommendation

It is recommended to install a cogeneration plant for a combined production of electricity and steam for technological needs. A back pressure steam turbine coupled with electricity generator with a capacity of 6 MWe could be installed.

Estimated Saving

	Description	Value	Formula	Notes
A	***Baseline***			
B	Electricity purchased from the grid	108 790,0 *MWh*		*based on 989 kWh/t pulp*
C	***Project Activity***			
D	*Steam Turbine operating hours*	8 040 hr.		*from site data*
E	*Steam parameters from extraction:*			
F	Steam extraction pressure	11,0 bar		*from site data*
G	Steam extraction temperature	290 ^{0}C		*from site data*
H	Steam extration flow	30,0 *t/h*		*from site data*
I	Steam specific enthalpy	3 030 *kJ/kg*		*from steam & water tables*
J	Steam enthalpy	25,3 *MW*	*H/3.6xI/1000*	
K	*Steam parameters from back pressure:*			
L	steam back pressure	5 bar		*from site data*
M	steam temperature	210 ^{0}C		*from site data*
N	steam back pressure flow	45,0 *t/h*		*from site data*
O	Steam specific enthalpy	2 877,0 *kJ/kg*		*from steam & water tables*
P	Steam enthalpy	36,0 *MW*	*N/3.6xO/1000*	
Q	Pressure control range	(4÷7) bar		*from technical literature*
R	Electric power of generator	6,2 MWe		*from Svilosa engineering plan*
S	Annual electric energy production	39 878 MWh/y	*RxDxload factor*	*at aveargе 80% max load*
T	***Savings***			
U	Annual electricity saving	39 878 MWh/y	*S*	

ENERGY EFFICIENCY MEASURE	SVP-05

Blow down heat recovery system for SRB

Observation

The existing SRB deposits considerable amount of waste heat with the water, resulting from the constant blow-downs. The heat losses are estimated to 3% from the SRB heat capacity.

Recommendation

It is recommended to install an automatic blow down heat recovery system, including electronic controlled blow down valve and a heat exchanger. This system will maintain the TDS (total dissolved solids) level in the admissible limits.

The blow-down condensate that remains can be used to preheat the boiler feed water or to heat water for technological uses using a low pressure liquid heat exchanger

Estimated Saving

	Description	Value		Formula	Notes
A	***Baseline***				
B	Annual steam production	70	*t/h*		*from engineering plan*
C	Annual working hours for SRB	8 040	*hours*		*from engineering plan*
D	Average blow down rate	3,0%			*estimation on benchmarking values*
E	Annual quantity of blow down water	0,58	*kg/s*	*BxDx1000/3600*	
F	Temperature inlet heat exchanger	250	*^{o}C*		*estimated*
G	Temperature outlet heat exchanger	60	*^{o}C*		*estimated*
H	Specific heat of water	4,186	*kJ/(kg ^{o}C)*		
I	***Project Activity***				
J	Heat recovery from blow-down water	490,78	*kW*	*ExHx(F-G)*	
K	***Savings***				
L	Energy savings from heat recovery	3 749	*MWh/y*	*KxC/1000*	

ENERGY EFFICIENCY MEASURE	SVP-06

Shift of production from pulp blocks to pulp sheets

Observation

The pulp mill has two main technological lines for production of pulp: pulp sheets and pulp blocks. The production cost for pulp blocks is higher than for pulp sheets due to additional consumption of diesel oil as a fuel for the drying furnace

Recommendation

Ceasing the production of block pulp and increasing the production of sheet pulp is recommended.

The main benefit for energy saving will be determined mainly by dropping off of diesel oil as fuel for the drying furnace for block pulp and replacing it with steam in the dryer of sheet pulp.

Estimated Saving

	Description	Value		Formula	Notes
	Baseline				
A	Block pulp output for 2004	32 203	*t/y*		*from site data*
B	Specific diesel consumption in blocks line	0,04	*t/tpulp*		*from site data*
C	Specific steam consumption in blocks line	0,96	*MWh/tp*		*from site data*
D	Specific electricity consumption in blocks	0,28	*MWh/tp*		*from site data*
E	Specific compressed air consumption in blocks	59,5	Nm^3/tp		*from site data*
F	Sheet pulp output for 2004	27 023	*t/y*		*from site data*
G	Specific diesel consumption in sheets line	0,00	*t/tp*		*from site data*
H	Specific steam consumption in sheets line	0,84	*MWh/tp*		*from site data*
I	Specific electricity consumption in sheets	0,16	*MWh/tp*		*from site data*
J	Specific compressed air consumption in sheets	0,0	Nm^3/tp		*from site data*
K	***Project Activity***				
L	Total pulp production	110 000	*t/y*		*from site data*
M	Production otherwise performed thru block pulp	64 405	*t/y*	*Ax2*	*at future production level*
N	***Savings***				
O	Specific diesel savings in sheet line	0,04	*t/tpulp*	*B-G*	
P	Specific steam savings in sheet line	0,12	*MWh/tp*	*C-H*	
Q	Specific electricity savings in sheet line	0,12	*MWh/tp*	*D-I*	
R	Specific compressed air savings in blocks	59,50	m^3/tp	*E-J*	
S	Compressed air COP	0,113	*kwh/Nm* ^{3}		*from site survey calcualtion*
T	Price of diesel oil	538,98	*€/t*		*from site data*
U	Steam cost from power plant	12,91	*€/MWh*		*from site data*
V	Price of electricity	26,27	*€/MWh*		*from site data*
W	Savings from reduction of diesel consumption	2 467	ton	*MxO*	
X	Savings from reduction of diesel consumption	30 686	MWh/yr	*Wx12.44*	*Diesel calorific value: 12.44 MWh/ton*
Y	Savings from reduction of steam consumption	7 407	MWh/yr	*MxP*	
Z	Savings from reduction of elctricity consumption	7 857	MWh/yr	*MxQ*	
AA	Total energy saved	45 950	MWh/yr	*X+Y+Z*	

MWH