BIOMASS UTILIZATION FOR FUEL SAVING AND MINIMIZE ENVIRONMENT IMPACT IN A PAPER MILL

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Abstract **– In this paper there are presented some possibility for biomass utilization and an example for a paper mill. For this paper mill it is presented, the first, an own power plant analyze. After that, there are some biomass utilization solution, fuel saving and reduction of environment impact.**

Keywords: *biomass, fuel saving, environment impact, paper mill*

1. INTRODUCTION

Pulp and paper mills are intensive energy users. Pulp and paper production requires a considerable amount of energy in various forms.

Electricity is needed for the motors that drive pumps, grinders, compressors, fans etc; heat in the form of steam is needed for drying.

Energy prices are increasing, competition is increasing and in Europe, new pressures in the form of emissions limitations and carbon trading are being brought to bear.

For this industry, improvement efficiency of its energy production and its use of energy at the mills in order to minimize costs and environment impacts is a necessity.

The use of cogeneration in a paper plant is an old concept. Most paper plants use fossil fuels such as natural gas, coal, etc. to generate steam in low-pressure boilers in which cogeneration is not adopted. But where the system exists, the steam is produced in a high-pressure boiler and routed through a high-pressure steam turbine. The bled steam from the interstage turbine is then used.

The switch from using fossil fuels for power and heat generation to biomass is a way for raising the overall thermal cycle efficiency and lowering CO_2 emission levels.

The paper mill's supply and production processes result in a number of primarily wood-based by-products like bark, wood, forest residues, brokes and fibre, as well as biological sludge.

A multi-fuel boiler can use all of these to generate energy.

It is also designed to burn separately. But, there are applied and another technologies for using biomass.

Both existing technologies and new technologies can be applied to achieve significant energy efficiency gains. Important improvements have been made and there is a strong focus on energy efficiency in the industry.

2. BIOMASS ENERGY USE

Biomass energy, or bioenergy, is the conversion of biomass into useful forms of energy such as heat, electricity and liquid fuels.

Biomass for bioenergy comes either directly from the land, as dedicated energy crops, or from residues generated in the processing of crops for food or other products such as pulp and paper from the wood industry.

Biomass energy can be used "traditional" when biomass is direct combustion, often in very inefficient device. "Improved" traditional biomass energy technologies refers to improved and efficient technologies for direct combustion of biomass e.g. improved cookstoves, improved kilns, etc. The conversion of biomass energy to advanced fuels namely liquid fuels, gas and electricity is a "modern" biomass energy use, [1].

Most of the biomass generated at pulp and paper mills is direct burned and converted to energy at the power plant. Direct combustion involves the oxidation of biomass with excess air, producing hot flue gases which produce steam in the heat exchange sections of boilers. But, the average biomass-to-electricity efficiency of the industry is low. For that, it must be improve process efficiency through:

- efficiency improvements in direct-combustion systems
- the use of co-firing of biomass in existing coal-fired power stations,
- the introduction of high-efficiency gasification combined-cycle systems,
- integrated gasification fuel cell systems,
- modular systems.

Efficiency improvements in direct-combustion systems made possible by the addition of fuel drying and higher performance steam cycles at larger scales of operation.

Co-firing with other fuels in existing boilers is an option for the use of biomass with low-cost. Co-firing refers to the practice of introducing biomass as a supplementary energy source in high efficiency boilers. Co-firing has been practiced, tested, or evaluated for a variety of boiler technologies, including pulverized coal boilers of both wall-fired and tangentially-fired designs, coal-fired cyclone boilers, fluidized-bed boilers, and spreader stokers. The term "coal-fired" is used to refer to power stations which burn a range of solid fossil fuels in boilers to heat water, thereby producing high pressure and high temperature steam. In the pulp and paper mills, [2], a variety of different fuels can be used. The main fuels are bark, sludge from effluent treatment, deinking sludge, peat, as well as pulverized coal. Oil is used as start-up and reserve fuel.

Another potentially attractive biomass option is gasification. Gasification for power production involves the devolatilization and conversion of biomass in an atmosphere of steam or air to produce a medium-or low-calorific gas. This "biogas" is then used as fuel in a combined cycle power generation plant that includes a gas turbine topping cycle and a steam turbine bottoming cycle. Biomass gasification systems will also be appropriate to provide fuel to fuel cell and hybrid fuel-cell/gas-turbine systems.

Stirling engine systems using biomass are ideal for remote applications, stand-alone or cogeneration applications, or as backup power systems. Since the Stirling engine is an external combustion system, it requires less fuel-gas cleanup than gas turbines.

3. POWER PLANT ANALYZE

The power plant is being built in the middle of the paper mill and it is combine condensing and CHP plant. There are three steams boiler with two fuels: natural gas and oil and three pressure levels: 40 bar, 11 bar and 3.5 bar.

The power plant was dimensioned for the full work company. But, at present, the company works at the low capacity.

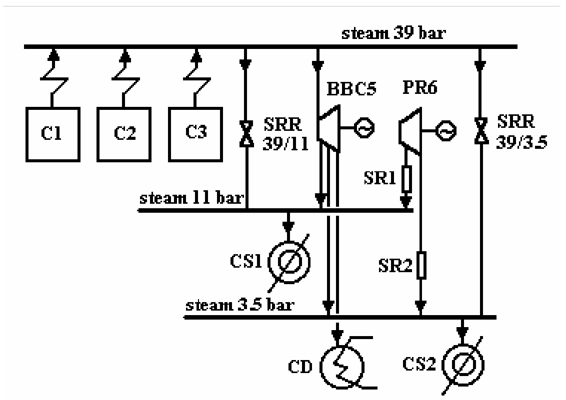

Figure 1: CHP scheme: C1, C2, C3 – steam boiler; BBC5-condensing turbine; PR6- back-pressure turbine; SRR- reduction-cooling station; SR- cooling station; CS1-consumers on 11 bar; CS2- consumers on 3,5bar; CD-condenser

The working regimes of the power plant in winter, in summer, with nominal parameters, with reduced parameters, without turbines were analyzed in detail,[3]. Here, there are shown only maxim and minim loads.

Compare to CHP, this power plant works with low efficiency. At present, the biggest consumer of 12 bar steam, pulp mill and ten paper machines, were uninstalled. A newsprint machine and a toilet paper machine work in the paper mill. These paper machines require low-pressure steam of 3.5 bar. Process steam is supplied from back-pressure turbine.

Indices	Minim load	Maxim load
Supply heat flux, MW	9	20.4
Electric power, MW	3.62	3.7
Total useful heat flux, MW	12.62	24.1
Conventional fuel, tcc/h	2.61	3.92
Efficiency, %	60	76

Table 1: The minim and maxim loads of power plant

For the minim load of power plant, steam boiler flow is smaller than admissible flow. For assurance of minimal steam flow, the condensing turbine must work. In this case, fuel specific consumption for electricity increases. Working of power plant without turbine, in the thermal plant regime with electricity supply from national system, determines the biggest fuel consumption. But, this regime isn't possible with existing steam boilers.

In conclusion, in the case of minim load, the option is installation of new boilers.

4. SOLUTIONS FOR BIOMASS UTILIZATION

Biomass utilization leads to the improving of energy efficiency and minimize environment impact.

Newsprint production is 12 t/h. For papermaking it is used mechanical pulping and reuse paper. The use of wood is about 30 m^3/h. From the debarking process result bark and wood residues in the amount of to 2.5 t/h. Available thermal energy of bark is about 22 GJ/h. Newsprint paper machine and toilet paper machine require, in winter-maxim load, low-pressure steam of 30 t/h, 3.5 bar with enthalpy of 2780 kJ/kg. If efficiency of bark boiler is 0.88, then available steam flow is about 7 t/h.

At present, this bark is removed to the landfill.

We propose two solutions for biomass utilization that should be applied in the paper mill analyzed:

1. Install two bark boilers (one – working and one - reserve) for about 7 t/h process steam of 3.5 bar. The additional demand for heat has to be produced in the old power plant, figure 2.

2. A new thermal plant with two steam boilers for about 25 t/h each and two bark boilers for about 7 t/h each process steam of 3.5 bar (one – working and one - reserve), figure 3

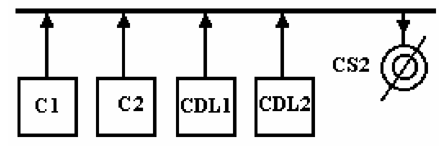

Figure.3: CHP scheme: C1, C2 – steam boiler; CS2 - consumers on 3,5bar

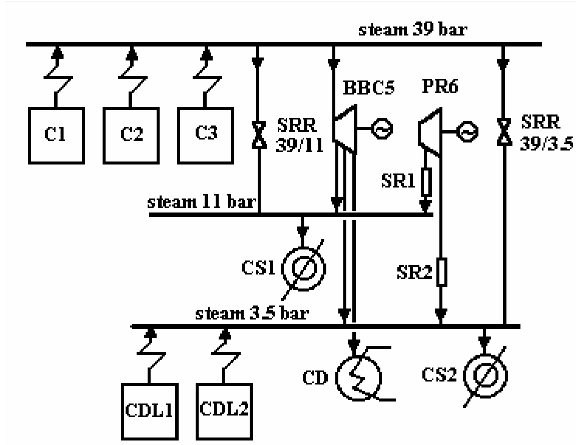

Figure.2: CHP scheme: C1, C2, C3 – steam boiler; BBC5 - condensing turbine; PR6 - back-pressure turbine; SRR - reduction-cooling station; SR - cooling station; CS1 - consumers on 11 bar; CS2 - consumers on 3,5bar; CD - condenser; CDL1, CDL2 – bark boiler

Disadvantages of these solutions are:

- all solutions necessity investment cost.
- the first solution - steam boilers are old and necessity expensive repairs.
- the second solution – new steam boilers necessity investment cost and there isn't electricity produced

Advantages of all solutions are fuel saving, reduction of waste disposal cost and reduction CO_2 emissions.

If paper mill works 8000 h/year, from the debarking process result bark and wood residues in the amount of 20000 tons. The fuel saving is about of 6800 tcc per year or 5900000 Nm^3 natural gas. CO_2 emissions reduction, calculated for natural gas, [4], corresponding to emission factor 56.1 tCO_2/TJ, is of 11000 tCO_2 per year.

We evaluate two indicators for to quantify the sustainability of the power productions paths: exergy efficiency (ε), which shows how well the energy quality is preserved in the system and exergy renewability, [5], (α), which considers the consumed exergy of renewable resources compared to the total of all consumed exergy. These indicators are calculated as:

$$\varepsilon = 100 \cdot E_u/E_c \quad (1)$$

$$\alpha = 100 \cdot E_{renewable}/E_c \quad (2)$$

where: E_u is useful exergy (sum of exergy of supply steam and generated power), E_c – chemical exergy of consumed fuel in the steam boilers and $E_{renewable}$ – chemical exergy of bark, in this case. These exergies were calculated using standard method, [6].

Results of exergy analysis are shown in the table 2.

Indices	U.M.	Present	Solution 1	Solution 2
Demanded steam flow	t/h	30	30	30
Steam flow of natural gas boilers	t/h	32	24.5	23
Steam flow of bark boilers	t/h	0	7	7
Natural gas flow	mc/h	3400	2610	1900
Bark flow	t/h	0	2.92	2.92
Demanded exergy	MW	5.95	5.95	5.95
Generated power	MW	3.78	2.9	0
Useful exergy	MW	9.73	8.85	5.95
Consumed exergy from natural gas	MW	31.88	24.44	17.74
Consumed exergy from bark	MW	0	5.94	5.94
Total consumed exergy	MW	31.88	30.38	23.68
Exergy efficiency	%	30.54	29.14	25.14
Exergy renewability	%	0	19.55	25.08

Table 2: Results of exergy analysis.

Calculus was made for the same demanded steam flow and steam parameters.

Note, from exergy efficiency view point, present situation is better than proposed solutions because more power was generated. Steam flow from bark boiler is delivered direct consumers and it doesn't pass through steam turbine. Therefore solution 2 is worst.

But, from exergy renewable view point, solution 2 is best. In this case, the ratio of exergy of renewable resources from total all consumed resources is better than present and solution 1.

In this analysis we not consider investment cost. It must be make completely feasibility study for to select the best solutions.

5. CONCLUSIONS

In the evaluation of feasibility of biomass utilization we need to have a balanced view of the factors of sustainable development: economic, social and environmental sustainability.

Paper mill must be interested for higher efficiency and reduced waste being sent to landfill. Biomass utilization is a way for raising the overall thermal cycle efficiency and lowering CO_2 emission levels. But, this necessity investment cost. If there is investment subsidy for a renewable energy, paper mill can opt for one utilization biomass solution, after a feasibility study.

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