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ENERGY-SAVING OPPORTUNITIES IN PULP AND PAPER MILLS

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Abstract:

The improvement of energy efficiency has become the most important tool for the industry striving to achieve excellence in cost competitiveness. Energy cost, one of the major components of the production cost, not only necessitates the installation of energy-efficient technologies but also inculcates energy-efficient best practices and methods amongst the plant personnel. The paper will cover opportunities & case studies on reducing energy consumption in paper mills, best practices from other sectors, and innovative technologies. The energy-saving opportunities described in the paper are identified during the detailed energy audit in various paper mills. The identified opportunities were found to be applicable in many paper mills and offer significant potential for energy saving. The energy-saving opportunities were identified in pumps, compressors, boilers, ID fans, vacuum pumps, steam systems etc.

Keywords: : Energy efficiency, Optimization, Energy reduction, Best practices

Introduction:

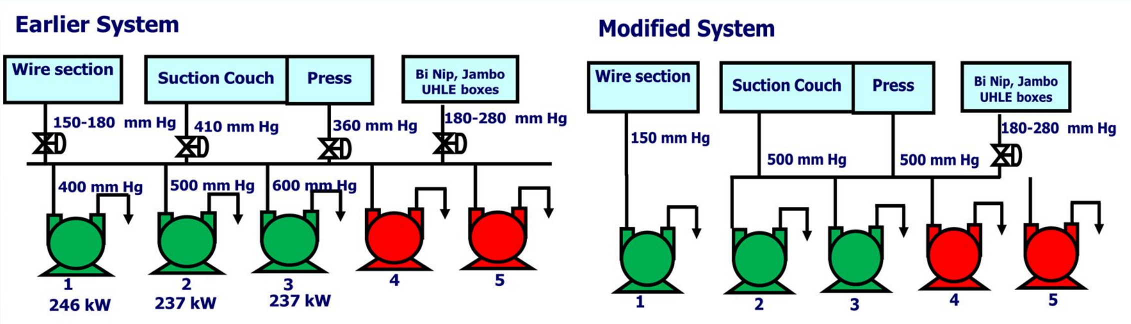
The Indian Pulp & Paper industry is highly fragmented with varying sizes ranging from 10 TPD to 1500 TPD. About 70-75% of production is from medium and small-category mills. The Pulp & Paper industry is highly energy intensive and therefore has a lot of potential for energy efficiency improvements. The energy consumption varies depending on the raw material used, the product, and the plant layout. There are significant opportunities in many paper mills to reduce energy consumption. Many low-hanging opportunities exist that offer good potential for energy reduction. Indian Paper mills have been consistent in adopting the latest technologies and best practices for energy conservation.

The Confederation of Indian Industry, through its Centre of Excellence, CII-Sohrabji Godrej Green Business Centre (CII-GBC), has been working on several initiatives to make the Indian Pulp and Paper industry world-class in green or sustainable development. This effort is part of the larger World Class Energy Efficiency initiatives of CII. During the detailed energy audit conducted by CII-GBC in many paper mills, it was observed that significant potential exists in many areas of paper mills for energy saving. The energy-saving ideas discussed in the paper can be fine-tuned to meet individual plant requirements. All these ideas are technically feasible and viable and have very high replication potential. The energy-saving opportunities identified in pumps, compressors, boilers, ID fans, vacuum pumps, steam systems etc. is described below

Optimizing the operation of vacuum pumps

Vacuum pumps are one of the major power consumers in paper mills. Inefficiencies within the vacuum system increase the electrical and or steam energy requirements. In many plants, the following situations were observed - the vacuum pumps were connected to a common header and operating at full speed but to maintain the required vacuum at various sections of the paper machine the valves were throttled near to the user end. This is an inefficient way of operating and will result in high power consumption. In other situations – the installed pumps were of higher capacity and operated with a throttled valve to maintain the required vacuum. Optimizing the vacuum pump operation by avoiding throttling will result in significant energy savings.

In one of the paper plants, after segregating the low and high vacuum requirements by avoiding a common header and optimizing the vacuum pump capacity has resulted in a saving of 60 kW in the vacuum pump system. The payback period will be in the range of 10 to 15 months.



The seal water temperature is another area to optimize in the vacuum pump system. The capacity of the vacuum pump decreases with an increase in the temperature of seal water. The recommended temperature of seal water for the vacuum pump is 30°C. Higher seal water temperature will result in deprivation of vacuum pump capacity or requirement of additional energy to achieve desired vacuum level.

Recovery of the flash steam from condensate in the paper machine

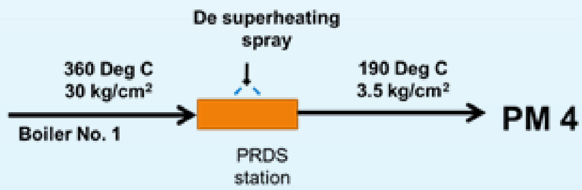
Condensate and flash steam recovery systems are one of the most crucial energy management systems in any industry. The cost of steam rises with the increase in fuel prices and so does the value of condensate. In any steam system seeking to maximize efficiency, flash steam will be separated from the condensate and can be used to supplement any low-pressure heating application. Every kg of flash steam used in this way is a kg of steam that does not need to be supplied by the boiler. The reasons for the recovery of flash steam are just as compelling, both economically and environmentally, as the reasons for recovering condensate.

Review of performance records of the one of the paper machines revealed that the specific steam consumption was 3 tons of steam/ton of paper. It was observed that the condensate was collected in a common tank and the flash from the condensate is let out into atmosphere. There exists a good potential for reducing the energy consumption in such case. This can be done by installing a thermocompressor. The payback period ranges from 2 to 3 years.

Optimize the operation of PRDS station

In any industry, steam is required at different locations, but the required steam pressure & temperature at each location varies according to the application. Therefore, high-pressure superheated steam is generated at a central location (boiler), distributed to various locations in the plant through a steam piping network, and then reduced to the operating pressure & temperature just upstream of the usage points. PRDS station is a modular steam conditioning unit to reduce the steam pressure & temperature at the point of usage. The recommended degree of superheat after the PRDS is 5 to 10^{0}C.

In many of the paper plants, it was observed that a high degree of superheat is maintained. The heat transfer is very effective when the steam is maintained near the saturation temperature thus reducing the steam consumption. In one of the paper plant, PRDS operations were studied and the following were the observations.



At present steam requirements for paper machine number 4 is met by process boiler 1 producing steam at 30 – 35 ksc and 360 Deg C. This high-pressure steam is passed though PRDS station and is then supplied to the users at 3.5 ksc at 190 Deg C. With the operating parameters, it was observed that the degree of superheat maintained is 43^{0}C. The higher degree of superheat is maintained for catering to the varying requirement of the paper machine. There is good potential to optimize the operation of PRDS operation close to saturation temperature and improve the heat transfer rates in driers. This would results in either increased steam availability for the process or can result in direct coal savings. It is recommended to increase the water spray to maintain the steam temperature close to the saturation temperature. In this case at least 0.5 TPH of additional LP steam can be generated.

Installation of vacuum pump in-lieu of steam ejector in turbine condenser

Main purpose of steam ejector is to remove the non-condensable gases from condenser with the help of high-pressure steam utilization. Using steam ejector is a normal practice in most of the captive power plants, whereas similar is not the case in utility power stations. In utility power stations, vacuum pump is used in lieu of ejector. The steam that is used for steam ejector is drawn from main steam line (in case of CPP) from where the pressure is reduced, de-superheated and then sent to the ejector. Here, we do not lose energy, but we lose the opportunity to generate more power. If the same amount of steam is sent to turbine instead of ejector, more power can be generated. Unlike ejector there wouldn't be any heat addition in vacuum pump, but the same amount of heat would be substituted in deaerator extraction.

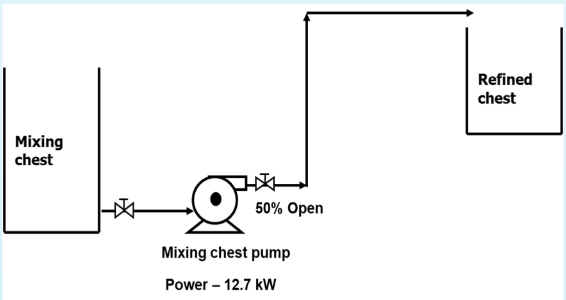
In one of the captive power plants of 15 MW capacity, 7 TPD steam at 10 kg/cm^2 is used in steam ejector. Corresponding power generation potential is 60 kW. The net power saving, after deducting the power consumption by the vacuum pump will be 15 kW. The simple payback period ranges from 2 to 3 years.

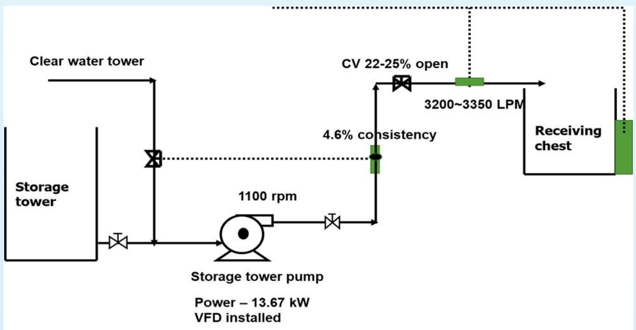
Application of heat-resistant paint on dryer side to avoid radiation loss and reduce steam consumption

The dryer sides normally have a surface temperature of 80 to 100^{0}C. The surface temperature can be reduced by the application of nanotechnology-based insulation paint. Dryer side coated with heat-resistant paint showed an average temperature reduction 15%. Maintaining the dryer end surface temperature in the range of 50 to 60^{0}C results in low heat loss and significant savings in steam consumption in the dryer. The payback period will be in the range of 2.5 to 3.5 years.

Avoid valve throttling in pumps

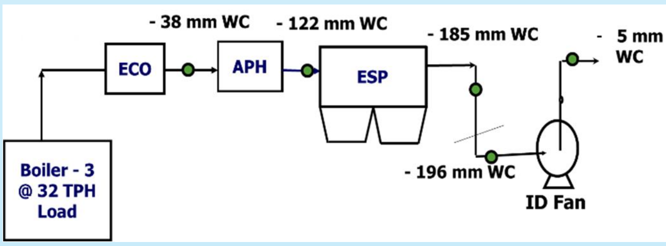
In many paper mills, it was observed that several pumps operate with valve throttling. Throttling valves and bypass loops are indications of oversized pumps. Throttling also makes the pumps operate inefficiently. The reasons for the throttling are generally an oversized pump because they were designed for maximum capacity (often for the future), process variations, changed process design etc. Avoiding valve throttling by installing variable frequency drives (VFD) or correct size pumps will result in good energy saving with a payback period of 1.5 to 2 years. Below schematic diagrams indicate pump throttling conditions, as observed in many paper mills.





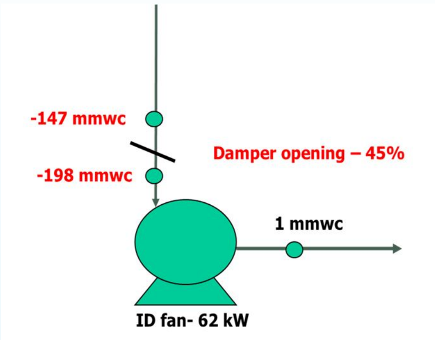
Reduce pressure drop across the flue gas path in boiler

An excessive pressure drop across the system will result in poor system performance and excessive energy consumption. Resistance to flow increases the drive power consumption. One such observation is across the flue gas circuit in the boiler system. During the energy audit in one of the plants, excessive pressure drop was observed across the APH and ESP. As seen in below schematic diagram, the pressure drop across the APH is 84 mmWc which is on higher side as compared to the norms of 40 mmWc. The high-pressure drop can be due to chocking of tube bundles



DP across APH	Recommended DP across APH	DP across ESP	Recommended DP across ESP	Fan Head	% Excess pressure drop	Fan power	Saving potential
mmWC	mmWC	mmWc	mmWc	mmWC	%	kW	kW
84	40	63	30	191	36	72	25

The pressure drop across ESP was 63 mmWc is also on the higher side as compared to the norms of 30 mmWc. This can be due to turbulence at ESP inlet duct and bends in the duct. The excess pressure drop in the above case was 36% of the fan head. Significant energy-saving potential exists in the boiler ID fan by reducing the pressure drop by checking the condition of the APH tubes, cleaning and or replacement of the tubes, conducting CFD study across ESP, and modifying the ESP inlet and outlet duct to reduce the turbulence and pressure drop. In the above case, 25 kW reduction in boiler ID fan power is possible.



Reduce pressure drop across damper in ID fans

Conservative engineering practices often result in the installation of fans that exceed system requirements. To match the system requirement, many fans are found to be operating with the damper control. The damper control is an inefficient way of controlling fan capacity. Such oversized fans lead to higher capital costs, higher maintenance costs, and higher energy costs than fans that are properly sized as per the system requirements. Avoiding the damper loss by installing VFD for the fan results in significant energy savings. As indicated in the following case study, the pressure drop across the fan inlet damper was 51 mmWc which was equivalent to 25% of the fan head. Installing VFD and opening the damper fully or removing the damper will result in a saving 25 kW in fan power. The power reduction will be as per the affinity law where power α speed3.

Optimize cooling tower fan operation

There exists a good energy-saving potential by optimizing the operation of cooling tower fans. In many plants, it was observed that the cooling tower fan operation is interlocked with the water temperature. During the favourable condition (winter season) when the water temperature is low, one or a few of the cooling tower fans will be turned off. This results in partial energy saving but on the other side, the heat transfer areas in the cooling tower is not fully utilized. In order to achieve higher energy saving and to utilize the complete heat transfer area, many plants are installing VFDs on each of the fans and then operating all the fans will 50% speed. The fan speed can be interlocked with the water temperature and the speed can be reduced based on the temperature. In axial fans, power is proportional to the pressure drop and pressure drop is proportional to the velocity2. This results in high energy saving in cooling tower fans.

Optimizing the power consumption of compressed air system

Many opportunities exist in a paper plant to reduce the power consumption of the compressed air system like reducing the generation pressure, segregating the low and high-pressure requirements, reducing the compressed air leakages, improving the compressor efficiency, avoiding the unloading, and proper selection of compressors. Energy savings from compressed air system improvement can range from 10% to 25% of total system electricity consumption. Reduction of 1 bar in compressed air generation pressure will result in 6% energy saving.

In one of the plants, a centralized distribution system was installed for compressed air. 2 centrifugal compressor was in operation (out of 4) to cater to the instrument air requirement in the plant. One of the compressors (SEC 0.13 kW/CFM) was fully loaded while the other (SEC 0.15 kW/CFM) was partially loaded (90% modulation). The efficiency of the partially loaded compressor was found to be low. One of the compressors (out of 4 for instrument air requirement) which was not in operation was found to be having good efficiency (SEC 0.11 kW/CFM). Various trail was conducted with different sets of compressors, and it was observed that operating the compressor with SEC of 0.11 kW/CFM along with a screw compressor (which was idle in another section of the plant) with VFD is offering a saving of more than 2000 units per day.

Replacement of traditional chest agitators with submersible agitators

Conventional agitators have high power consumption due to design (belt & pulley/gear arrangement, low-efficiency motors) and also require high maintenance. Replacing the conventional agitators with compact submersible agitators results in more than 50% reduction in power consumption and has less than 6-month payback period. Submersible agitators can be mounted inside the existing chest without long stoppage.

Application	UOM	Before	After	Energy Savings
Ch No: 3 Agitator	Connected Load	30 KW	10 KW	65%
	Consumption, KW	17.3 KW	5.7 KW	

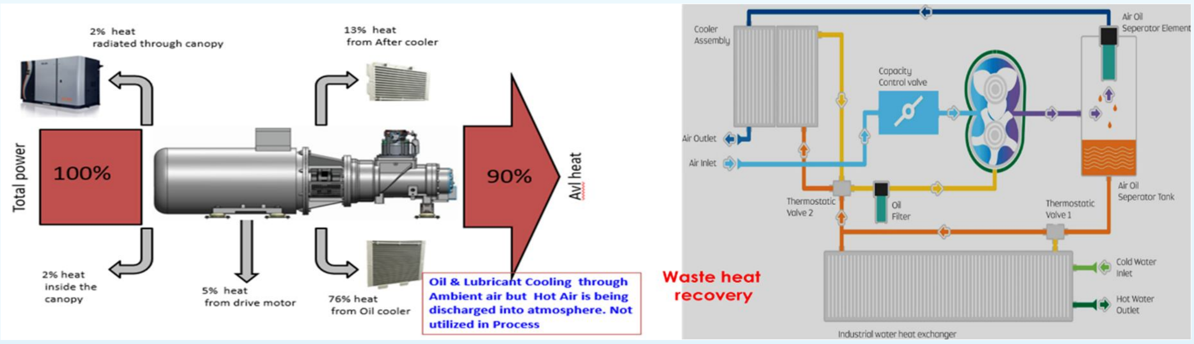
The case study in one of the paper plants indicates a saving of more than 65% in agitator power.

Waste heat recovery from air compressor

Air compressor accounts for a significant amount of electrical energy. Only 10% -30% of energy reaches the end user, remaining large amount of electrical energy is getting wasted in the form of heat. If not recovered this heat is dispelled into the atmosphere while the majority is lost via the oil cooler. By re-directing the hot oil to a high-efficiency oil-to-water heat exchanger, the heat can be transferred to water, raising the temperature to a required level for various applications.

Implementing a heat recovery system in air compressors eliminates the need for additional equipment required to heat air or water thereby reducing emission and energy consumption significantly. The application is best suited for industries like paper where hot water is required for the process. The heat can also be utilized to preheat the boiler feed water.

As per the compressor manufacturers, 76%- 78% of the input energy to the compressor will be dissipated as heat, only through the oil cooler. The waste heat recovery unit can be installed between the compressor and oil cooler and can recovers heat before it enters cooler. This recovered heat can be used to heat water up to 80^{0}C. The payback period is 1 to 3 years.



Conclusion

Significant potential exists in paper plants for reducing energy consumption. The opportunities discussed above are applicable to many plants. The energy-saving ideas discussed in the paper can be fine-tuned to meet individual plant requirements. All these ideas are technically feasible and viable and have very high replication potential. Many of the identified opportunities have a relatively short payback period.