Utilizing the unused energy flows inside the paper mills

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INTRODUCTION:

As the energy and material prices are going higher, it makes sense to take a look into the overlooked energy flows inside the building. In the paper mills the heating is not usually the problem, but saving electricity never goes wasted.

One great way to save energy is to use more of the existing energy flows inside the building. This includes hot and cold water, steam and exhaust gases that are not yet used in the process but are given out as waste. In hot side this is widely implemented already, and less heat is wasted, but there are also possibilities in the lower temperatures that do not get so much attention.

In this article I am talking about the water flows inside the paper mills, and how they can be utilized better to lower the energy consumption of the mill. Included are some example calculations and suggestions for the utilization.

BM Green Cooling has over 30 years of experience of cooling in paper mills. During recent years heat recovery and heating has taken a bigger role, as the technic is maturing and the focus in this field is turning more and more to the total system efficiency instead of optimizing separate parts of the process.

What are the overlooked flows?

Overlooked flows are usually found in the lower end of the temperature range in the paper mills, meaning 100 °C and under. These can include for example warm process water, affluent water, and cold process water if they are not needed in any particular task.

Cold process water means the fresh water before it is warmed up to be used as process water. With special climate cabinets this water can be used to cool down the e-rooms inside the mill, saving in two places. When the cold water is used in cooling, there is no need for a chiller, and the warmed water can be given back to the process water, so it does not need to be warmed as much, and therefore the heating energy needed is less than before. This means 100% heat recovery and big savings in electrical energy.

Warm water that needs to be cooled down can be used as a heat source for a high temperature heat pump. With a high temperature heat pump up to 90 °C temperatures can be reached, allowing a more versatile use.

If there is too much warm process water that is not used for anything and needs to be cooled down, an absorber cooler is a great option. With as low as 70 °C water the absorber can provide you with energy efficient cooling.

Absorption chiller uses hot water to replace the electrical energy of the compressor in the chiller. This means that by implementing the warm water flow into the chiller, you are cooling warm water, and you are getting chilled water in exchange, with almost no electrical power. Only electrical power needed in this process is in the automation and in the dry coolers that act as condensation coolers for the absorber chiller.

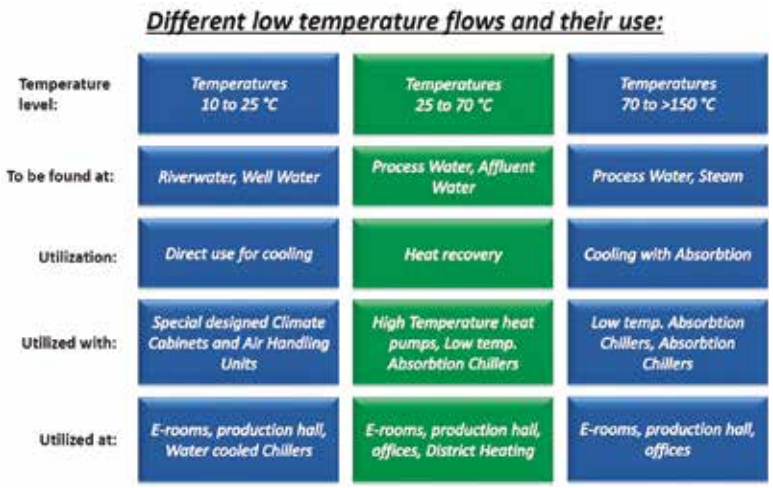

Figure 1: Matrix of the temperatures and uses, "Diagram for the temperatures and usability of the flows".

Why use the energy flows?

Using the overlooked energy flows help to reduce the emissions and decrease the costs and environmental impact of running the mill. This can be achieved by using the existing energy sources more effectively, reducing wasted energy and the energy used.

Taking unused flows and turning them into used flows increases the overall efficiency of the plant, as less energy is used and less energy is given out. Using less of the energy coming from outside and utilizing more energy that was inside the whole time, the overall efficiency of the plant increases. The optimizing process is all about using the least amount of energy while getting the work done.

As affluent water temperatures are getting warmer and the regulations are getting tighter, cooling in the affluent water is needed more often. This can be made for example with high temperature heat pumps, producing warm enough water to be used in heating. With high temperature heat pumps the water can be heated up to 90 °C, allowing a more versatile use.

Using the energy flows

In the next part of the article, we are focusing on the flows, dividing them by the temperature levels and suggesting some ways to utilize them.

Cold Water – from 10 to 25 °C

Cold water can be usually directly used in cooling of certain areas of paper mills. Either E-rooms or halls, usually the fresh water in Europe is cool enough that the cooling effect can be utilized in certain branches.

With specially engineered climate cabinets the E-rooms can be cooled with fresh water. The Paper Line of climate cabinets by BM Green cooling is specifically designed to be able to use higher water temperatures and still maintain the air temperature on the level that is specified in the ASHRAE norms. The climate cabinets can also be supplied with stainless steel piping if the water quality demands it. Additionally, the stock Paper Line cabinets include the Siemens S7 control unit for easy controlling with the existing Process Control System (PCS) of the mill. Available are also versions without their own control units, so they can be controlled directly by the PCS.

Cold water can also be used in the summer to cool down the hot halls in the mills, like the warehouses, roller halls or packing halls.

After using the cold water in cooling, it is returned to the flow it was taken from. This means that the overall water consumption of the mill is not increased, and we get the additional benefit of 100% heat recovery. As cooling the hall increases the water temperature, this means that the water does not need to be warmed as much later when used in the process.

Figure 2: The Climate Cabinet: "Special Engineered Climate cabinet for the paper industry, with Siemens S7 control unit and A-shape coil to enable high natural cooling share for a year".

Warm Water – from 25 to 55 °C

Warm water is for example the affluent water that is going to be given back to the water source. Usually, this water needs to be cooled down before being released back into nature to minimize the environmental impact. The water is however not warm enough to be useful in heating applications.

During recent years we have faced increasing demand for cooling of the affluent water. The regulation is getting tighter, and the environmental questions are getting more important. Affluent water can be cooled down with dry coolers, adiabatic dry coolers or closed cooling towers. What is common in all these solutions is that they are closed systems to prevent the affluent water from vaporizing.

This way the risk for Legionella and problems with steam is prevented.

While cooling the affluent water is possible, it is not the most efficient solution as the heat is dissipated into the surrounding air and wasted. That is why using heat recovery would be the best option for the overall efficiency of the mill.

The affluent water is mostly not warm enough to be used directly in any heating applications, but it can be utilized as a heat source for heat pump. With high temperature heat pump the water temperature can be raised to up to 90 °C, which allows versatile use in various applications. In the winter the heated water can also be used in heating the offices or other social parts of the building, or it can be sold for district heating.

Figure 3: Heatpump "High temperature Heat Pump for heat recovery".

Hot water and steam – from 70 to >150 °C

If there is hot water that cannot be used in the process and needs to be cooled down, there are options to utilize this water. In winter this could be used in the heating, but on paper mills there is usually too much heat. This means that during the summer there are not many great options to use this water in heating.

One option is an absorber chiller. An absorption chiller uses the hot water to provide chilled water for the cooling applications. In absorption process the heat energy from the hot water replaces the electrical energy needed for the compressor in the traditional chiller solution. This solves the problem of having too much heat in the paper mill and can be used for example to cool the E-rooms in the process.

While previously the absorption could be done with 100 to 90 °C water, the technique has matured and currently it is possible to use as low as 70 °C inlet water for the absorption chiller. Possibility for using lower temperatures means that the technique can be used more often on the mills.

Modern absorber chillers can also use gas and steam as a heat source, enabling a very wide range of applications.

Normally the benefits of the absorption system are highest in the summer when there is too much heat on the mill and the need for heating is reduced.

With absorption and adsorption technic the needed electrical energy is drastically reduced. To cool 1.000 kW the absorber needs only 9 kW of electrical energy. Additionally, there is the electricity needed for fans of the condensing unit, and this depends on the

outside temperature. Based on our existing projects the highest consumption here is about 60 kW for cooling capacity of 1.000 kW. The calculated EER (Energy Efficiency Ratio) of this solution for the electrical energy needed here is then 14,5 (1.000 kW/69 kW) in the worst scenario in the summer. Comparing this to the normal EER of chillers which is on the level of 3-4, the efficiency is on another level. We must not forget that absorption solution uses the heat energy for the cooling effect, but if it is possible to use heat which would be otherwise wasted, the efficiency is raised a lot.

Other not so commonly known option is to use a small generator that uses the hot water to produce electricity. While this might not be suitable for most of the mills, it could be the optimal solution for some. By using the hot water in electricity production, the water is cooled down, and the generated electricity can replace the bought electrical energy, therefore saving costs and total energy consumed.

Figure 4: Absorber chiller "Low Temperature Absorber that uses 70 °C water as a heat source".

Reducing the electricity consumption in cooling

Reducing the energy consumption in cooling in the high heat load areas such as papermills is also a crucial part of saving energy. For example, the E-rooms require constant cooling when the paper process is running. Yearly this equals to high energy consumption as the heat loads are high and the need for cooling is constant.

Ways to reduce the energy needed include mostly simply taking the most energy intensive part of the cooling out of the equation. This would in most cases be the chiller compressor, whether the cooling is done with DX (Direct Expansion) or water/air cooled chillers.

Freecooling

Reducing of the energy needed for cooling can be done by utilizing free cooling, where the cooling medium is outside air. With purposefully designed climate cabinets for example the E-rooms of paper mills can be cooled with indirect free cooling up to 14 °C outside temperatures. This means that during outside temperatures under 14 °C no mechanical cooling is needed. For example in Düsseldorf, Germany, the temperature remains under 14 °C for 64 % of the year.

When mechanical cooling is replaced with free cooling or natural cooling (for example fresh water inside the plant) the savings can be up to 95% in the electrical power consumed. On yearly basis in Düsseldorf this would then mean roughly 60 % saving in the electricity consumption in the cooling system compared to a traditional mechanical cooling solution.

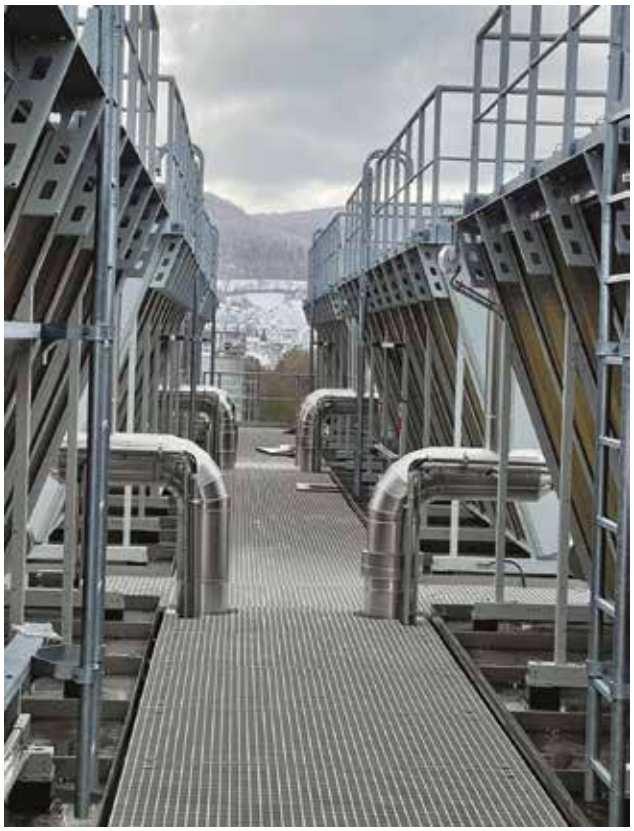

Figure 5: Drycoolers "Drycoolers to provide freecooling up to 14 °C Outside temperature".

Natural cooling

If the cooling of the E-rooms can be done with the cold water, the energy efficiency is even higher as we are taking the fans of the dry coolers away from the equation. The only parts that use energy are the pumps, but the pump using is comparable to other liquid-based cooling solutions, whether it is with free cooling or compressor cooling.

CONCLUSION

When considering the energy savings on the paper mill, utilizing the existing energy is a great way to go. Whether the flows are hot or cold or something in between, usually there is a way to use it in a way that saves energy and the environment. Problems can still arise from the material choices and compatibility of the different utilization solutions between each other, and even availability of the said flows during the different times of the year. As the pioneer of natural cooling in the paper mill, on top of engineering of the natural cooling solutions BM Green Cooling also provides study projects for plants to get a better understanding of the usability of the different flows and how to better utilize them inside the paper mill. With the information the customer has a better understanding of the possibilities, the needed investment, special requirements to take into consideration and the savings potential of the solution.