Renewable gas for tissue drying hoods enabled through collaboration between Sofidel, Meva Energy and ANDRITZ

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INTRODUCTION:

Combustion of fossil gas to generate process heat for tissue drying is one of the few remaining unsolved sustainability challenges within the tissue production industry. High quality demands on the hot air due to its direct contact with the tissue, combined with demands for low cost and high availability, has rendered renewable energy unfeasible...until now! At Sofidel's tissue mill in Sweden, a renewable gas production unit from Meva Energy will be installed directly at the mill, supplying the tissue drying hoods with decentralized renewable gas from biomass. This has been enabled through extensive research and verification with Sofidel, Meva Energy, ANDRITZ and the research institute RISE.

Producing tissue involves drying the tissue to create the softness and fluffy character required to get a high-quality product. To achieve this, the best practice today is to let the paper travel over a large heated steel cylinder, a yankee, at high speed. The yankee cylinder is generally heated from the inside with steam and from the outside with hot air. Direct combustion in gas burners is used to generate this hot air, wherein the hot flue gases are blown into a drying hood and used to dry the tissue paper.

Figure 1: Example of combustion chambers at a tissue mill, generating heat for the drying hoods.

As the hot air is in direct contact with the paper it needs to be free from particles and other contaminants in order to ensure high paper quality: black particles or a unpleasant odour cannot be accepted. To achieve low cost, with stable and high quality process heat, the best practice today is to combust fossil gas, i.e. natural gas or LPG, in tissue drying hoods. This contrasts with low-carbon sustainability targets within the tissue industry and it needs to be resolved to enable fossil free tissue production.

The steam used to heat the inside of the yankee can be generated through direct combustion of wood residues and other biomass because the heat is not in contact with the paper product. However, this principle cannot be applied to the production of the hot air that is subjected directly on to the paper, as direct combusting of solids is inherently associated with high emissions of particles.

One interim solution which has become more popular has been to install co-generation, or even tri-generation, solutions where fossil gas is combusted in a gas turbine which can generate both steam for the inside of the yankee as well as power and heat for tissue drying hoods. In this way a better usage of the fossil gas can reduce the energy cost and the CO2 footprint, but as long as such a solution is still based on fossil gas energy it can never be truly sustainable. The problem is the source of energy: fossil gas needs to be replaced with renewable gas.

Decentralized energy production through Meva Energy's technology

A new type of biomass gasification developed by the Swedish company Meva Energy, spun out of Luleå Technical University and the RISE Center for Energy Technology, has proven to overcome these issues. The gasification principle, entrained flow gasification, is simple and robust which gives a clean and stable gas quality. The technology could use a variety of feedstock, even fine fraction residues such as sawdust and wood fibre.

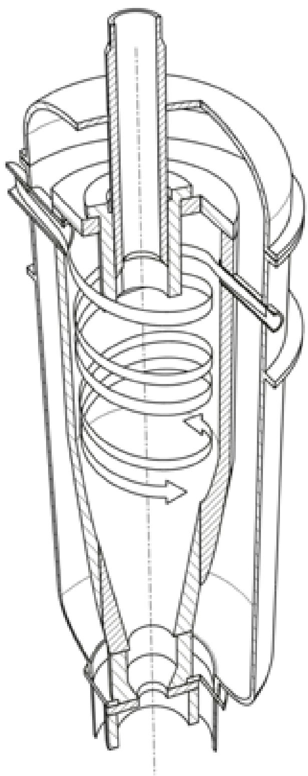

Figure 2: Meva Energy's entrained flow gasification technology enables a stable gas quality.

Meva Energy's philosophy is to produce and deliver gasification units that use local biomass residues to generate energy on-site. Hence, without the need for costly and complex upgrading, unnecessary transport and parasitic losses. The gas needs to fulfil the function of its use, and not meet a standardized gas quality just for the sake of it. These factors are key in creating a cost-efficient solution that can be even cheaper than existing, fossil, solutions.

Biogas is normally associated with gas produced from anaerobic digestion of sewage sludge or manure, i.e. a wet slurry. The technology developed by Meva Energy is a thermochemical conversion process which uses solid biomass, e.g. wood-based residue or agricultural residue. By contrast, the energy content in solid biomass differs from the energy content of wet slurry by a factor of 1000, which means that to get the same output the reactor of the anaerobic digestion plant must be much larger than the plant hosting the thermochemical conversion process. Hence, the capex for a thermochemical conversion process can be lower per MWh of energy.

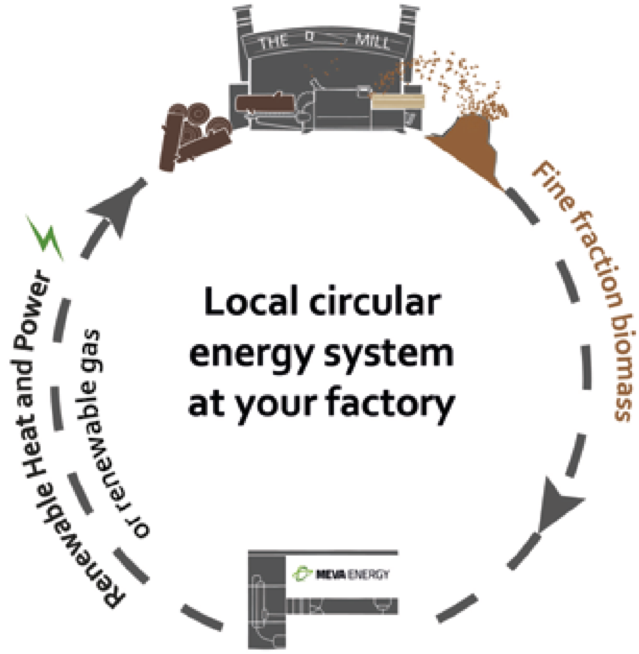

Figure 3: Using the energy locally where it is produced means cost-efficient and robust energy solutions.

There are several technologies for thermochemical conversion, fixed bed, updraft, downdraft, fluidized bed etc, but what makes the technology of Meva Energy so interesting for this application is the patented entrained flow principle. Biomass particles enter into the hot reactor at a continuous flow, providing a stable process that gives a stable gas quality.

The technology was first developed for industrial scale combined heat and power production. Therefore, the first full scale plant built with the technology, situated in Hortlax, a small village outside the city of Piteå in northern Sweden, was built for combined heat and power. The plant is connected to the district heating grid and the power grid with a capacity of 1,2MWe and 2,4MWth.

Figure 4: Meva Energy's CHP demo plant with Cummins Genset and capacity of producing 1,2MWe and 2,4MWth

Combustion and tissue drying verified at demo plant in Sweden

Interest from the tissue industry and the report, "Fossil free tissue drying" (Energiforsk, report 2016:231), which investigated the effects of replacing LPG with syngas using mathematical models became the starting point to look deeper into the possibility of replacing the fossil gas with Meva Energy's stable renewable gas in the tissue drying hoods. Some questions remained: could a low-calorific gas be used in a suitable gas burner and generate stable sufficient heat without resulting in imperfections such as smoothness, smell or similar on the tissue? How could the availability of the paper machines be ensured? What needs to be upgraded in the existing infrastructure of the mill and what effect could it have on the whole tissue drying system?

The first step to answer these questions was to give the research institute RISE ETC (Research Institute of Sweden, Energy Technology Center) the task to evaluate the suitability and further sort out the uncertainties.

Figure 5: Combustion trials at Meva's plant in Sweden where a mini-yankee was used to dry tissue paper.

A major test campaign was pursued, where syngas from Meva Energy's full-scale biomass gasification plant were burnt in a combustion chamber and the combustion gases then analysed in terms of particle content and combustion. RISE also investigated tissue drying with a mini-yankee cylinder, whereupon the tissue paper samples were analysed in terms of odor and visual damages.

The result showed:

- No odor or visual damages at all
- Sufficient heating value
- Low level of particles in the exhaust gases
- Stable and even combustion without any need to enrich the biogas

These tests were conducted with a swirl type of burner and followed up by commercial burner manufacturers testing the gas in more conventional burners for tissue drying hoods, accepting multi fuels.

Figure 6: Burner trials with renewable syngas showing full combustability of the low-calorific gas.

These tests concluded:

- Works in both duct and corner burners
- Possible to co-fire LPG/NG and renewable syngas in same burner
- No need to redesign or expand existing burner chambers

These results mean that the transition from a fossil solution to a renewable gas can be done simply. Hence, keep the existing infrastructure as a redundancy and only exchange the burners to multi-fuel types.

Renewable gas and burner system developed together with ANDRITZ

The combustion and tissue drying tests revealed another opportunity: by optimizing the gasification and burner solution the gasification system could be simplified, compared to the solution Meva Energy had developed for gas engines, which requires more purified gas then an industrial burner. If the burner accepts a higher moisture content and lower calorific value in the gas, it means that more low-cost biomass can be utilized as well as the gas cleaning system being simplified, giving a more robust and simple system.

Together with ANDRITZ burner solutions, Meva Energy and RISE, a prototype multifuel burner was developed to be able to run on standard fossil gas, in this case LPG, as well as Meva Energy's renewable gas. Meva Energy's process engineers generated a simulation of how different low-value feedstocks would affect the gas quality and based on those requirements the burner was developed. The burner was installed in combustion chamber that mimic the combustion conditions at a tissue mill and then installed at Meva Energy's demo plant in Sweden.

The Meva Energy plant was adjusted so the gas could be extracted at different points along the gas cleaning system. The tests showed that the burner could easily switch between 100% syngas to 100% LPG back, and forth and syngas from all the tested sampling points could be combusted nicely.

Sofidel and Meva Energy to install renewable syngas plant at Swedish mill

Following this, a study of the effects of introducing the renewable syngas on the tissue drying system as a whole has been conducted by ANDRITZ Novimpianti and the University of Pisa. After successfully concluding this pre-project, Sofidel Sweden and Meva Energy finally announced a commercial agreement specifying the world's first commercial use of renewable gas for fossil-free tissue drying. The agreement means that Meva Energy will build and operate a gas production plant at Sofidel´s tissue mill in Kisa, Sweden and deliver renewable gas to Sofidel on a long-term contract. The target is to commission the gas plant in mid 2023.

Negative CO2 emissions and potential of cost reduction

Switching to renewable Meva gas, it is estimated that Sofidel´s Kisa mill will reduce its CO2 emissions by 8500 tons per year compared with the carbon footprint of today's consumption of fossil LPG. The biomass used as fuel will be locally sourced wood residue. The decentralized principle of on-site generation in combination with not having to refine the gas to pure methane is the basis for reaching a high conversion efficiency, as well as realizing high levels of CO2 emission reductions. Based on this, the Meva Energy technology can realize more substantial cuts of CO2 emissions than conventional types of biofuel. As the Meva Energy system also produces biochar, a stable form of renewable carbon that creates a carbon sink when used for soil improvement, the net CO2 emissions can potentially even be negative.

The starting point for converting to a renewable solution is sustainability, but of course, the economic aspect is of the utmost importance when looking into replacing fossil gas in tissue drying hoods; energy usage constitutes a considerable share of the cost for a mill. Fossil gas is subject to a global market where the price fluctuates dramatically, and the long-term forecasts clearly point towards higher costs. During the last 18 months the costs for European emission allowances have sky-rocketed from 18 EUR/tons to over 60 EUR/tons. Few people think it has reached its top level and there is strong political push towards an even higher emission allowance price. What will the cost of combusting fossil natural gas be a few years from now?

Figure 6: Combustion chamber representing conditions at Sofidel.