ENVIRONMENTAL SUSTAINABILITY DEVELOPMENTS OF THE LEATHER INDUSTRY

Wolfram Scholz

W_2O Environment Ltd. Gymnasium Strasse 6/12, 1180 Vienna, Austria, +43 676 782 9383, wolfram@w2oenvironment.net

ABSTRACT
The leather industry worldwide is continuously improving the sustainability by reducing water and energy consumption, by recycling and by reducing solid waste generation and disposal. Tanneries have successfully reduced their water usage for leather processing with membrane-based water recycling plants achieving up to 75% water recycling.
The implementation of energy efficient effluent treatment systems, using efficient pumps, blowers and biological aeration has demonstrated that energy consumption of effluent treatment can be reduced by more than 50%. The installation of solar power heaters for hot water production have reached the goal of 100% renewable hot water production for leather processing and sludge drying. Sludge dryers operated with renewable heat achieve a reduction of the disposable sludge volumes by 2/3. Many tanneries are reducing and reutilising their waste in a productive manner by recovering chrome, gelatine and tallow to produce biodiesel. Solid waste is converted in biogas- or gasification plants to a renewable source of heat and energy, contributing up to 98.5 % of energy usage for a tannery in Germany and in the UK. With the implementation of sustainable measures many tanneries worldwide have achieved a great reduction of environmental impacts and cost savings, by reducing their water and energy usage and by reducing costs of solid-waste handling and landfill.

Keywords: Tannery, sustainable developments, water consumption, energy consumption, solid waste reduction, recycling

1. Introduction

Consumer pressures as well as the raising production and environmental costs urge the leather industry to implement sustainable production schemes with the main objectives of saving resources by process- and production-integrated measures to minimise environmental impacts.

By strictly regarding economical demands, an approach of "green-processing" has been developed, that enables the leather industry to reduce environmental and operational costs and to improve their sustainability. The implementation of processes-integrated measures and recycling technologies using Membrane bioreactor technology and Nanofiltration has shown to be technical and economical feasibility for recycling and to fulfil the quality criteria for leather processing.

Tanneries have developed renewable energy using solar power heaters to pre-heat water for leather processing and have implemented technologies to convert solid waste to energy, thus replacing fossil fuel by a sustainable source of generating heat and energy.

2. Membrane Bioreactor treatment

Membrane bioreactors (MBRs) combine an activated sludge process with membrane ultrafiltration to facilitate complete retention of the biomass. The process relies on membrane filtration to effectively retain all the biomass

in the bioreactor as opposed to conventional treatment, where the biomass is continuously lost during clarification. As a consequence, the MBR process is operated at 3 folds higher mixed liquor concentrations of up to 10 g/l MLSS, than conventional biological treatment. This increase of concentration of wastewater bacteria allows reducing the aerated biological tank dimensions by 55%, compared to conventional biological treatment, which consequently also reduces aeration requirements by 35% (Scholz, Rougé, Bodalo and Leitz, 2005).



Photo 1: Membrane Bioreactor

A further benefit of MBR, resulting from increased sludge retention times and operating temperatures, is the reduction of surplus sludge generation.

Due to the high sludge retention time and high MLSS, the bioreactor is severely carbon limited and the influent carbon sources are predominantly utilized for metabolic purposes than other cellular growth, e.g., maintenance, thus minimizing biomass production. Large scale MBR plants have shown that only 6.7% of the metabolized COD was incorporated into surplus sludge production, compared to 30-50% in a conventional activated sludge system. This minimizes the surplus sludge and consequently the amount of disposable biological sludge by more than 86%. The Membrane Bioreactor system achieves 92% COD, 98% BOD, 93% total nitrogen reduction and suspended solids free and transparent permeate (Scholz, 2012).

Nanofiltration

The application of recycling normally relies on suitable process technology for water purification. The wide fluctuation in tannery effluent quality coupled with the requirements for process water of reliable quality tend to favour the application of membrane processes. Membrane filtration processes inevitably play nowadays a key role in modern water recycling since they can produce a water of consistent and reliably high quality. Membranes form a highly selective barrier and are tolerant to shock-loads. Therefore, the produced permeate quality is varying little with the feed water quality. The main advantage of a membrane-based process is that the concentration and separation is achieved without a change of state and without use of chemicals or thermal energy, thus making the process energy efficient and ideally suitable for recycling.

Nanofiltration technology is suitable, where a final polishing of effluents, without complete salt retention is required. The Nanofiltration membrane offers a small pore size of 400 – 600 Dalton, which retains efficiently multivalent ion such as total hardness and certain charged or polar molecules. However, sodium chloride a mono-valent salt passes the membrane. High reductions of COD, BOD and colour are achieved, due to the fact that the Nanofiltration membrane retains organic fractions. The produced permeate is reduced in COD, completely clear and contains minor concentrations of salt. Nanofiltration applied as a polishing step after MBR treatment allows high quality water recycling of up to 65% back into the tannery process. The use of consistent high quality process water has also have a positive influence in regards of saving process chemicals and improving the leather quality (Scholz, Lapoulle, Cruickshank, Gigante, 2007).



Photo 2: Nanofiltration for water recycling

Improved energy efficiency of treatments

Tannery effluent treatment is very energy consuming with most of the energy used for the aeration of aerobic biological treatments. The implementation of an anoxic Pre-denitrification, followed by a Nitrification process has shown to reduce biological aeration and be suitable to improve the cost effectiveness of removal of ammonia and total nitrogen, thus reaching international discharge standards of 2mg/l ammonia and 30 mg/l for total nitrogen. Another benefit is that the anoxic pre-treatment step reduces COD and BOD without any aeration requirements and consequently reduces the aeration energy consumption of the overall biological treatment by 52% (Scholz, 2015).

Solar power heaters

The tanning industry uses large amounts of hot water especially for post tanning operations. Many tanneries, which have used fossil fuels to heat up the process water in boilers, have replaced their conventional heating by solar water heating systems. In addition to produce hot water, tanneries benefit of reducing their energy costs and reliance on fossil fuels, as well as the carbon footprint.

Solar power heaters comprise of a series of glass tubes containing a heat transfer liquid, which is circulated through black solar tubes. When a set-temperature of 65 – 75 C is reached the transfer liquid is pumped though a heat exchanger to heat up water in the hot water storage tank.

The Vietnamese tannery has installed a 5000 m^2 flat plate collector field, which produces 100% renewable energy for re-tanning and also thermal heat for sludge drying.



Photo 3: Solar Power heaters installed in a Vietnamese tannery

Low cost Sludge drying

The major cost of operating a tannery wastewater treatment plant arises from sludge de-watering and sludge disposal. Mixed Primary and secondary sludge have a dry matter content of 6 % and is de-watered using a decanter centrifuge, beltpress or filterpress.

The filtercake with 30-40% dryness can be further de-watered with a sludge dryer to a dryness of 85 - 90%. The sludge falls through a hopper and is conveyed into the stainless steel chamber of the dryer, where the sludge is macerated and dried with steam-heated screws, which transport the sludge through to the outlet of the sludge dryer.

A heat exchanger provides for heat recycling from the outlet conveyor back to the inlet, where the sludge is pre-dried. The condensate is collected in steam traps and recycled back to the dryer. The exhaust steam and dust is cleaned in a washing tower.



Photo 4: Filter-cake at 30% dryness and dried sludge at 90% dryness

The sludge dryer achieves consistently high sludge dryness, thus reducing solid disposal and landfill costs by 67% (Scholz 2015).

Anaerobic treatment and Biogas generation

Anaerobic treatment of effluent treatment sludge and by-products from the tanning industry is a well- known technique which can be used to produce energy from waste. The anaerobic digestion is a biological degradation of organic compounds without oxygen and is generating biogas, which can be combusted and produce heat or energy TAN (2011).

The advantages of anaerobic treatments are that they are closed systems, reducing smells. Further advantages are that compared to energy intensive aerobic systems with 0.5 kg / kg BOD of surplus sludge, only small amounts of surplus sludge of only 0.1 kg / kg BOD of sludge are generated. The anaerobically stabilised sludge is an excellent fertilizer and can be used as a soil conditioner for agriculture.

The Biogas plant of the German tannery Südleder comprises of a substrate puffer, where the waste sludge from the tannery effluent treatment is mixed with solid waste such as hair, fleshings and trimmings. The pre-treated substrate is then transferred to 2 mixed anaerobic tanks with 4000 m^3 capacity each, where the substrate is methanised by anaerobic bacteria.

The biogas is collected in a 2000 m^3 biogas holding tank and then cleaned in the biogas purification plant to remove sulphides. The purified biogas is combusted in the CHP cogeneration of heat and power, achieving an electrical output of 1,400 kW and heat output of 1,200 kW. The anaerobic treatment plant is in operation since 2012 and provides up to 98 % of the energy and heat requirements of the tannery (Proleder 2013).



Photo 5: Anaerobic treatment of tannery sludge and by-products

Results

The implementation of a pre-denitrification system reduces total nitrogen and aeration demand of the overall biological treatment by 52%

The implementation of membrane bioreactor treatment reduces biological aeration requirements by 33% and biological surplus sludge generation from 50% down to 10% and achieves energy and sludge disposal savings.

The combination of MBR treatment with Nanofiltration allows high quality water recycling of up to 65% back into the tannery process.

Solar power heaters have shown to produce 100% renewable energy for re-tanning and also thermal heat for sludge drying. The implementation of low-cost sludge drying achieves sludge dryness of up to 90% and reduces sludge disposal volumes by 2/3.

Anaerobic treatment of tannery effluent treatment sludge and solid waste, has shown to generate 98 % of the energy and heat requirements of a tannery.

Conclusions

Many tanneries worldwide have successfully implemented sustainable measures and have achieved great reduction of environmental impacts and cost savings, by reducing their water and energy usage and by reducing costs of solid-waste handling and landfill.

References

Scholz W. G., Rougé P., Bodalo A. and Leitz U. (2005) Desalination of mixed tannery effluent with Membrane Bioreactor and Reverse Osmosis Treatment, Journal of Environmental Science & Technology, 39 / 21, p. 8505 – 8511

Scholz W.G, Huang T. and Hill K. (2012) "Lower carbon footprint using Best Available Technologies" Leather International, p. 46-48, Nov./Dec. edition

Scholz W.G (2014) "Membrane bioreactor treatment with nitrogen removal and sludge drying", International Leather Maker, p 18-20, Dec./Jan.

Scholz W.G, Lapoulle A., Cruickshank D., Gigante J.M. (2007) "Tannery effluent treatment using Reedbed and Nanofiltration technology", Leather International, p. 26-28, April.

Scholz W.G, (2015) "The challenges of biological nitrogen removal and reduction of sludge handling and disposal costs" Proceedings for the XXXIII Congress of the IULTCS, Novo Hamburgo, Brazil, Prime Asia, Vietnam, courtesy photo and company information.

Tanning of Hides and skins (2011) - Best Available Techniques for the Tanning of Hides and Skins, chapter 4 p. 195

Proleder (2013) "In energieautarke Zukunft starten" April, p.15