TECHNICAL PAPER

REUSE OF CONTAMINATED WASHING WATER FROM TORREFIED PRODUCT DESALINATION PROCESS.

Description of the water purification process and basic design of the purification installation, including mass balance.

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ABSTRACT
When using low value biomass containing residual flows as feedstock for the torrefaction process the increased chlorine and sulphur content of these flows will be partly present in the torrefied product to that extent it will give rise to corrosion problems when used by the customer.

Washing of the torrefied product with hot water will remove to a high content chlorine and sulphur (desalination). It is recommendable to reuse the contaminated washing water. In order to realize this, the water used must first be purified again. By that a water purification is needed.

Together with potential suppliers of water purification equipment a basic design has been carried out and a balance sheet drawn up, based on test and analysis results.

CONTEXT OF THE PAPER
This technical paper is part of a number of articles that describe the use of low-value biomass-containing residual flows as a raw material for the torrefaction process, whereby the torrefied product (BioCarbon) could replace fossil black and brown coal in various types of application.

TORRCOAL

REUSE OF WASHING WATER DESALTING PROCESS

INTRODUCTION

The washing process (desalination) with hot water (about 70 °C) consists of two process steps (see fig. 1):

- soaking process (solid dry material : soaking water = 1 : 2 ; soaking time 30 min.)
- counterflow washing process (3 times rinse; solid dry material : clean rinsing water = 1 : 1).

This washing process removes the following compounds:

	Removed by washing (%)
Sodium (Na+)	71,6
Potassium (K+)	53,3
Calcium (Ca2+)	8,4
Magnesium (Mg2+)	10,5
Chloride (Cl-)	86,0
Sulphate (SO42-)	22,2

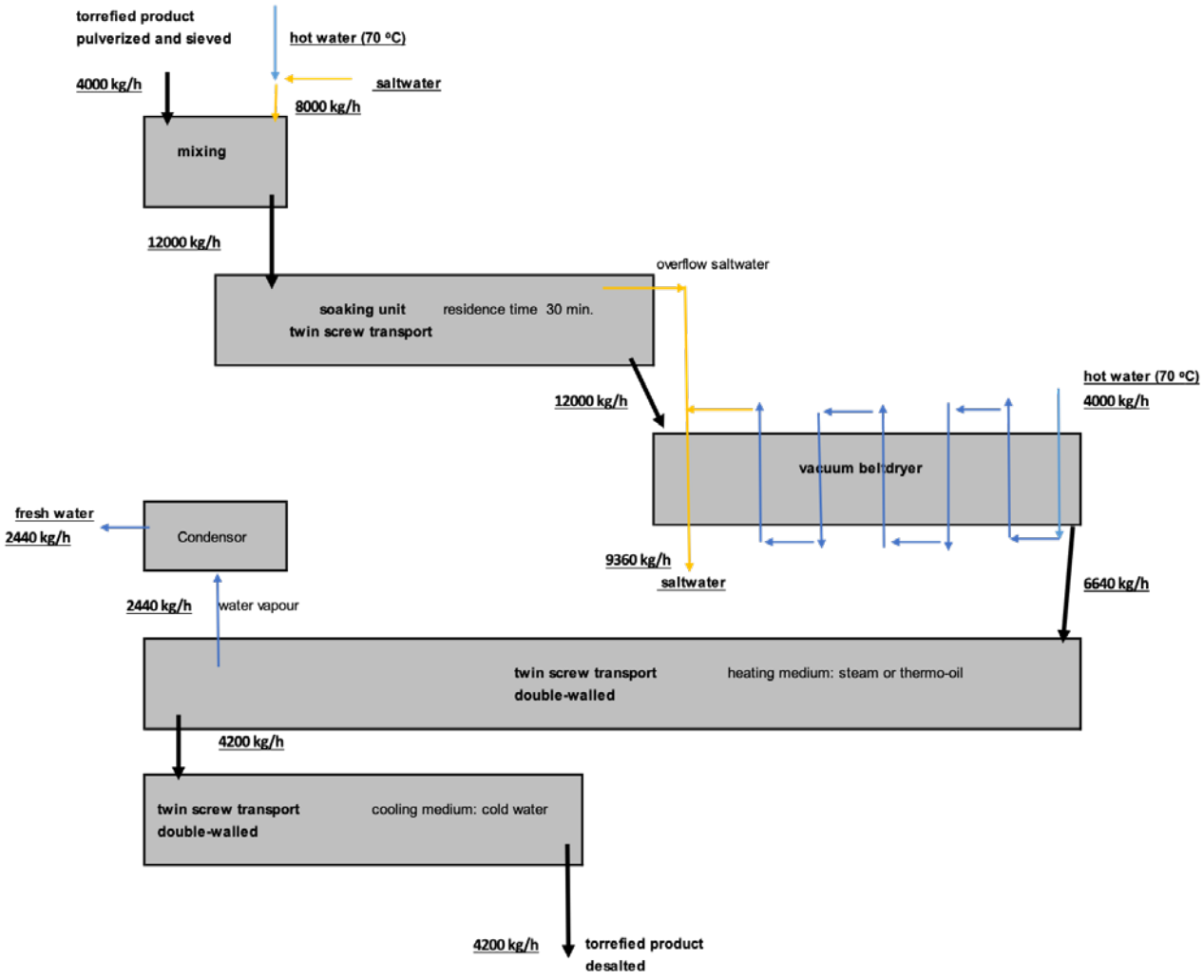

Fig. 1: setup product cleaning process.

Due to the fact large amount of washing water is used for this desalination process it makes sense for economic and environmental reasons to purify the water and next to reuse it.

PURIFICATION OF THE WASHING WATER USED

As indicated before the washing water used is contaminated with soluble salts and next to that also with organic compounds and very small particles torrefied material. In the following table a possible composition of the washing water used is indicated. These values of the composition of the washing water used are based on analysis results of washing torrefied Solid Recovered Fuel and 50% of the polluted washing water is being used again for the soaking process without purifying (see fig. 2: flow diagram and mass balance waste water treatment).

TOC-value is strongly determined by the degree of torrefied particles, present in washing water used. Next it can be seen, that the inorganic composition of the washing water used looks comparable to the composition of seawater. By that the washing water used will show an extreme corrosive behaviour. This will have large consequences concerning the choice of the equipment components for desalting the product and purifying the polluted washing water.

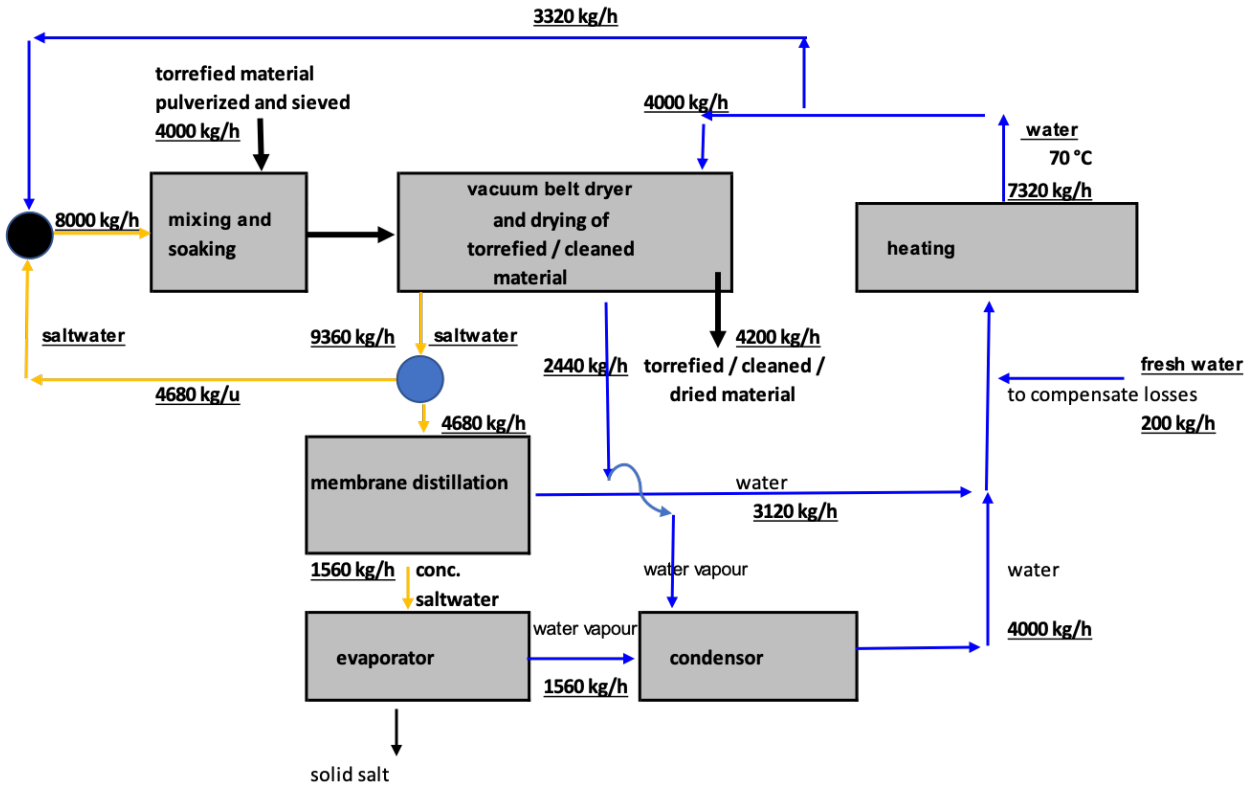

fig. 2: flow diagram waste water treatment.

Organic
Methyl-ethyl keton: 0,5 mg/l
Tetra hydro furane: 0,26 mg/l
Propoxy substances: 56 mg/l
Fatty acids: 4 mg/l
Caprolactam: 4 mg/l
Caffeïne: 0,3 mg/l
Other organic divers: 1 mg/l
TOC value about 5000 mg/l

Inorganic
Ca (2+): 5 g/l
Mg (2+): 1 g/l
K (1+): 5 g/l
Na (1+): 9 g/l
Cl (1-): 15 g/l
SO4 (2-): 6 g/l

For comparison composition of seawater:

24 g/l NaCl	Ca (2+): 0,3 g/l
5 g/l MgCl2	Mg (2+): 1,3 g/l
4 g/l Na2SO4	K (1+): 0 g/l
0,7 g/l CaCl2	Na (1+): 10,3 g/l
0,8 g/l MgBr2	Cl (1-): 18,7 g/l
	SO4 (2-): 6 g/l

To get again clean washing water, which can be re-used again for the washing process, it is important to get rid of dissolved salts and small particles torrefied material. Membrane distillation seems to be the first meaningful process step of this waste water treatment. Using this technology, it will be possible to increase the salt concentration up to max. 12 %.

Membrane distillation functions with the help of micro porous hydrophobic membranes. These membranes contain very narrow pores and by the fact the membrane material has hydrophobic properties it means liquid water cannot pass the membrane. The pores of the membrane do not contain liquid but only pure air / gas.

By creating a temperature difference between the feeding side (saltwater) and distillate side (fresh water) of the membrane a difference in vapour pressure will arise. Due to this difference in vapour pressure water (and other volatile components) will evaporate and pass the membrane and condensate at to other cold distillate side (see fig. 3: principal operation membrane distillation).

Membrane distillation (supplier AquaStill) shows some additional advantages:

- A small quantity amount of low-grade heat is needed to operate the process.
- The equipment components of this membrane distillation are not susceptible to corrosion.
- Expand of capacity is rather easy by adding more membrane distillation modules.

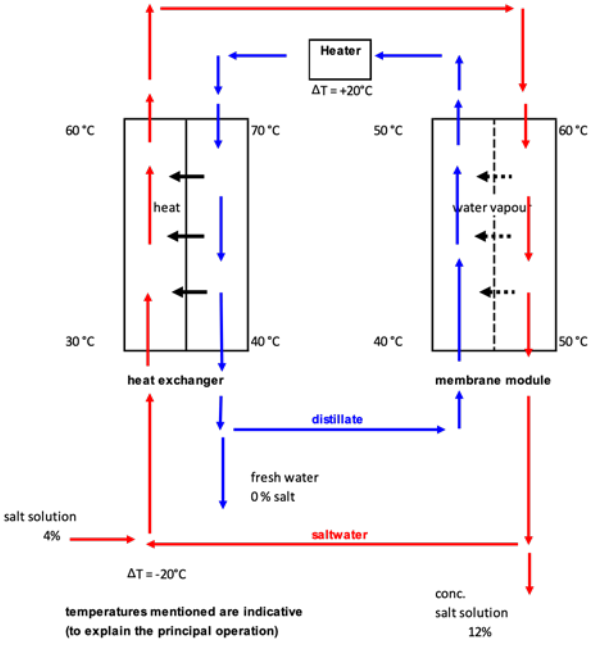

fig. 3: principal operation membrane distillation.

The obtained 12 % salt solution must be further thickened (to get a higher concentration). In principle This can be realized by a vacuum dryer (low-grade heat needed) or spray dryer (high-grade heat needed). However, this kind of installations are rather susceptible to corrosion. An alternative with some good advantages is DVR – ZLD desalination module (supplier SaltTech; see fig. 4).

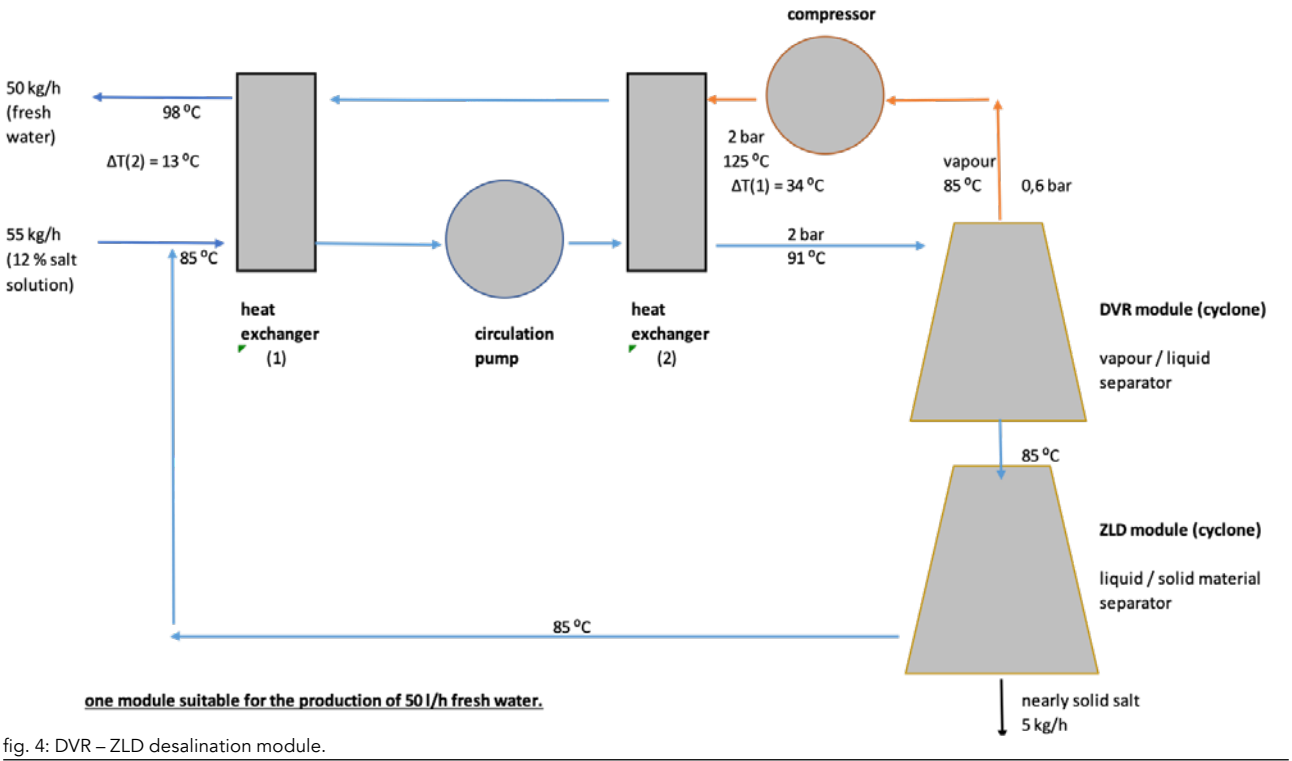

fig. 4: DVR – ZLD desalination module.

Advantage DVR - ZLD module:

- efficient separation fresh water /solid salt.
- nearly no scaling / fouling.
- not susceptible to corrosion.
- low maintenance costs (0,5 % of Capex).
- Expand of capacity is rather easy by adding more DVR – ZLD modules.

At the end a solid salt flow, contaminated with an amount torrefied material, is left. Until now no useful application for this solid salt flow has been found. For the time being it must be removed as chemical waste (storage in former salt mines).

The energy (high-grade heat, low-grade heat and electrical energy) needed to purify the washing water for the indicated different techniques and amount of needed purified washing water:

process step	possible techniques	quantity to process	energy needed		
			high-grade	low-grade	elektr.
cleaning of the washing water used	membrane distillation	3120 kg/h water removal*	–	0,12 MW	5 kW
	vacuum evaporater	1560 kg/h water removal**	–	1,10 MW	20 kW
	spray drying		1,10 MW	–	10 kW
	DVR - ZLD techn.		–	–	90 kW

* to increase the salt concentration up to 12%
** three possible techniques (vacuum evaporater; spray drying; DVR - ZLD techn.) available

CONCLUSION

If using low value biomass containing residual flows as feedstock for the torrefaction process the increased chlorine and sulphur content of these flows will be partly present in the torrefied product to that extent it will give rise to corrosion problems when used by the customer.

Washing of the torrefied product with hot water will remove to a high content chlorine and sulphur (desalting). It is recommendable to reuse the contaminated washing water. In order to realize this, the water used must first be purified again. By that a water purification is needed.

Purification of the washing water used and reuse of this water means, that the fresh water consumption will be about 50 kg instead of 1170 kg per 1000 kg output of torrefied washed product.

Together with potential suppliers of water purification equipment a basic design has been carried and a balance sheet drawn up, based on test and analysis results. Membrane distillation and DVR – ZLD desalination are preferred, because these techniques have a number of advantages with regard to energy consumption and corrosion resistance.

To purify the water 30 kW low grade heat and 24 kW electricity are needed for the indicated purification techniques (membrane distillation and DVR – ZLD desalination) per 1000 kg output of torrefied washed product.

Detail engineering and installing a pilot test installation are not yet planned at this time for this water purification process.

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