TECHNICAL PAPER

PRODUCT CLEANING (DESALTING) AFTER TORREFACTION OF LOW VALUE BIOMASS CONTAINING RESIDUAL FLOWS

Description of the washing cleaning process and basic design, including mass balance, of the washing installation.

TorrCoal Technology B.V.
Jo Sluijsmans, BSc
Manager R&D / QHSE

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.

Tests, done by TorrCoal , showed, that cleaning (removing chlorine and sulphur: desalting) of the torrefied product can be done in an effective and controlled way by washing it with hot water after the torrefaction process.

Consultation with potential suppliers and test done by these potential suppliers of washing equipment indicated what a basic design of washing installation probably should look like.

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

DESALTING LOW VALUE TORREFIED MATERIAL

INTRODUCTION

Subjecting various biomass containing flows to a torrefaction process (heating up to 300 °C in an oxygen low environment), the properties of these flows will be changing in such a way these can be used as a black coal substitute for energy production and chemical industrial processes (like syngas and steel production).

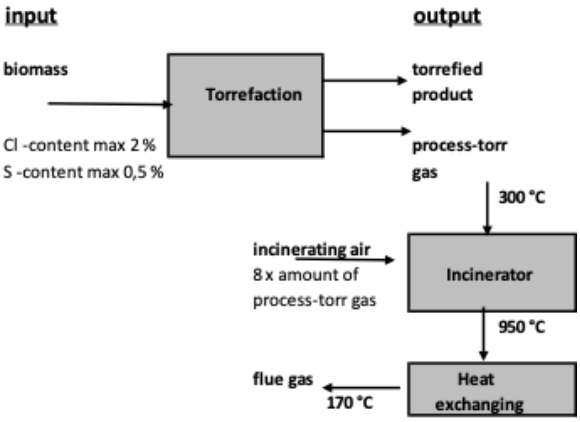
For business economic and sustainable reasons biomass containing flows are used, which cannot be used in their original form for other high-quality applications.

Unfortunately, these biomass containing flows mostly show an increased chlorine content (max. 2 w.-%) and / or sulphur content (max. 0,5 w.-%). During torrefaction the present chlorine and sulphur move partly to the process-torr gas and partly these elements stay behind in the torrefied product.

The solid torrefied product will show such an amount of chlorine and sulphur, that it can lead to problems for the customer (corrosion; exceeding emission standard), if it will be used as a black coal substitute. By that it can make sense to remove on request of the customer as much as possible chlorine and sulphur from the solid product (product cleaning: desalting).

PRODUCT CLEANING (DESALTING)

Chlorine and sulphur, present in the feedstock, stay partly in the solid product.



Distribution Cl and S: input to output

	torrefied product		process-torr gas	
	min.	max.	min.	max.
Cl	10%	50%	50%	90%
S	40%	80%	20%	20%

Some users of this product appreciate it, if the delivered torrefied product shows a low chlorine (< 0,1 %) and sulphur (<0,5 %) content. It is known that chlorine and sulphur, present in the torrefied product, is bounded inorganically (anion: Cl(-) and anion sulphate: SO4(2-)). This would mean, that these can be removed partly from the product by washing with water.

Before removing chlorine and sulphur from the torrefied material, this material must be pulverized to a particle size < 3 mm. Experiments have shown, that a crushing roller mill is the most suitable equipment to do this. Parts, which are larger than 3 mm., must be removed by sieving (vibrating, shaker sieve) after passing the crushing roller mill.

Processing 4000 kg/h torrefied material, about 75 kW installed electrical power is needed for the crushing roller mill and sieve.

The fraction, which has been removed by sieving, consists mainly of material, that has not been torrefied in a proper way and does not have the right properties and for that reason should not belong to the final torrefied product. The fraction, which passes the sieve (particle size < 3 mm.) has been torrefied in a proper way and can be used for the next washing process steps.

LABORATORY TRIALS

In 2015 and 2016 it has been determined on laboratory scale how the product washing can be done in the most effective way. The washing cleaning process with hot water (about 70 °C) on laboratory scale consisted of two process steps:

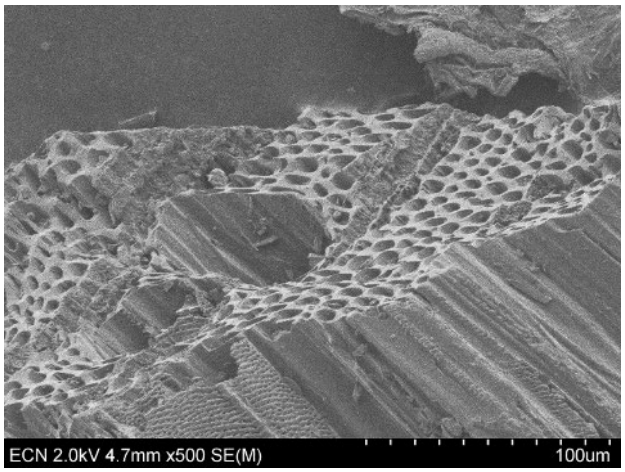
- soaking process (solid dry material : soaking water = 1 : 2 ; soaking time 30 min.)
- counterflow washing process (3 times rinse; solid dry material : clean rinsing water = 1 : 1).

After a lot experiments concerning this washing process the following results have been obtained:

	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

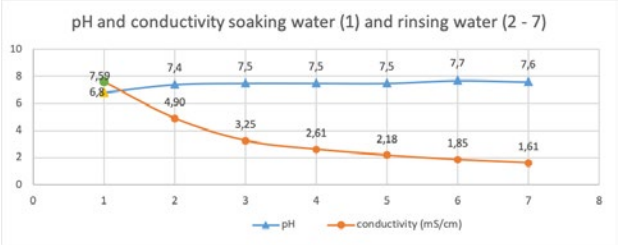
As can be seen removing sulphate by washing is in contrast to Chloride not an effective process, because CaSO4 and BaSO4 show a bad solubility in water.

The rinsing process has been done at -0,8 bar under pressure (0,2 bar absolute). At this under pressure the water content of the washed product was ultimately about 40 %. It should be noted, that the water content, next to the used under pressure, is strongly determined by the degree of channel formation in the torrefied material (observed by using Scanning Electron Microscopy). The degree of channel formation is determined by the torrefaction degree and composition of the feedstock (input torrefaction process). Especially torrefied wood shows to a large extent channel formation.



Channel formation torrefied material

The results of the trials show, that rinsing more than three times does not make sense anymore (no further removal of anion and cation from the torrefied washed product). This has been determined by measuring the conductivity and Ph of the rinsing water. After three times rinsing these values did not change any more significant.



Conductivity and Ph of the rinsing water

PRODUCT CLEANING (DESALTING) ON INDUSTRIAL SCALE

With the outcome of the laboratory tests, consultation with potential suppliers and test done by these potential suppliers of washing equipment an installation has been devised, which should be able to clean the product (removal of anion and cation) on industrial scale (*see fig. 1*).

The first step of the product cleaning step (removal of soluble salts) means, that one mass part torrefied material will be mixed with two mass parts hot water (about 70 °C) during about 30 min. During this intensive mixing the present soluble salts dissolve in the water. This process is called soaking.

After this soaking process the solid material / hot water mixture is transported to the vacuum belt dryer. At the beginning of this vacuum belt dryer the excess of water is removed from the solid product by using under pressure. After that a three times counterflow rinsing with hot water takes place. For this part of the process clean hot water is added at the end of the vacuum belt dryer (last rinsing step: one mass part of clean hot water for one mass part of solid dry material). This water is used in counterflow in the two previous rinsing steps and will be polluted more and more by the soluble salts, organic compounds and very small particles torrefied material.

After passing the vacuum belt dryer the water content of the solid desalted product is about 40 %. Next to that a waste water flow has arisen, contaminated with soluble salts, organic compounds and very small particles torrefied material. The mass size of this polluted water flow equals 2,34 times one mass part dry torrefied solid product (mass mixing ratio of cleaning process: soaking 1 : 2; rinsing 1 : 1; moisture content solid product after rinsing equals 40 %; *see fig. 2*: 9360 / 4000 = 2,34).

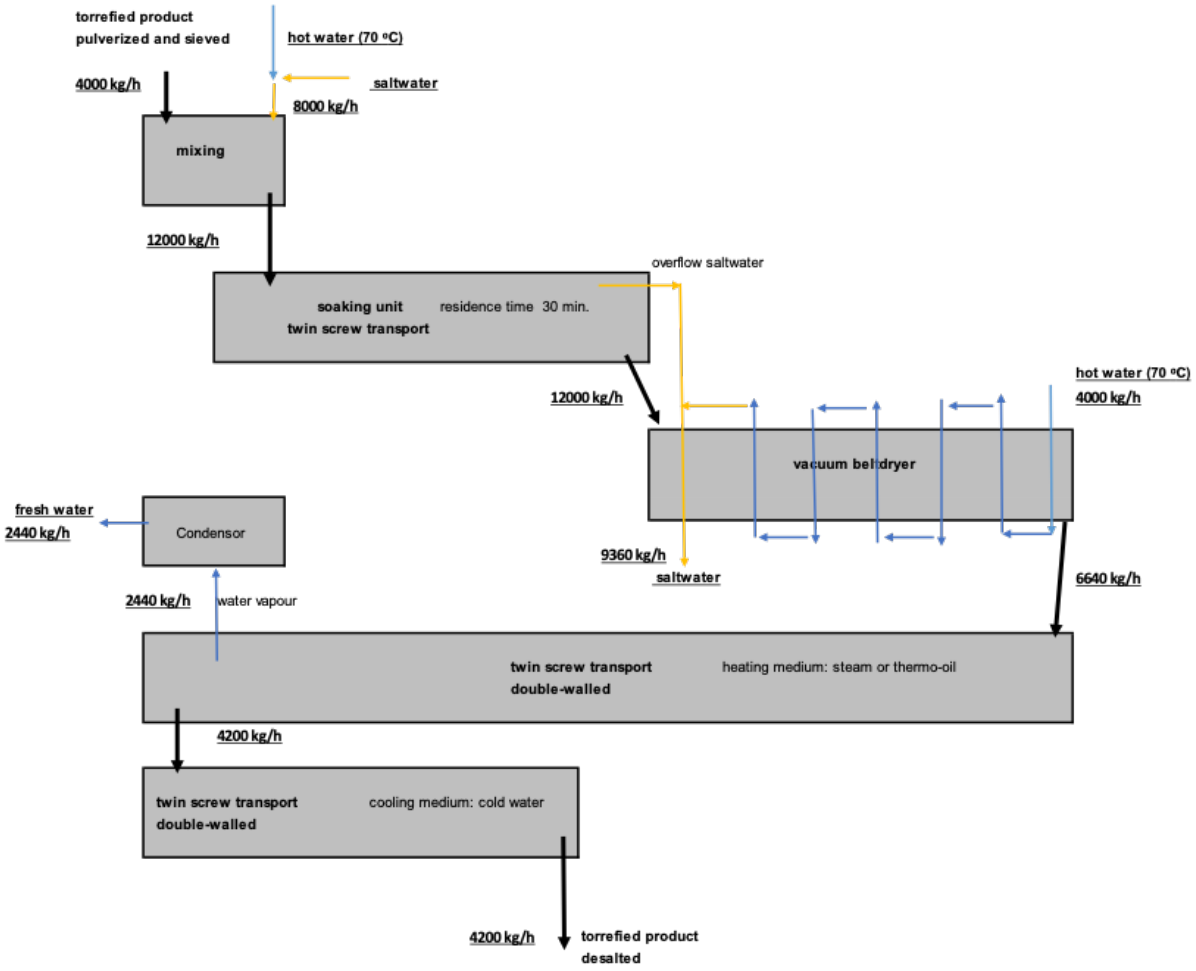


Fig. 1: setup product cleaning process.

The wet product (moisture content about 40 %) must be dried to a water content < 5 %.

A conventional technology will be used to realize this, namely an indirect heated twin screw transport. The resulting water vapour is discharged, condensed and used again as clean rinsing water. Finally, the torrefied, cleaned and dried product is cooled to about 20 °C.

The energy needed to clean the torrefied material is intended for:

- The mixer (soaking) and vacuum belt dryer (rinsing) to remove salts from the torrefied material.
- Drying and cooling of the cleaned torrefied product by an indirect heated / cooled twin screw transport. Hot / cold liquid is transported through a double walled twin screw.

In the following table can be seen how much of what kind of energy is needed for which process step at 4000 kg/h product input (after torrefaction, pulverizing and sieving) and 10 % heat losses during heat exchanging processes.

process step	quantity to process	energy needed		
		high-grade	low-grade	elektr.
mixing and rinsing product	4.000 kg/h product	–	–	100 kW
drying an cooling product	2.440 kg/h water evaporation	1,70 MW	–	15 kW

CONCLUSIONS

Low value biomass containing rest streams, like agricultural residues, wood from park and forest maintenance (branches), demolition wood and separated household waste (SRF), can be used as a raw material for the torrefaction process, whereby the torrefied product (BioCarbon) must replace fossil black and brown coal in various types of application.

Some of these raw materials will show an increased content chlorine (up to 2 w-%) and sulphur (up to 0,5 %) and by that these elements will be partly present in the torrefied product (chlorine up to 50 % of original quantity in the raw material; sulphur up to 80 % of original quantity in the raw material) to that extent it will give rise to corrosion problems when used by the customer.

Tests, done by TorrCoal Company, showed, that cleaning (removing chlorine and sulphur: desalting) of the torrefied product can be done in an effective and controlled way by washing it with hot water after the torrefaction process. About 86% of the chloride (Cl-) and about 22% of sulphate (SO42-) can be removed by this method. Removing sulphate by washing is in contrast to Chloride not an effective process, because CaSO4 and BaSO4 show a bad solubility in water.

Consultation with potential suppliers and test done by these potential suppliers of washing equipment indicated what a basic design of washing installation probably should look like. The combination of a mixing tank, vacuum belt dryer and twin screw heater / cooler show the most promising results.

Washing and drying the torrefied product needs 425 kW high grade heat and 29 kW electricity 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 washing process.

REFERENCES / LITERATURE

Outotec Larox;
filtration@outotec.com; *www.outotec.com*

STOWA 2013-W03: Marktconsultatie slibdroging- en slibontwatering
ISBN 978.90.5773.601.8
stowa@stowa.nl. ; www.stowa.nl

°Celsius Screw Heat Exchangers;
info@celcius.nl; www.celsius.nl