Does mechanical screening improve fuel properties?

Effects of mechanical screening of stored logging residue chips on ash chemistry and other parameters relevant for combustion

Marjan Bozaghian[1,*], Anna Strandberg[2], Theresa de la Fuente[1], Mikko Karjalainen[3], Nils Skoglund[2], Mikael Thyrel[1], Dan Bergström[1], Sylvia H. Larsson[1]

[1] Swedish University of Agricultural Sciences, Department of Forest Biomaterials and Technology, S-901 83 Umeå, Sweden
[2] Umeå University, Department of Applied Physics and Electronics, Thermochemical Energy Conversion Laboratory, S-901 87 Umeå, Sweden
[3] Luke Natural Resources Institute Finland, Technologiankatu 7, 67 10 Kokkola, Finland

[*])corresponding author, . E-mail: marjan.bozaghian@slu.se

INTRODUCTION

Forestry and the forest industry plays an important role in the Swedish economy. From forest operations and at sawmills and pulp and paper mills several by-product assortments are generated and these are providing the basis for the highly developed Swedish bioenergy sector. Logging residues constitute a major resource and is utilized as fuel in heat and power plants. However, due to a relatively low heating value and high management costs, this resource is still underutilized.

Logging residue chips have irregular particle size, high moisture content (30-60%) and high ash content (8-15 %) and these features cause most of the problems encountered during the operation of feeding systems and combustion processes. Ash, present both in endogen plant tissues and as extrinsic matter such as sand and clay minerals, is of especially big concern for small-size plants.
In this on-going work screening of logging residue chips was performed. Different mechanical screening methods was applied with the aim to provide a homogenous fuel with a higher quality for combustion purposes. Through screening, the chemical fuel composition is also altered and this affects combustion behavior and ash chemistry.

The objective of the present study is to, from a combustion process perspective with emphasis on ash chemistry, evaluate the overall effects of different screening procedures when applied on stored logging residue chips.

Figure 1. Mobile star screen "Backers 3mal".

METHODOLOGY

Screening settings

	Rotation speed of the stars in the fine deck (% of the maximum speed)	Speed of the feeder (% of the maximum speed)	Windshifter
M100	100	80	No
MW100	100	61	Yes
M90	90	80	No
MW90	90	61	Yes
M80	80	80	No
MW80	80	60	Yes

Fuel preparation – Single-pellet press

Thermogravimetric analyzer (TGA) at a single-pellet scale

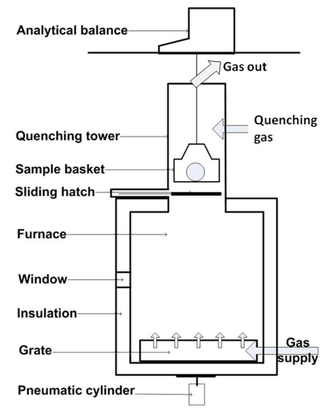

Figure 1. Schematic image of the used single-pellet reactor. Adopted from Fagerström et al.

Analyses performed on residual ashes

Elemental analysis – Scanning electron macroscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS)

Zeiss EVO-LS15 equipped with a X-Mmax^N 80 mm^2 EDS detector

Quality measurements of crystalline phases - Powder X-ray Diffraction (XRD)

Bruker D8Advance with CuKα-radiation and fitted with Våntec-1 detector

PRELIMINARY RESULTS

Screening

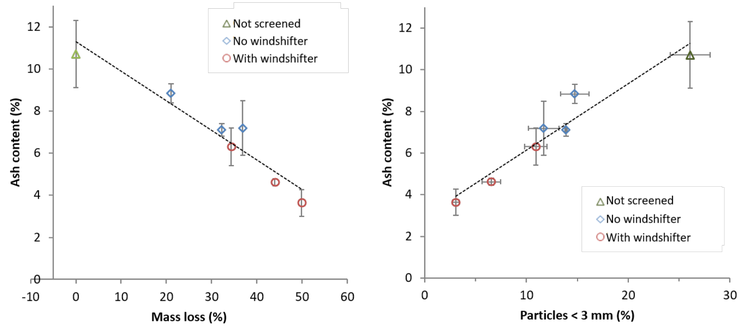

Figure 2. Quantified effects of different mechanical screening settings on ash content vs. biomass loss and ash content vs. particles < 3 mm .

Screening of logging residue chips resulted in a reduction in ash content and fines for all screening settings used. The MW80 setting is the most efficient setting for reducing the ash content and the amount of fines. Although apparent fuel quality is improved, it is done at the expense of substantial biomass loss.

Compositional and SEM analyses

Fuel analysis of main ash-forming elements before combustion shows that Si was the dominating element, balanced mainly by Ca, K and Al. Windshifting had the greatest impact on the reduction of extrinsic Si and thereby the concentrations of Ca, K and P in the ashes where slightly increased.

Area analysis of residual ashes, analysed with SEM-EDS, showed that the elemental compositions of the ashes were quite comparable with fuel analysis of main ash-forming elements before combustion.

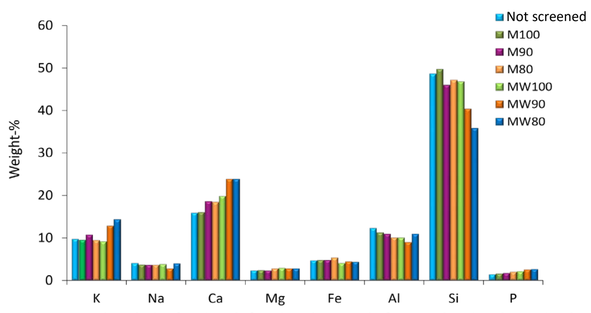

Figure 3. Fuel analysis of main ash-forming elements before combustion determined by ICP-AES.

Slagging tendencies

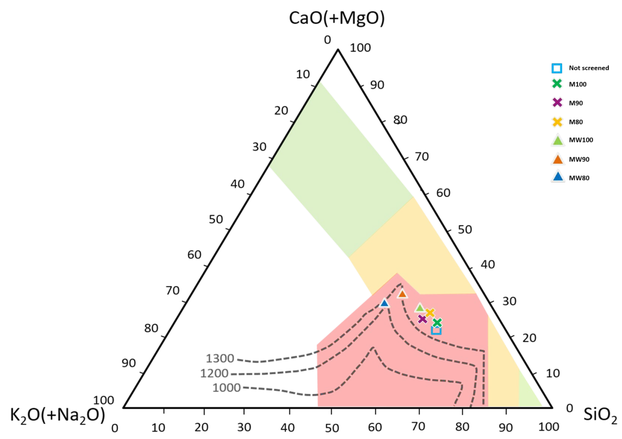

Figure 4. Fuel ash composition normalized to the SiO2-K2O(+Na2O)-CaO(+MgO) system. Adopted and modified from Näzelius et al.

Colors of areas corresponds to green = no/low slagging tendency, yellow = moderate slagging tendency, and red = major slagging tendency.

CONCLUSIONS

- Screening reduces ash content and the amount of fines but at the expense of substantial biomass loss
- The strongest ash compositional impact of screening was the reduction of Si
- A consequence of Si reduction in the ash is a relative increase of K and Ca which skews the cation and anion proportions toward lower slagging temperatures
- **This study shows that although screening reduces ash content - mass losses are substantial and ash melting behaviour can even be worsened**

Research performed by

SLU
UMEÅ UNIVERSITY
Luke

Work funded by

SLU
bio hub