FORMEC Romania 2017

Hybrid Solutions as Measure to Increase Energy Efficiency - A Prototype of Hybrid Technology Chipper

Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen

@FORBIOproject

Luke
NATURAL RESOURCES INSTITUTE FINLAND

Outline

- Background
- Hybrid chipper technology
- Material & Methods
- Results
- Discussion & Conclusions

Background

It has been made from the perspective of improving the performance of the machine as well as the fuel economy

Background

Prototype was developed during the INFRES project:

‘Innovative and effective technology and logistics for forest residual biomass supply in the EU –INFRES’

Additional calculations were performed within the FORBIO project:

@FORBIOproject

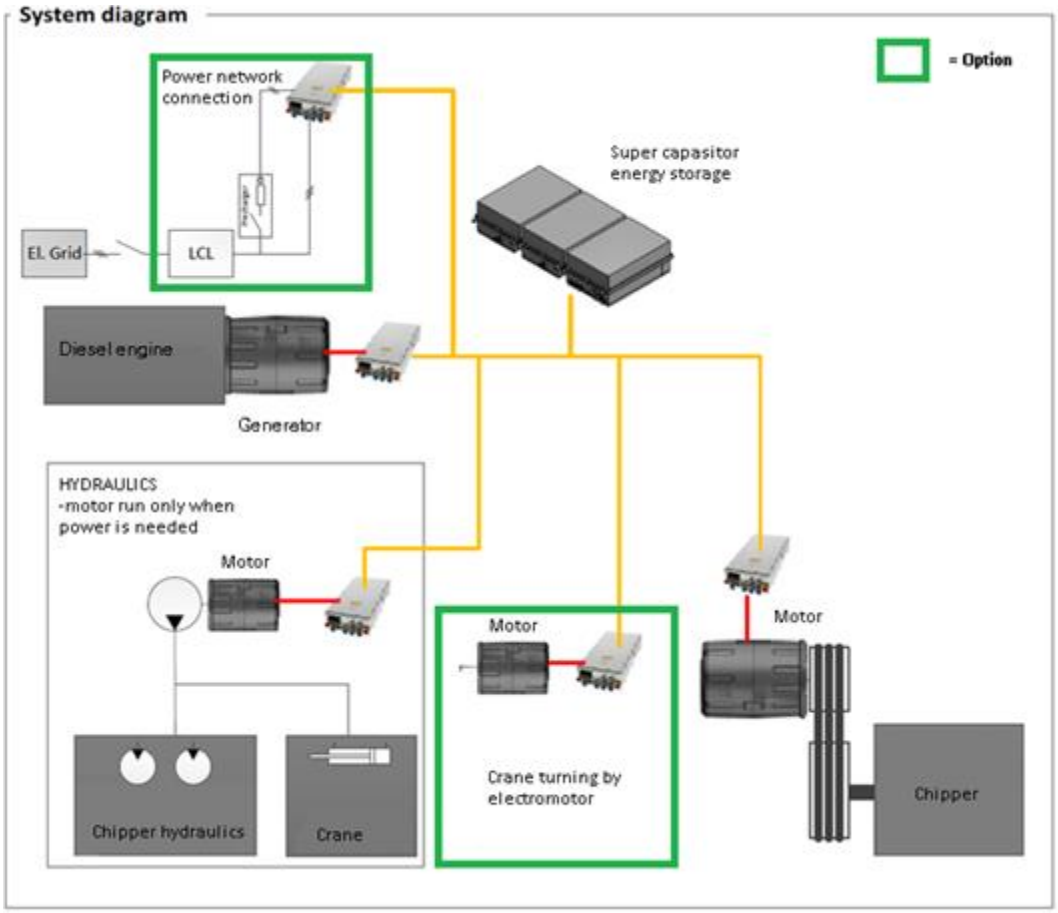
Background

- **Kesla C 860 H hybrid chipper**
- Truck-mounted on Volvo FM 440
- Engine power of 160 kW
- Kesla 2112T crane
- mass: 8200kg
- Drum chipper with eight knives
- Intake openining 800 x 600 mm
- Sieve size 100 x 100 mm
- electric drivetrain
- super capacitor energy storage unit

Hybrid chipper technology

- There is no mechanical connection between diesel engine and chipper
- The electric drivetrain powers the wood chipper and the crane used for feeding the wood into the chipper
- This makes the diesel engine an independent power source and makes the variable-speed power generation possible
- The needed energy is generated by the diesel engine with the support of super capasitor energy storage
- The motors driving the chipper and hydraulic pumps are permanent-magnet motors, and the total system minimizes loss of energy and provides high energy efficiency

Hybrid chipper technology



Source:
Petri Kaksonen, Kesla Oyj

Hybrid chipper technology

- Expected benefits:
  - Higher efficiency due to missing mechanical connection between diesel and chipper
  - diesel engine power can be smaller
  - Smaller vehicles are possible
  - diesel-engine can work closer to optimal for most of the working time
  - Possible connection to power network (polution not local)
  - Fuel cost saving

Material & Methods

- Chipping of logging residues
  - logging residues (Norway spruce -dominated mixed coniferous)
  - Kesla C 860 H hybrid chipper was compared with Kesla C 1060 A drum chipper at the same location and same material
  - chipping roadside in Rauma

- Chipping of pulpwood
  - conifer pulpwood raw material (predominantly Lodgepole pine pulpwood)
  - Compared with truck-mounted Kesla C 1060 A drum chipper and tractor-powered Kesla C 1060 T with raw material from Scots pine pulpwood from the first thinning
  - chipping at power plant wood-yard in Joensuu

Material & Methods

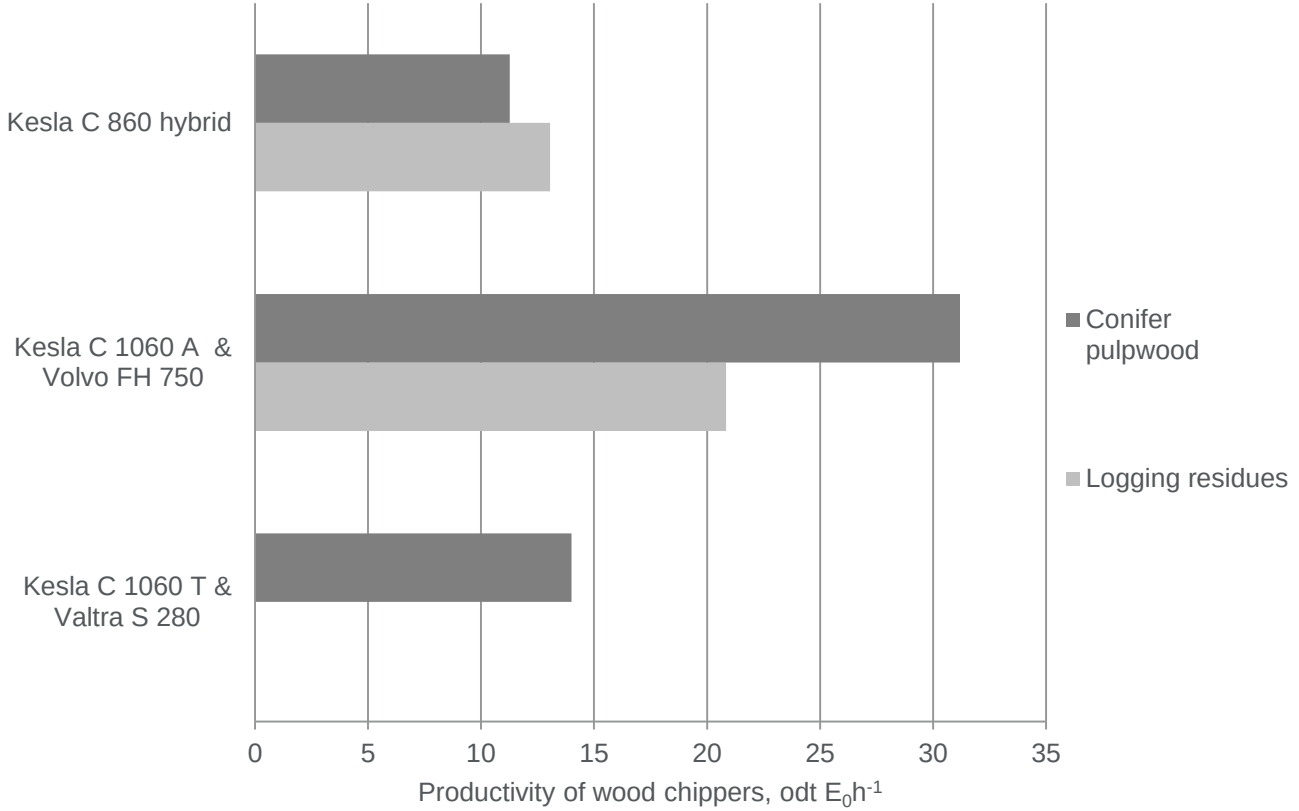
- time studies using a Rufco-900 field computer
- continuous time study method
- total of eight work elements
- effective working time (E_0h)
  - boom out, grip, boom in, feeding, adjustment and chipping
- number of grapple loads for each load
  - average grapple load weight in feeding
- fuel consumption
- quality parameters of wood chips
  - particle size distribution, moisture content, basic density, ash content, and net calorific value
  - samples taken directly from each truck
- indication of noise level (chipping of logging residues)

Material & Methods

- Indication of emission factors
  - LIPASTO-calculation system was used
  - based on emission factors listed for another drivable machine with similar power, in this case a dumper (emissions per kWh are the same for all diesel engines above 130 kW)
  - emissions factors were calculated based on the fuel consumption per dry mass (odt) of chips
- Indication of energy consumption
  - in kWh per dry mass (odt) of chipped material
  - based on the effective hourly output of the chipper and
  - based on average power
- *Hybrid chipper results were compared to findings examining conventional drum chippers:*
  - *tractor-powered Kesla C 1060 T and*
  - *truck-mounted Kesla C 1060 A*

Results: productivity

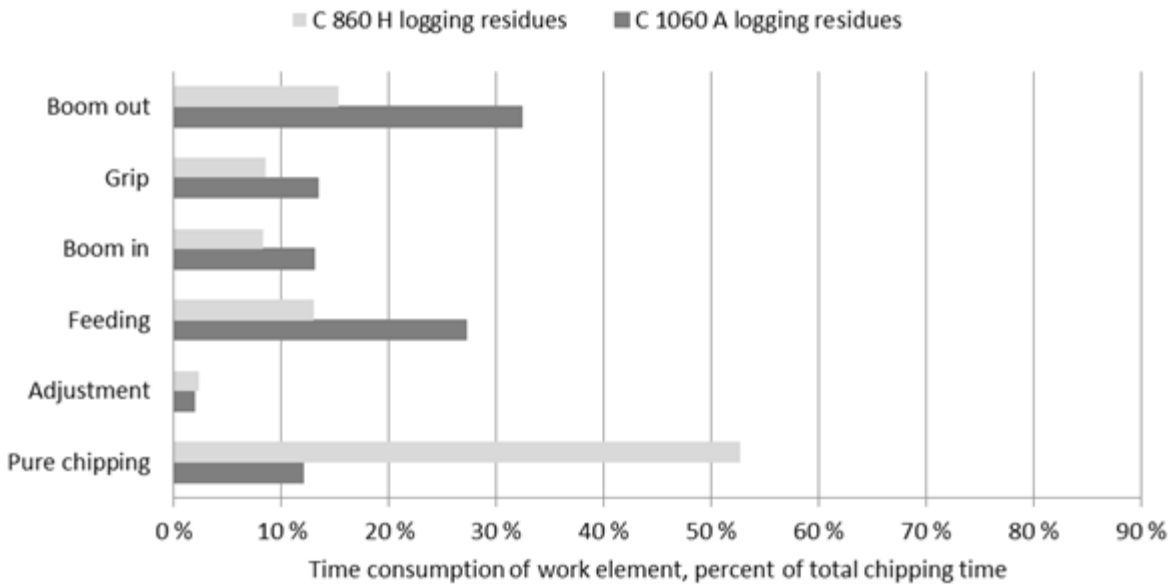
"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;



The average chipping productivity of Kesla C 860 H hybrid chipper unit was 11.3 oven dry metric tonnes (odt) per effective hour (E0h) when chipping pulpwood. The average chipping productivity with logging residues was 13.1 odt per effective hour.

Results

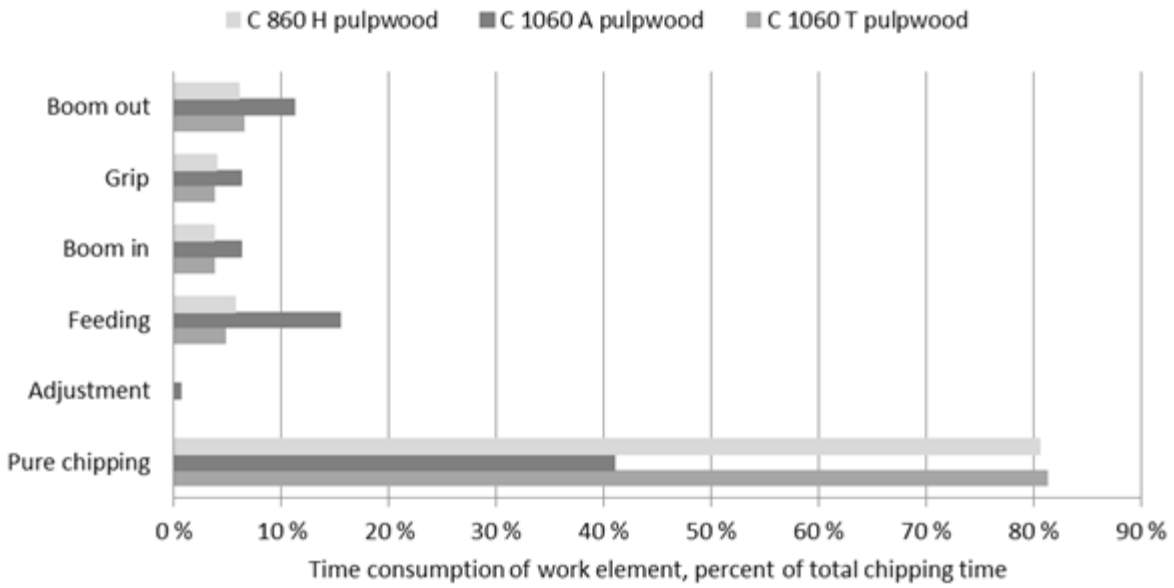
time consumption of work elements



"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;

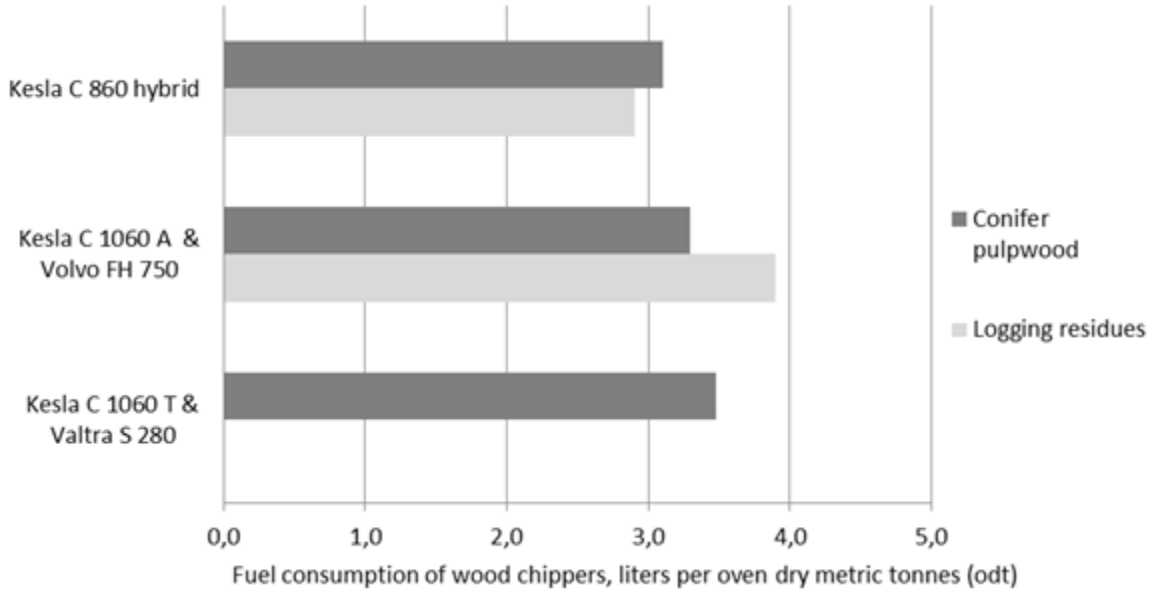
Results

time consumption of work elements



"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;

Results: fuel consumption



Fuel consumption of Kesla C 860 H hybrid chipper was 3.1 litres per odt when chipping pulpwood and 2.9 litres per odt for logging residues.

"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;

Results: indication of energy consumption

Chipper	Energy consumption [kWh odt^{-1} of chipped logging residues]
Kesla C 860 H hybrid	12.2
Kesla C 1060 A & Volvo FH 750	26.8

Chipper	Energy consumption [kWh odt^{-1} of chipped conifer pulpwood]
Kesla C 860 H hybrid	14.2
Kesla C 1060 A & Volvo FH 750	17.9
Kesla C 1060 T & Valtra S 280	14.8

Kesla C 860 H was the most efficient chipper (kWh odt^{-1} of chipped material)

"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;

Results: indication of emissions

C 860 H	Unit emissions [g odt^{-1} of chipped material]								
	CO	HC	NO x	PM	CH_4	N_2O	SO_2	CO_2	CO_2-eq
logging residues	35.7	7.8	47.3	2.0	0.5	0.1	0.0	7714.2	7765.5
pulpwood	38.2	8.4	50.6	2.1	0.5	0.1	0.0	8246.2	8301.1

hybrid chipper was the most efficient chipper (kWh odt^{-1} of chipped material)
-> consequently resulted in the least amount of emissions

"Hybrid Solutions as Measure to Increase Energy Efficiency – Study of a Prototype of Hybrid Technology Chipper", Robert Prinz, Juha Laitila, Lars Eliasson, Johanna Routa, Natasha Järviö, Antti Asikainen; manuscript;

Discussion & Conclusions

- Chipper and hybrid system were working well
- Kesla C 860 H hybrid´s fuel consumption was lower compared to conventional chippers
- Kesla C 860 H hybrid´s productivity was lower compared to conventional chippers
- chip quality was good and met user demands for small-scale residential boilers
- hybrid chipper was the most efficient chipper (kWh odt^{-1} of chipped material) and consequently resulted in the least amount of emissions

Discussion & Conclusions

- hybrid system is under continuous development
- presented results are indicative due to the study limitations
- follow up-studies are needed for a more accurate determination of long-term productivity, fuel consumption and operating costs

Thank you!

More information:

Robert Prinz
Natural Resources Institute Finland (Luke)
Tel. +358 295 32 3086
robert.prinz@luke.fi

www.luke.fi

Luke
NATURAL RESOURCES
INSTITUTE FINLAND