Saving Fuel in the Operation of Forest Machinery

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Abstract:
In the course of the project of the European Union EFFICIENT20, strategies for fuel reduction in forest machinery operation were surveyed and tested. Strategies were developed to optimize the drive train and the machinery settings in order to obtain minimized fuel consumption. Furthermore the influence of optimized cooler cleaning and further special components was investigated for a complete fuel saving package which would enable operators of forest machines to reach the project goal of fuel savings of 20 % compared to their actual consumption.

Keywords: fuel economy, fuel consumption, maintenance

1 Introduction

Forest harvesting operations are very energy intensive. In view of the continuous rise in fuel costs, consumption is a key cost factor for the machine owner. Over time, even small reductions can add up to a significant sum. Within the framework of the EU project Efficient20, nine countries are searching for fuel reduction potentials in agriculture and forestry. The objective of this endeavour is to reduce fuel consumption by up to 20%, in line with the EU-wide target to achieve a 20% reduction of energy consumption by 2020.

The German partner, KWF (KuratoriumfürWaldarbeit und Forsttechnike.V.), has been coordinating activities in the forest sector. In contrast to the situation in agricultural systems, forest machines must often work under an extreme variety of conditions. This complicates the exact measurement of fuel consumption for particular work steps on the one hand, and also the determination of relevant saving potentials on the other hand.

This paper describes the effects of different forwarder drive train settings on fuel consumption. Also included are the results of an investigation of the fuel saving potential of clean radiators in an agricultural tractor fitted with a reversible ventilator.

2 Material and methods

All forwarder trials took place on an identical test route: a 100 m long skid trail section specially selected for testing different settings of an equally loaded machine driving uphill and downhill. The following settings were adjusted: working gas, engine speed increase and the Inch potentiometer. The different machine settings and the resulting test variants are summarised in Table 2. The test machine was a Valmet Type 860.4 8-wheeler forwarder with a Ritter traction cable winch. The rated power output of the 6-cylinder diesel engine is 140 kW. The average slope gradient of the test route was around 20%. Since the terrain beyond the test section was much steeper and wetter in places, the machine was equipped with band tracks (Fig.1).

Figure 1: Test machine Valmet 860.4 on the skid trail

Modern agricultural, industrial and forestry machines are equipped with several radiators for water, intake charge air, transmission, fuel and air conditioner. These require high power ventilators, which may easily produce a "vacuum cleaner effect", which causes the intake grid and radiator to clog up with dirt. An additional experiment was set up to investigate how a clean radiator may contribute towards saving fuel. In order to simulate the difference between clean and dirty radiators, the experiment was carried out with a patented Cleanfix reversible ventilator produced by the company Hägele GmbH. The radiator was built into a tractor, type Steyr 4110 Profi Classic with a 4-cylinder common-rail diesel engine, Ad Blue Technology and a rated power output of 82 KW according to ECE R120.

The unique profiled fan blades of these ventilators can be rotated along their long axis. The model used for this experiment was equipped with a temperature dependant, variable pitch control. The thermal actuators of this ventilator consist of wax-filled components, which are also used in heating thermostats and cooling water thermostats. In a defined temperature range, the wax expands and moves a small piston, which adjusts the angle of the blades from a low to a steep angle. Since all the blades are connected to a common piston, the synchronization of their movement is ensured. A radiator temperature increase causes a rise in cooling power and quicker removal of excess heat. As a result, the engine temperature returns to normal faster. In order to remove dirt sucked into the radiator, the position of the ventilator blades can also be reversed. In the reverse position air is no longer sucked into the radiator but blown out together with all the dirt in the radiator. This removes air flow resistances in a soiled radiator, which reduces air flow rates to such an extent that the ventilator is forced to work continuously at high power levels.

Two test series were carried out to investigate the effects of low and high blade angles on fuel consumption. With the engine running at a constant 1500 Rev/Min and 2000 Rev/Min the blade angles were changed from 13° to 38°. Fuel consumption was measured over an appropriate time period in a test tractor equipped with special measuring devices. In this set-up, a clean radiator is simulated by the flat blade position, while steep blades simulate a very dirty radiator.

Fuel consumption was measured using a flowmeter Type OME 13 made by Kral. In conjunction with the appropriate software, this analytical measuring system displays and stores data obtained from the screw spindles installed in the supply and return lines.

Table 1: Technical data KRAL OME 13

		KRAL OME 13
Flow		
Q_{max}	l/min	15
Q_{nom}	**l/min**	**10**
Q_{min}	l/min	0,1
Pressure		
P_{max}	bar	40
Temperature		
$T_{min}...T_{max}$	°C	-20 to +125
Viscosity		
$V_{min}...V_{max}$	mm^2/s	1 to $1x10^6$
K factor		
K	Imp/l	1214
Frequency		
f at Q_{nom}	Hz	202

3 Results

3.1 Forwarder

The results of the test runs reveal that changing the settings has a significant effect on average fuel consumption, required driving time and total consumption. While the absolute differences were lower in the downhill test drives, the total consumption when driving uphill on the test route varied by as much as 0.6 litres, which corresponds to around 27% (Fig. 2).

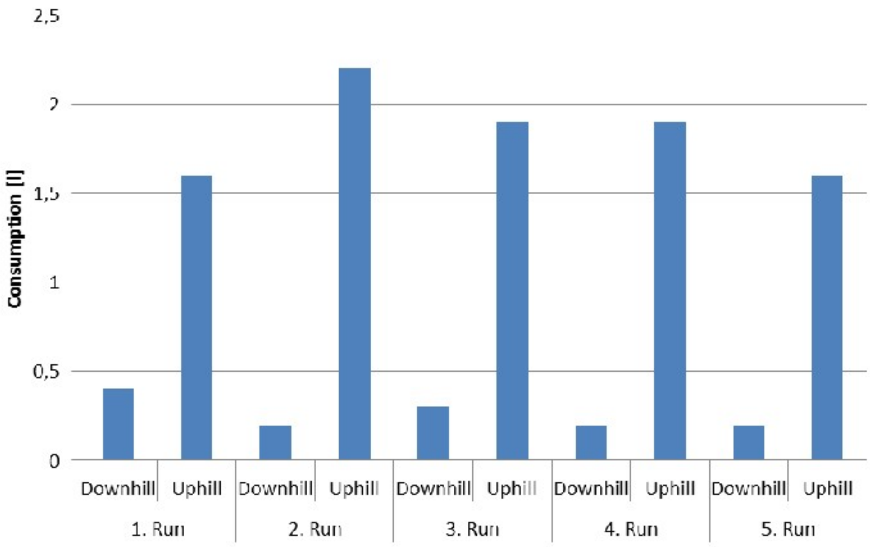

Figure 2: Total fuel consumption in the different trials according to the driving direction

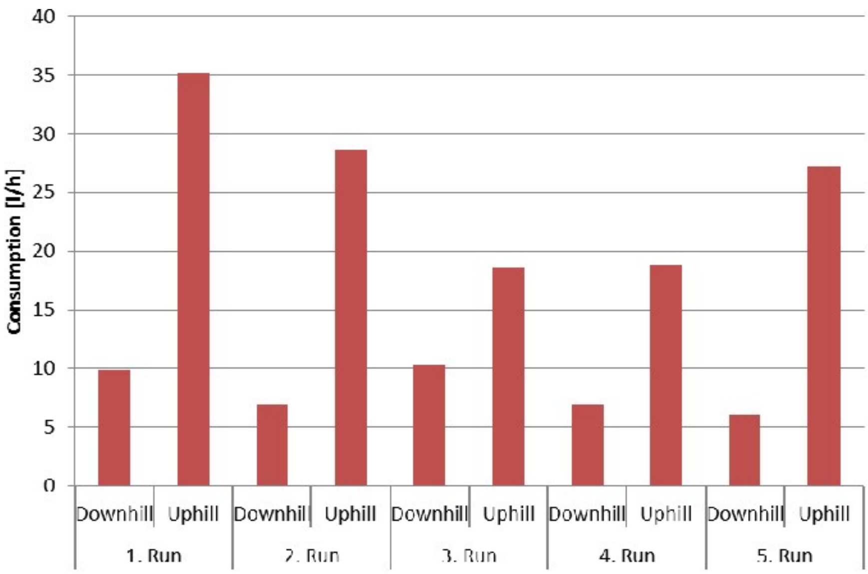

Figure 3: Average fuel consumption in the different trials according to the driving direction

The values for average fuel consumption vary considerably (Fig. 3). The results also show a large time difference between the different trial runs especially for driving uphill. Here the values vary between 2:48 and 6:01 minutes. Downhill drive time varies between 1:33 and 2:05 minutes.

Table 2: Overview of the different trial runs

	1. Run	Working gas, continuous drive speed increase, Inch 50 %	
	Duration [min:sec]	**ø consumption [l/h]**	**total [l]**
Downhill	02:05	9.8096623	0.4
Uphill	02:48	35.1529165	1.6
	2. Run	Working gas, continuous drive speed increase, Inch 100 % downhill, 25 % uphill	
	Duration [min:sec]	**ø consumption [l/h]**	**total [l]**
Downhill	01:34	6.83488691	0.2
Uphill	04:29	28.5672606	2.2
	3. Run	Working gas, no drive speed increase, Inch 100 % downhill, 25 % uphill	
	Duration [min:sec]	**ø consumption [l/h]**	**total [l]**
Downhill	01:33	10.2526303	0.3
Uphill	06:01	18.572322	1.9
	4. Run	downhill no working gas, no drive speed increase, uphill Inch 25 %	
	Duration [min:sec]	**ø consumption [l/h]**	**total [l]**
Downhill	01:41	6.88024566	0.2
Uphill	06:00	18.7615297	1.9
	5. Run	as 4., however variable Inch uphill 25-45 %	
	Duration [min:sec]	**ø consumption [l/h]**	**total [l]**
Downhill	01:39	6.038292	0.2
Uphill	03:22	27.2227018	1.6

3.2 Radiator/reversible ventilator

At a constant engine speed of 1500 Rev/min the test showed a difference in the average fuel consumption of 0.59 litres between the low and maximum blade angle (Fig. 4). This is equivalent to a difference of 11.65 %.

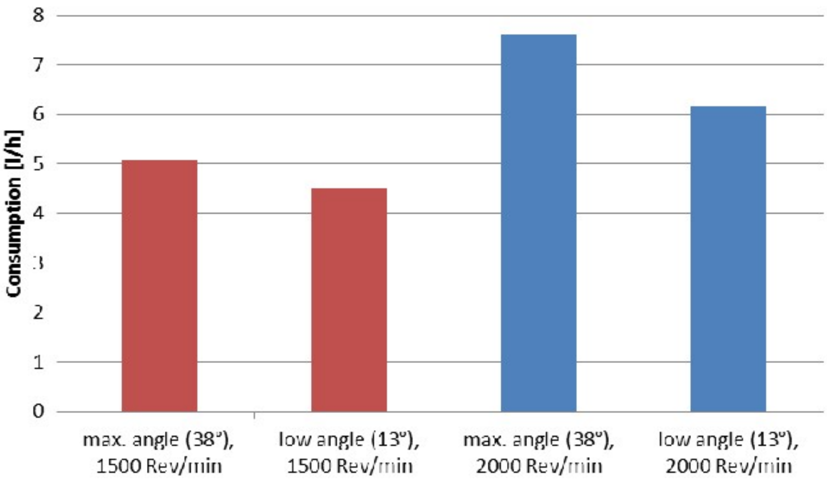

Figure 4: Comparison between the average fuel consumption at 1500 Rev/min and 2000 Rev/min engine speed with low and maximum blade angle

The difference between blade angles was more distinct at higher engine speed (2000 Rev/min). Here the lower blade reduced the average fuel consumption by 1.45 litres or 19.1 % during the test period.

4 Discussion

The trial runs of the forwarder showed that modern forest machines possess a high optimizing potential for adapting to different working conditions. The five different tests revealed significant differences in drive time and fuel consumption. The results also indicate that the potential for saving fuel is considerable when driving uphill. Here consumption could be reduced by up to 27 %. The absolute consumption differences were somewhat smaller for driving downhill. Despite this result, the correct use of the engine brake via the inch settings seems to be a promising approach. Unnecessary braking should be avoided as much as possible without compromising safety. The overall evaluation of the results indicates that it is more efficient to drive at higher speed, since the decisive factor is the total consumption for the specific job. Based on past experience, it is generally advisable to point out the possibilities and potentials of a machine specifically adjusted to the prevalent working conditions in training courses.

Changing the blade angle to simulate dirty and clean radiators caused differences in fuel consumption of about 19 % at higher engine speeds. The experiment showed that maintaining soiled radiators of machines usually working in dusty and dirty conditions holds a significant potential for saving diesel. In practice this is exacerbated by the effect caused by clogged air filters. In addition to this, failing to clean these components may cause time and cost intensive work disruptions and machine downtime due to overheating damage.

The results provide starting points for an efficient operation of forest machines by specifically adjusting machine settings to suit the working conditions. Proper exploitation of the drive train and the reduction of driving resistances hold the greatest potential for fuel increasing efficiency. In order to fully utilize the possibilities of the machine, it seems advisable to provide operators, especially the less experienced ones, with relevant training. This is all the more important under the prevailing cost pressure and pressure to perform and the increasing complexity of the systems and helps trained machine operators to recognize and avoid unnecessary fuel consumption.

5 References

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