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TSG (Technical Collaboration Group) recommendation 2005-01: Determination of the fuel-consumption index for forwarders

SKOGFORSK

Innehåll

Introduction

Harvesters and forwarders are used in forestry to fell and extract timber to roadside landings. To run these operations, approximately 1 litre of diesel fuel per cubic metre of harvested timber (solid i.b.) is used in felling, and 0.75 litres of diesel in extraction. With a total annual cut in Sweden of about 65 million m3, this means that some 115 million litres of diesel is consumed in logging. Consequently, it only takes a relatively small percentage reduction in fuel consumption to produce significant savings in fuel, which in turn reduce emissions, the use of fossil fuels, and the operating costs of the machine users. Currently, diesel fuel accounts for some 10% of the logging costs. So there are many good reasons to develop a standardized method for measuring and declaring fuel consumption.

In the motor industry, there are well-developed methods for providing figures on fuel consumption. A potential car buyer can therefore compare the fuel-consumption figures of different makes of car and thus be able to choose a fuel-efficient model. In forestry, however, no such method is available at present that can offer a standard way of comparing fuel consumption in logging machines, despite the pressing need. What is required is a method that can provide details of fuel consumption under clearly specified conditions, with measurements that are reproducible.

Time elements in forwarding

A breakdown of forwarding work is shown in Table 1.

Table 1.
Time elements in forwarding.

Element	%
Driving unladen	13
Loading	41
Driving whilst loading	11
Driving laden	16
Unloading	14
Miscellaneous	5

As can be seen from the table, time consumption is spread over different types of knuckleboom work and driving. The figures shown in Table 1 are an average, and can fluctuate widely from one site to another, and depending on the logging method and machines used.

Knuckleboom work

Practical work with a forwarder's knuckleboom is complex, and the skill of the operator greatly influences the time taken and, hence, fuel consumption. In standardized work, it is therefore vital to control the working tempo, which should be such that the time taken for boom operation is 30 s/boom cycle or two boom cycles per minute. To enable boom work to be replicated, the boom is used only with an empty grapple; and to keep the operation as similar as possible between machines, the boom operates as shown in Figure 1.

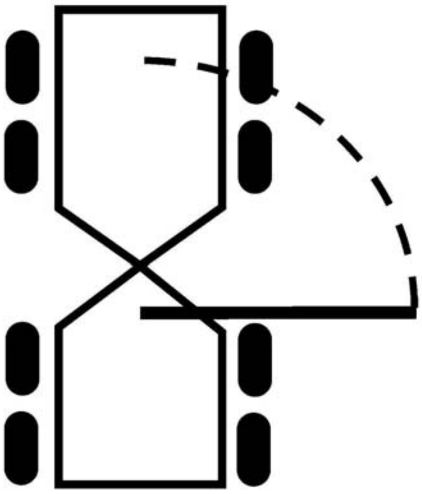

Figure 1.
Knuckleboom operation on forwarder.

To perform a lift, the boom must be operated from a point on the ground at right angles to the machine, slewing the grapple over the stakes and into the bottom of the load bay, and then back the same way. The farthest point from the base plate of the boom will vary with the size of the forwarder, as shown in Table 2.

Table 2.
Recommended farthest point for different forwarder sizes.

Forwarder size	Farthest point, m
Light-duty <10 tonne	6.0
Medium-duty 10–14 tonne	6.5
Heavy-duty >14 tonne	7.0

Experience to date suggests that each fuel reading should include a minimum of 10 boom cycles to achieve a stable value.

Readings should be taken at engine speeds of 1 100, 1 300 and 1 500 rpm.

Driving

Forwarder driving modes also vary according to the skill and experience of the operator.

To create conditions that are as consistent as possible between machines, driving should take place on a level, asphalted road, with a driving pattern as shown in Figure 2.

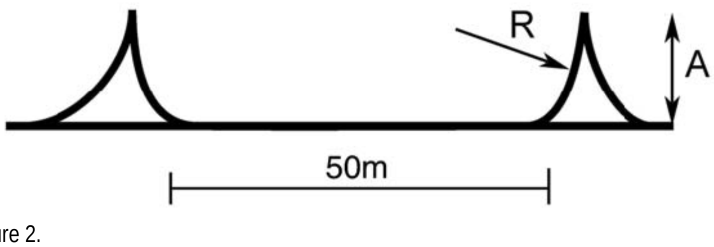

Figure 2.
Stylized drawing of on-road driving pattern.

The forwarder starts from one end of the 50-m stretch of road. When it reaches the end of the road, it turns left or right until it is at right angles to its original direction of travel. The forwarder now reverses (backs up), simultaneously swinging the front of the vehicle until it is pointing back along the line of the road.

The entire process is repeated until a stable reading for fuel consumption is obtained (usually after 3 round trips/6 straight passes).

Because the forwarder has to turn round, the operation covers not only driving but also acceleration/deceleration and off-road manoeuvring.

The speed between the turns should be 3 km/h, which corresponds to 50 m/min. The lock on turning should be such that the radius, R, in the figure is 7 m, and the driving distance, A, approximately 13 m.

During the test, the forwarder must be unladen, and the engine speed set at 1 300, 1 500 and 1 700 rpm, respectively.

General

Because the temperature of the engine and hydraulic fluid affect fuel consumption, the machine must be at normal running temperature when readings are taken. This is achieved by leaving the engine running at idling speed for about half an hour, and operating the boom for 15 minutes before the test is started. The ambient temperature must be above 5°C.

The fuel used must be to Swedish Environment Class ”MK1”.

All consumer units, eg, air conditioning (AC), lights and cab fan, must be switched off during the test.

The ambient temperature and weather conditions at the time of the test must be noted in the test report, together with the forwarder’s tyre specifications, number of wheels, wheelbase and engine specification.

The knuckleboom used must be of a standard type, and its make, model and reach must be specified.

The fuel-measuring equipment must be accurate to within 2%.

Weighted fuel consumption

When readings are taken of fuel consumption during knuckleboom operation and driving, a number of values are generated under a variety of conditions. To enable comparisons to be made between different machines, it is more expedient to use only a limited number of readings.

The values can be calculated from the time elements in Table 1 and the fuel readings.

Since the only fuel-consumption figures of interest here those taken when the machine is being driven unladen, and during boom work with an empty grapple, we can simplify Table 1 by confining the time elements to driving (42%) and boom work (58%). The remaining time is then distributed proportionately between these two.

Next, by multiplying time taken by fuel consumption, and calculating the sum of the sub-values, we obtain the average fuel index for the given combination of speeds (rpm). The speeds at which fuel consumption is determined are indicated by ”X” in Table 3.

Table 3.
Fuel indices for different combinations of rpm during driving and boom work.

		Boom work		
		1 100	1 300	1 500
	1 300	X		
Driving	1 500		X	
	1 700			X

In addition to the values given in Table 3, fuel consumption is also measured with the engine idling at speeds of 1 100, 1 300, 1 500 and 1 700 rpm.

Comment

In developing a method for measuring fuel consumption, our aim was to produce readings that were both representative of fuel consumption in practical operations and appropriate for making comparisons between machines. Unfortunately, this was not possible.

It is therefore important to understand that the weighted readings of fuel consumption do not constitute a practical value; that is why the term ”fuel index” is used.

Current experience suggests that the value of the fuel index is approximately 60% of the real volume of fuel consumed in operational logging.

Appendix 1

Specifications

General	
Weather conditions	
Ambient temperature	
Base machine	
Tyre specification	
Number of wheels	
Wheelbase	
Engine specification	
Knuckleboom	
Knuckleboom specification	
Outreach	
Power unit	