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Contents

Transporting more while consuming less: performance comparison of two different-size engines

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Abstract

FERIC conducted a study on two trucks that were identically specified except their engine size, to compare their performance. The data collected by two onboard computers showed that the truck with the smaller engine was more energy efficient and just as productive when it came to the quantity of wood transported.

Keywords:

Fuel consumption, Onboard computers, Performance, Productivity, Engines, Trucks.

Introduction

Wood transport currently accounts for half the cost of getting wood fiber to processing mills. Given that fuel consumption alone represents 30% of trucking costs, FERIC has been working on many different fronts to identify energy saving solutions.

At the present time, most truck owners want the most powerful engine available from the manufacturers. However, conditions permitting, FERIC recommends instead the use of smaller engines that consume less fuel. To convince users to change their habits, it was necessary to show that such a change had a positive impact, even in difficult transport conditions.

FERIC had the opportunity to work with Transports Poirier et Frères Inc., a Gaspé contracting business that acquired in 2004 two identical trucks except for the engine (Table 1). The trucks were used in the same operating areas and driven by their regular truck drivers (ensuring that driving habits stayed the same over time). As a result,

Table 1. Truck specifications

Truck Nº	Make and model	Year	Transmission*	Ratio	Tires	Engine - Volume
201-05	Kenworth W900	2005	1650 lb-ft - 18 V	4.11	11-R-22	C13 - 12.5 L
401-05	Kenworth W900	2005	1850 lb-ft - 18 V	4.11	11-R-22	C15 - 15.2 L

* Transmissions were identical in terms of weight and gear ratios.

conditions were optimal for a rigorous evaluation the engines' performance, especially since the roads used were notorious for being among the most difficult in Quebec.

Initially at 430 HP, the C13 was reprogrammed up to 470 HP in July 2005. Changes were also made to the C15's electronic programming at the start of the study, which were supposed to reduce its fuel consumption. However, the engine remained at 475 HP throughout the project.

Methodology

Onboard computers were installed in each of the two trucks and recorded engine parameters from the electronic control module (ECM) along with the geographic location provided by a GPS receiver.

Data on the trucks' loads were also collected. These data came from the scale reports at the sawmills supplied by the two trucks. Only part of the data was available, but sufficient to ensure that results were statistically significant.

The trucks were monitored continuously from March 2005 to February 2006. Monthly analyses made it possible to assess potential changes in:

- **Performance**, determined by fuel consumption, as compared with engine parameters (speed and RPM) and human factors (excess speed, RPM and idling);
- **Productivity**, represented by the quantity of wood transported per unit of time (speed and cycle time).

Calibration

The use of onboard computers facilitates the study of engine performance since it enables continuous monitoring without disturbing trucking operations. However, it is necessary to check data recording and accuracy throughout the project.

For this purpose, four calibrations were done. The following protocol was repeated each time: during one week, we compared distances travelled and total fuel consumed as provided by the onboard computers versus manual records (fuel tank fill-up and odometer). Computer data were then adjusted according to this calibration, until the next repetition.

The following observations were made:

1. The onboard computer data (from the ECM) can vary up to a 10% with reality, depending on the trucks' configuration, specifications and engine programming.
2. When these parameters (specifications and programming) remain constant, the difference varies only slightly over time. Once calibrated, the onboard computers can capture fuel consumption data to an accuracy of ± 2%.
3. The error varies according to weather and road conditions. When two trucks performing the same operations are compared (therefore in the same conditions), the precision is further improved.

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Results

Performance

Over the year, the C15 consumed nearly **4 L/100 km** or 5.9% more than C13 (Table 2).

The two engines were reprogrammed during the project. In both cases, there was no marked impact on the observed data, whether for fuel consumption (Table 3) or RPM and speed profiles.

The observed fuel-consumption difference varied only 0.25%, which was not statistically significant. It is therefore possible to assume that displacement (volume) is the chief engine parameter that determines fuel consumption. In this study, the modification of engine power didn't affect consumption.

Table 4 presents the main driving parameters having an impact on average fuel consumption. The higher these parameters are, the higher the fuel consumption. The figures shown would tend to increase the

Table 2. Annual fuel consumption

Truck*	Total distance	Total consumption	Average consumption
C13	95 943 km	62 767 L	65.42 L/100 km
C15	111 308 km	77 096 L	69.26 L/100 km

*Designated by engine size here and hereafter.

Table 3. Changes in fuel consumption (L/100 km)

	March – July	August – February
Difference C13 - C15	5.86%	5.61%

Table 4. Engine data

Truck	Average speed	Average idling	Excessive idling > 5 min	Excessive speed > 90 km/h	Excessive RPM > 1650 RPM
C13	58.1 km/h	17.8%	3.5%	12.1%	2.7%
C15	57.3 km/h	17.2%	3.2%	11.9%	1.8%

consumption of the C13 compared with that of the C15. It can thus be concluded that the 4 L/100 km difference observed is possibly conservative since the C13 drivers appear to have slightly less energy-efficient driving habits.

It is also interesting to note the RPM and speed profiles of both trucks in Figures 1 and 2, since they provide a fairly accurate overview of the drivers' impressions with regard to the engines. These figures show the percentage of driving time spent in various RPM and speed classes. In this case, they are data from a single trip taken in February 2006, but are representative of the overall performance of both trucks.

It is possible to observe a shift in profiles when compared to each other. The C15 shows higher speeds for lower RPMs. It is therefore necessary to maintain the C13 at a higher RPM to keep up with the C15. However, the C13 does run mainly in the recommended range (1200 to 1600 RPM).

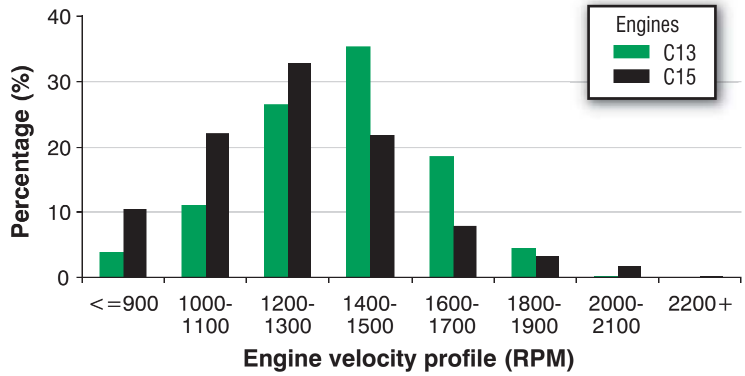

Figure 1. RPM profile.

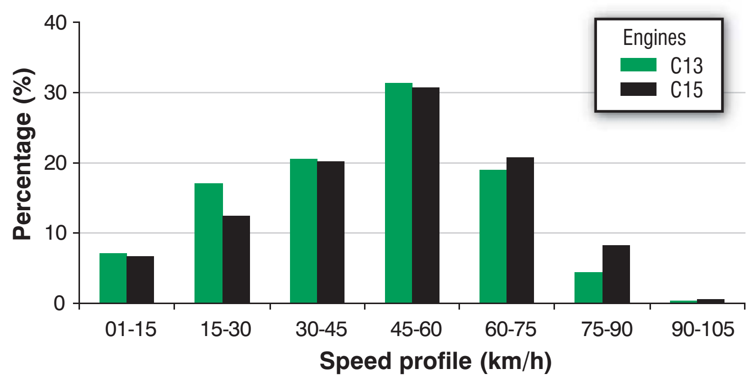

Figure 2. Speed profile.

Productivity

Load data, provided by Produits Forestiers Temrex, S.E.C., cover an eight-month period from late July 2005 to late March 2006, for a total of 309 loads for C15, and 279 loads for C13. This disparity in loads was caused by wood availability problems and the fact that C13 was sometimes used for other types of transport.

In Table 5, there is a difference of over 600 kg in the trucks' empty weight. The difference in engine weight was 281 kg and there was a further difference due to the C13's cab protector since it was made of aluminum. However, this was compensated by a less optimal average load (lower GVW). In the end, C13's payload was 300 kg heavier than that of C15.

To compare truck productivity, data were collected at different periods during the study, i.e. in March, August and December 2005 and in February 2006, for a total of 60 loads. For each period, the average payload per hour of driving (distances were equal) was calculated, along with the fuel consumption per tonne of wood hauled based on the onboard computer data.

Table 5. Average loads (tonnes)			
Truck	**Average GVW (gross vehicle weight)**	**Average empty weight (tare)**	**Average payload**
C13	54.75	19.26	35.49
C15	55.07	19.88	35.19

Table 6. Difference in productivity		
Equal distances	**Productivity Payload tonne/hour**	**Performance L/payload tonne**
Difference C13 - C15	+ 0.03	- 0.30

It can be seen that the C13 was certainly no less productive than the C15 over an identical route (Table 6). Moreover, at equal productivity, it performed better in terms of fuel efficiency (0.30 L less per tonne of payload transported). Based on 35 tonnes per load, it therefore consumed **10.5 L** less fuel during each trip.

Conclusions

The energy efficiency of the C13 engine made it possible to save roughly 4000 L of fuel (based on 100 000 km travelled) during the study year. This represents a total gain of **$3400** with fuel at 85¢/L.

An estimate of productivity-related benefits can also be added, considering that the trucks do the same amount of work during the year, i.e. about 400 trips. Based on 300 kg of additional wood transported per trip, at $15 per tonne, this represents **$1800** for the year.

Over the truck's service life of four years, the potential total savings from a C13 engine compared with a C15 are therefore over **$21 000**, for an initial investment that costs nothing.

These results are specific to the situation described herein (operating conditions, specifications), but they do show that reducing the size of engines can be very profitable even in difficult transport conditions. The decision therefore rests with owners and it is up to them to make the best choice.

Acknowledgments

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