DYNAMON

Comparison of Low-PPK-Cost and Fuel-Optimised Tyres at Millbrook Proving Ground

Final Report

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Involved Parties

ASDA, Continental, Tructyre, MiX Telematics, Millbrook, Michelin, Tyre Maintenance, microlise

Overview

Dynamon conducted a 4-day trial at Millbrook Proving Ground to demonstrate the impact tyre choice has on HGV fuel consumption, and therefore the importance of performing the correct analysis to choose a tyre policy that balances both cost and fuel performance.

Typically, fleets look for the cheapest tyre price or Pence Per Kilometre (PPK) rate when purchasing tyre policies. To facilitate this, tyre providers have designed tyres with hard wearing rubber compounds and deep tread for maximum longevity. Over the duration of a PPK contract this means fewer tyres and tyre changes need to be supplied, allowing a cheap PPK rate. However, these tyres significantly increase fuel consumption and, in many cases, increase total costs for fleets. To identify a tyre policy that achieves minimum total cost of ownership (TCO) fleets must consider both the cost of the tyre policy and the real-world fuel performance. Dynamon has developed a data analytics service which combines fleet telematics data with a growing database of tyre performance to help fleets choose tyre policies that provide minimum TCO.

This trial compared the fuel consumption of a tyre policy optimised for low PPK cost to a tyre policy optimised for fuel performance. The two sets of tyres were tested under a replication of constant speed motorway conditions. Fuel consumption was assessed during short (30 min), medium (90 min), and long (180 min) journeys, to account for the effects of tyre warm up time on fuel performance. This case study presents the results of this controlled trial.

Results

Details of the low-PPK-cost tyre policy and fuel-optimised tyre policy used in this trial can be found in **Appendix 1.** A detailed description of the experimental methodology can be found in **Appendix 2.** Tyres were sourced from new and were initially given a ‘run-in’ period, after which the trial took place over two days, with the fuel-optimised tyres tested on the first day and the low-PPK-cost policy the next. To mitigate environmental effects a second vehicle was utilised to act as a control. The control vehicle had a constant set of tyres over the trial period and drove the same drive-cycle as the test vehicle at the same time. Any changes in fuel performance of the control vehicle were used to normalise the fuel performance of the test vehicle. Further details of this process can be found in **Appendix 3.**

The tractors used throughout the trial were Scania 4x2 G410LxA MNA (2017). Tractors towed 4.2 m refrigerated trailers loaded to ~70% capacity, further details of the vehicle setup and axle weights can be found in **Appendix 4.** Throughout the trial vehicles were set to cruise control and maintained a constant speed of 50 mph.

The primary focus of this trial was to compare tyre performance under constant (fully warmed up) conditions over a 180 min driving period. However, results are also presented for a short (30 min) period as the tyres warmed up from ambient temperature, and also a 90 min driving period that followed a tyre cooling period (30 min driver break). The key findings of the trial are presented in **Table 1.**

Test Duration (mins)	Tyre Temperature Conditions	Fuel Saving (mpg)	Fuel Saving (%)
30	Ambient to warmed	2.1	18.4
90	After 30 min driver break to fully warmed	2.4	16.7
180	Fully warmed	2.4	17.0

Table 1. *Fuel saving by changing from the low-PPK-cost tyres to fuel-optimised tyres across several driving periods and tyre temperature conditions. Fuel Saving (mpg) describes the increase in mpg seen moving from low-PPK-cost to fuel-optimised tyres. Fuel Saving (%) describes the change in mpg performance as a percentage of the low-PPK-cost tyre fuel performance. Both Fuel Saving (mpg) and Fuel Saving (%) were normalised using the performance of the control vehicle (details in* **Appendix 3***).*

The results presented in **Table 1** demonstrate a 17% fuel saving for the most direct (fully warmed up) and statistically significant (180 min drive period) comparison between low-PPK-cost and fuel-optimised tyres. Some insight into the reasons behind this saving can be found in the tyre temperatures shown in **Figure 1**. The main contributor to a tyre's rolling resistance (and therefore energy loss) is the process of hysteresis as the tyre rolls. The deformation and reshaping of the tyre is not an energy conserving process, instead the movement of the rubber compound generates heat through internal friction. The energy loss due to this heat generation must be overcome by the vehicle's engine and therefore results in wasted fuel (it is worth noting that the sound generated by the tyres is also an energy loss mechanism but in this case is small compared to the heat loss). For the warmed up, 180 min driving period shown in **Figure 1** a clear increase in the operational temperature of the low-PPK-cost tyres compared to the fuel-optimised tyres can be seen across all axles, with the largest difference seen in the drive tyres. The difference in fuel consumption can be thought of as the fuel that must be consumed every second to maintain this temperature difference, which in this test accounts for a 17% difference in fuel bill.

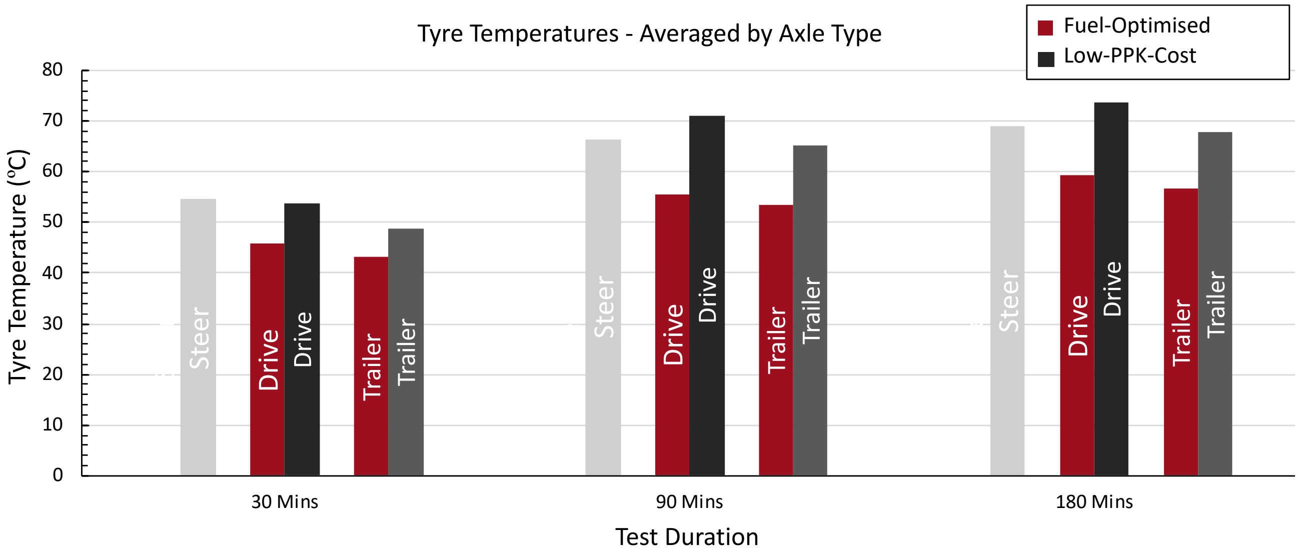

Figure 1. *Axle-by-axle comparison of the final temperature of the low-PPK-cost and fuel-optimised tyre policies after testing period.*

During the 30 min test a slightly larger fuel saving of 18.4% was observed. The raw results presented in **Appendix 3** show an ~1 mpg improvement from the fuel performance during 30 min test to the 180 min fully warmed up tests, demonstrating that all tyres perform better as they warm up. The slightly larger fuel saving during the 30 min test suggests the fuel-optimised policy tyres approach their optimum temperature faster than the low-PPK-cost policy tyres, this can be seen in **Figure 1** by comparing the final tyre temperatures after 30 and 180 mins.

During the 90-minute test, which followed a 30-minute simulated driver break, a similar fuel performance was observed to the 180-minute fully warmed test. This was perhaps to be expected as there was very little change in the tyre temperature (~2-4°C) during the 30-minute break. It should be noted that the weather conditions (see **Appendix 5.**) during this test were warm (24 °C) compared to the UK average temperature (6-13 °C). It is likely that under cooler weather conditions a larger temperature drop, and therefore fuel performance difference, would be observed. However, further lower temperature testing would be required to confirm this.

Conclusions and Next Steps

This case study has demonstrated that **significant fuel savings** can be achieved by optimising tyre choice. To identify a tyre policy with minimum TCO, the PPK rate must be balanced against the predicted fuel performance over the lifetime of the tyre policy.

This test measured the fuel performance of the tyres at constant speed, elevation, and full tread depth. To convert the results of this test to the likely fuel saving a fleet will achieve, the drive cycle of the fleet and the performance of the tyres over their full lifetime must be considered.

Dynamon has developed an analytical model which uses a fleets unique, real-world drive-cycles directly from telematics, along with the exact rolling resistance coefficients of tyres measured at multiple wear points over the tyre’s life, to predict the true, real-world fuel cost of a tyre. This can then be balanced against the tyre PPK in the Dynamon tyre optimisation tool to find the most cost-effective tyre policy for a fleet. The **17% fuel saving** measured in this test suggests significant TCO savings are available by choosing a tyre policy that balances both PPK cost and fuel performance.

Appendix 1 – Tyre Specifications

All tyres in this experiment were purchased new (or 'new retreaded') from an independent local tyre supplier (Tructyre) and were expected to be in off-the-shelf condition. Details of the tyre types and specifications are shown in **Table A.1.1**. All tyres were pre-fitted to new identical rims to avoid any influence of rim weight/compound on the trial. All tyres were inflated to the recommended pressure (Steer: 120psi, Drive: 95psi, Trailer: 125psi) at the ambient temperature and monitored using the TPMS. Tyre fitting was provided by an independent tyre fitment company (Tyre Maintenance).

All tyres in the following table had their exact rolling resistance measured independently at the accredited EU tyre labelling facility UTAC CERAM. Note that due to difference in casing quality and damage retread tyres will likely have a spread of rolling resistances, the following measurement provides an estimation of the rolling resistance.

Tyre Type	Axle	Name	Dimensions	Rolling Resistance Band	Tread Depth (mm)
Fuel-optimised	Steer	Michelin XLINE Energy Z	315/70/22.5	B	13.0
	Drive	Michelin XLINE Energy D2	315/70/22.5	A	13.5
	Trailer	Michelin XLINE Energy T	385/65/22.5	A	12.4
Low-PPK-cost	Steer	Continental Hybrid HS3 XL	315/70/22.5	C	15.5
	Drive	Bandvulc BD08	315/70/22.5	E	24.0
	Trailer	Bandvulc BT08	385/65/22.5	D	20.0

Table A.1.1 *Low-PPK-cost and fuel-optimised tyre policies tested during the trial.*

Appendix 2 – Detailed Methodology

Testing took place over four days; an outline of the schedule follows:

- Day 1 – vehicle setup
  - At the outset of the test identical trailers for test and control vehicle were selected. Due to an issue with rim offsets the original Schmitz Cargobull test vehicle trailer was replaced with a similarly spec'd Montracon. This had no impact on the validity of the results as no comparison is made between the test and control vehicles. Low-PPK-cost and fuel-optimised tyres were compared only on the test vehicle. The replacement trailer had a near identical geometry to the original so no significant deviation from the control vehicles response to environmental effects was present.
  - Continental TPMS and Mix Telematics monitoring systems were fitted to cabs (TPMS sensors were pre-installed in tyres).
  - Current tyres on the test vehicle were replaced with new tyres of the low-PPK-cost tyre policy
  - Trailers were loaded with one tonne concrete blocks (on pallets) giving the loading distribution described in **Appendix 4**.
  - Vehicles were weighed axle by axle at weigh-bridge.
- Day 2 – new tyre run-in
  - Low-PPK-cost policy tyres were run-in for 150 mins at constant speed.
  - Warm-up time of low-PPK-cost policy tyres in ambient conditions was assessed.
  - Tyres were changed to fuel-optimised tyre policy.
  - Fuel-optimised policy tyres were run-in for 150 mins at constant speed.
  - Warm-up time of fuel-optimised policy tyres in ambient conditions was assessed.
  - Vehicles were refuelled to same level to ensure constant weight.
  - Tyres left to cool overnight completing the 'run-in'.
- Day 3 – testing of fuel-optimised policy tyres
  - Fuel-optimised tyres were tested for 30 mins, starting from ambient temperature, at constant speed.
  - Tyre cooling period of 30 mins.
  - Fuel-optimised tyres were tested for 30 mins at constant speed.
  - Tyre cooling period of 30 mins.
  - Tyres were tested for 90 mins at constant speed (this test served as the planned full warm up for the following constant condition testing).
  - Short driver break (15 mins).
  - Tyres were tested under pre-warmed-up conditions for 180 mins at constant speed.
  - The control vehicle followed an identical driving cycle maintaining close distance to the test vehicle but avoiding slipstreaming (1/4 mile back on the circular track).

  - Fuel-optimised policy tyres fitted.
  - Vehicles were refuelled to same level to ensure constant weight.
- Day 4 – testing of low-PPK-cost policy tyres
  - Testing schedule identical to day 3.
  - Strip down and unloading of vehicles.

Appendix 3 – Normalisation of Results

A control vehicle with a constant tyre set, which drove an identical driving pattern separated by no less than 1/4 mile from the test vehicle, was present throughout the trial. Variations in the control vehicle mpg, caused by fluctuations in the environmental conditions, were used to normalise changes in the test vehicle mpg. The measured mpg and corrected fuel performance change of the test vehicle due to tyre choice are shown in **Table A3.1.** For the test vehicle "Fuel Saving Unnormalized" represents the fuel saving from changing tyre policy. For the control vehicle "Fuel Saving Unnormalized" represents the apparent change in fuel consumption due to the difference in environmental conditions that occurred between the days when the low-PPK-cost and fuel-optimised tyres were trialled on the test vehicle. As no change in tyre policy occurred on the control vehicle, if there was no change in environment a fuel saving of 0% on the control vehicle would be expected. This percentage change in fuel consumption on the control vehicle was subtracted from the percentage change in fuel consumption observed on the test vehicle to obtain the normalised fuel saving.

Vehicle	Test Duration (mins)	Low-PPK-cost Tyres (mpg)	Fuel-Optimised Tyres (mpg)	Fuel Saving Unnormalised (%)	Fuel Saving Normalised (%)
Test	30	11.0	13.1	18.8	18.4
	30	11.6	14.0	20.5	21.2
	90	11.9	14.3	20.4	16.7
	180	11.9	14.4	20.4	17.0
Control	30	12.3	12.4	0.4	N/A
	30	13.1	13.0	-0.7	N/A
	90	13.2	13.6	3.7	N/A
	180	13.2	13.6	3.4	N/A

Table A3.1 *Raw and normalised fuel performance results for each measured drive cycle.*

As seen in **Table A5.1**, throughout the trial both the temperature and precipitation conditions remained consistent between the testing days for the low-PPK-cost (26/07/2018) and fuel-optimised tyres (25/07/2018). There was a small increase in wind strength (wind direction has little influence due to driving in a circular bowl) on the afternoon of the 26th, which likely caused the small increase in control vehicle fuel consumption observed during the 90 and 180 min tests. This effect was removed from the test vehicle by the normalisation procedure.

Appendix 4 – Loading Details

The loading distributions of the test and control vehicles are shown in **Table A4.1**. Note that due to weighbridge constraints at Millbrook the rear two trailer axles were measured simultaneously as a combined weight. For the purposes of analysis, the load was assumed to be an even spread between these axles. This assumption is consistent with the load on axle 3.

Vehicle	Steer	Drive	Trailer Front	Trailer Middle	Trailer Rear	Total
Test	6755 kg	9474 kg	5582 kg	5576 kg	5576 kg	32963 kg
	20.5%	28.7%	16.9%	16.9%	16.9%	100%
Control	6925 kg	9560 kg	5588 kg	5482 kg	5482 kg	33037 kg
	21.0%	28.9%	16.9%	16.6%	16.6%	100%

Table A4.1 *Axle-by-axle loading of test and control vehicles in kg and as a percentage of the total vehicle load.*

Appendix 5 – Ambient Weather Conditions

Table A5.1 displays the ambient weather conditions present during the trial period. Weather readings taken from the nearest weather data in Kempston (located 6 miles from Millbrook). No rain was present on either trial day.

Tyres Tested	Date	Time (UTC)	Temperature (°C)	Wind Speed (mph)	Wind Direction (°)	Rainfall (mm/h)
Fuel-optimised Tyre Policy	25th July 2018	09:00	20	4	315	0
		12:00	24	2	292.5	0
		15:00	27	4	315	0
Low-PPK-cost Tyre Policy	26th July 2018	09:00	22	4	90	0
		12:00	25	5	180	0
		15:00	28	9	180	0

Table A5.1 *Ambient weather conditions during the Millbrook trial.*