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FLATSPOTTING TIRE TESTING

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Abstract: *The tire testing is a part of the tire testing program, which are the authors conducted over the several years. The underlying idea in most of the programs was to replicate real-life conditions in order to better understand tire behaviour while using the advantage of quasi-controlled conditions.*
Keywords: *tire testing, flatspot.*

1. INTRODUCTION

Tire flatspots can be quantified by measuring the tire's low or high speed force uniformity or radial run-out [1], [2], [5], [12], . A radial force uniformity based test was organized with real-life driving and tire parking during 10 days (2 x 5 working days – no weekend activity).

The general concept of real life flatspot test is shown in Fig. 1 which can be adjusted to several scenarios [3], [6], [7], [8], [10].

2. MAIN STEPS OF THE REAL TEST

There are 4 main steps during one day [9], [11].

1. **Warm-up**. The first step is warm-up step in which the tire are run on a selected course, city-type of driving for about 33Km on 90% highway (100 km/h max speed) and 10% local roads with curves (50km/h max speed).
2. **Warm measurement**. Second step in the process is measurement of the tire uniformity (RFV) by using a balancing machine with Radial Force Variation measurement capability.
3. **Flat Spotting**. The car is parked during the day in one phase and during the night in the other.
4. **F/S measurement**. At the end of the flatspotting step, we measure tire uniformity and compare the results with the initial measurement. We're using absolute values for the RFV [13] (we subtract the initial measurement value from flat spotted measurement value).

Fig. 1. Real-life flatspotting tire testing

In order to better understand the program, here below (Table 1) we have the daily schedule. All of the tires have very good uniformity values. Radial Run-out values are under 0.4mm and Lateral Run-out values are under 0.12mm. Tires are also requiring minimal balancing weights [14].

Table 1 Daily Schedule

Daily Schedule		
7:30 - 8:30	Drive 1	Warm-up drive as explained above (about 33Km, 90% highway driving, 100km/h top speed).
8:30 – 9:00	Msr 1	We're measuring "warm" RFV.
9:00 – 17:00	Day F/S	We park the car for 8h in outside parking spot, ambient temperature, open sky.
17:00-17:30	Msr 2	Measuring Day Flatspot RFV
17:30 - 18:30	Drive 2	Drive on the same cours as Drive 1
18:30 - 19:00	Msr 3	Measuring "warm" RFV
19:00 - 7:00	Night F/S	Park the car for 12h in ourside parking spot, ambient temperature, open sky
7:00 - 7:30	Msr. 4	Measuring Night Flatspot RFV

Table 2 TWA uniformity data

Tires	TWA Run-Out (mm)		Balancing Wghts (0z)		RFV (lbs)
	RRO	LRO	Bal In	Bal Out	
Tire 1	0.38	0.09	0	0.25	3
Tire 2	0.27	0.085	0.25	0	2
Tire 3	0.32	0.12	0.25	0.25	5
Tire 4	0.31	0.11	0.5	0	5

We can see that there is a very large difference between the RFV before and after F/S. Here below (Fig.) we can see Msr3 and Msr4 for example on Tire 1, Day 2.

And we also we're representing the data from one full day as an example (

Fig. 2). For better representation / understanding we've chosen to start the testing day at 7:30am and finish next day at 7:30am. Drive 1 and Drive 2 are on the same driving course (normal city driving home - work).

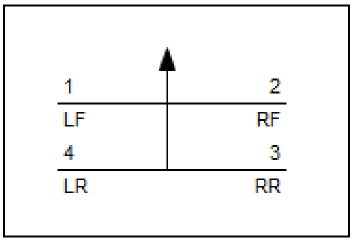

Fig. 2 Tire position [4]

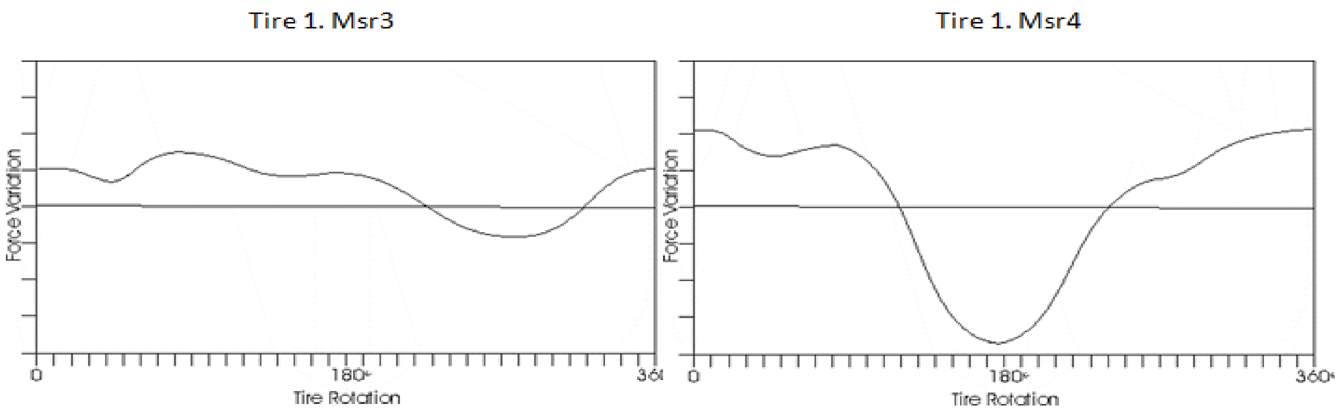

Fig. 3 Tire 1 before and after F/S RFV

The graph is also representing the hourly temperature variation for the testing day. We note that daytime flatspotting is shorter (and at higher ambient temperature) than nighttime flatspotting exposure. We have chosen this scenario in order to better represent a normal, daily life situation.

We notice that after the first warm-up drive the RFV values are relatively low. We can reasonably assume that those values are very close to the TWA normal RFV values. However, since we have a "real-life" situation the warm-up condition / tire internal temperature can be different from Drive 1 to Drive 2 on a day to day basis.

We also notice that Msr1 (tire "initial") values are slightly higher than Msr3 values. This can be explained by the fact that overnight tire flatspotting may have a longer imprint on tire uniformity than the daytime flatspotting.

We see very well from this chart that daytime F/S (Msr 2) induces much lower RFV values than the nighttime (Msr 4) (Fig. 4).

It is interesting to note the fact that Tire 1 & Tire 2 have higher RFV values at Msr4 than Tire 3 & Tire 4 in spite of the fact that at the "initial" measurement (Msr1) Tire 1 & 2 RFV values were lower than RFV values for Tire 3&4.

This can be reasonably explained by the fact that the engine weight can have a higher impact on tire flatspotting overnight. Tire position can be seen in Figure 2.

For the whole duration of the program, here below we have the daily temperature (

Fig. 3) with average, maximum day and minimum night temperature. The minimum and maximum temperatures are reported on the left axle and the average temperature on the right axle (Fig. 5).

The chosen period for the testing was relatively normal for month of November from weather point of view during the 10 days (

Fig. 4). We only had rain in Day 5 (9mm), Day 8 (3mm) and Day 10 (6mm) with stronger gusty winds in Day 1, 5 and 10 (Fig. 6).

We notice that the night temperature values have an upper trend over the 10 days period of time (Fig. 7).

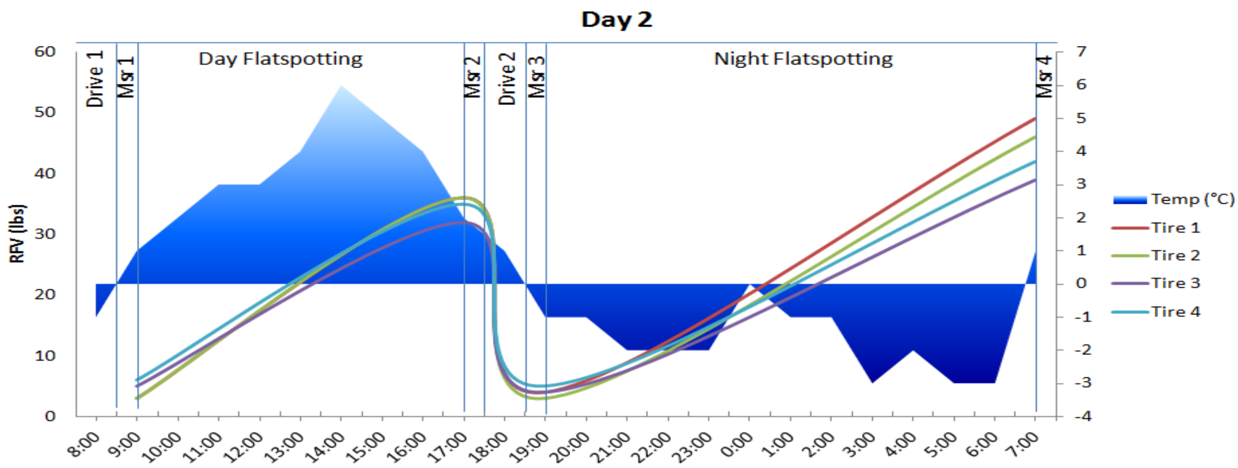

Fig. 2 Example of tire exposure during one full day

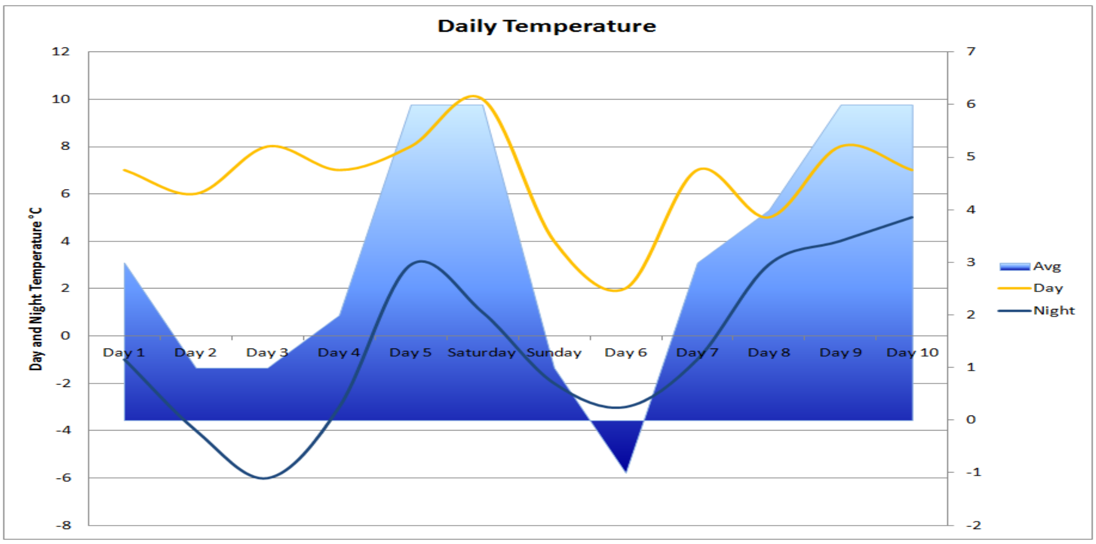

Fig. 3 Daily temperature during the program

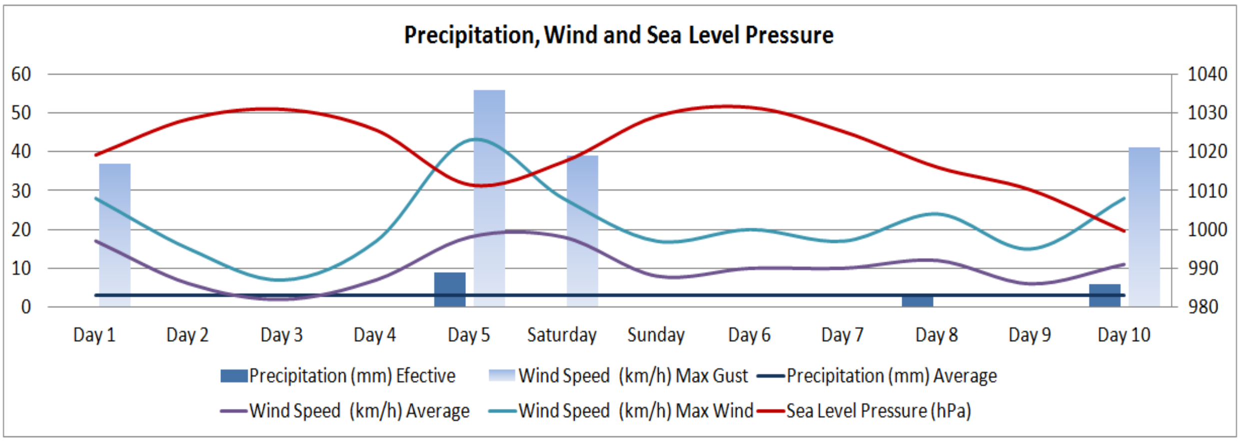

Fig. 4 Precipitation, Wind and Sea Level Pressure

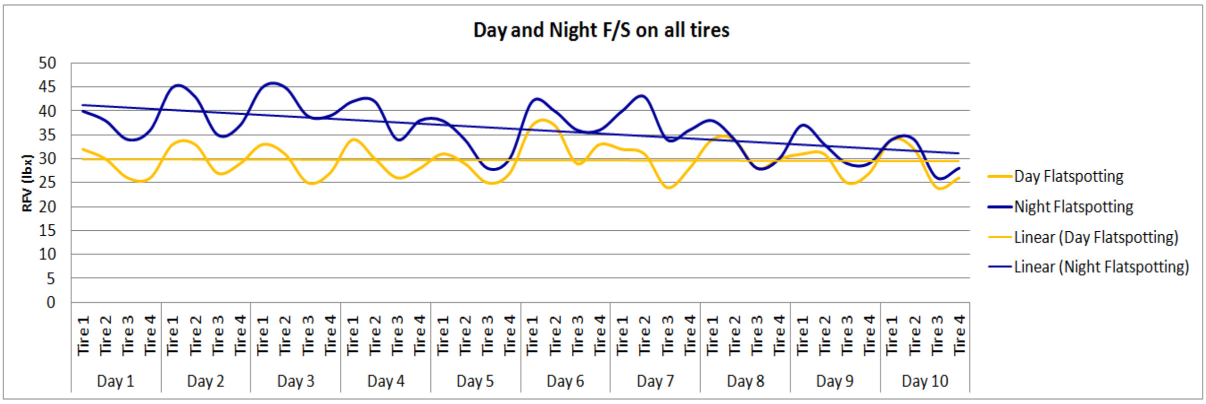

Fig. 5 Day and Night F/S on all tires

3. CONCLUSIONS

In order to represent close to absolute RFV values over the time we've subtracted Msr1 from Msr2 and Msr3 from Msr4. On a day-to-day basis, we're seeing that front tires (T1&2) have consistently higher values than the rear tires. Relatively to all tires, we see that the average trend line for both Day F/S and Night F/S values is going down over the time with night F/S values having a steeper trend line. This can be explained by the above comment on the fact that night temperatures are going up for the testing period (Fig. 8).

On a tire by tire basis, we see that the RFV values are somehow related to the average temperature variation. When temperature drops, the RFV is increasing in value. Night F/S values are consistently higher than Day F/S values. We also notice a clear gap between front tires and rear tires (Fig. 9).

If we consider both, Day ambient temperature and Night ambient temperature we notice very well that the highest RFV values are clustering in the period of time with the highest temperature variations (Day 1 – 5), especially for the tire RFV measurements during the night.

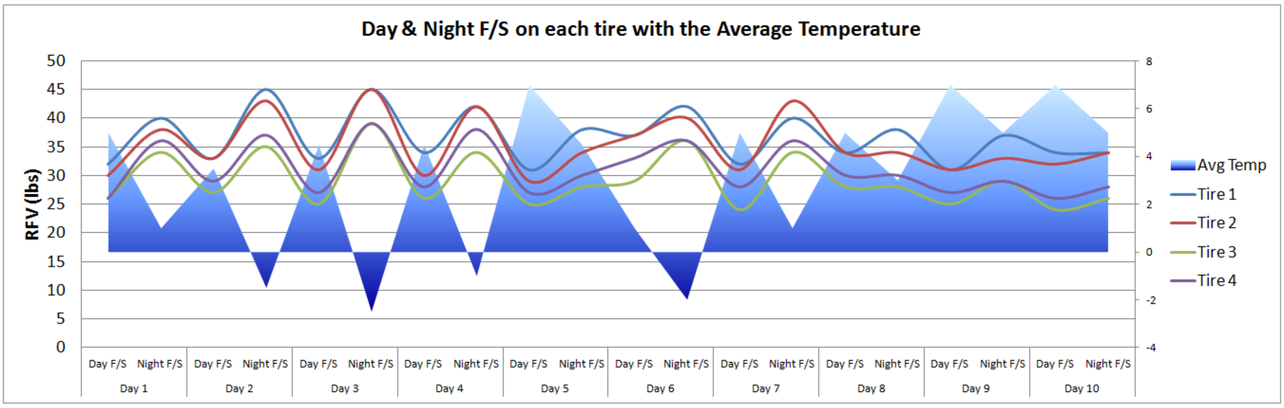

Fig. 6 Day & Night F/S on each tire vs. the Average Temperature

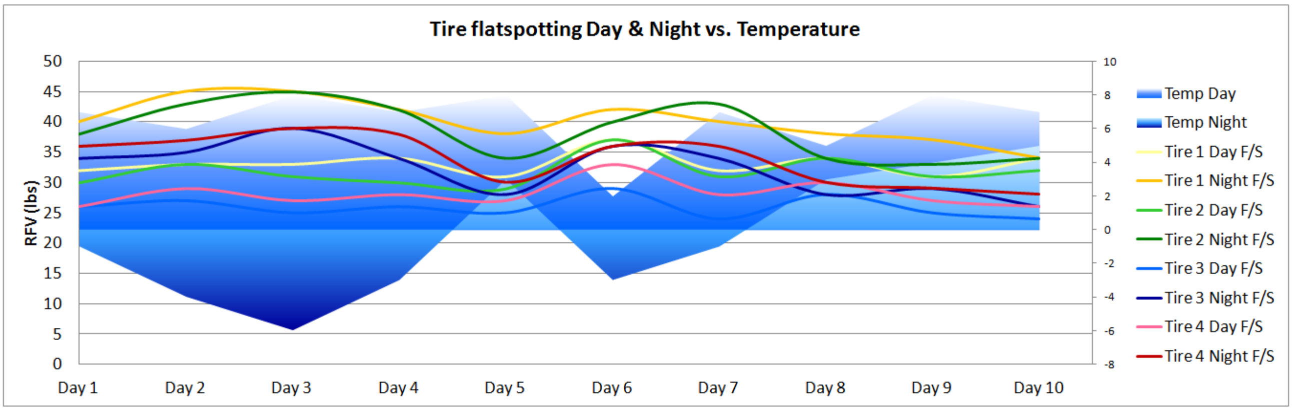

Fig. 7 Tire flatspotting Day & Night vs. Day and Night Temperatures

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Testarea la aplatisare a cauciucului

Rezumat: *Testarea de aplatisare a pneului este parte component a unui program de testare a pneului, cu care autorii s-au ocupat câțiva ani. Cea mai importantă idee este aceea că se caută soluții în viața reală, pentru o mai bună înțelegere a condițiilor în care lucrează pneul precum şi avantajele utilizării condițiilor cvasi-reale.*

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