

LEON-T project: airless truck tires – first prototype

Presented by Dr Ulf Sandberg
Swedish National Road and Transport Research Institute (VTI)
with co-author:
Hans-Erik Hansson, Euroturbine AB, Finspång, Sweden



19 March 2024



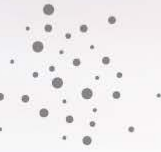
tire
TECHNOLOGY
EXPO 2024

The logo for the Tire Technology Expo 2024. It features the word 'tire' in a large, white, bold, sans-serif font. Below it, the words 'TECHNOLOGY' and 'EXPO 2024' are stacked in a smaller, white, bold, sans-serif font. The background of the logo is a dark, textured image of a tire tread.

DEUTSCHE MESSE, HANNOVER, GERMANY
March 19, 20 & 21, 2024 - Exhibition and Conference
March 18, 19, 20 & 21, 2024 - Short Courses

TYRE ROAD PARTICLES

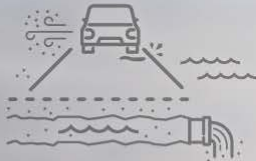
TYRE NOISE



SOURCE



SOURCE



TRANSFER PATH



TRANSFER PATH

LEON-T

TRANSVERSALITY

LEON-T investigates the relationship between the source, the transmission/fate and the effect on the receiver of tyre related particles and noise.

LEON-T = Low particle Emissions and Low Noise tires



RECEIVER



RECEIVER



LEON-T, Work Package 5: Development of airless tires for heavy goods vehicles

Partners:

VTI (Sweden – WP Leader)

Euroturbine (Sweden)

Idiada (Spain)

Audi (Germany)

LingLong tires (China)

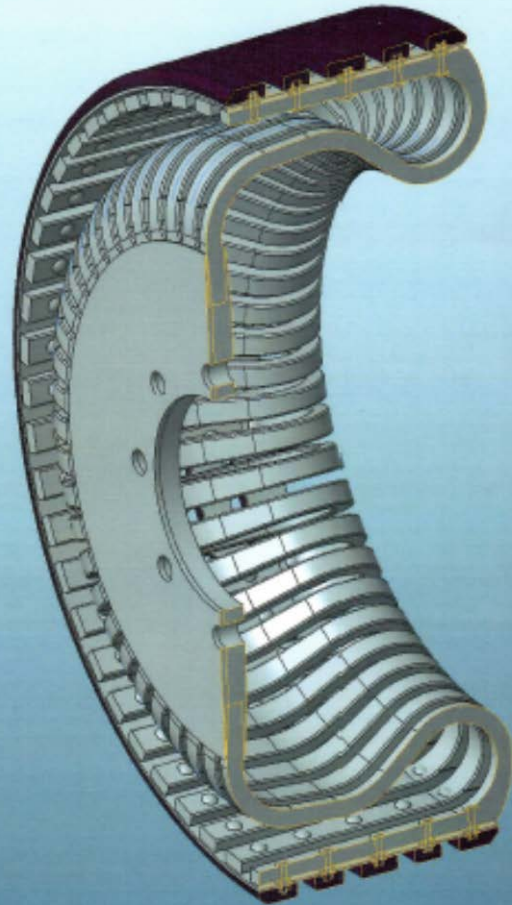
We planned to scale-up the car "composite wheel" from 2008 to HGV size:

285/70R19.5

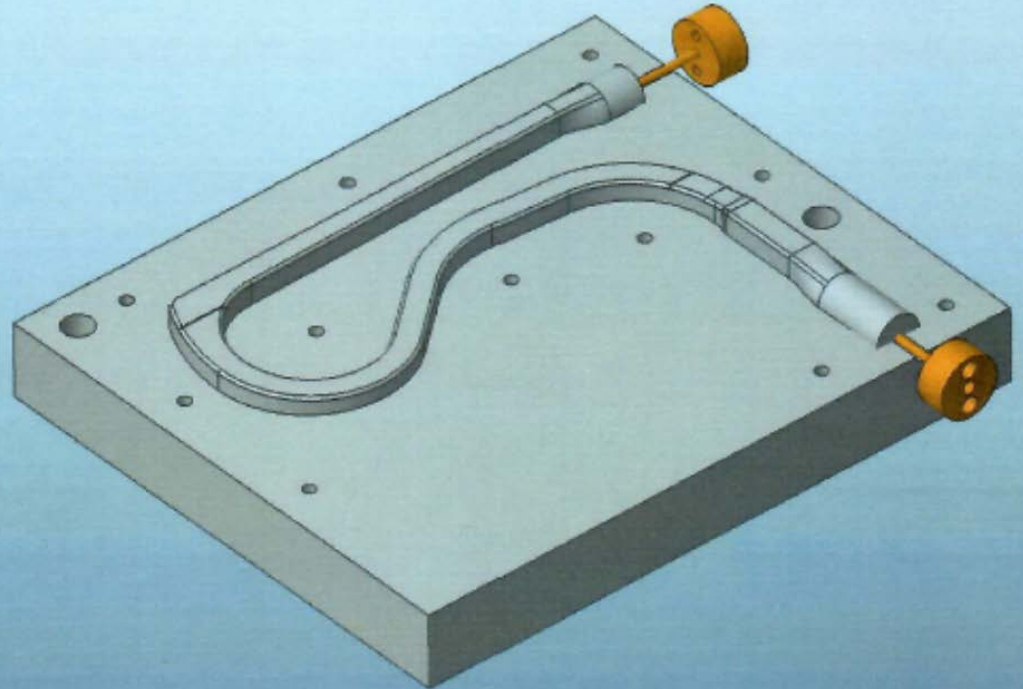
LI = 145/143



Calculations for spokes (springs) in composite material

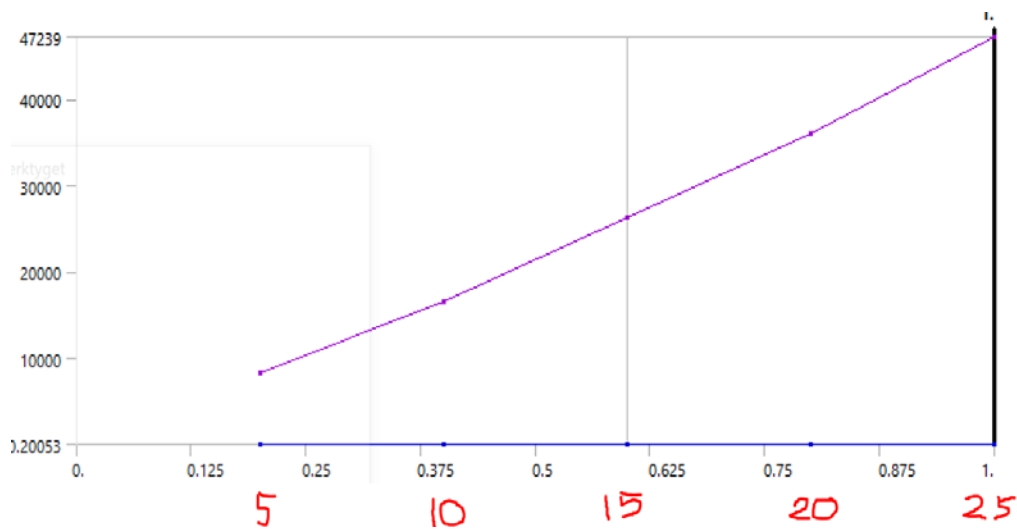


Spokes in (unidirectional) carbon fiber-reinforced plastic laminate
Appeared to be too weak to carry a mass of 2800 kg (LI 145/143)



Calculations/modelling for spokes made of high-strength steel (fossil-free) showed acceptable performance

The steel spring and assembled wheel has been analysed for static loads in ANSYS. Target was a reaction force of 40 kN at 25 mm displacement and as low stresses in the springs as possible.



Made by Lightness by Design AB (Dr Fagerberg)

D: Static Structural 900A 220320

Total Deformation

Type: Total Deformation

Unit: mm

Time: 1 s

Deformation Scale Factor: 1.0 (Total)

2022-04-11 09:43

26.863 Max

23.878

20.894

17.909

14.924

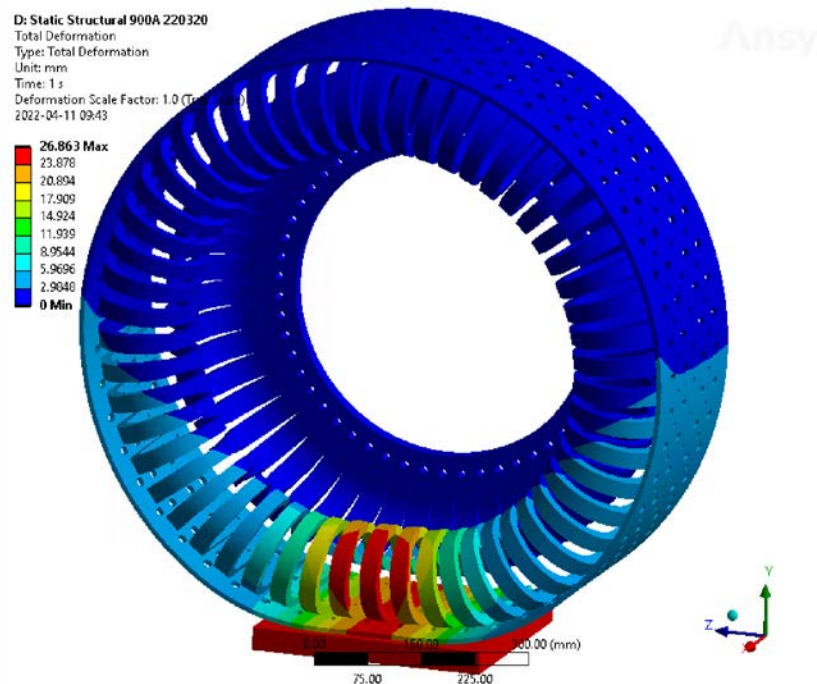
11.939

8.9544

5.9696

2.9848

0 Min



Calculations/modelling further by Idiada gave promising results

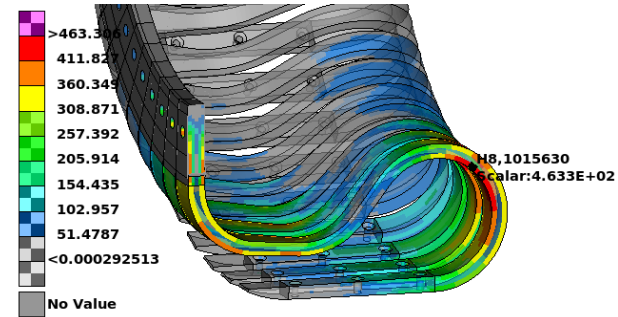
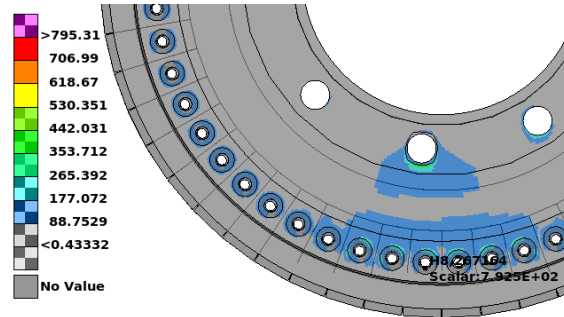
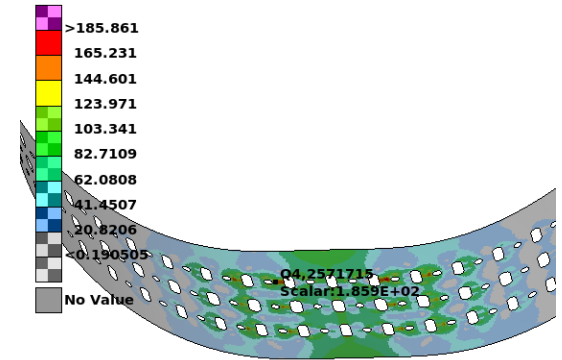
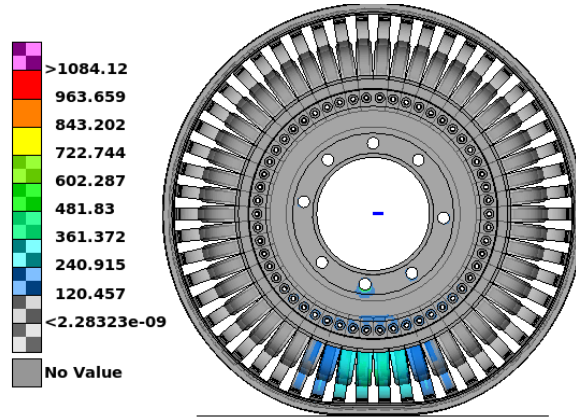
FE model setup

Material property definitions

tire loading and stiffness calculations

Stresses in the models

Rubber behaviour



Dynamic behaviour modelling by Idiada

FE model setup

Material property definitions

Tire loading and stiffness estimation

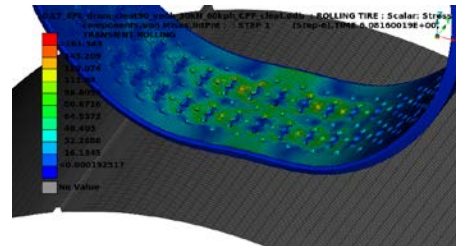
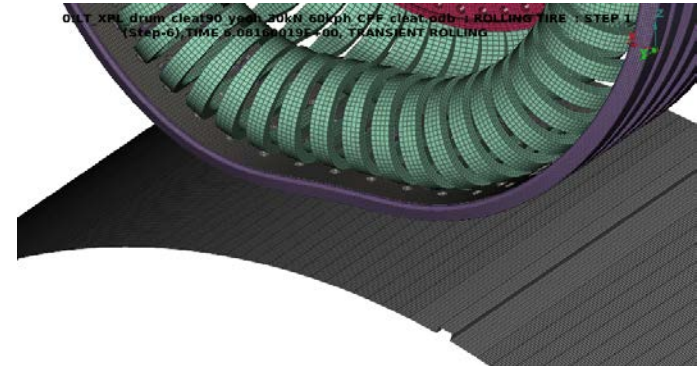
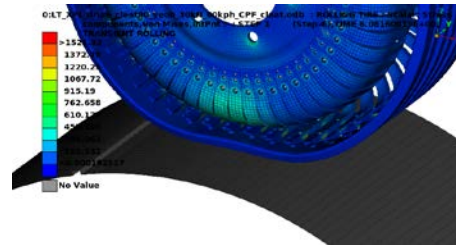
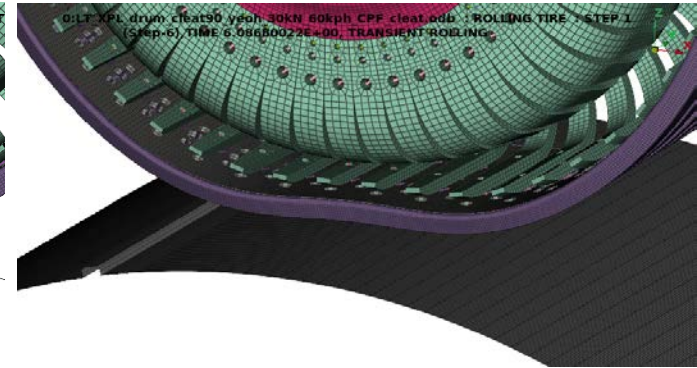
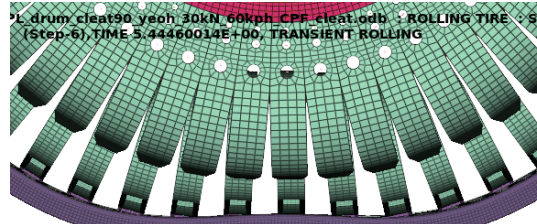
Composite damping investigation

Modal analysis model

Modal analysis results

→ Tire roll over cleat

Tire rolling speed – 60 km/h



Manufacturing of spokes is a challenge

Spokes must meet strict tolerances in order for tire to be round and not to be unbalanced

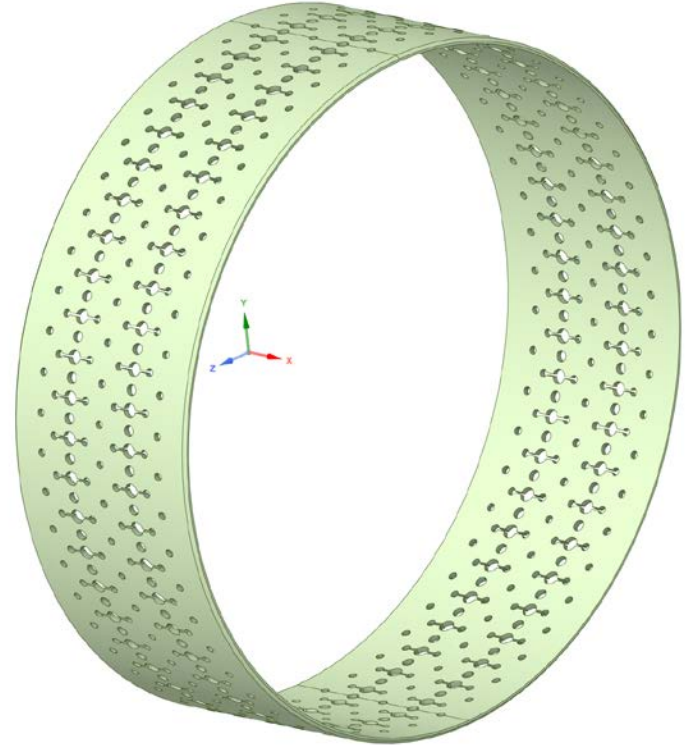
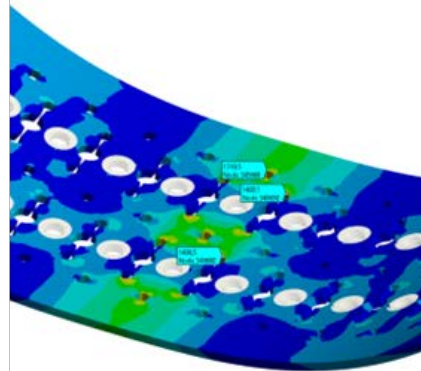
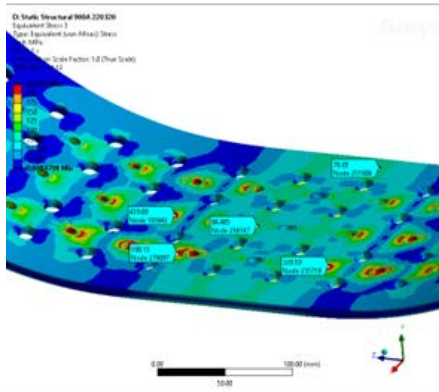


Belt in composite material (CFRP)

Belt in (quasi-isotropic) carbon fiber-reinforced plastic (CFRP) laminate

The belt was modified with stress-reducing holes between the spokes. Also, air- and water-ventilating holes were drilled to improve noise and wet grip properties.

The improved belt design was included in the stress analysis.



Manufacturing of belt and rubber tread

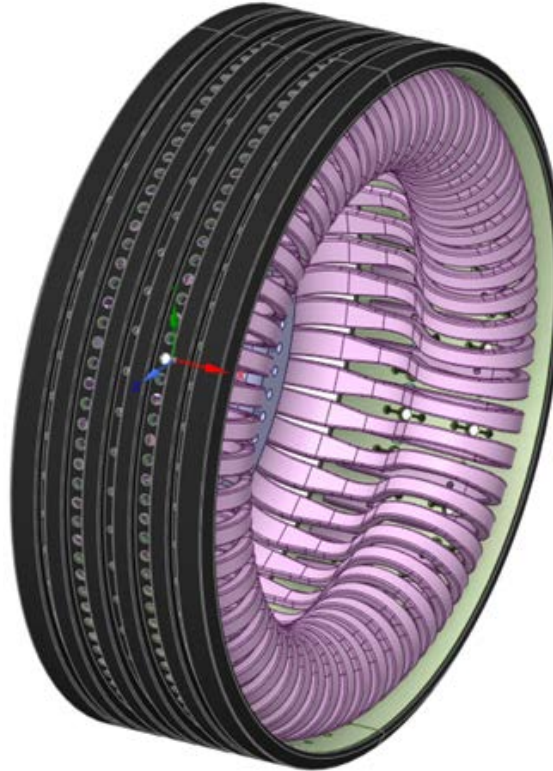
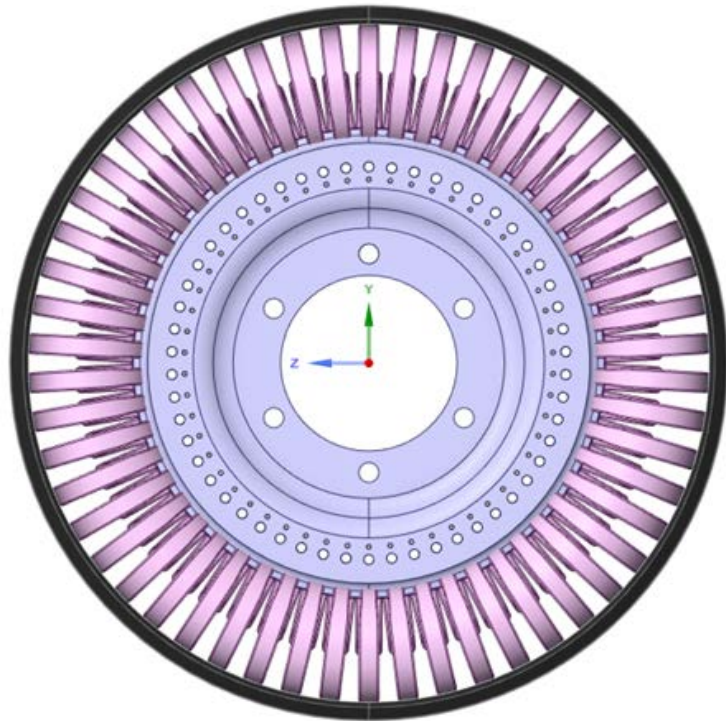
The composite belt is prepared in an autoclave using a quasi-isotropic lay-up of glass-fiber prepregs. Thickness is approx. 7 mm. The belt is machined and dressed with a rubber tread from Linglong Tires (China). Longitudinal grooves are made and then the rubber and belt system is vulcanized in an autoclave.



Vulcanization is made at conditions similar to those at re-treading



To first prototype, available in September 2023



Weight is an issue

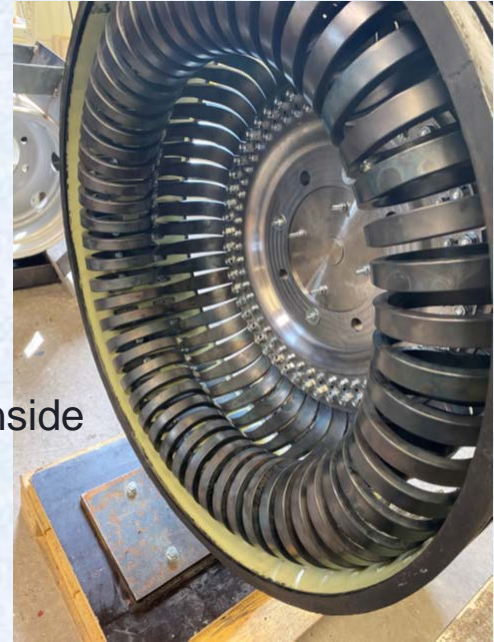
The weight is 150 kg, which is 50 kg more than desired.

But weight can be reduced by replacing bolts and nuts with other means of fastening, and using a lighter rim

With more advanced resources, composite material could replace steel and a lot of weight can be saved



Outside



Inside

First assessment of the prototypes' performance: Part 1

We needed a suitable host truck on which the prototype could be mounted as the outer tire on a drive axle with double-mounted tires.

We were allowed to use a Volvo FL Electric truck having "our" tire dimension (285/70R19.5), and to run it on a large asphalt area and on a 2 km long local asphalt road.

Test were conducted in November 2023.



First assessment of the prototypes' performance: Part 2



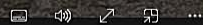
Cruise-by at 75 km/h with a tire load of appr. 2000 kg



00:00:09

00:00:08

MVL_4311



First assessment of the prototypes' performance: Part 3

Results and observations of the first test:

Tire had appr. 30 mm larger overall diameter than the pneumatic tire it is intended to replace

Tire/road contact length was approx. 170 mm

The truck was unloaded, in which case it had a total weight of approx 11 500 kg

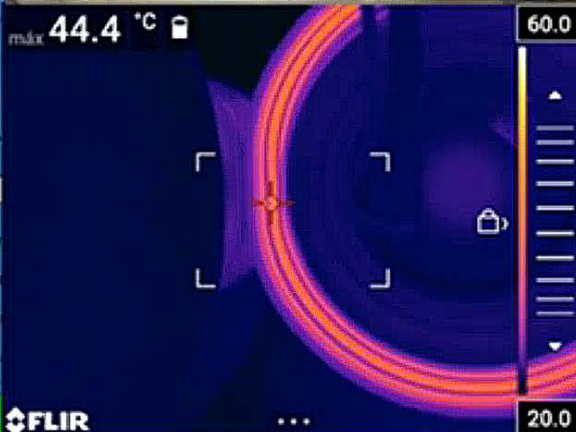
The airless tire load was 1946 kg (the pneumatic one 1195 kg)

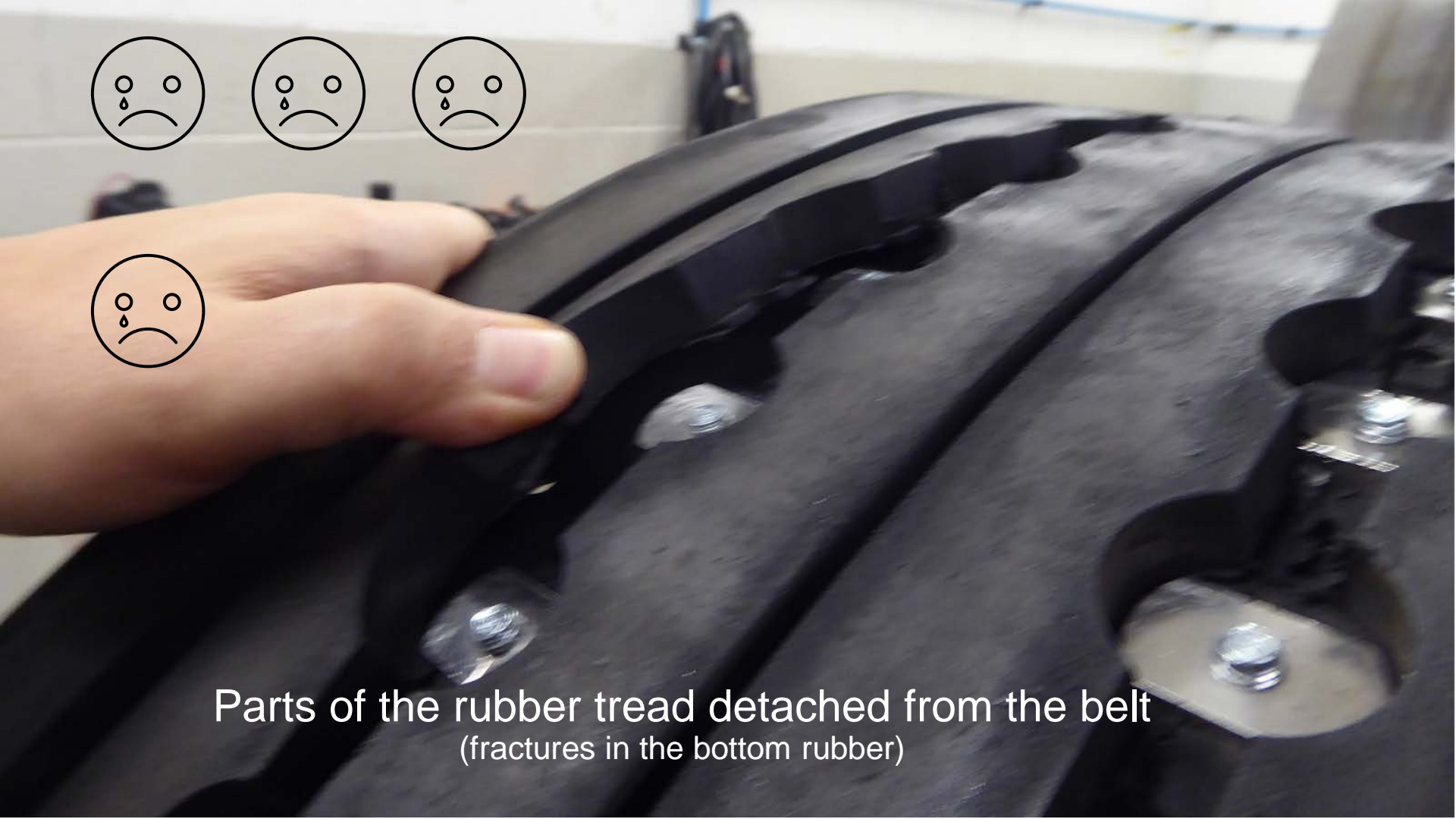
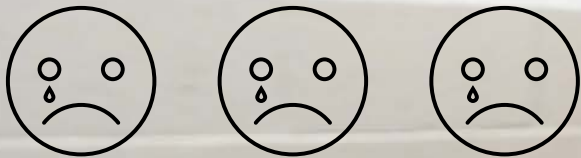
The tire was driven a total of 10 km at speeds 0 – 75 km/h, including light accelerations, braking and turning

No disturbing tone could be heard at pass-by

No roundness problem could be seen, no damages or signs of fatigue were seen

Next step: Running on laboratory drum at Idiada





Parts of the rubber tread detached from the belt
(fractures in the bottom rubber)

First prototype: Second version

A second version now ready for new drum test at Idiada. It is improved as follows:

- New belt, this time made of carbon fibers
- New type of rubber
- Sipes cut on the ribs (at about 30°)

Question: Are the vulcanization conditions typical of retreading fine in this case, or should one use the conditions of full-tire vulcanization?

The strength of the bond between belt and rubber has thus increased by a factor 7.5 (from 1.4 to 10.6 N/mm).



New test to be made at Idiada, in two weeks

If endurance is ok, then rolling resistance will be tested, to be followed by noise tests

The image displays a control interface for a tire testing machine, overlaid on a photograph of the machine in a laboratory setting. The interface shows various parameters and controls for the test.

Control Interface Data:

- Duración ensayo: 00h: 52min: 41seg
- Tiempo actual de ensayo: 00h: 00min: 00seg
- Temperatura ambiente: 21.647 °C
- Temperatura media ensayo: 0.000 °C
- Potencia motor: -4.2 W
- Par eje motor: -1.600 Nm
- Temperatura flanco neumático: 20.78 °C
- Velocidad lineal tambor: 0.000 km/h
- Carga Normal (Fz): 11650.1 N
- Valor tarado: -0.4 mm/min
- Distancia Neu-Tambor: -3.6 mm
- Temperaturas rodamientos:
 - Neumático: 21.2 °C
 - Tambor ext: 21.5 °C
 - Tambor int: 20.7 °C
 - Motor int: 20.2 °C
 - Motor ext: 19.8 °C

Photograph of the Machine:

The photograph shows a large industrial machine with a prominent red drum and a tire mounted on it. The machine is situated in a laboratory environment with various cables and equipment visible.

FLIR Thermal Imaging Overlay:

A FLIR thermal imaging overlay is visible in the bottom right corner, showing a temperature scale from 20.0 to 60.0 °C. The current maximum temperature (máx) is 22.9 °C. The FLIR logo is also present.

Potential advantages

- Structure may live as long as the vehicle: only treads replaced (retreading)
- No punctures
- Production by additive manufacturing (3D printing) easier than for pneumatic tires
- Reduction in rolling resistance
- Water in the contact patch is easily escaping through holes in tread/belt
- Exterior noise reduced with appropriate construction
- Noise from the air cavity resonance is no issue any more
- There is no air inflation that can vary and cause higher rolling resistance
- More eco-friendly materials and less raw material needed (less rubber needed, steel may be fossil-free)
- Flatter (rectangular) tire/road contact patch, may reduce rubber wear
- May have more space for brakes, or for integrated electric motors
- Particular interest: Conti's concept "The Zipper" on easy changing of tread

Potential disadvantages and risks

- Can we avoid increasing weight, or maybe even reduce it, compared to conv. tires?
- Can we get sufficient endurance and avoid fatigue problems?
- How to get a durable connection between spoke and belt (no heavy bolts and nuts)?
- Debris in the structure?
- Exterior noise from the spoke impact (??)
- In-cabin noise from the spoke impact, when no sidewalls are there to reduce it
- One cannot play with air inflation to adapt to varying loads
- Conicity; if a problem, one can turn every second spoke 180 degrees
- New factories required (except for treads)

Major challenge

Project ends 30 November 2024

A project with a duration of only 3½ years and a budget of appr. ¼ of a typical EU Horizon project is too short for this kind of innovative work, where setbacks may (will) occur and remedies must be found and tested

Acknowledgements



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The content of this report reflects only the author´s view CINEA is not responsible for any use that may be made of the information it contains.

Additionally, the first author wants to thank the following individuals:

- Mr Hans-Erik Hansson at Euroturbine, for being the inventor of this airless tire construction and also has led the construction phases
- Dr Linus Fagerberg at Lightness by Design, for making advanced calculations of the strength of especially the spokes, for various materials
- Dr Bharath Anantharamaiah, at Applus+Idiada, for modelling several aspects of the construction
- Dr Juan Jesus Garcia, at Applus+Idiada, for coordinating the LEON-T project and his deep interest in the airless tire



The end