The Liberty Wheel project: Part 3: Stresses and strains in tyred wheels

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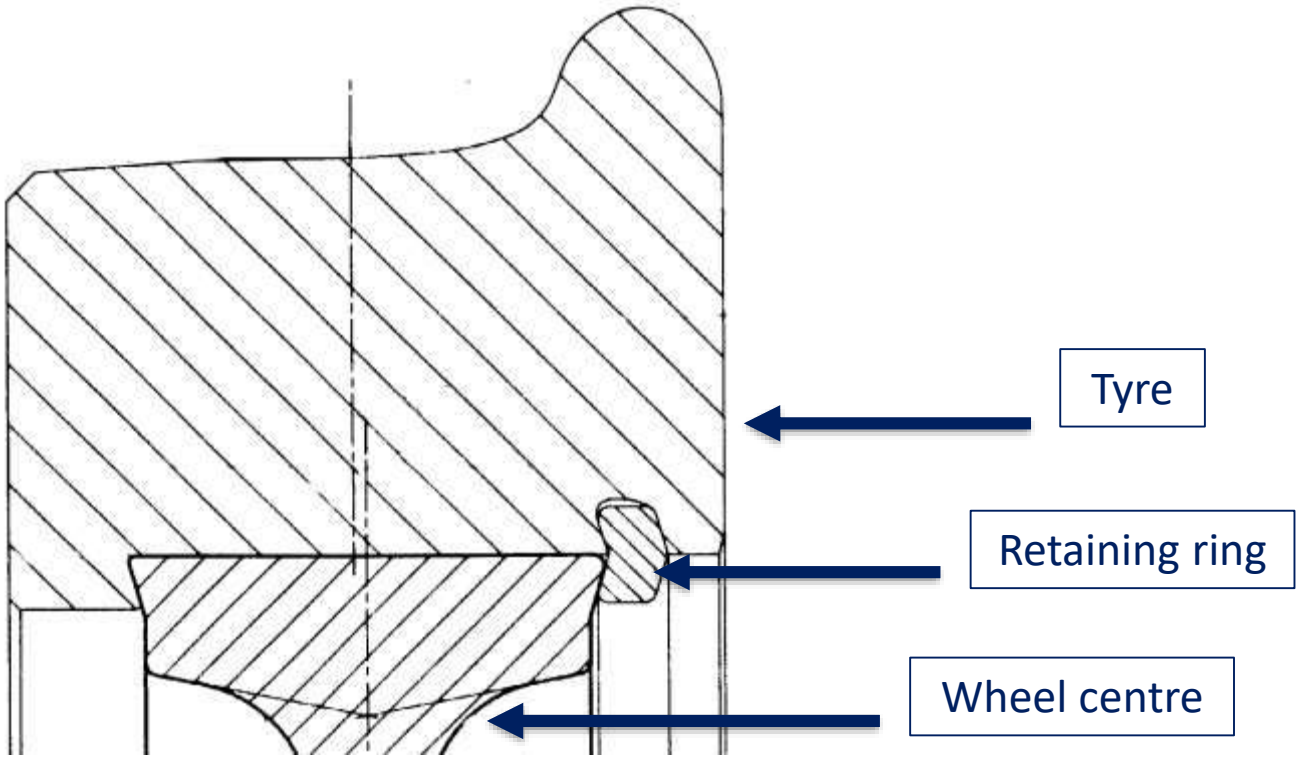
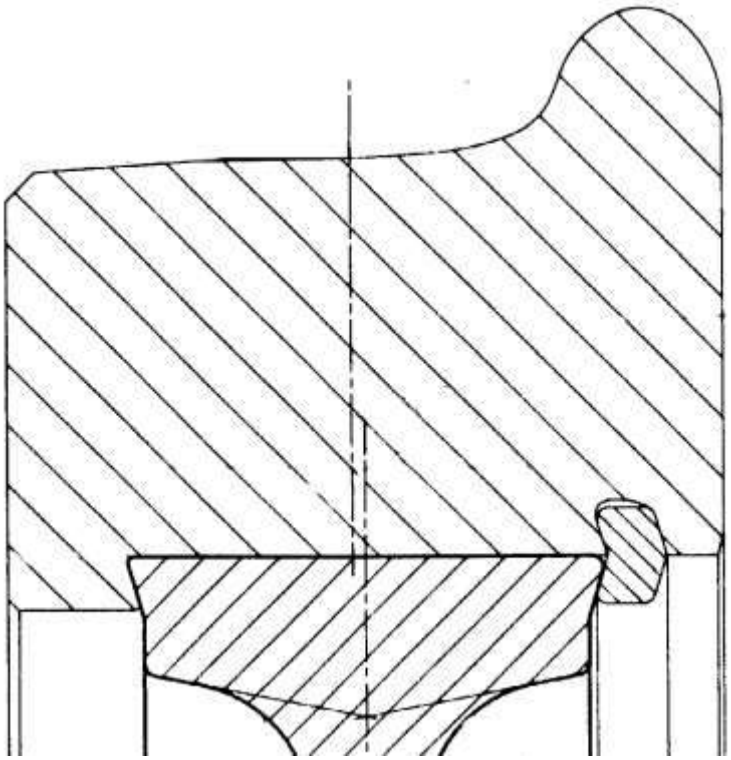
Design of conventional tyred wheels

- The only available standards are the old UIC codes
- No difference between tyred wheels applied to different kind of vehicles
- Mounting parameters have never been updated

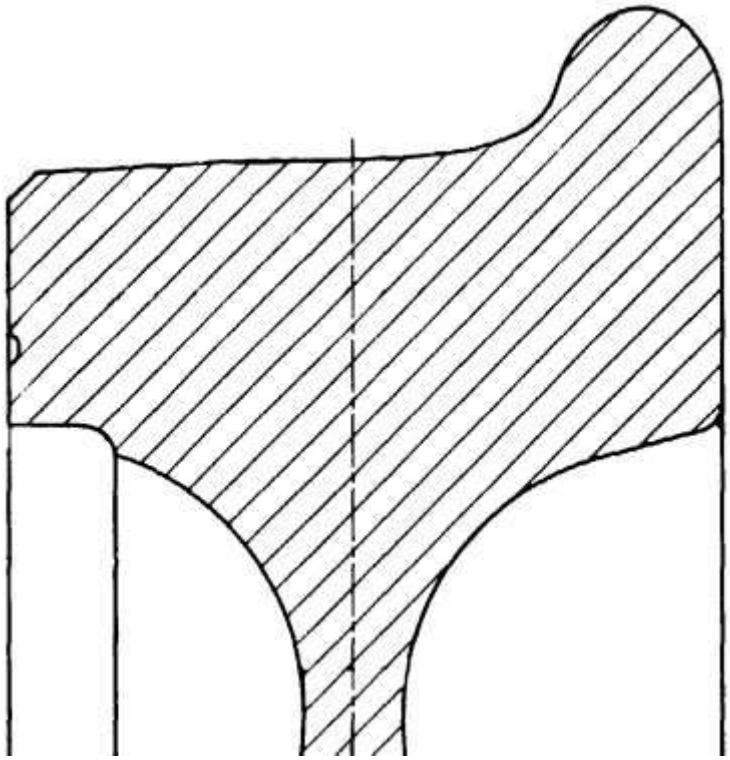


Tyred wheel vs monobloc wheel

External diameter:
940 mm
Tyre thikness:
75 mm
Total mass:
420 kg



External diameter:
940 mm
Tyre thikness:
50 mm
Total mass:
340 kg



Tyre fitting process

- Tyre is shrink fitted on the wheel centre
- 120 °C of overtemperature are needed to recover the interference (0.9 ÷ 1.1 mm)
- Interference value depends only on mating diameter

$$i_e = \frac{1.3 \pm 0.1}{1000} * D_e$$

IP 3156:2013 from Trenitalia

5 - Production of the tyred wheels

5.1 - Wheel tyres

The wheel tyre must be produced in accordance with the information given on the drawing of the purchasing railway and must conform with UIC Leaflet 810-2.

Unless other values are given in the purchasing order, the following values must be observed :

$$C_{\text{wheel tyre bore}} = C_{\text{wheel centre}} - \frac{X \,.\, C_{\text{wheel centre}}}{1000}$$

$C_{\text{wheel centre}}$ = the value measured on the outer diameter of the wheel centre rim in mm

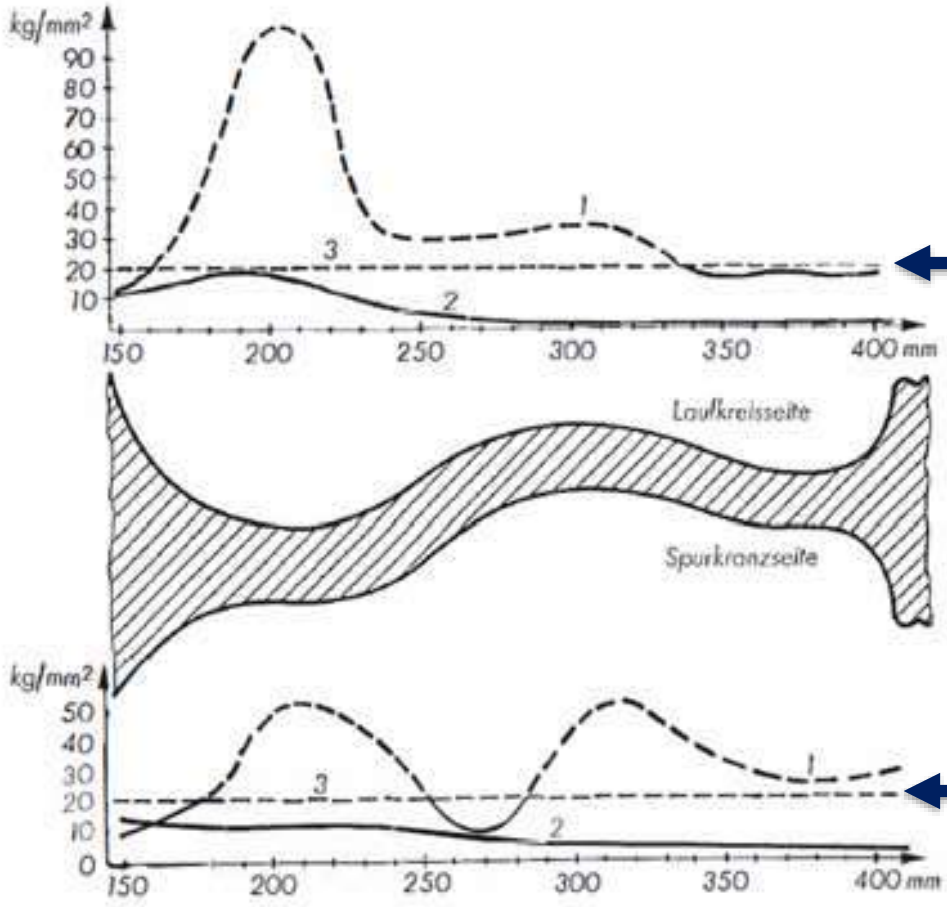
X = a factor within the range from 1.3 to 1.8 to make allowance for influences, such as wheel centre design and stiffness. (1)

(1) The "X" factor may be brought down to 1.1 for large diameter wheels.

UIC 812-4:1990

Measured strains and stresses

High value of interference = High values of strains (and stresses) on the wheel centre



YIELD LIMIT !

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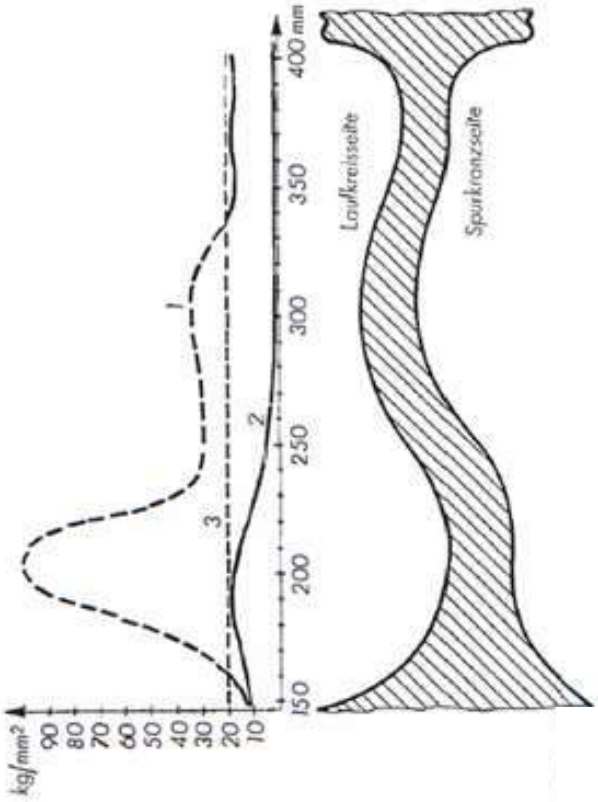
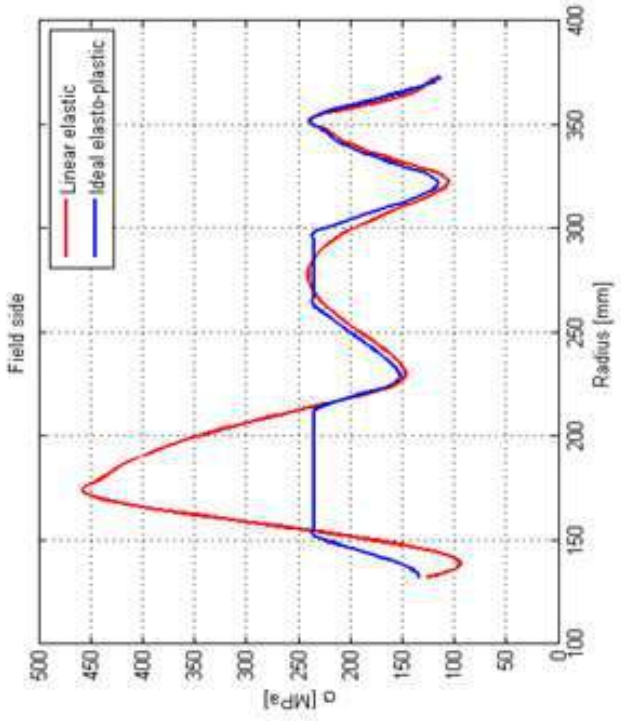
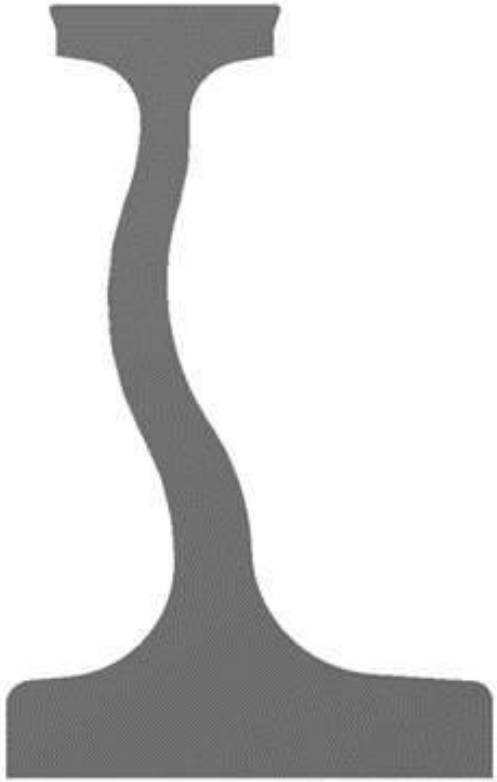
K. Sachs, "Elektrische Triebfahrzeuge" Band 1, Springer-Verlag, 1973

FEM model

A Finite Element model was devoloped and verified by these experimental diagrams



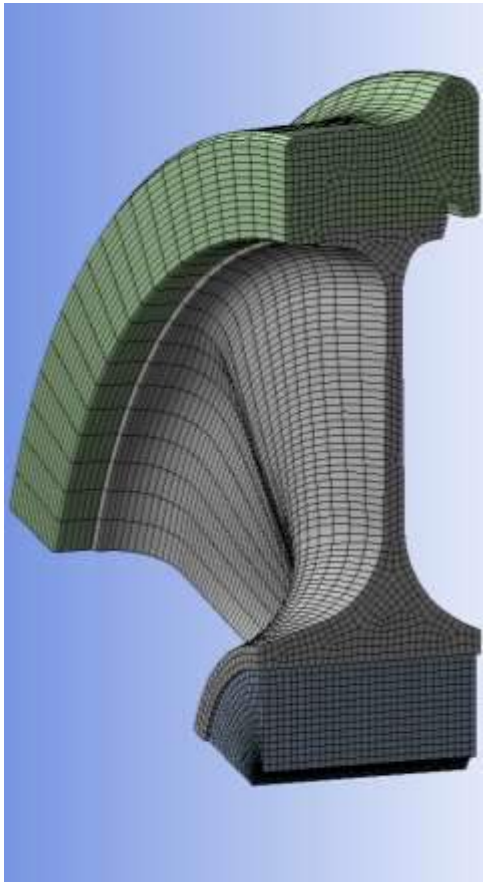




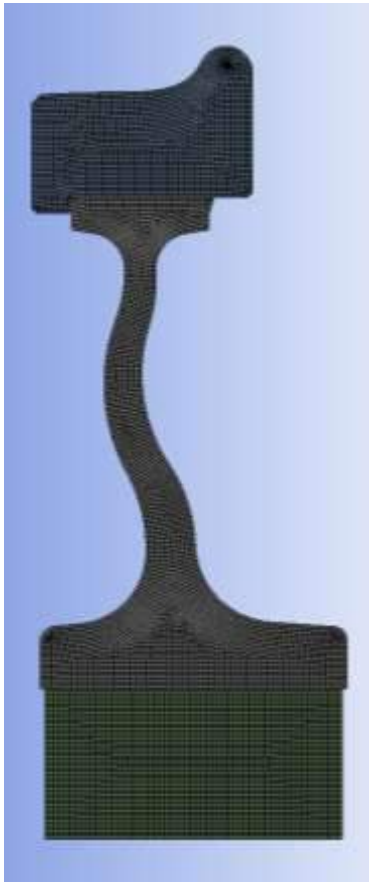
PERMANENT DEFORMATIONS MAY OCCUR:
Unpredictable behaviour after fitting

Investigation about current design

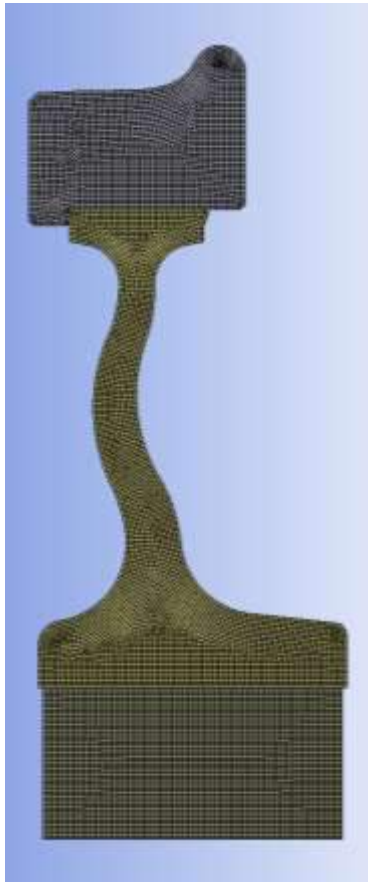
Increasing radial stiffness of the wheel centre



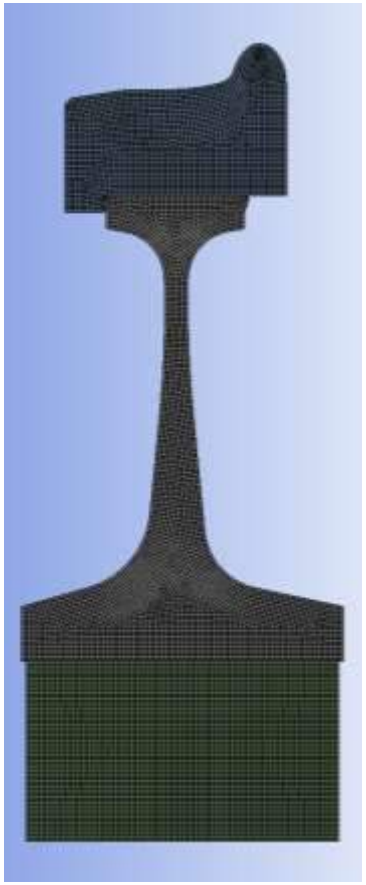
Metro vehicle



Freight wagon

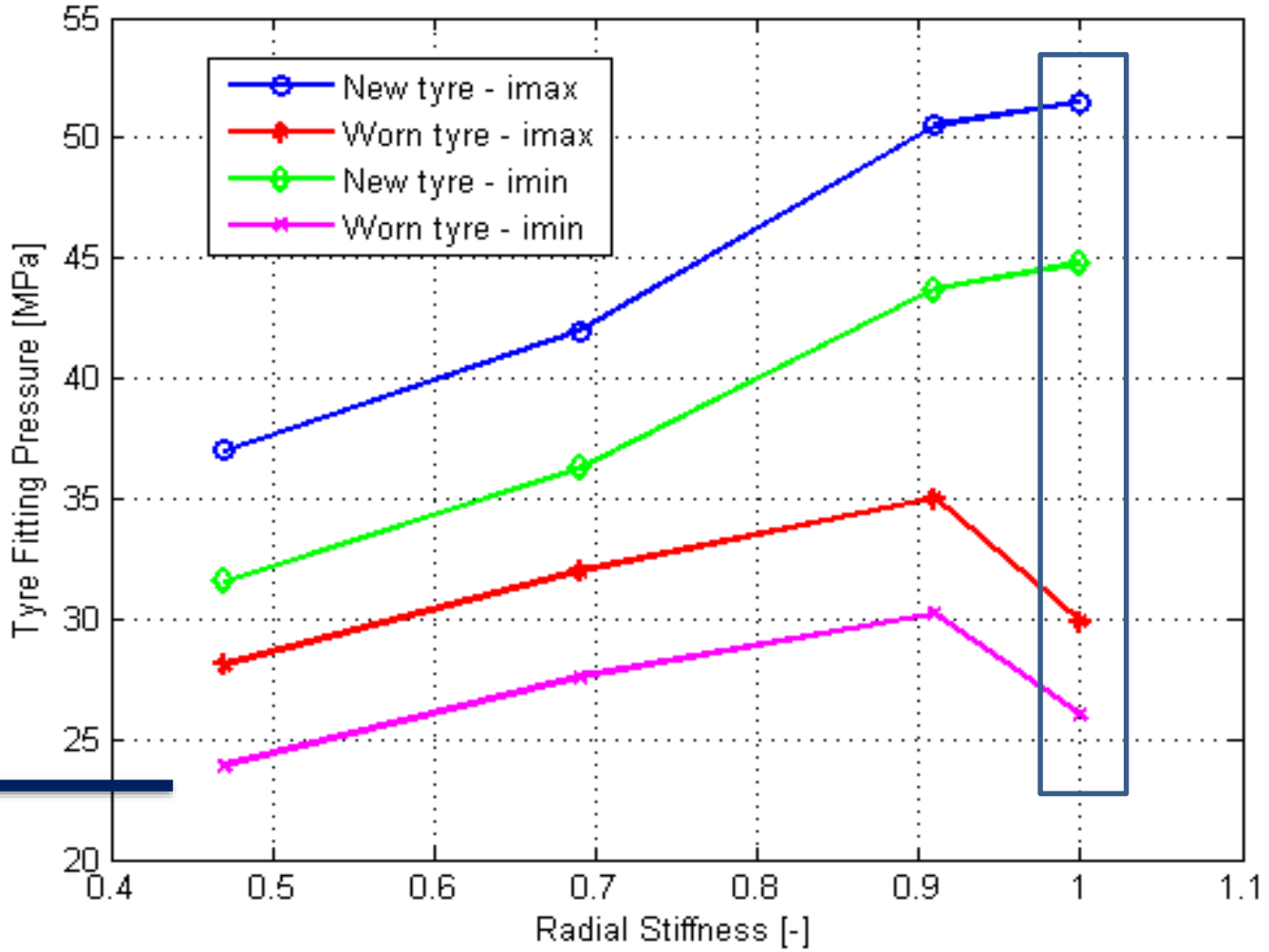


Passenger vehicle



Derived from a monobloc wheel

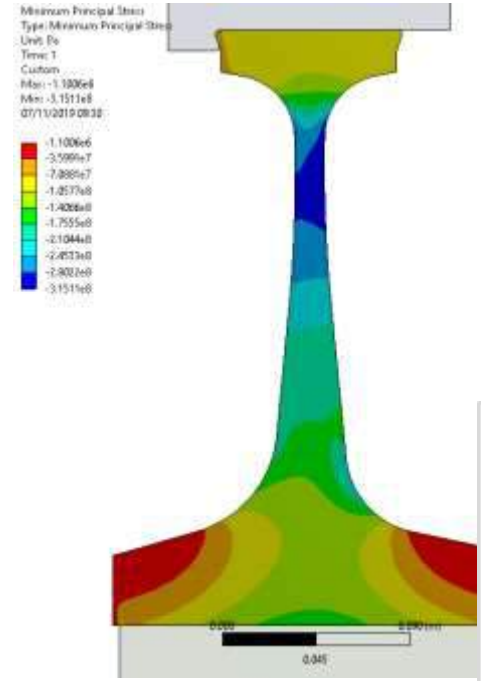
Pressure



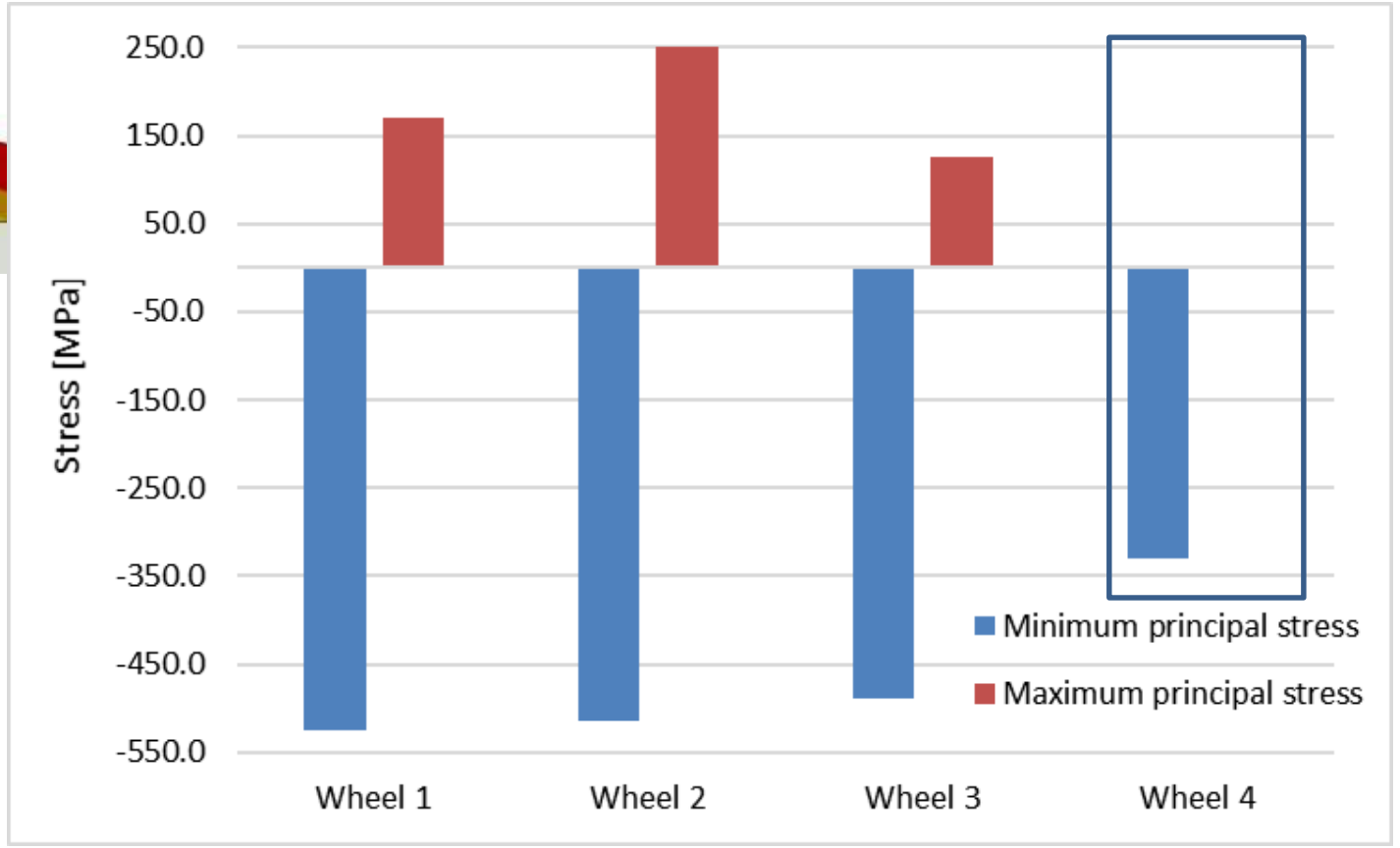
Minimum value:
24 MPa

In the worst condition the transmissible torque at the tyre is 2.5 times higher than the transmissible torque at the hub

Wheel centre stress

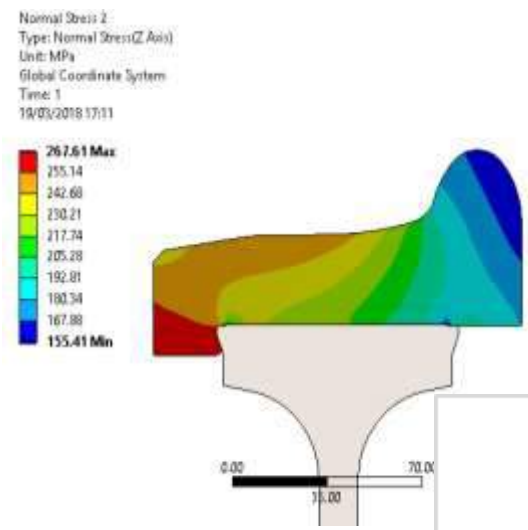


Up to 250 MPa of tensile stress



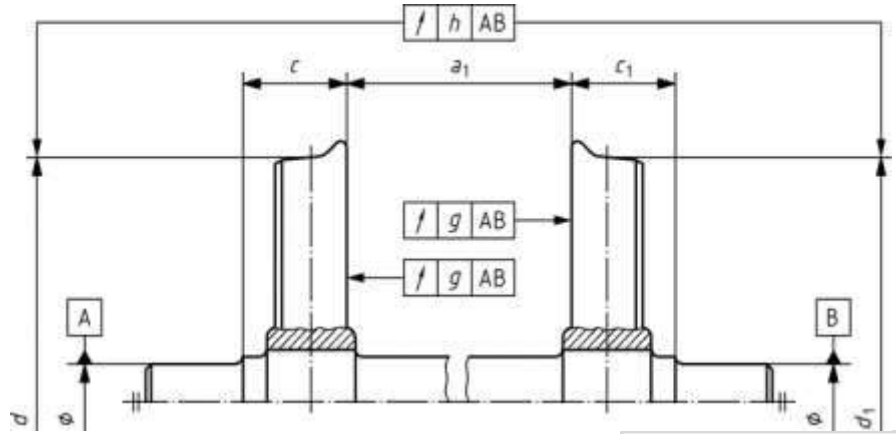
Down to 500 MPa of compressive stress

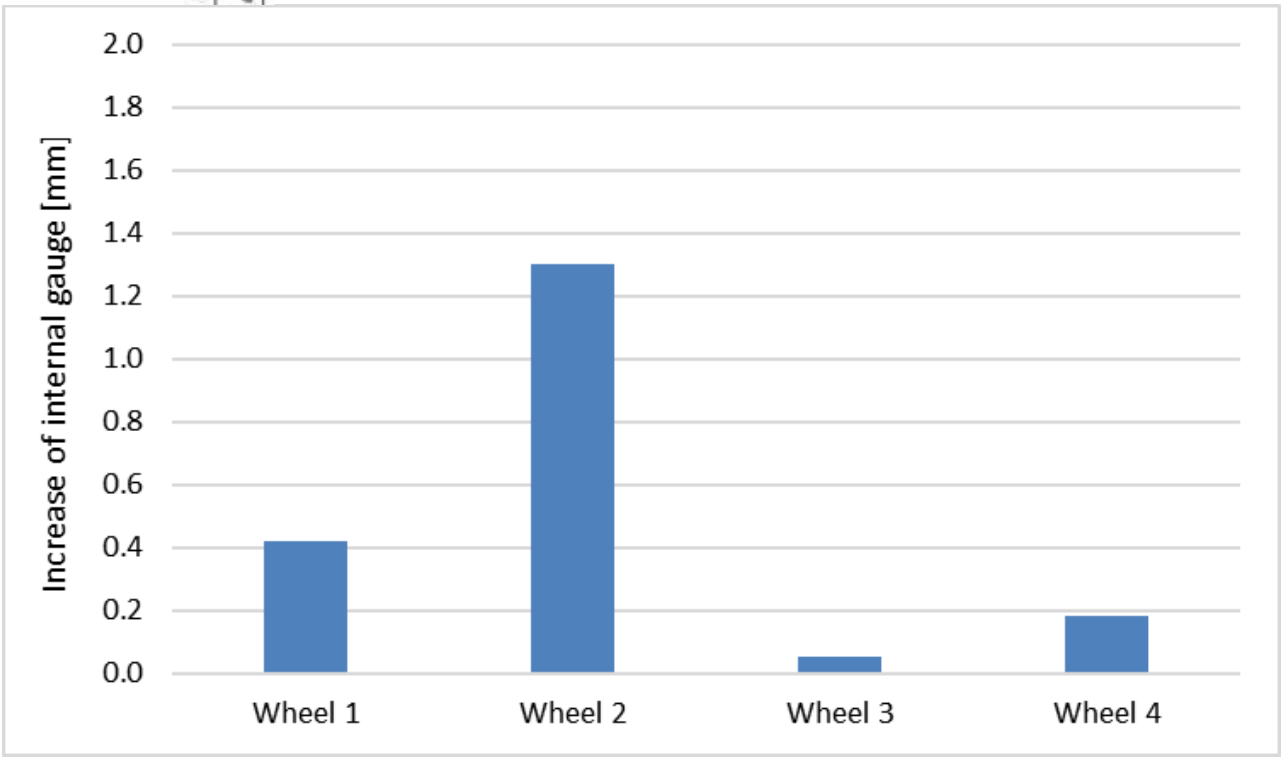
Tyre stress



OVER 200 MPa in worn conditions

Tyre lateral displacement





Lower than the maximum admitted (2 mm)

Conclusions

- High initial mating pressure between tyre and wheel centre is needed
- In worn conditions a greater residual tyre thickness is needed to maintain the initial the mating pressure
  - **WITHSTAND TO TREAD BRAKING (DRAG BRAKING)**
    - **And if tread braking is not applied?**

Residual tyre thickness: 50 mm

Residual tyre thickness: 25 mm