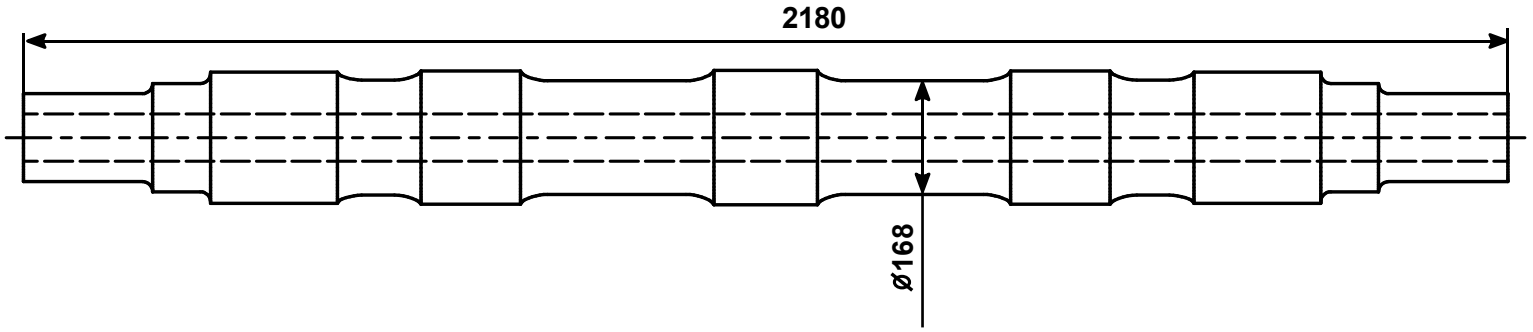
RESIDUAL LIFETIME OF PARTS WITH RESIDUAL STRESS

Student: Ing. Pavol Dlhý
Supervisor: doc. Ing. Luboš Náhlík, Ph.D.

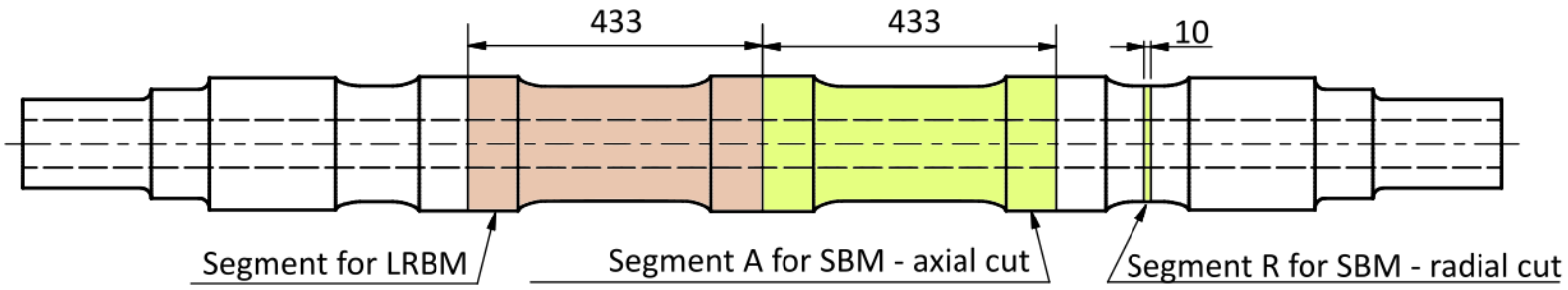
Institute of Physics of Materials
CEITEC BRNO UNIVERSITY OF TECHNOLOGY
GHH-BONATRANS Pioneers of wheelset solutions


2180
ø168

Induction hardening surface treatment

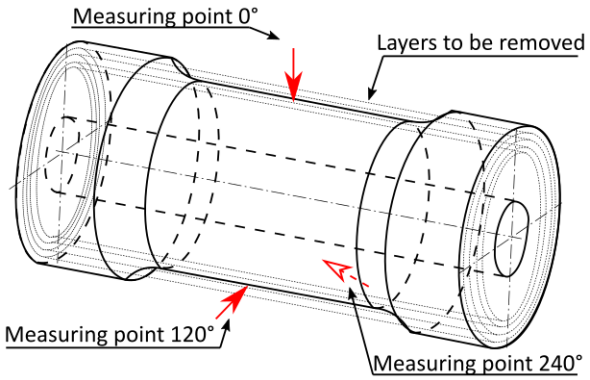
- Surface heat treatment.
- Metal material is induction heated and quenched.

Residual stress determination

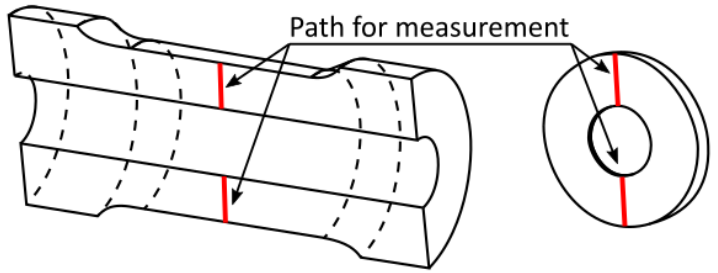


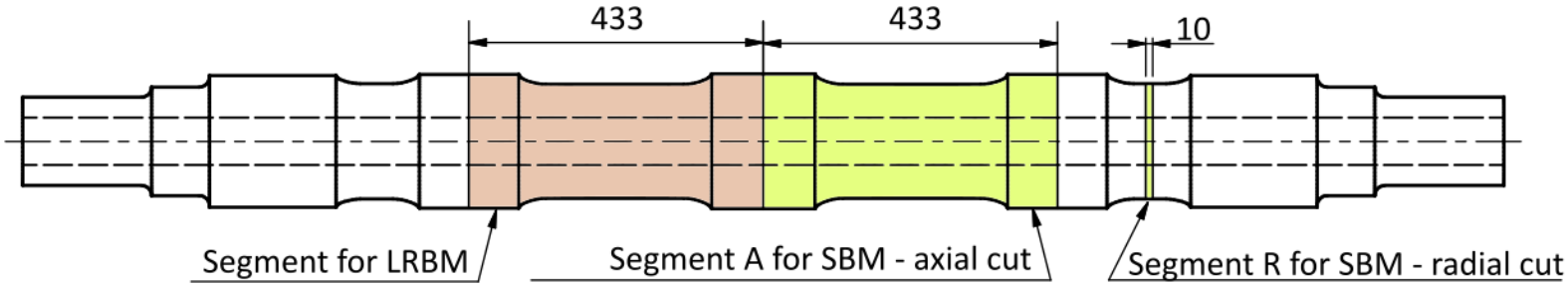
Residual stress determination

- Layer removal based method (LRBM)



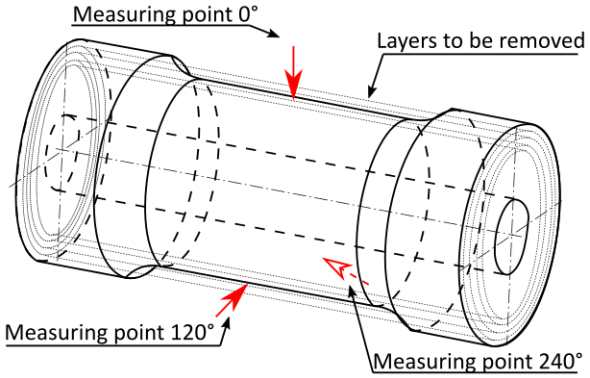
- Sectioning based method (SBM)



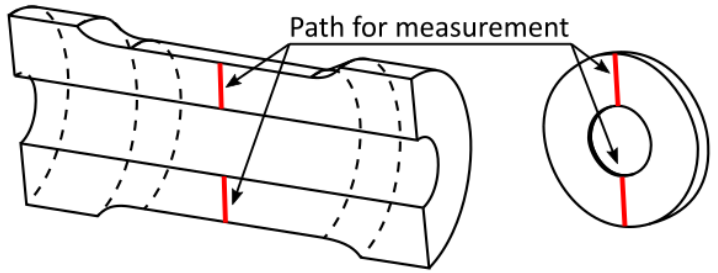


Residual stress determination

- Layer removal based method (LRBM)

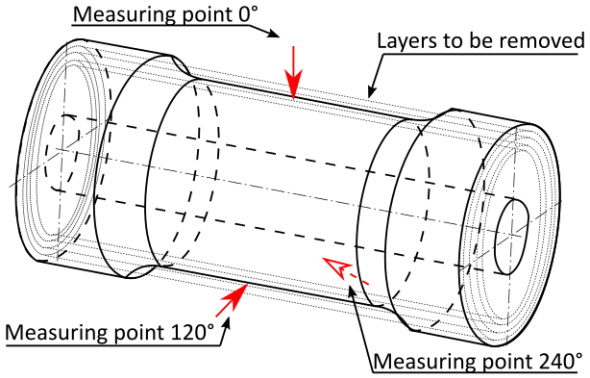


- Sectioning based method (SBM)

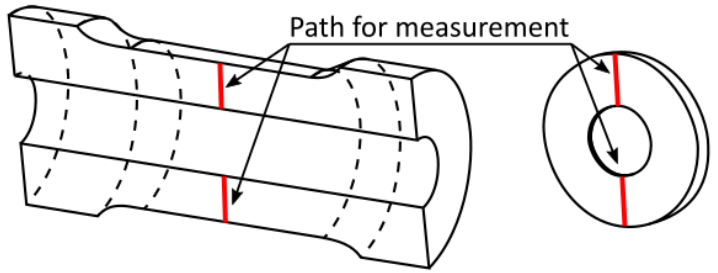


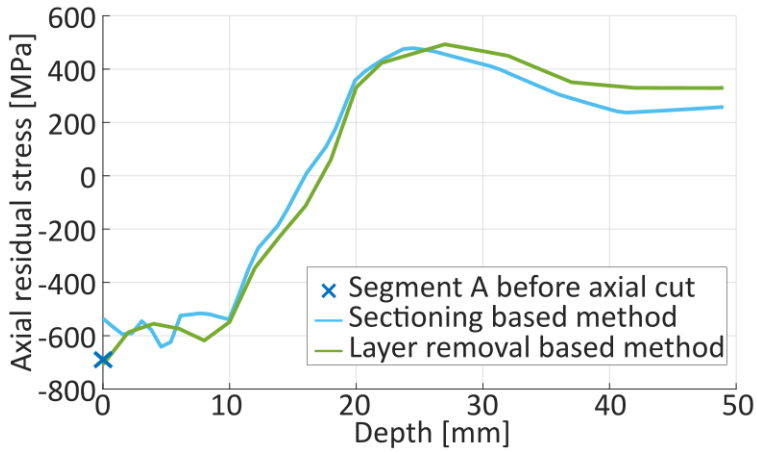
Residual stress determination

- Layer removal based method (LRBM)

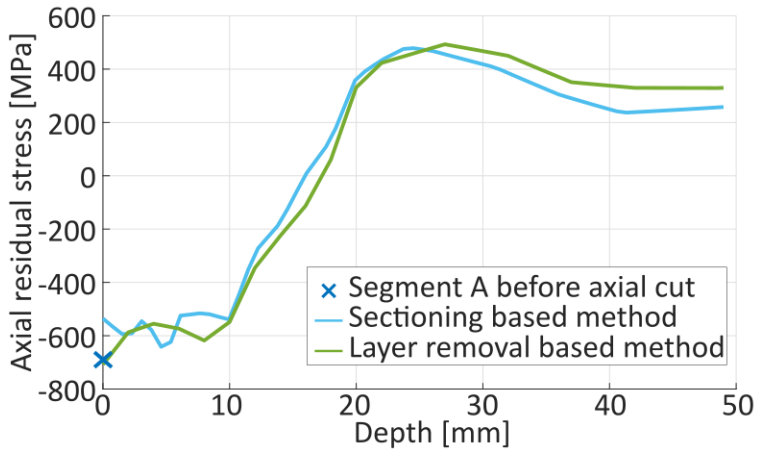


- Sectioning based method (SBM)



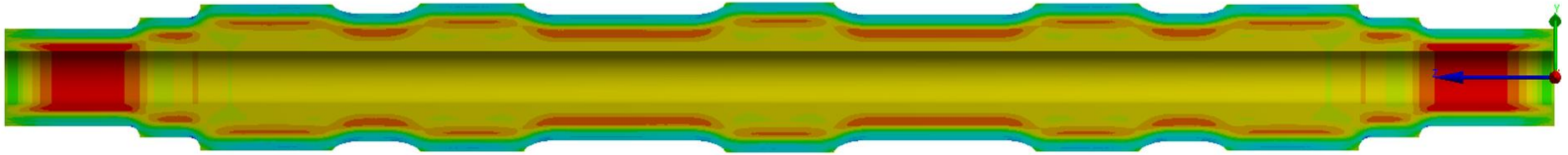


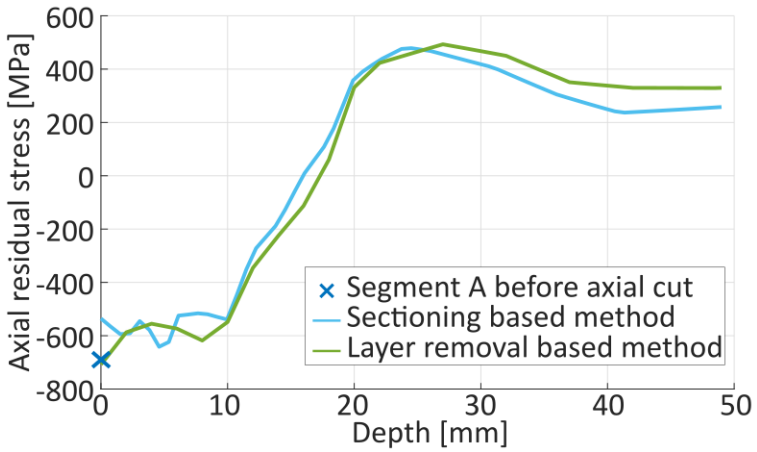
Residual stress determination



Residual stress determination

- Axial residual stress estimation for the whole railway axle





Residual fatigue lifetime estimation

- NASGRO approach,

$$v = \frac{da}{dN} = C\left(\left(\frac{1-f}{1-R}\right)\Delta K\right)^{n} \frac{\left(1-\frac{\Delta K_{th}}{\Delta K}\right)^{p}}{\left(1-\frac{K_{max}}{K_c}\right)^{q}}$$

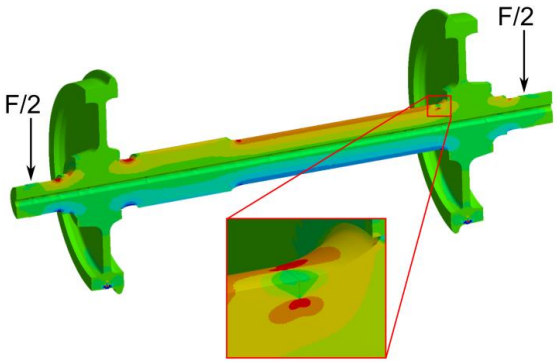
Residual fatigue lifetime estimation

- NASGRO approach,

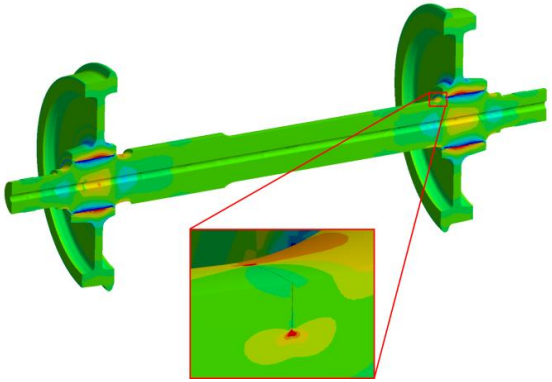
$$v = \frac{da}{dN} = C\left(\left(\frac{1-f}{1-R}\right)\Delta K\right)^{n} \frac{\left(1-\frac{\Delta K_{th}}{\Delta K}\right)^{p}}{\left(1-\frac{K_{max}}{K_c}\right)^{q}}$$

- Loading condition.

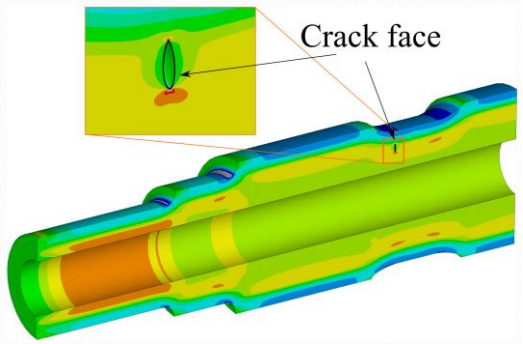
1) Bending load (B)



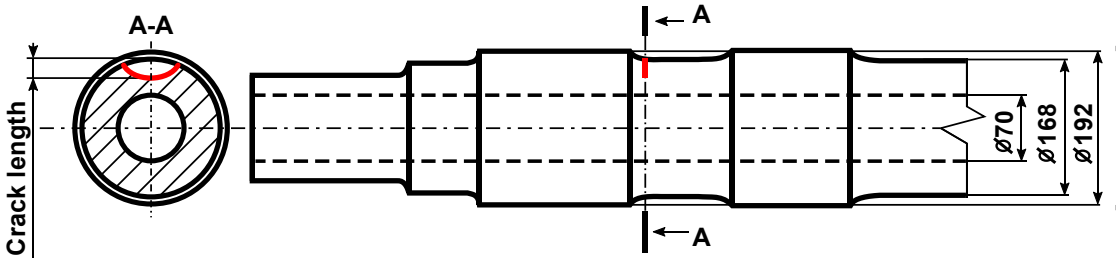
2) Press-fit load (PF)



3) Residual stress load (RS)



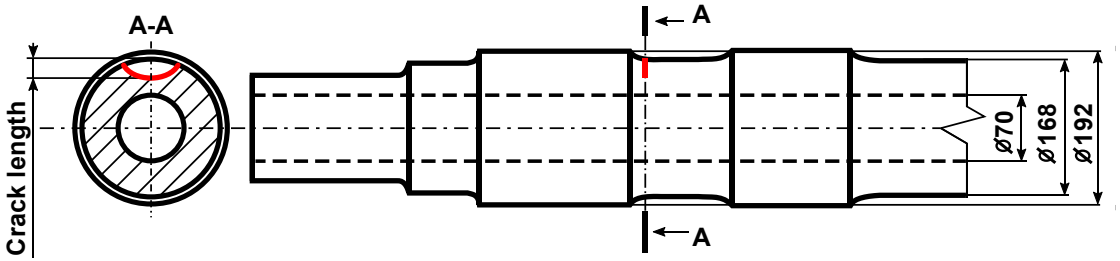
Residual fatigue lifetime estimation



[Klinger C, Bettge D. Axle fracture of an ICE3 high speed train. Eng Fail Anal 2013;35:66–81. https://doi.org/10.1016/j.engfailanal.2012.11.008. http://eisenbahn.egghof.com/2008/11/ice-radsatzwellen-gedanken.html]

[Odanovic Z, Ristivojevic M, Milosevic-Mitic V. Investigation into the causes of fracture in railway freight car axle. Eng Fail Anal 2015;55:169–81. https://doi.org/10.1016/j.engfailanal.2015.05.011]

Residual fatigue lifetime estimation



[Klinger C, Bettge D. Axle fracture of an ICE3 high speed train. Eng Fail Anal 2013;35:66–81. https://doi.org/10.1016/j.engfailanal.2012.11.008. http://eisenbahn.egghof.com/2008/11/ice-radsatzwellen-gedanken.html]

Final crack length 25 mm.

residual stress effects to mileage	considered initial crack length			
	2 mm	3 mm	5 mm	10 mm
no RS	128 000 km	43 000 km	19 000 km	10 000 km
RS due to standard hardening	46 813 000 km	376 000 km	42 000 km	13 000 km
RS due to induction hardening	infinite	infinite	infinite	infinite

[Odanovic Z, Ristivojevic M, Milosevic-Mitic V. Investigation into the causes of fracture in railway freight car axle. Eng Fail Anal 2015;55:169–81. https://doi.org/10.1016/j.engfailanal.2015.05.011]

Thank you for your attention!