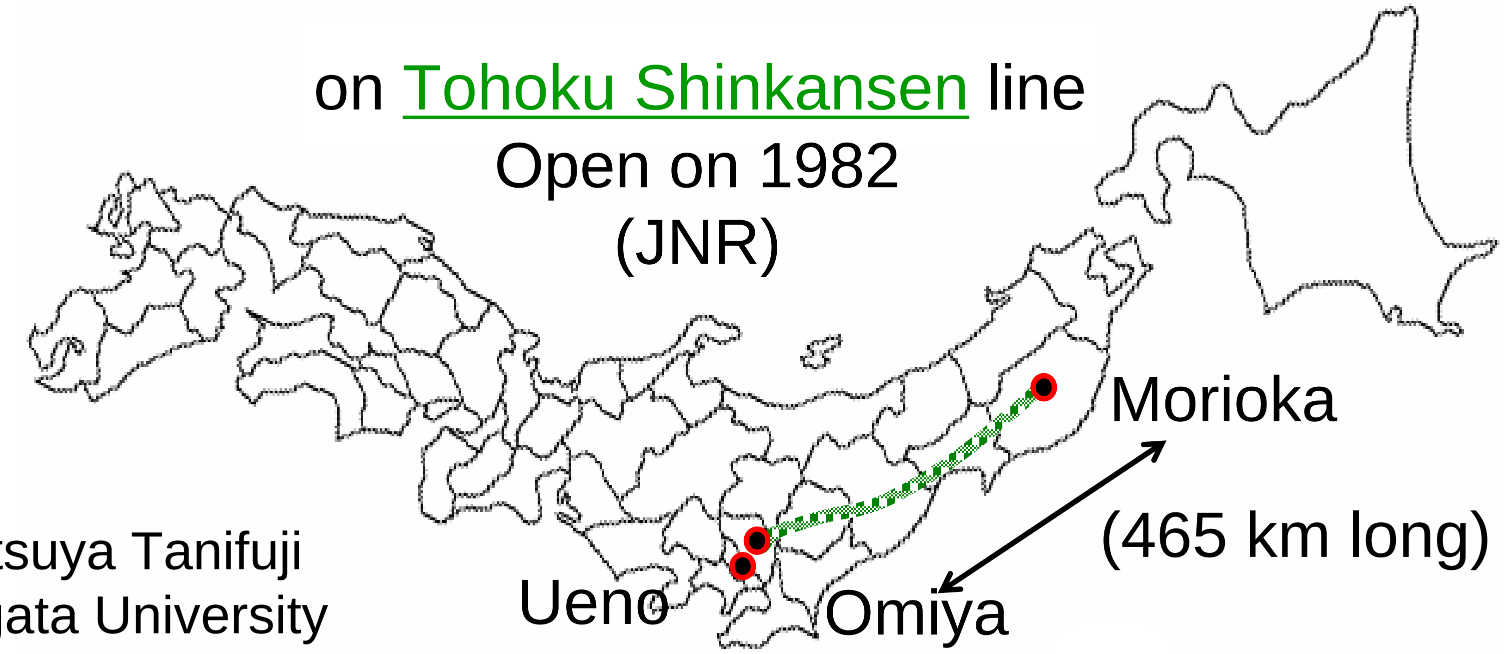
A Study on Prediction of Wear Progress of Railway Wheel

Background

"Long-term endurance test" running at 240 km/h
(from Sept. 1983 till Sept. 1984)

on Tohoku Shinkansen line
Open on 1982
(JNR)



Katsuya Tanifuji
Niigata University
Japan

Test train
(Type 925 electric and track inspection train)

6-car train

Test running

Period: 1 year

Running distance:

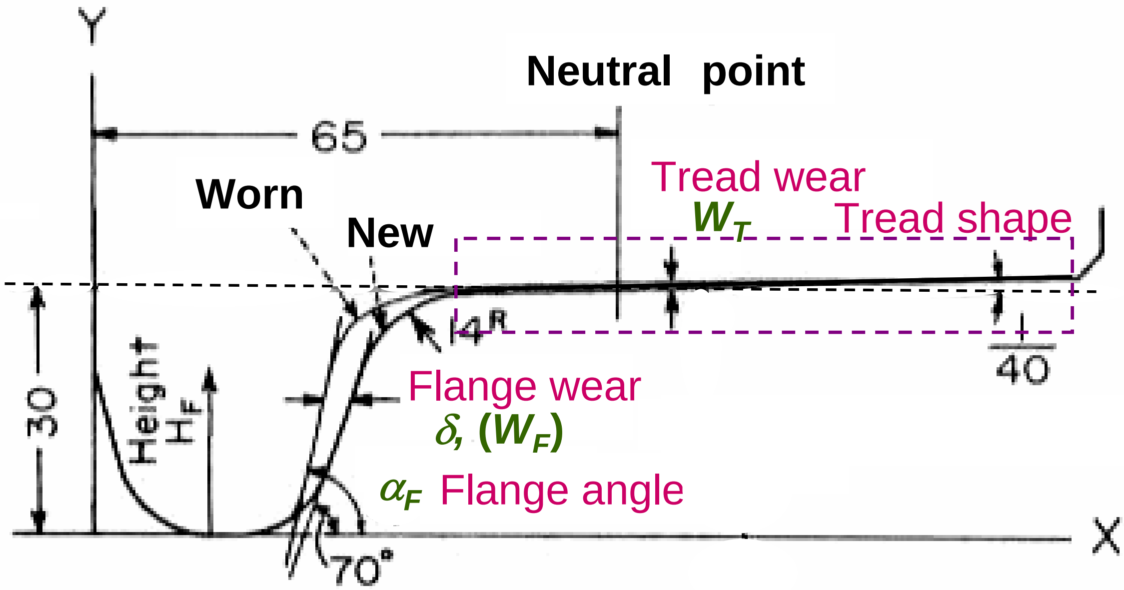
total 268 000 km

Bogie features

○ with side bearers

○ wheel of 1/40 conical tread

Wheel shape and object parameters



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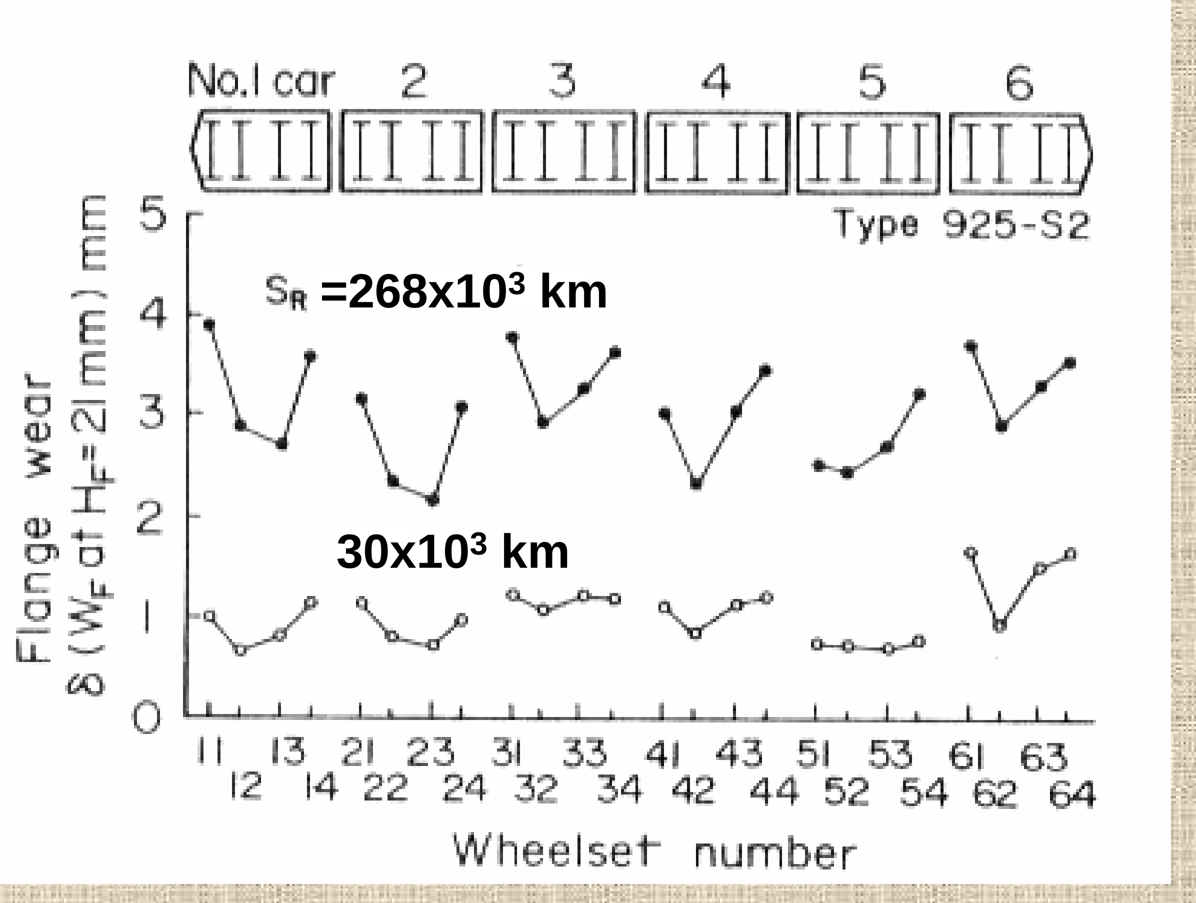
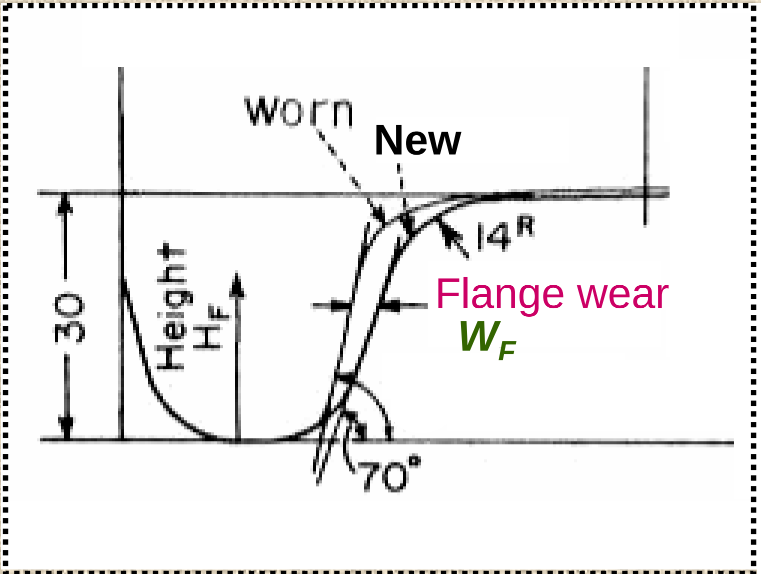
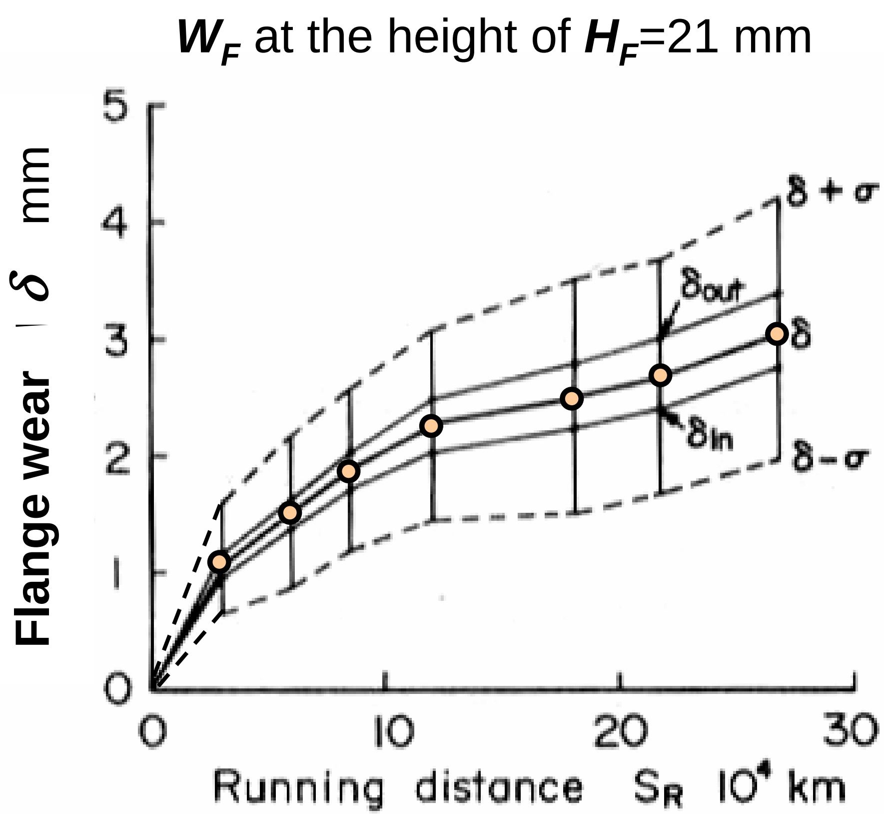
Comparison of flange wear among wheelset positions



Flange wear





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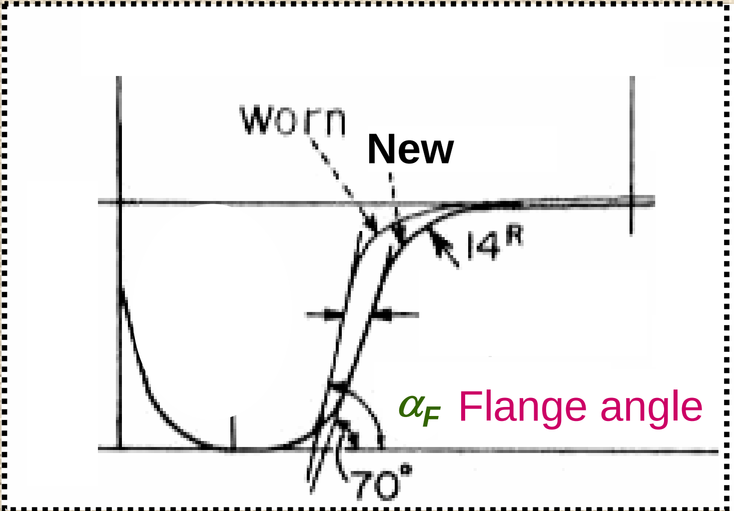
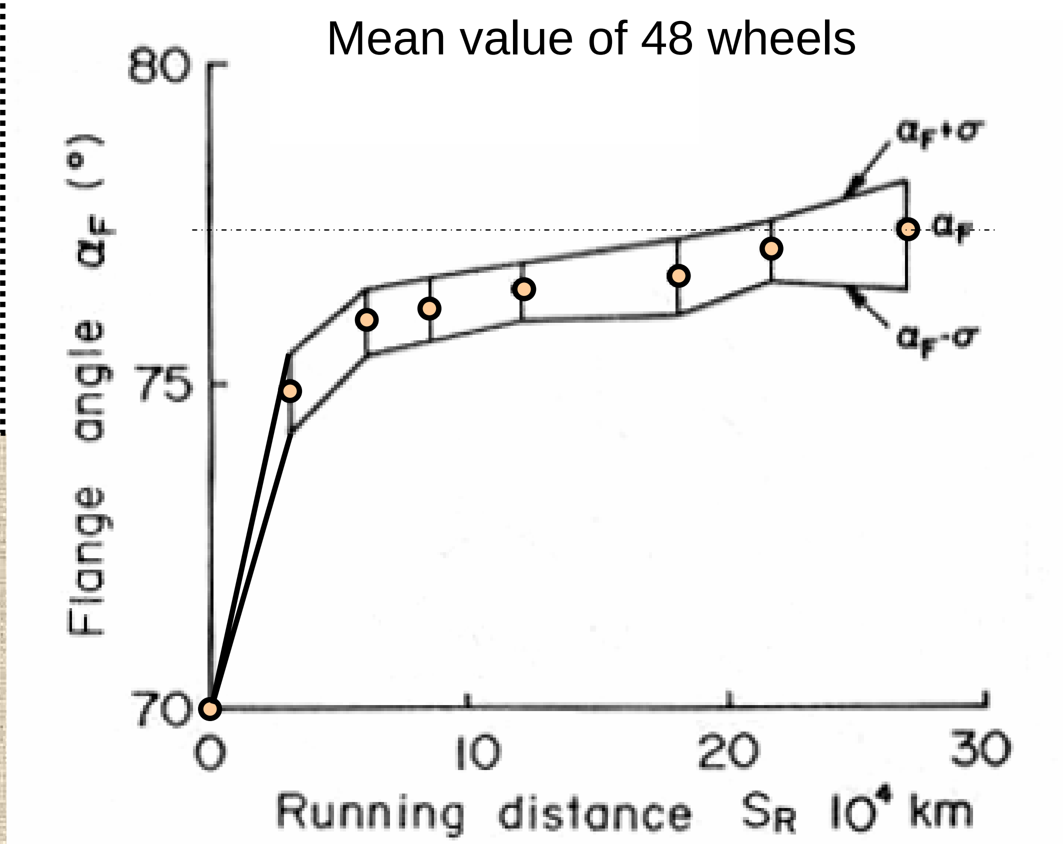
Flange angle





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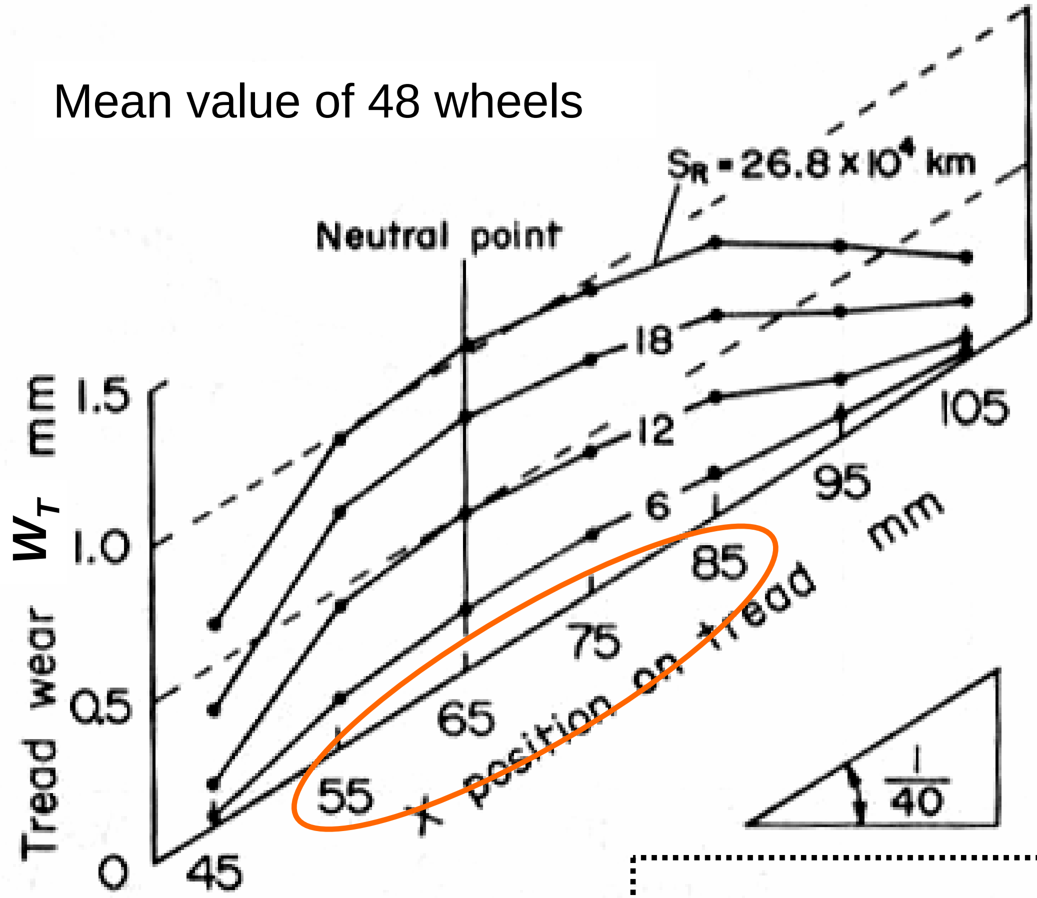
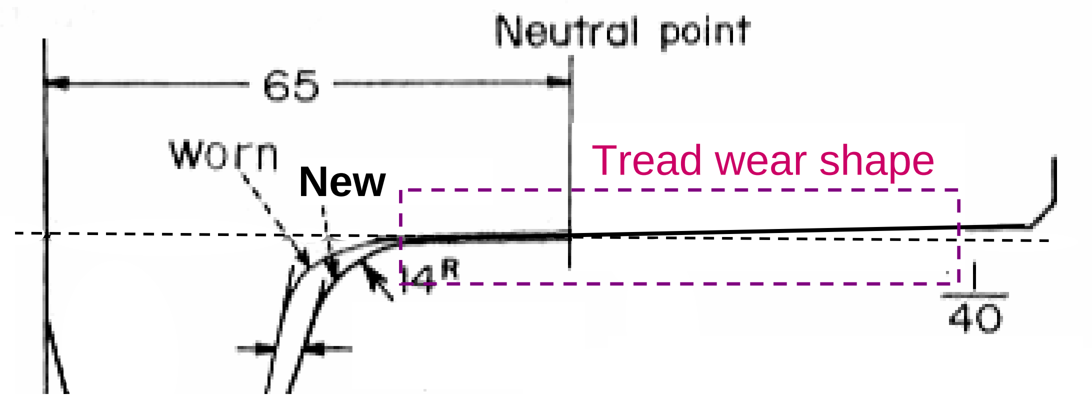
Profile of tread wear

Mean value of 48 wheels





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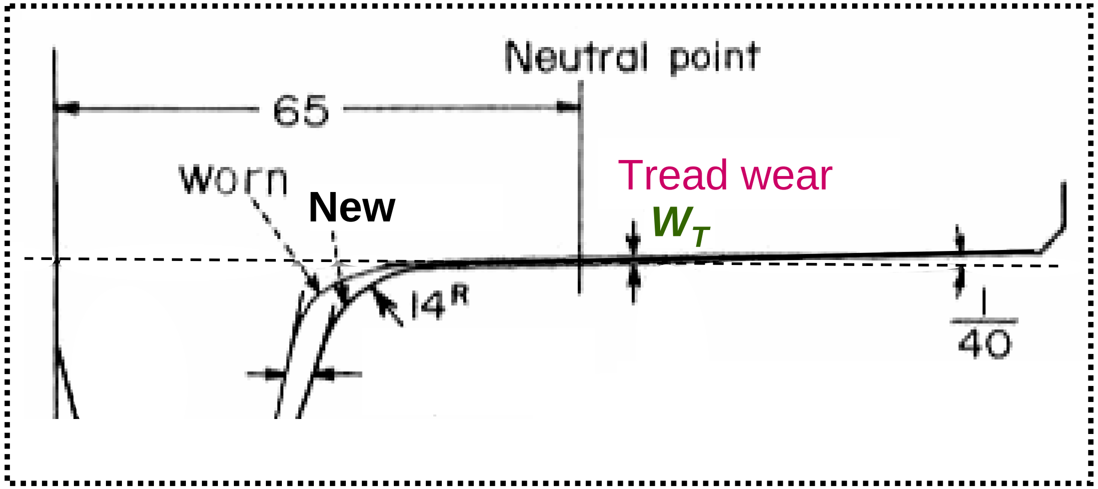
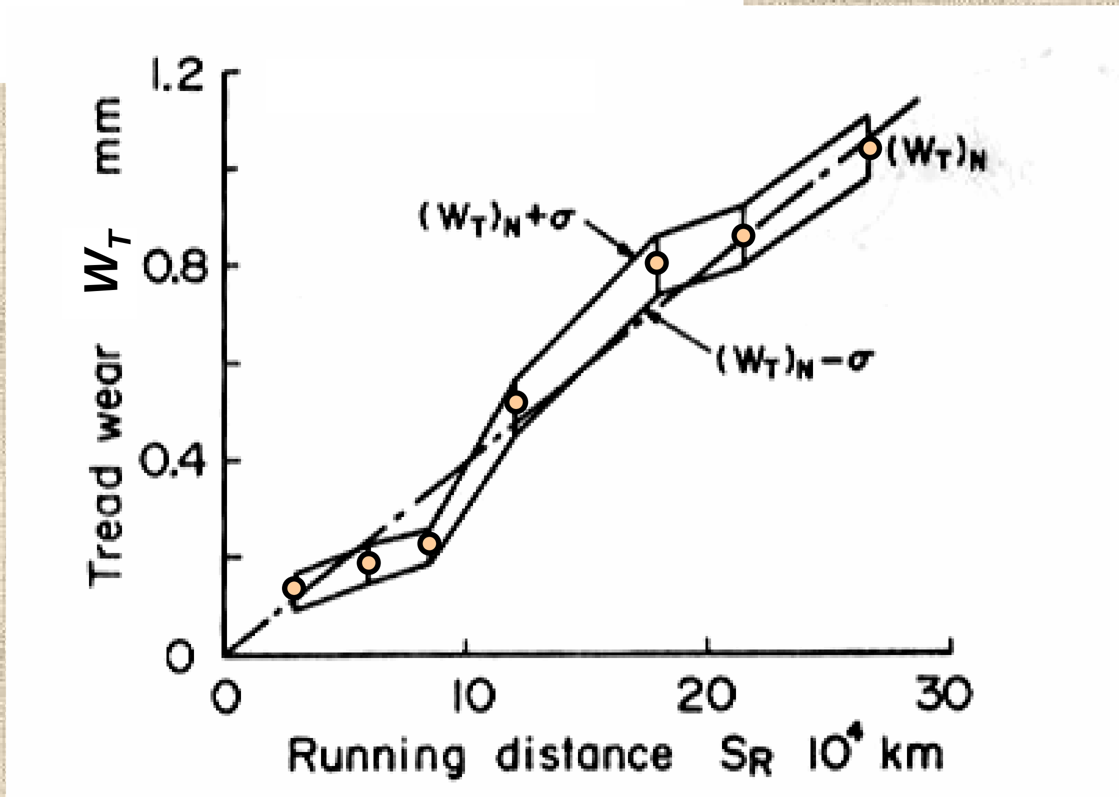
Tread wear at neutral point





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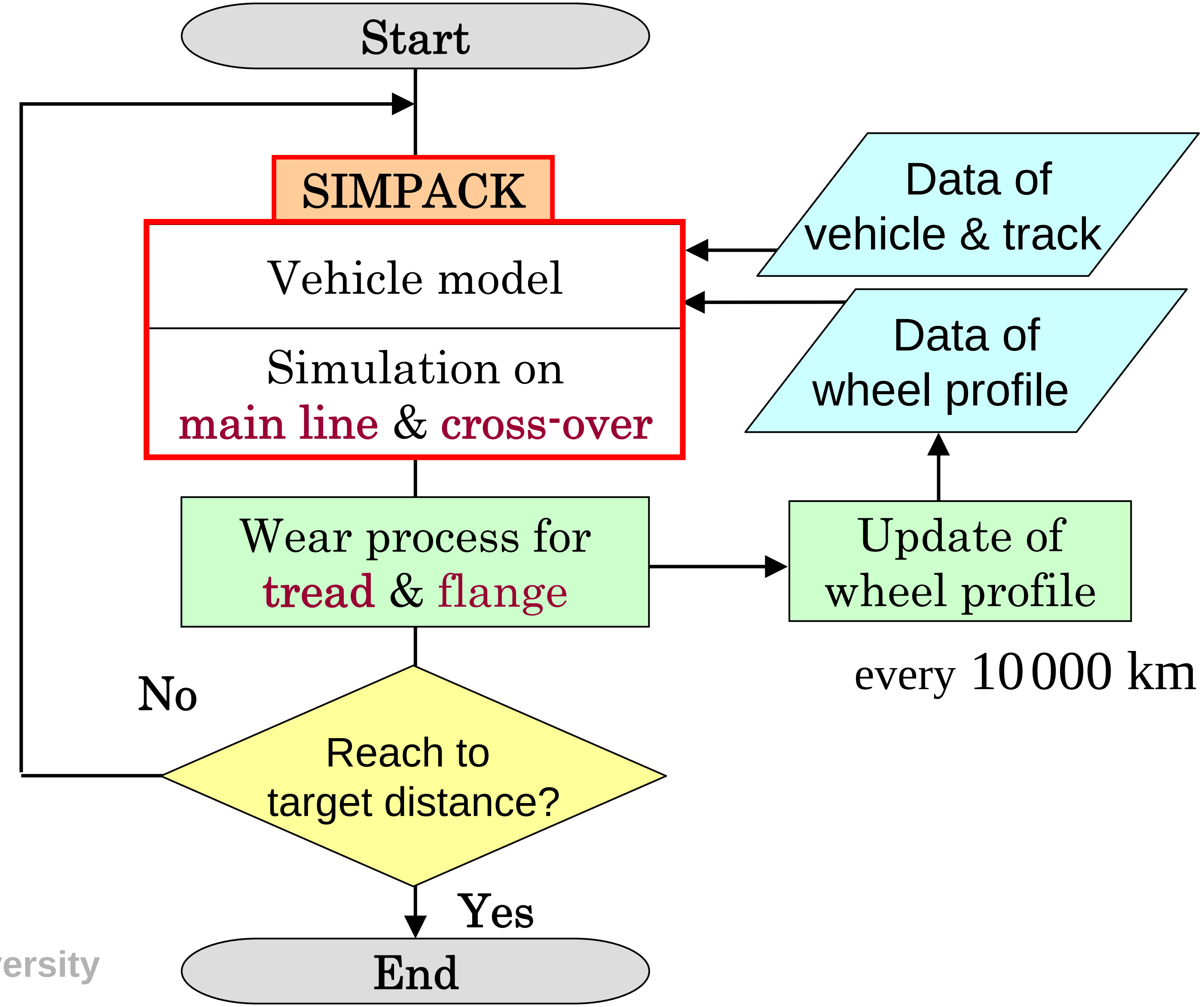
Flow chart for wear prediction



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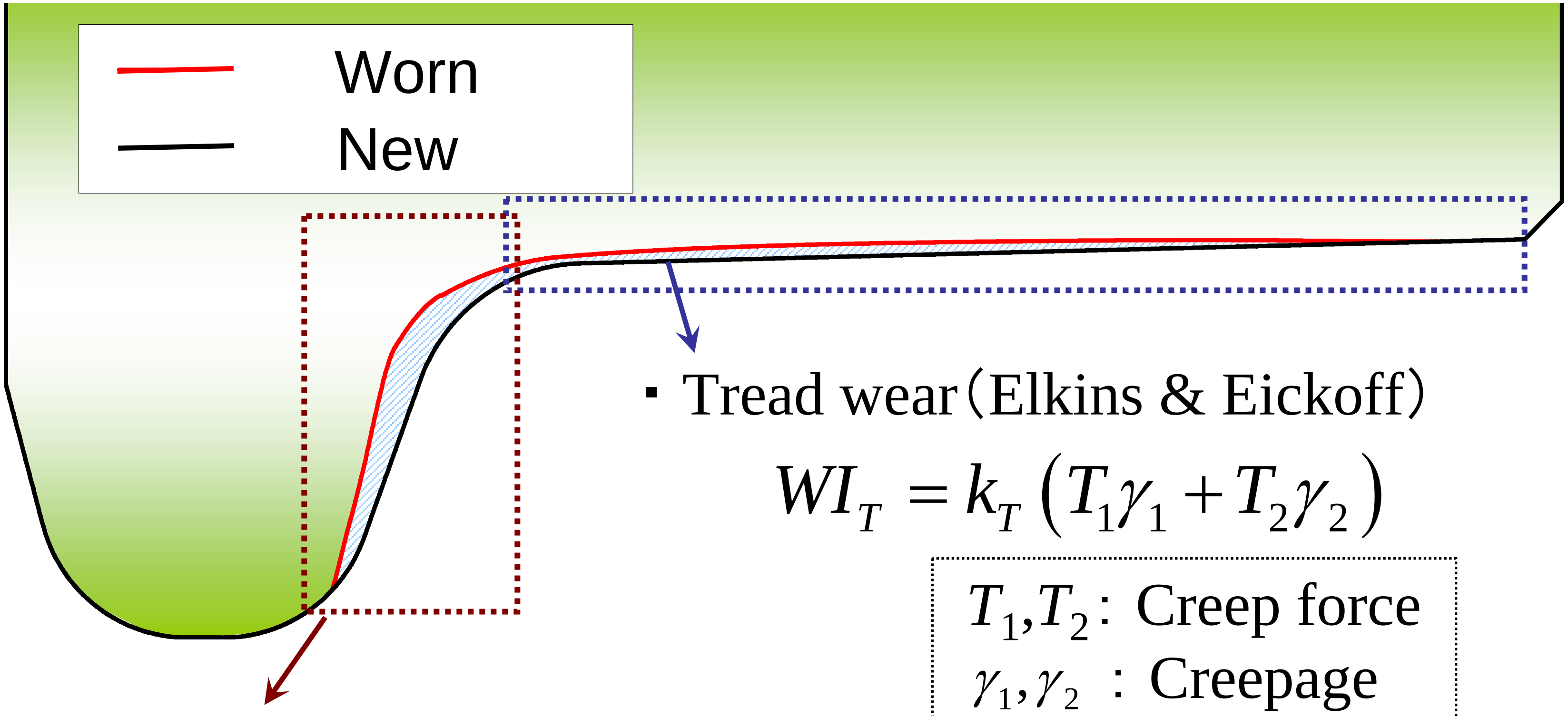
Wear indices



▪ Tread wear (Elkins & Eickoff)

$$WI_T = k_T\left(T_1\gamma_1 + T_2\gamma_2\right)$$

T_1, T_2 : Creep force
γ_1, γ_2 : Creepage

▪ Flange wear (Heumann)

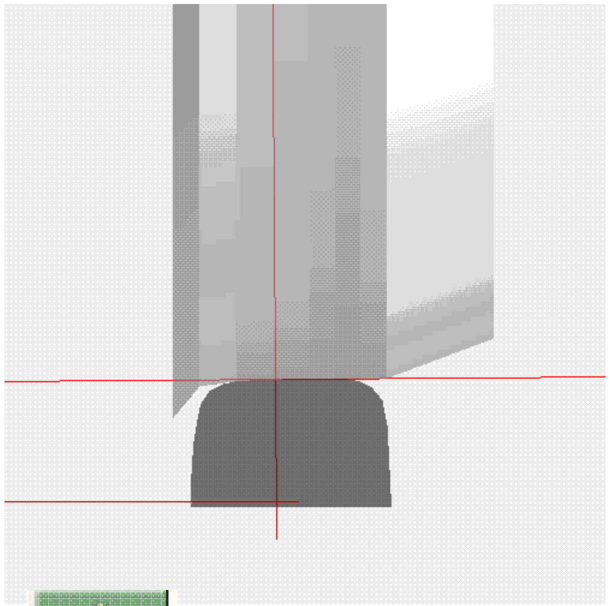
$$WI_F = k_F\left(\mu_F F_F \psi\right)$$

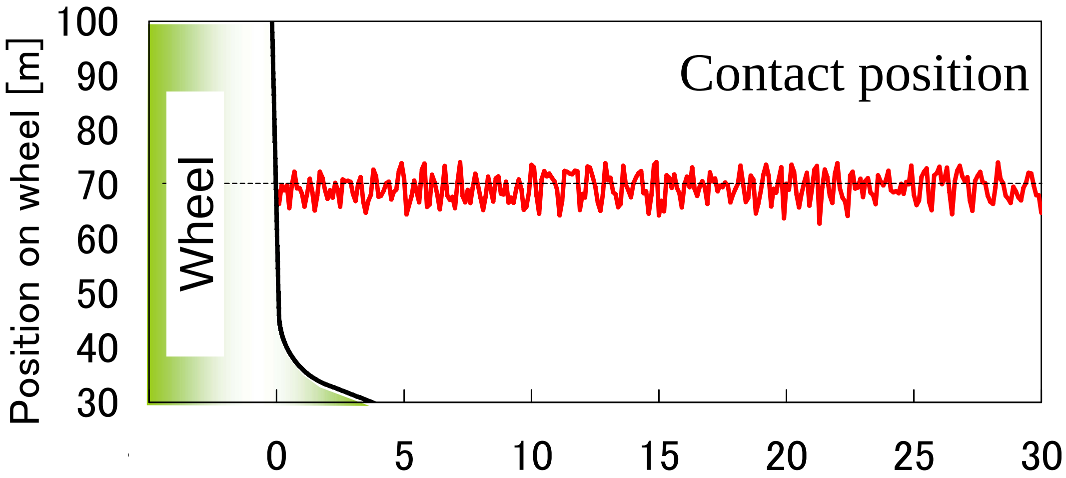
μ_F : Coefficient of friction
F_F : Flange force
ψ : Attack angle

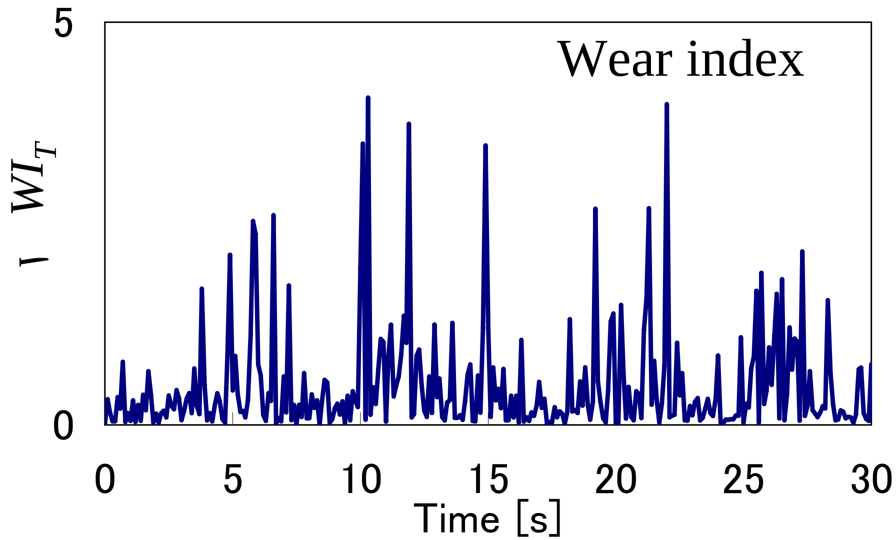
Wear process on tread

① Contact position and wear index

Running simulation with SIMPACK







Wear process on tread

② Conversion to wear & accumulation

Interim wear based on Pearce, *et al.*

δ_T : Interim wear thickness [mm]

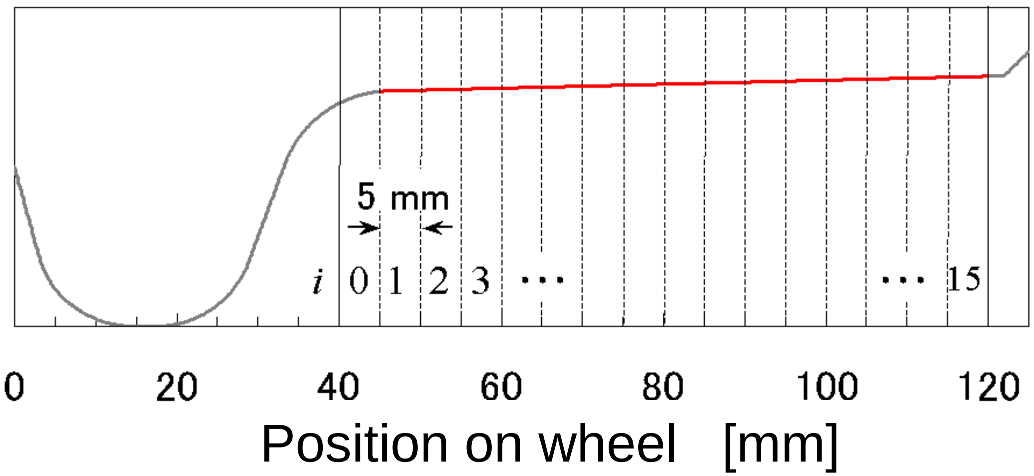
$$\delta_T = 0.25F/D \qquad : F < 100 \ [\mathrm{N}]$$

$$\delta_T = 25.0F/D \qquad : 100 \le F < 200 \ [\mathrm{N}]$$

$$\delta_T = (1.19F - 154)/D \qquad : F \ge 200 \ [\mathrm{N}]$$

where $F = T_1\gamma_1 + T_2\gamma_2$, D: Wheel diameter [mm]

Accumulation into 5 mm partitions $\boldsymbol{H_i}$



Wear process on tread

③ Distribution of wear thickness

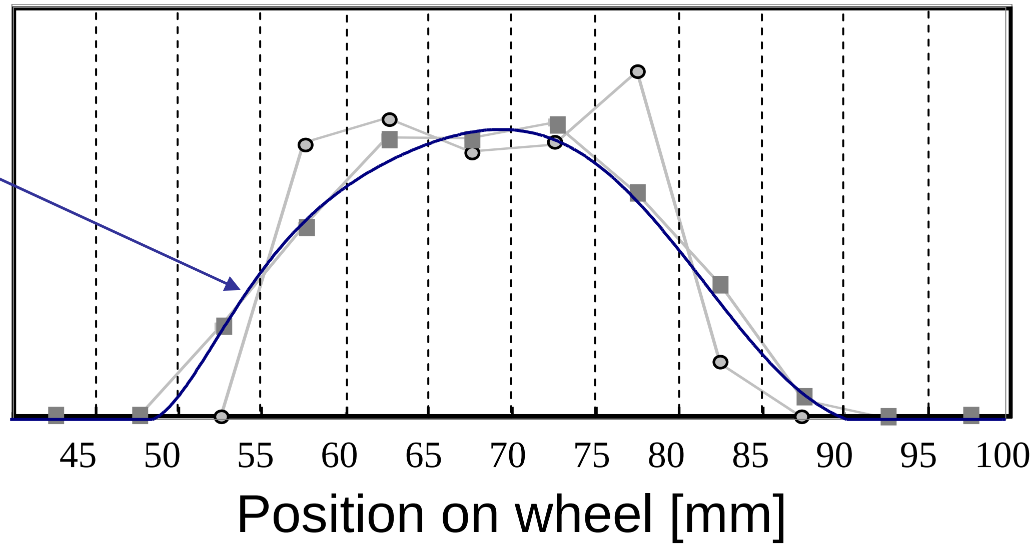
- Wear thickness $\Delta_{Ti} = c_T \cdot H_i$

c_T : Coefficient determined from measured data at running distance **60 000 km**

- Smoothing of distribution

(1) Averaging among 3 partitions $\Delta_{Ti}' = \left(\Delta_{Ti-1} + \Delta_{Ti} + \Delta_{Ti+1}\right)/3$

(2) Smoothing of Δ_{Ti}' by polynomial



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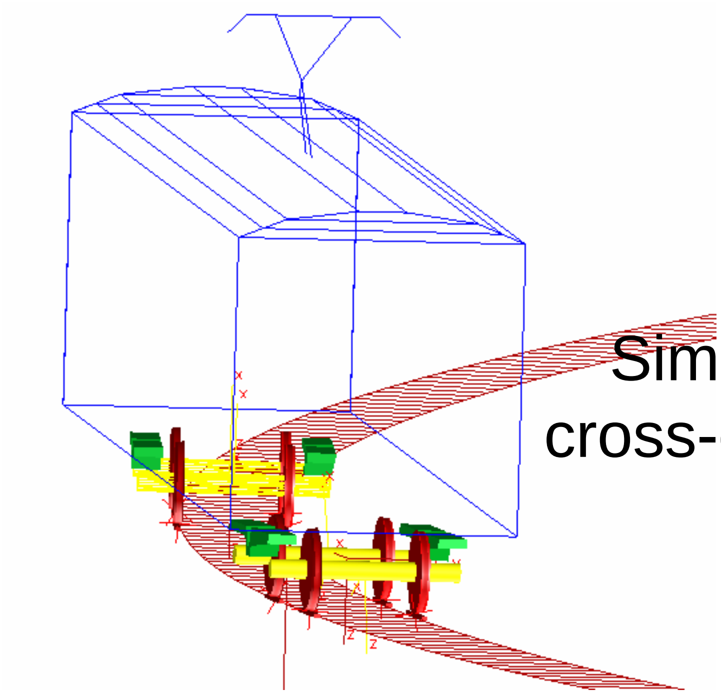
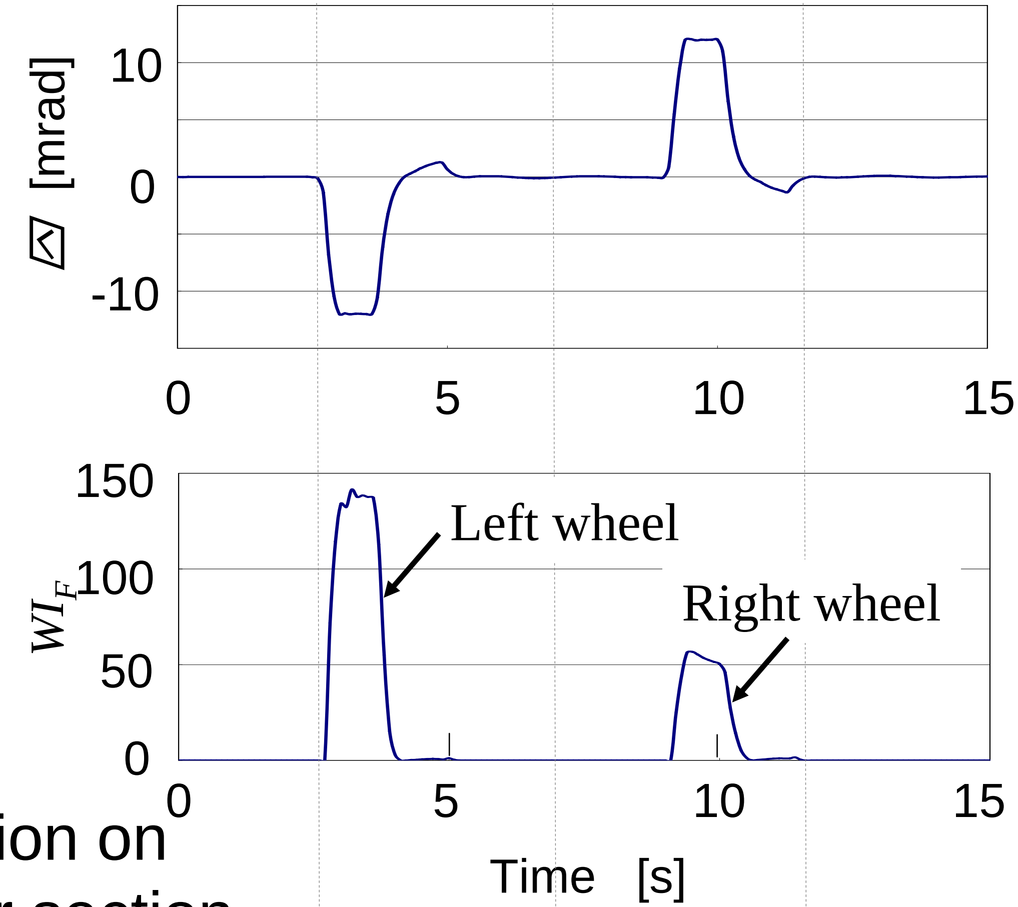
Wear process on flange

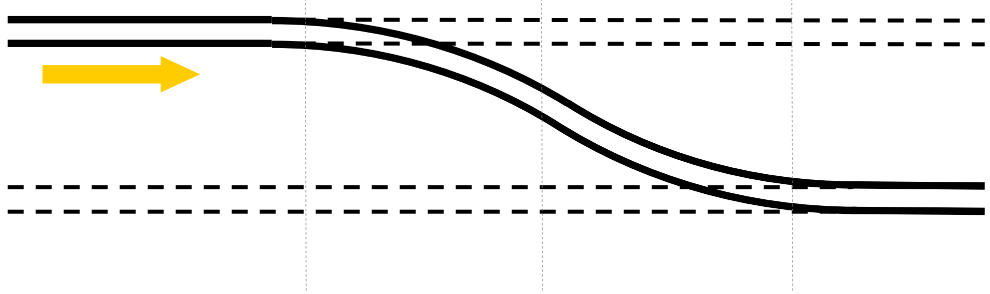
Wear index

$$WI_F = \left|\mu_F F_F \psi\right|$$





Simulation on cross-over section



Wear process on flange

① Wear index in unit area w_F

$$w_F = WI_F / A$$

A: Contact area

② Accumulation of w_F into partitions

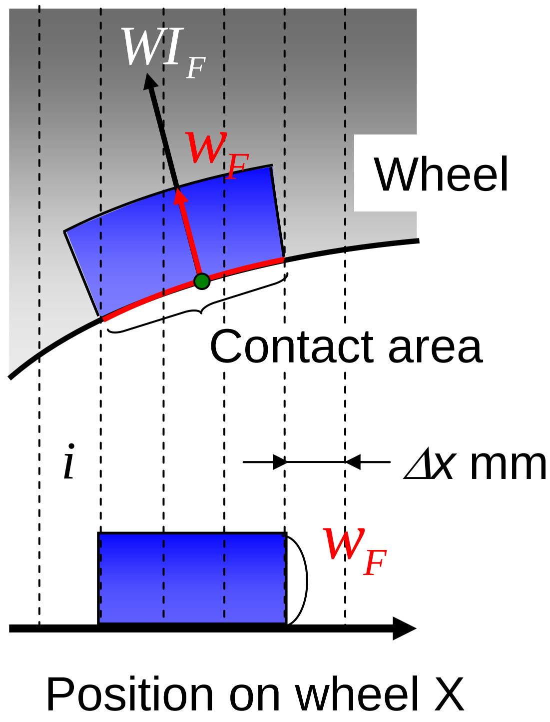
W_{Fi}

Conversion to wear thickness

$$\Delta_{Fi} = c_F \cdot W_{Fi}$$

c_F : Coefficient determined from measured data at running distance 60 000 km

③ Distribution of wear Δ_{Fi}



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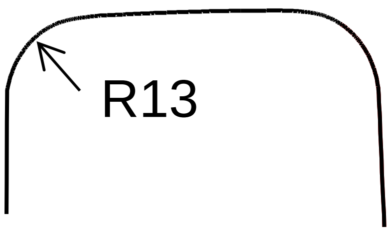
Wear process on flange

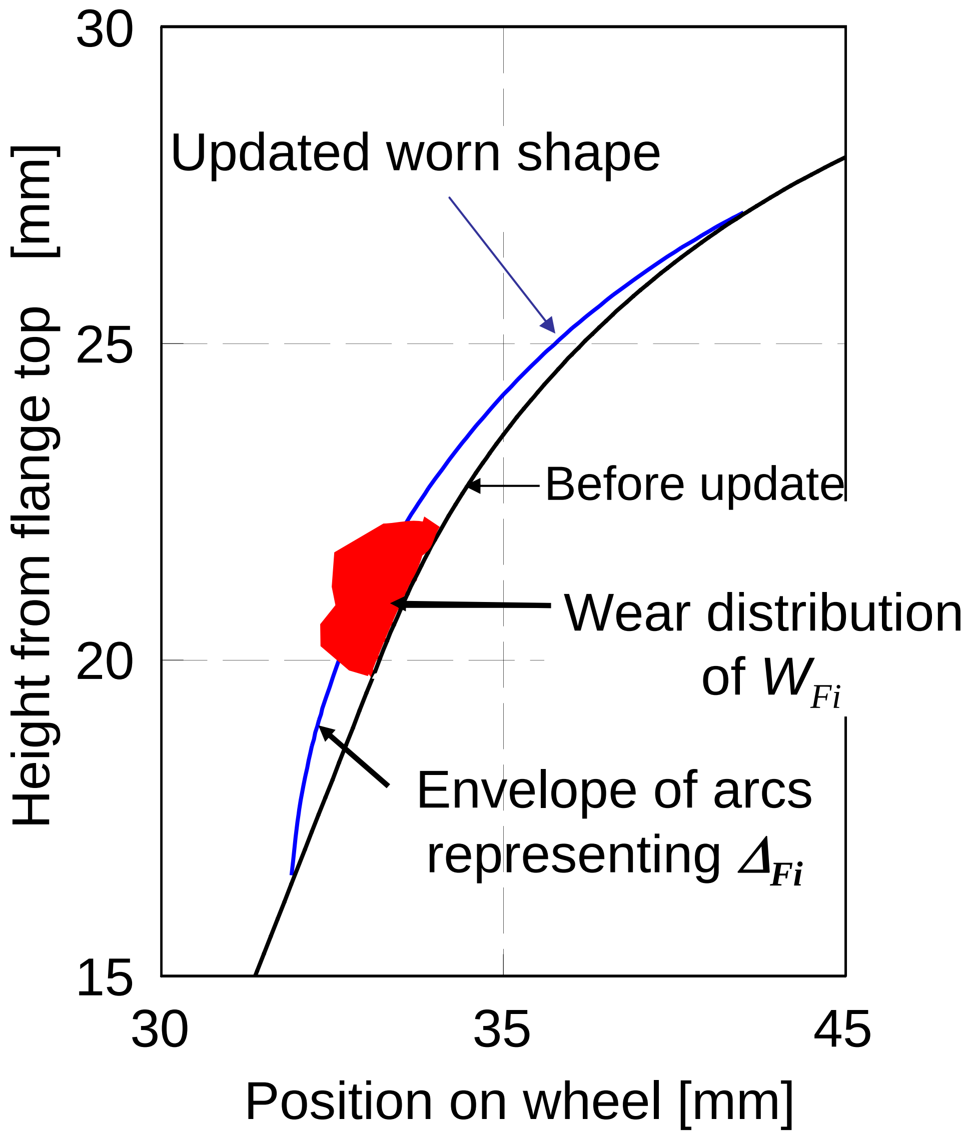
Wear distribution around flange root

Wear distribution of W_{Fi}

↓

Envelope of arcs
with the radius of rail edge
representing Δ_{Fi}



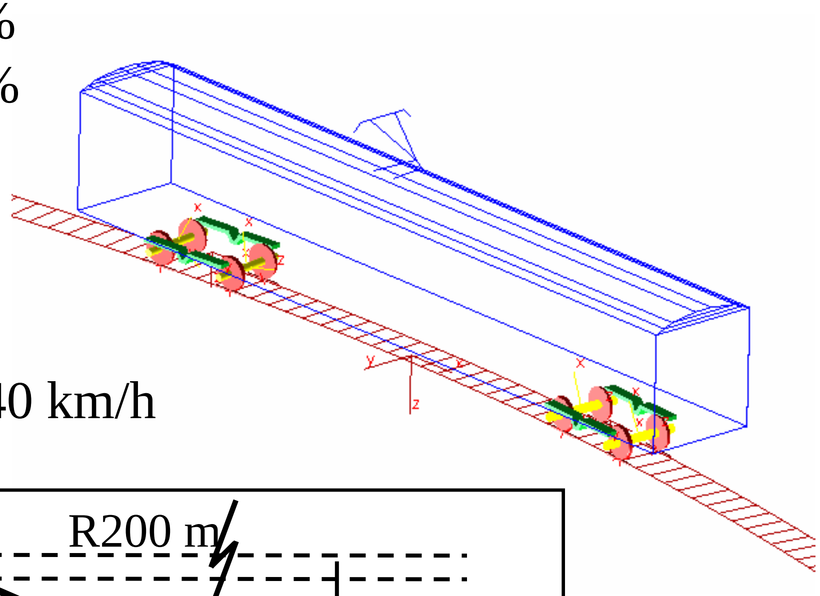


Track conditions for simulation

Main line

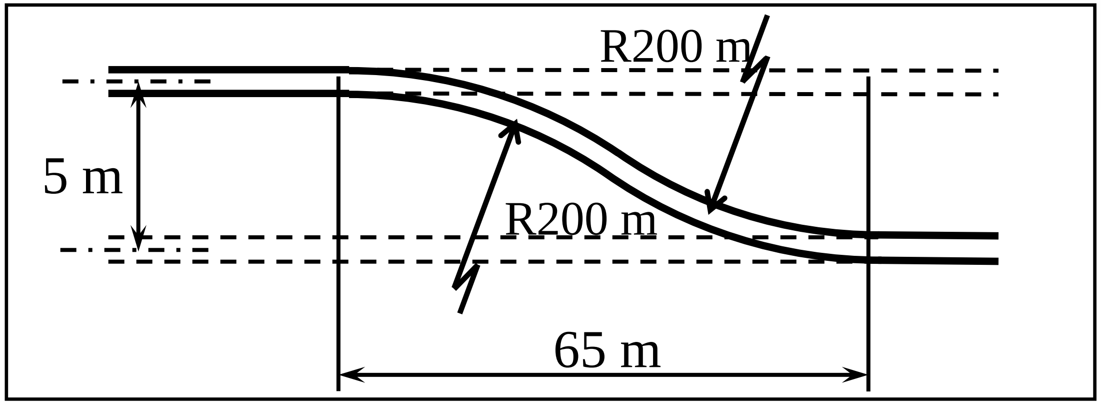
Running speed 240 km/h

- Straight track ···85%
- Curved track (R 4 000 m) ···15%
  - With alignment irregularities
  - New rail of Type 60-kg



Sharp curve (cross-over section)

Running speed 40 km/h



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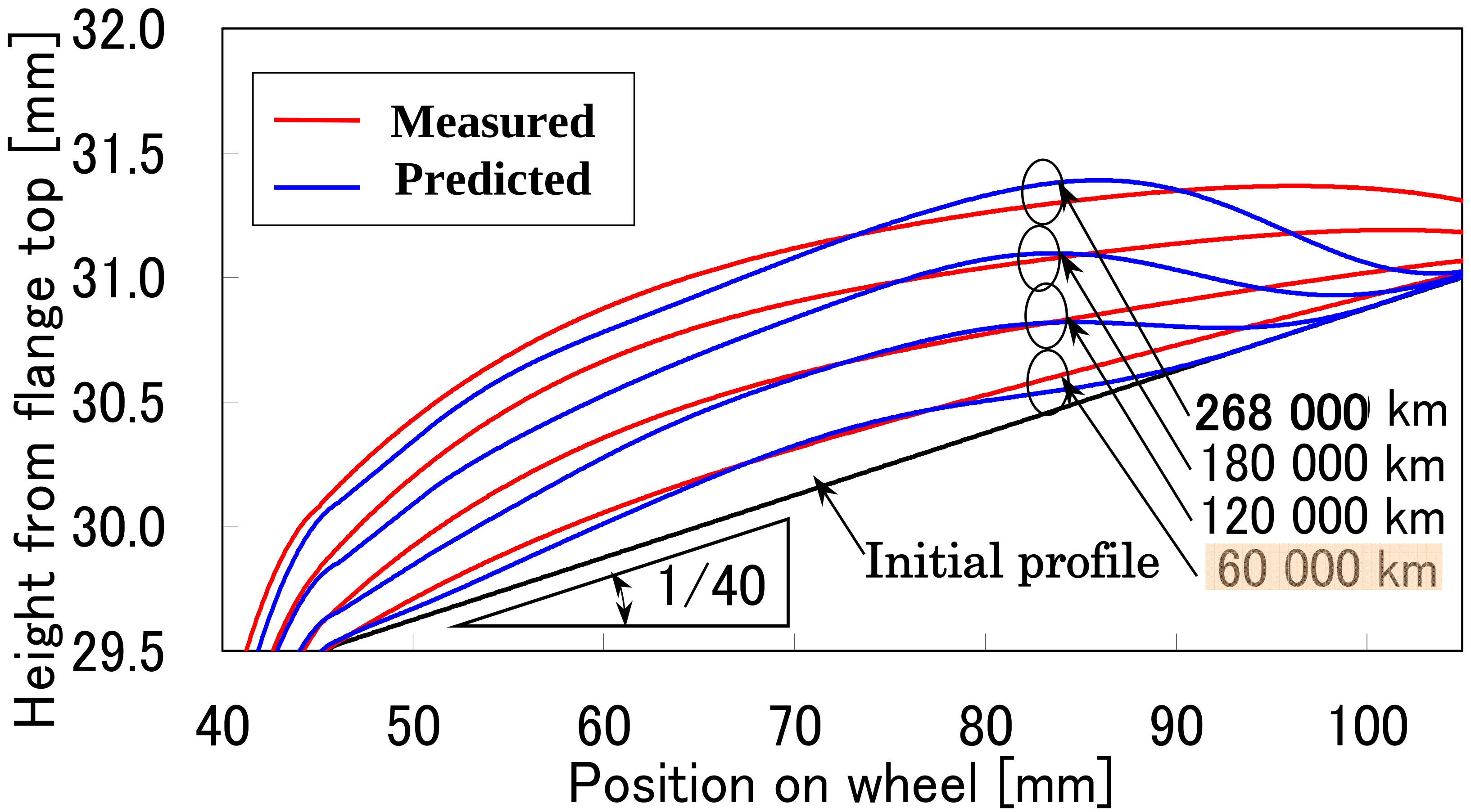
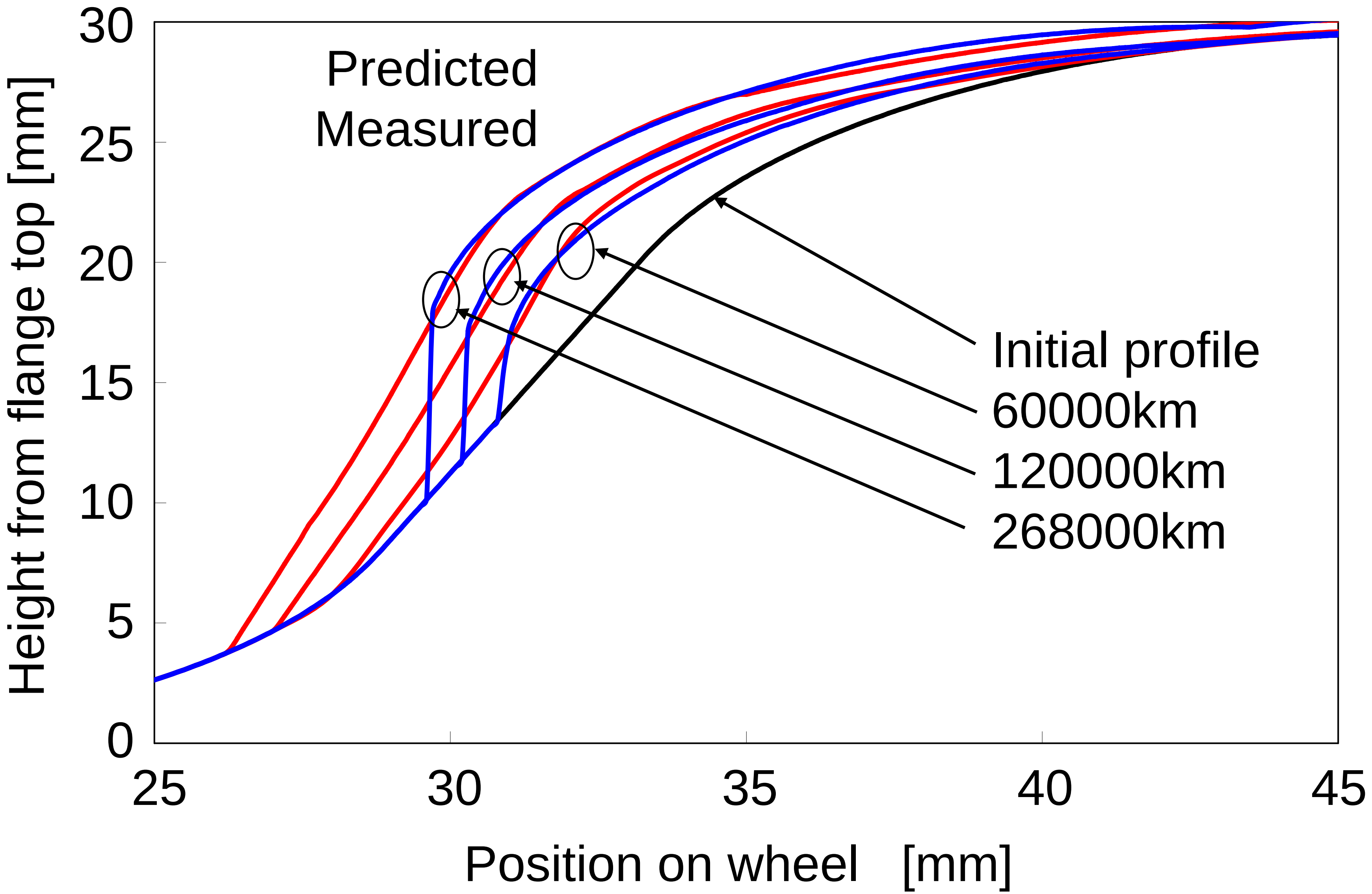
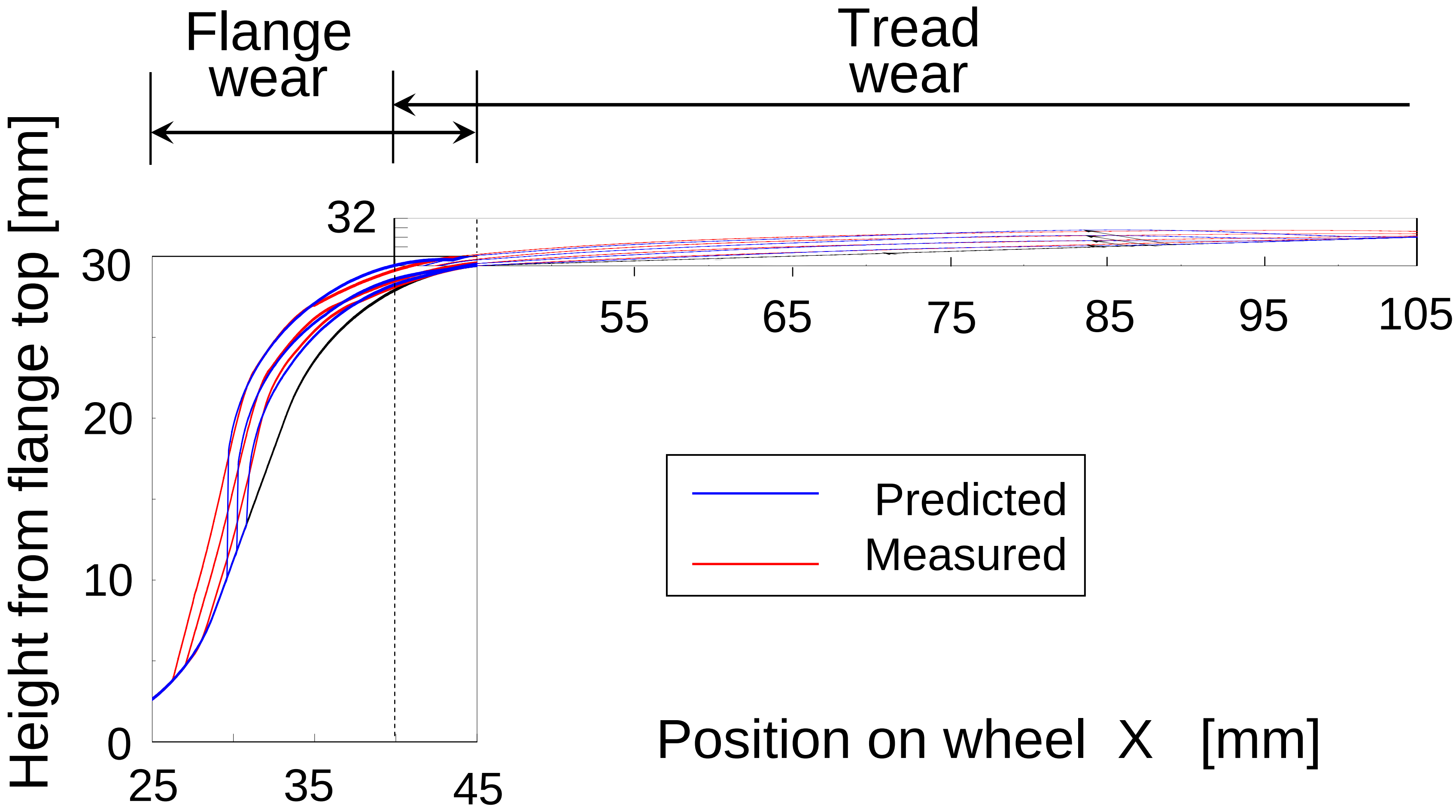
Comparison of worn profiles between prediction and measurement (wheel tread)



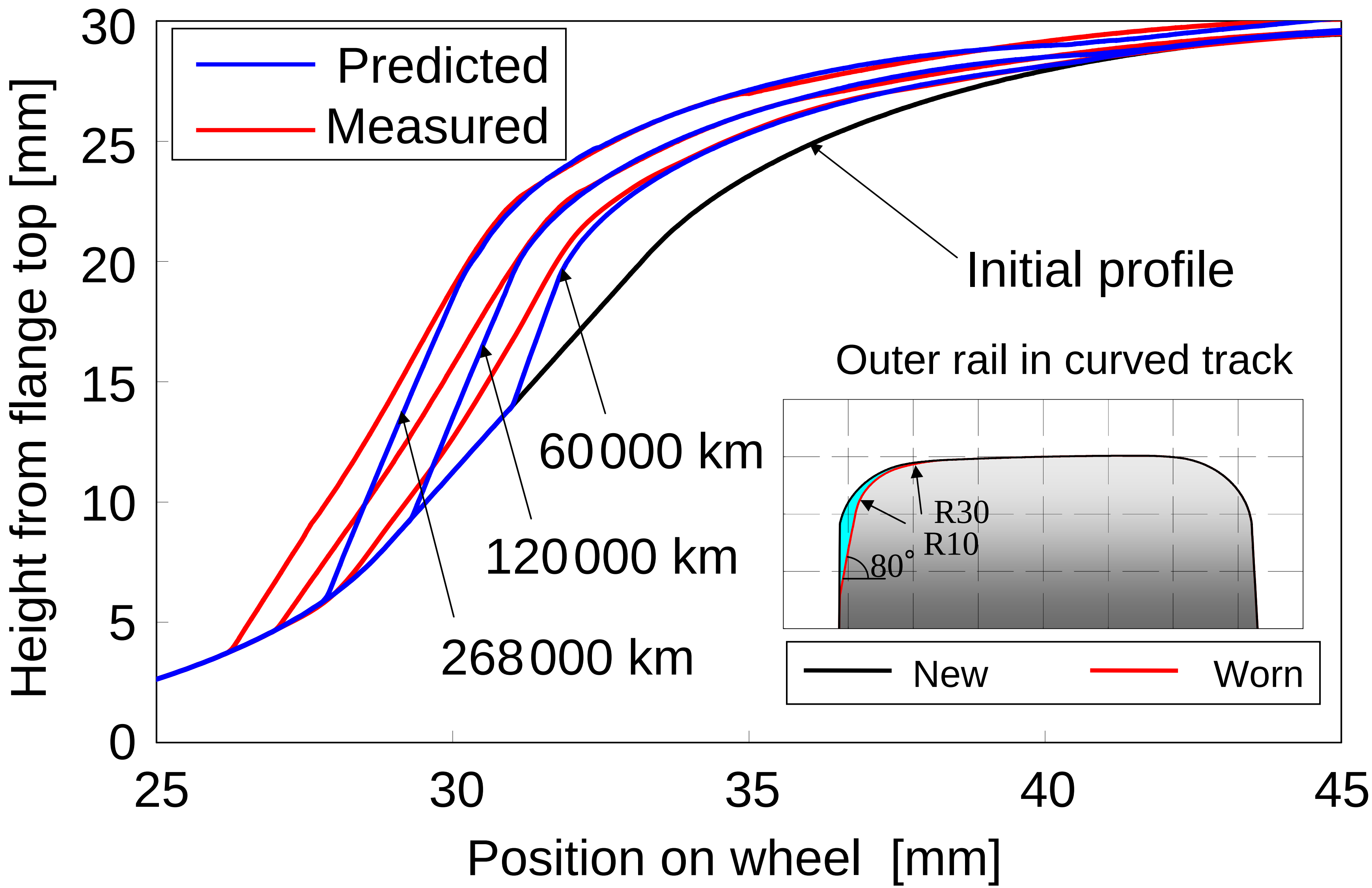
Comparison of worn profiles between prediction and measurement (wheel flange)



Composition of wear profiles in equal scales



Predicted flange shape in case of worn outer rail in sharp curve



Concluding remarks

A wear progress of railway wheel was compared with measured data in a field test.

(1) For the tread wear, the general tendency is predictable although the wear is limited within the narrower region. It is thought that the difference comes from the rail profile and switch structure which are not considered in the simulation.

(2) For the flange wear, the predicted profile greatly depends on the inner side shape of the outer rail and tends to follow the worn rail shape in sharp curves.

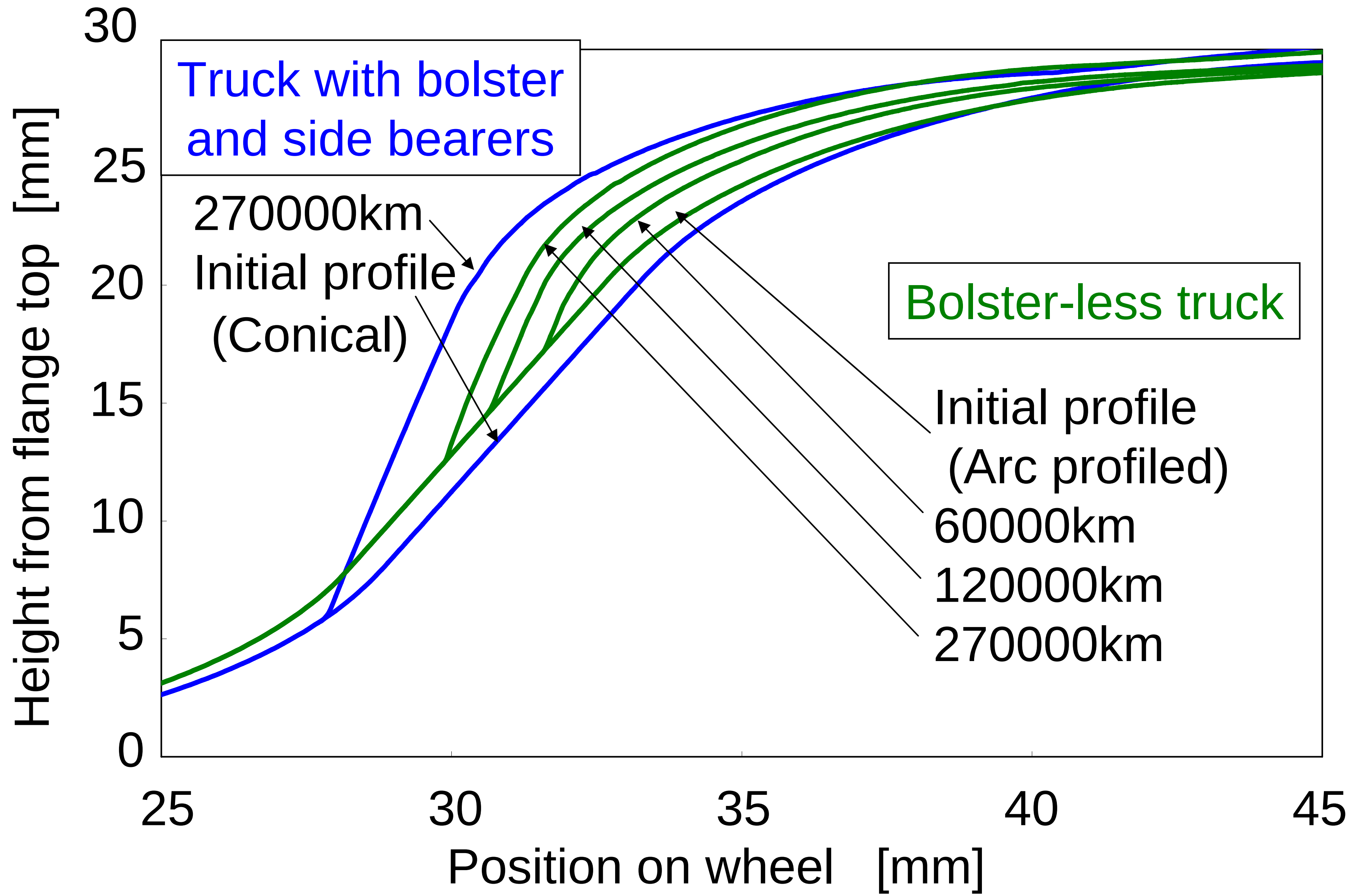
Concluding remarks

As mentioned above, it is perceived that practical rail profile is necessary to predict the real wear profile of wheel.

(3) This prediction can be useful, however, if we are interested in the comparison of influences between bogie structures or between railway line conditions such as the rate of contained curved section.

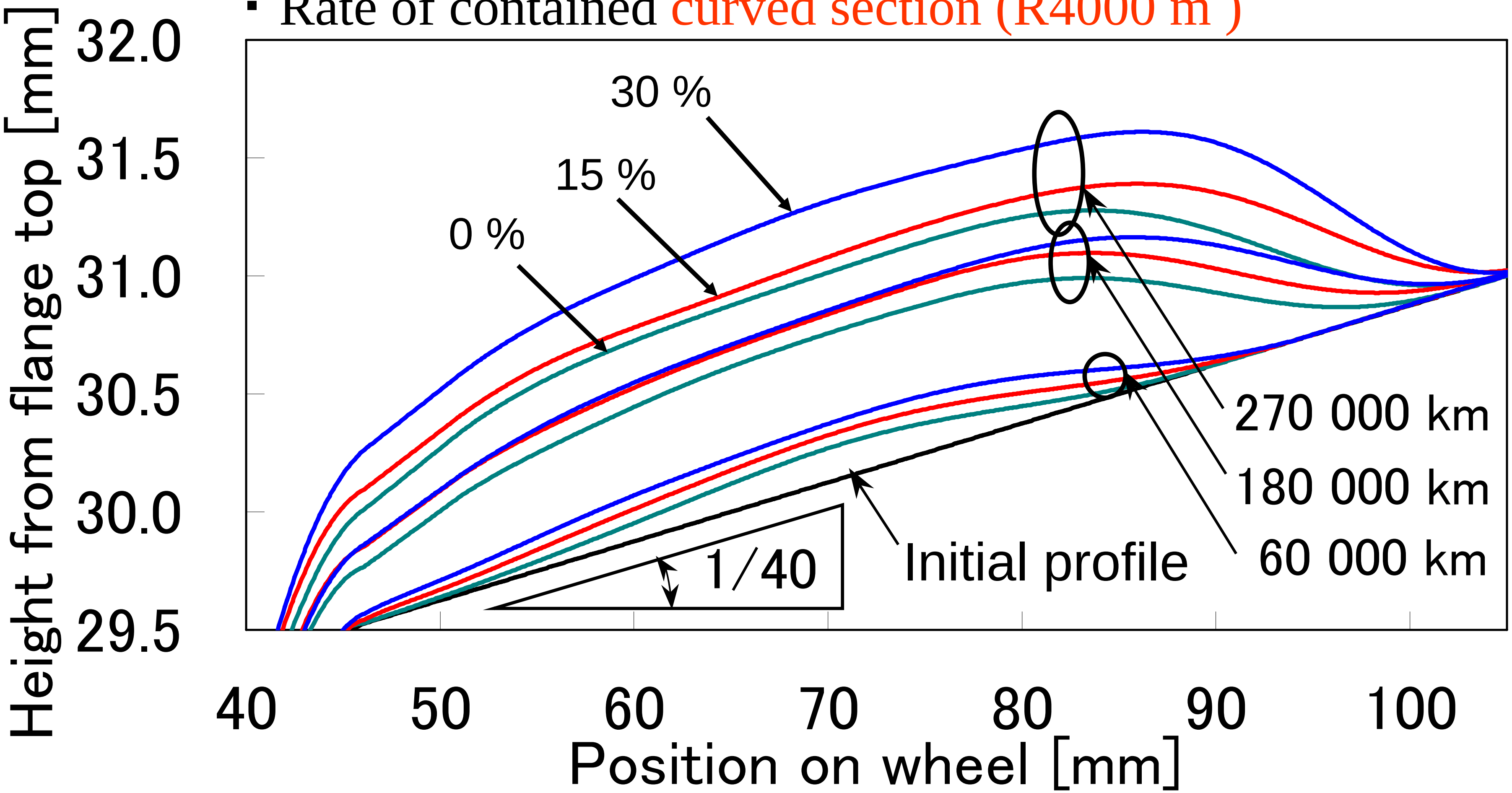
Such examples are as follows:

Comparison of flange wears between bogie structures



Comparison of tread wears between the rates of contained curved section

- Rate of contained curved section (R4000 m)



Thank you for your kind attention

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