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A new small-scale test rig for the wheel-rail contact studies

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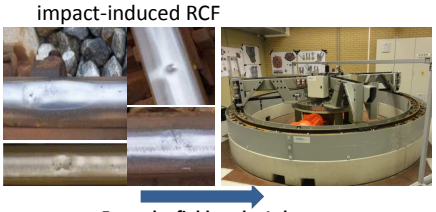
Motivations to build a new rig

- High costs of the rolling contact fatigue problem in the wheel and rail materials
- Unclear root causes of rail squats
- Uncertain relations between the microstructural and mechanical effects
- Difficulties in field tests/uncertainties in numerical/theoretical modelling
- Lack of similarity of tests to the reality
- No available test setup to simulate the impact-induced RCF



From the field to the Lab

Design process of the new setup

Step1: Literature survey on available setups for wheel-rail contact experiments

Step2: Determine the operational mechanism of the new test rig by evaluating various methods

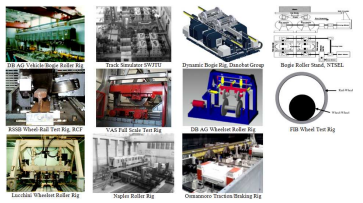
Step3: Perform a dimensional analysis and determine the proper scaling strategy for the new rig

Step4: Finite element analysis of the downscale test rig to finalize the concept design and dimensions

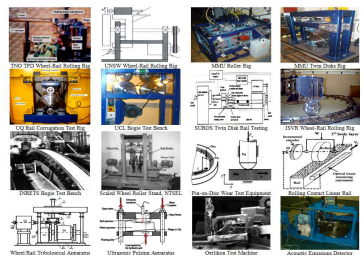
Step5: Compare fatigue mechanism and cyclic behaviour of the new test rig with the real system

Step6: Perform the detailed mechanical and electrical design of the setup → manufacture the new test rig

Step1: Literature survey on existing rigs

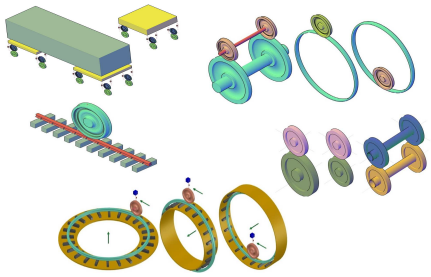


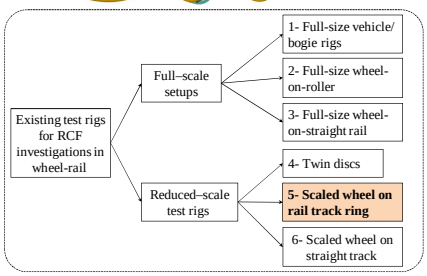
Examples for the Full-scale test rigs



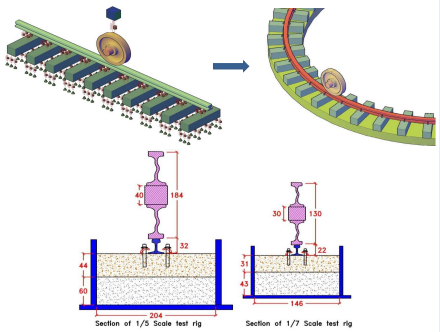
Examples for the Small-scale rigs

Step2: Which operational mechanism?



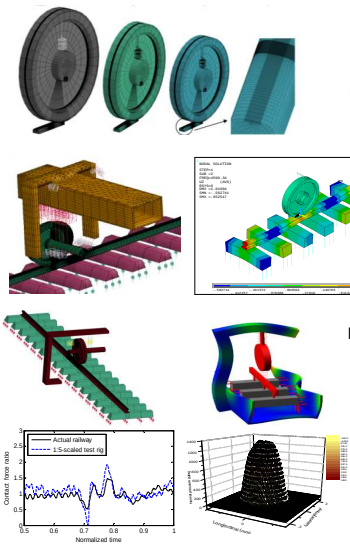


Step3: Dimensional/scale analysis



Variables/ parameters	Variable notation	Units	Scale notation	Iwnicki (1998)	Cholllet (1986)	Jaschinsk i (1999)	Current study
Distance	L	m	ϕ_L	1/N	1/N	1/N	1/N
Cross section	A	m^2	ϕ_A	$1/N^2$	$1/N^2$	$1/N^2$	$1/N^2$
Volume	Vol.	m^3	ϕ_{Vol}	$1/N^3$	$1/N^3$	$1/N^3$	$1/N^3$
Moment of inertia	I	m^4	ϕ_I	$1/N^4$	$1/N^4$	$1/N^4$	$1/N^4$
Mass	M	kg	ϕ_M	$1/N^3$	$1/N^3$	$2/N^3$	$1/N^3$
Force	F	N	ϕ_F	$1/N^4$	$1/N^2$	$2/N^2$	$1/N^2$
Moment	T	Nm	ϕ_T	$1/N^5$	$1/N^3$	$2/N^3$	$1/N^3$
Stress	σ	N/m^2	ϕ_σ	$1/N^2$	1	2/N	1
Strain	ε	None	ϕ_ε	1/N	1	1	1
Stiffness	K	N/m	ϕ_K	$1/N^3$	1/N	$2/N^2$	1/N
Damping	C	N.s/m	ϕ_C	$1/N^5$	$1/N^2$	$2/N^{5/2}$	$1/N^2$
Frequency	f	Hz	ϕ_f	1	N	$N^{1/2}$	N
Time	t	s	ϕ_t	1	1/N	$1/N^{1/2}$	1/N
Velocity	V	m/s	ϕ_V	1/N	1	$1/N^{1/2}$	1

Step4: Finite element modelling

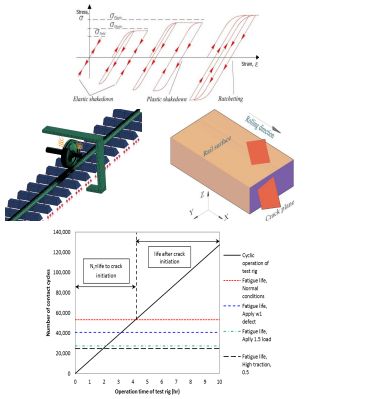


Static models

Dynamic models

Some results

Step5: Fatigue similarity analysis

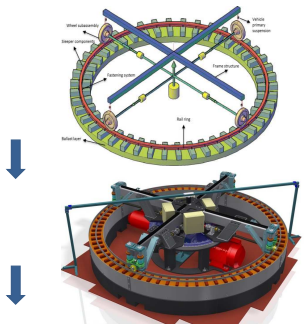


Test duration with the test rig (hours)	1	6	12	24	48	72	96	120
Number of wheel cycles	69,198	415,186	830,373	1,660,746	3,321,491	4,982,237	6,642,982	8,303,728
Number of rail contact cycles	12,732	76,394	152,789	305,577	611,154	916,732	1,222,309	1,527,886
Eq. tonnage (MGT)	0.25	1.53	3.06	6.11	12.22	18.33	24.45	30.56

Step6: Finalizing the concept design

- A spinning frame structure on a ring track bed fixed on the ground
- Including multiple (four) wheel components
- Having a rail-track ring with all components
- Flexible scale from 1/5 (basic) to 1/7
- Similarity in dynamic and impact loading conditions and rolling contact behaviours
- Similarity in stress-strain behaviours by using real materials of the wheel and rail
- Adjustable loading conditions, driving and braking torques, frictional behaviours
- Flexible rolling angle and creep forces

From concept design to the real setup



The final concept design

Detailed design of the new setup

The final built setup in the Lab, TU Delft