

Electronic supplementary materials

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Determination of the dynamic characteristics of locomotive drive systems under re-adhesion conditions using wheel slip controller

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Table S1 Parameters of the frame suspended driving system

Symbol	Physics mean	Value
M_w	Mass of wheelset (kg)	3138
I_w	Pitch inertia of wheelset ($\text{kg}\cdot\text{m}^2$)	440
M_d	Mass of motor stator and gearbox (kg)	3014
I_d	Pitch inertia of motor stator and gearbox ($\text{kg}\cdot\text{m}^2$)	1619
M_r	Mass of rotor (kg)	650
I_r	Pitch inertia of rotor ($\text{kg}\cdot\text{m}^2$)	19.7
l_1	Longitudinal distance from driving system mass center to wheelset (mm)	512
l_2	Longitudinal distance from rotor to wheelset (mm)	660
l_3	Longitudinal distance from motor suspension rod to wheelset (mm)	1165
l_4	Longitudinal distance from motor suspension seat to wheelset (mm)	600
K_β	Torsional stiffness of six-bar double hollow shaft coupling ($\text{MN}\cdot\text{m}/\text{rad}$)	5/8/12/30
K_{px}	Primary longitudinal stiffness (kN/mm)	10/37.4/50
i_r	Transmission ratio of gear system	5.722

Table S2 Parameters of the locomotive model

Parameters	Value	Parameters	Value
Axle load (t)	30	Pitch inertia of bogie frame ($\text{kg}\cdot\text{m}^2$)	14415
Bogie wheelbase (mm)	2900	Yaw inertia of bogie frame ($\text{kg}\cdot\text{m}^2$)	27813
Distance between bogie centers (mm)	9000	Number of tooth of small gear	18
Wheel radius (mm)	625	Mass of small gear (kg)	105.5
Roll inertia of wheelset ($\text{kg}\cdot\text{m}^2$)	2230	Number of tooth of middle gear	49
Yaw inertia of wheelset ($\text{kg}\cdot\text{m}^2$)	2244	Mass of middle gear (kg)	143.3
Mass of car body (kg)	76900	Number of tooth of large gear	103
Roll inertia of car body ($\text{kg}\cdot\text{m}^2$)	1.202e5	Mass of large gear (kg)	559
Pitch inertia of car body ($\text{kg}\cdot\text{m}^2$)	1.928e6	Normal modulus (mm)	9
Yaw inertia of car body ($\text{kg}\cdot\text{m}^2$)	1.922e6	Normal pressure angle ($^\circ$)	20
Mass of bogie frame (kg)	6032	Helix angle ($^\circ$)	4
Roll inertia of bogie frame ($\text{kg}\cdot\text{m}^2$)	16967	Backlash (mm)	0

Table S3 Degrees of freedom of the locomotive model

Element	Longitudinal	Lateral	Vertical	Roll	Pitch	Yaw
Carbody	X_c	Y_c	Z_c	Φ_c	θ_c	Ψ_c
Bogie frame	X_{fi}	Y_{fi}	Z_{fi}	Φ_{fi}	θ_{fi}	Ψ_{fi}
Wheelset	X_{wj}	Y_{wj}	Z_{wj}^*	Φ_{wj}^*	θ_{wj}	Ψ_{wj}
Hollow shaft				Φ_{hj}		Ψ_{hj}
Motor stator (gearbox)	X_{sj}	Y_{sj}	Z_{sj}	Φ_{sj}	θ_{sj}	Ψ_{sj}
Motor rotor					θ_{tj}	
Hanger rod (traction motor)				Φ_{hmk}	θ_{hmk}	
Horizontal traction rod					θ_{thi}	Ψ_{thi}
Inclined traction rod					θ_{tri}	
Hanger rod (traction rod)				Φ_{hti}	θ_{hti}	
Pinion					θ_{sgj}	
Middle gear					θ_{mgj}	
Big gear					θ_{bgj}	

Note: the symbol * denotes dependent freedoms: $i=1-2, j=1-4, k=1-8$.