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Multi-objective aerodynamic optimization design of high-speed train head shape

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Key words: HST, Multi-objective optimization, Aerodynamic performance, Parametric model, Kriging model, Genetic algorithm

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Optimization Design Process

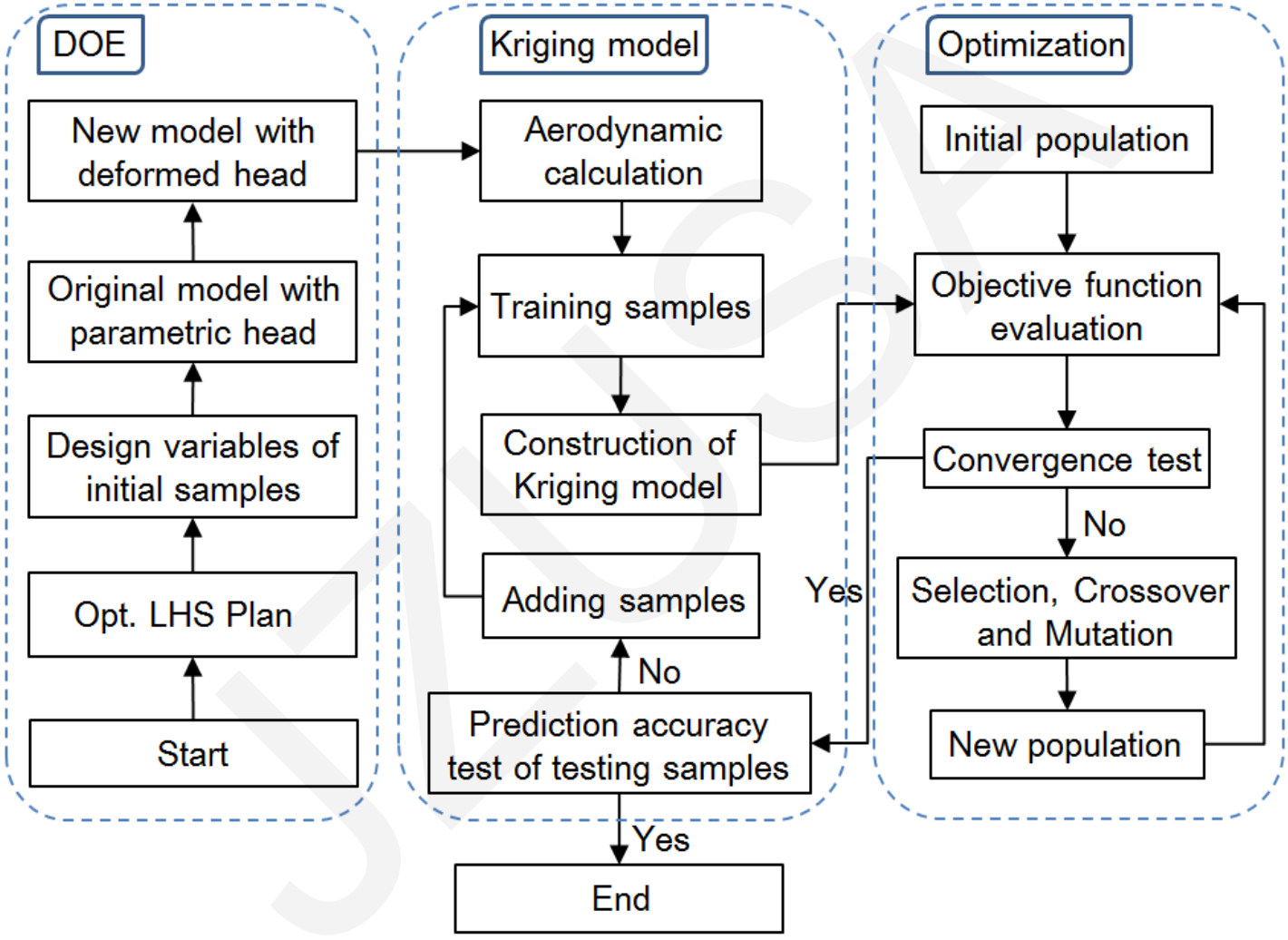


Fig. 1. Schematic representation of the whole optimization design process

Parametric Method of Train Head

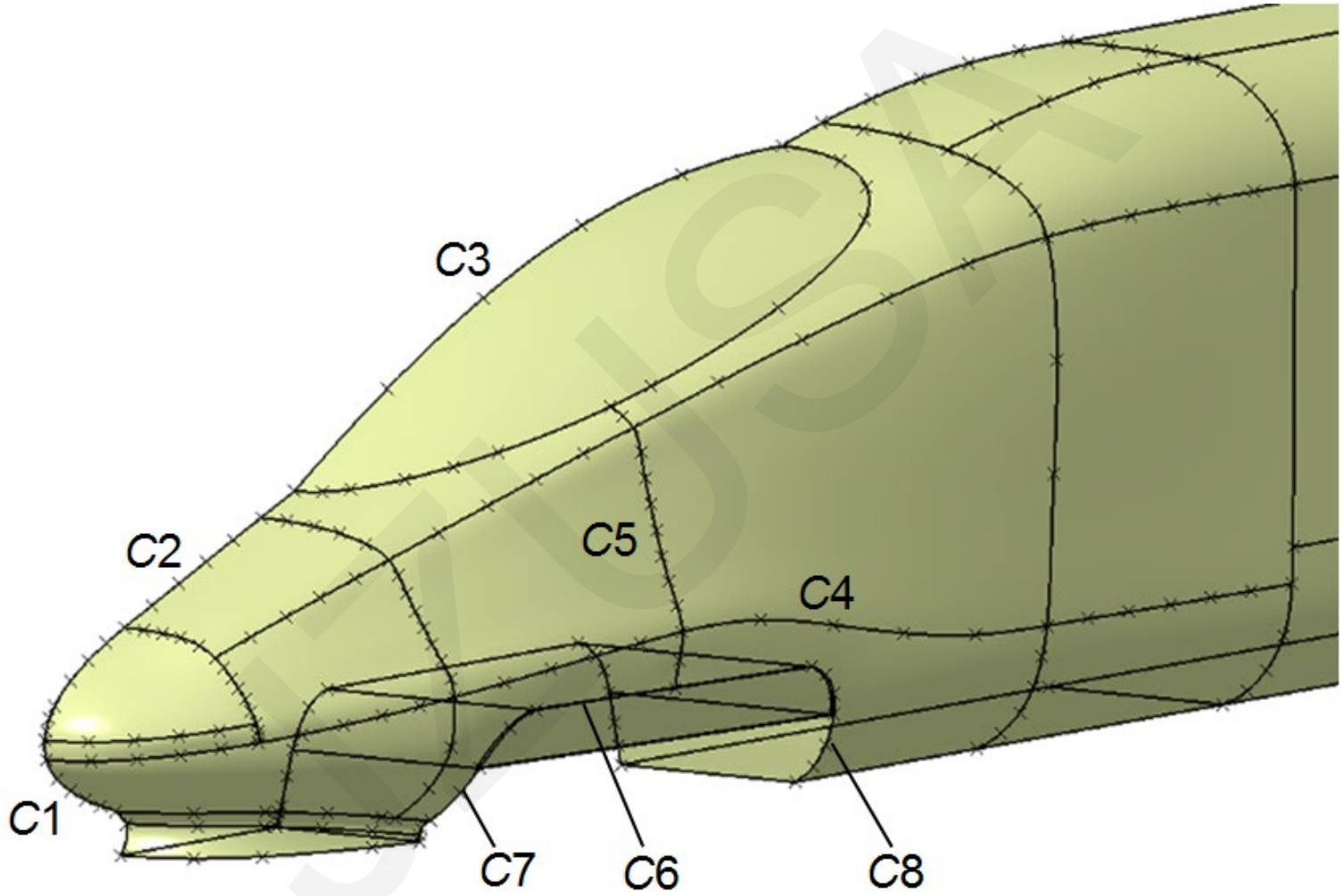


Fig. 2. Numbers of the main control curves of the streamlined head

Computational Model & Domain

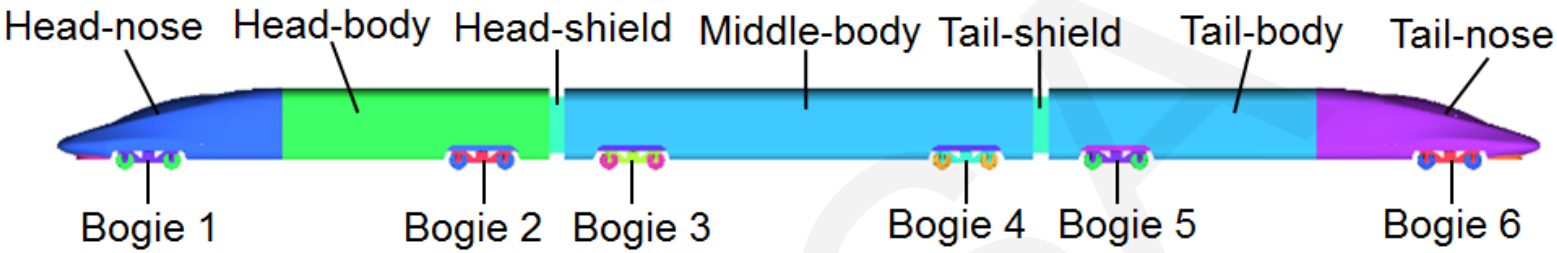


Fig. 3. Train model

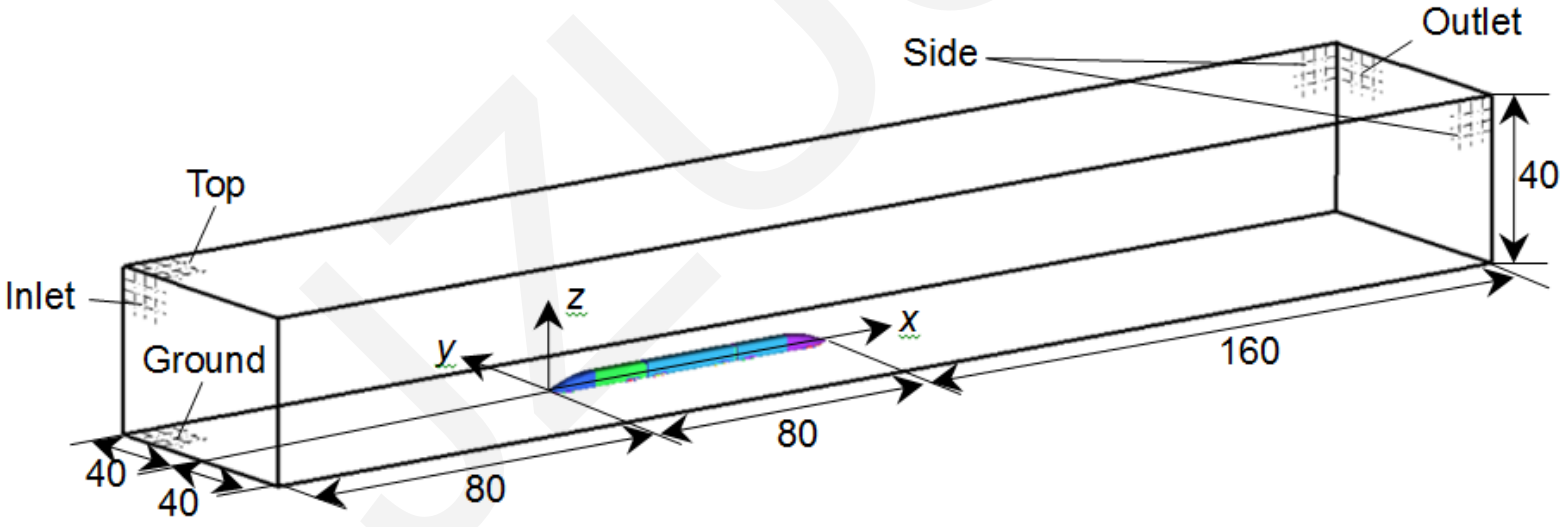


Fig. 4. Computational domain (m)

Results and Discussions

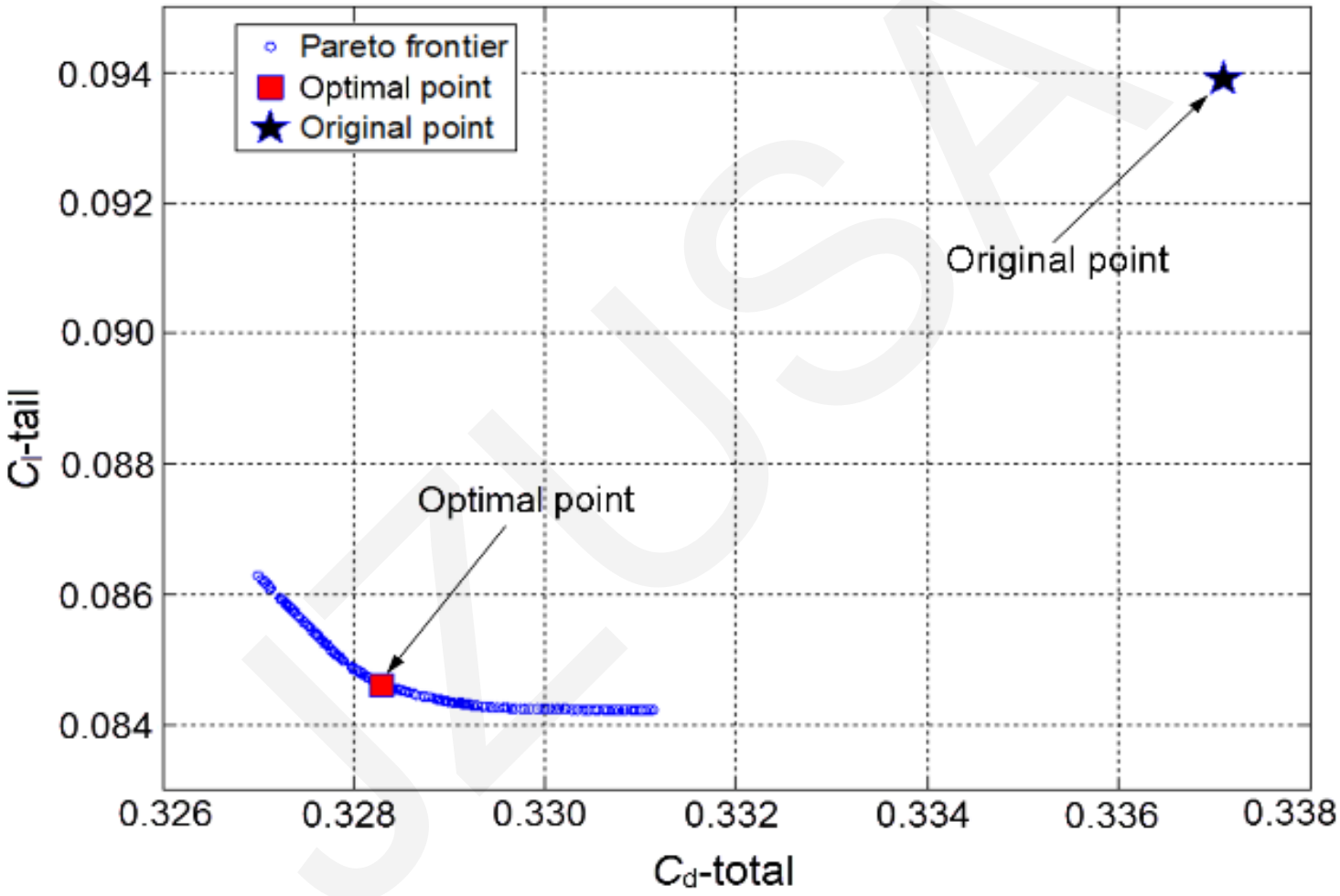


Fig. 5. Pareto front based on total C_d and C_l of the tail coach

Results and Discussions

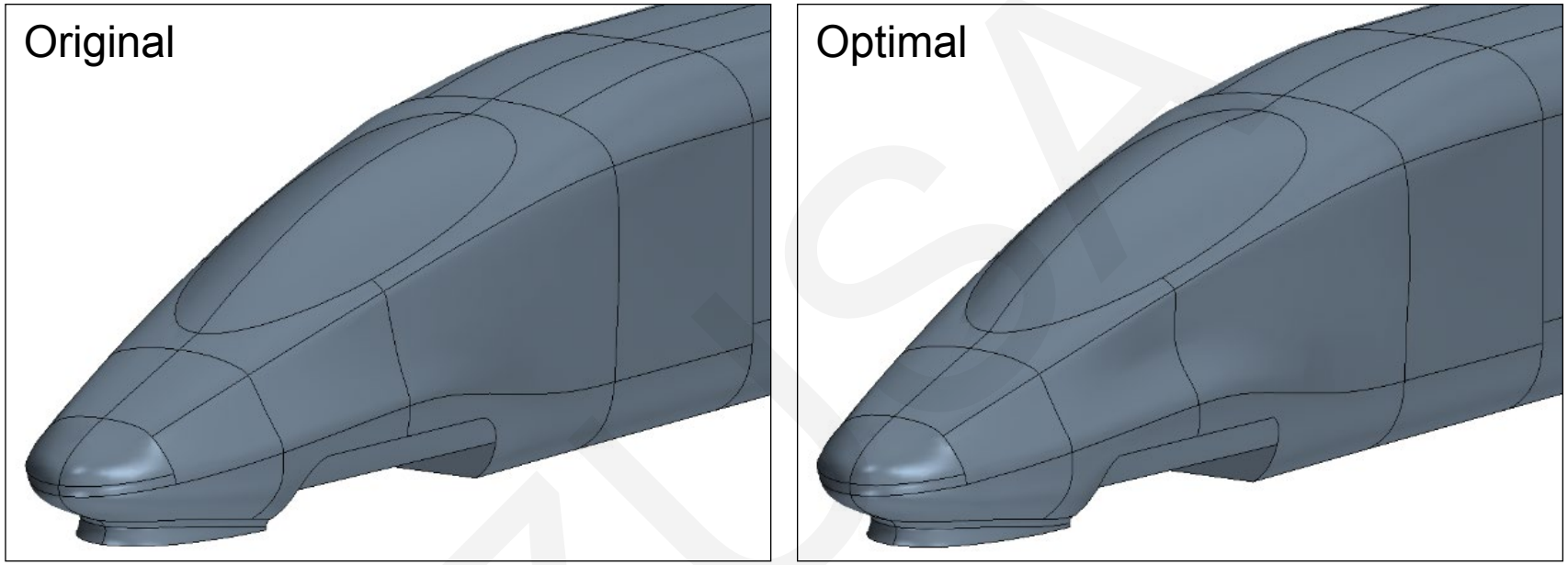


Fig. 6. Head shapes of the original train and the optimal train

Table 1. Values of design variables and optimization objectives of the original train and the optimal train

Model	zs_1	dz_2(mm)	dz_3(mm)	dy_4(mm)	ys_5	dy_6(mm)	xs_7	C_d	Tail C_l
Original train	1.000	0.0	0.0	0.0	0.0	0.0	1.0	0.3371	0.0939
Optimal train	1.026	15.4	47.1	-30.0	-0.2	0.3	0.5	0.3283	0.0846
Reduction (%)	—	—	—	—	—	—	—	2.61	9.90

Results and Discussions

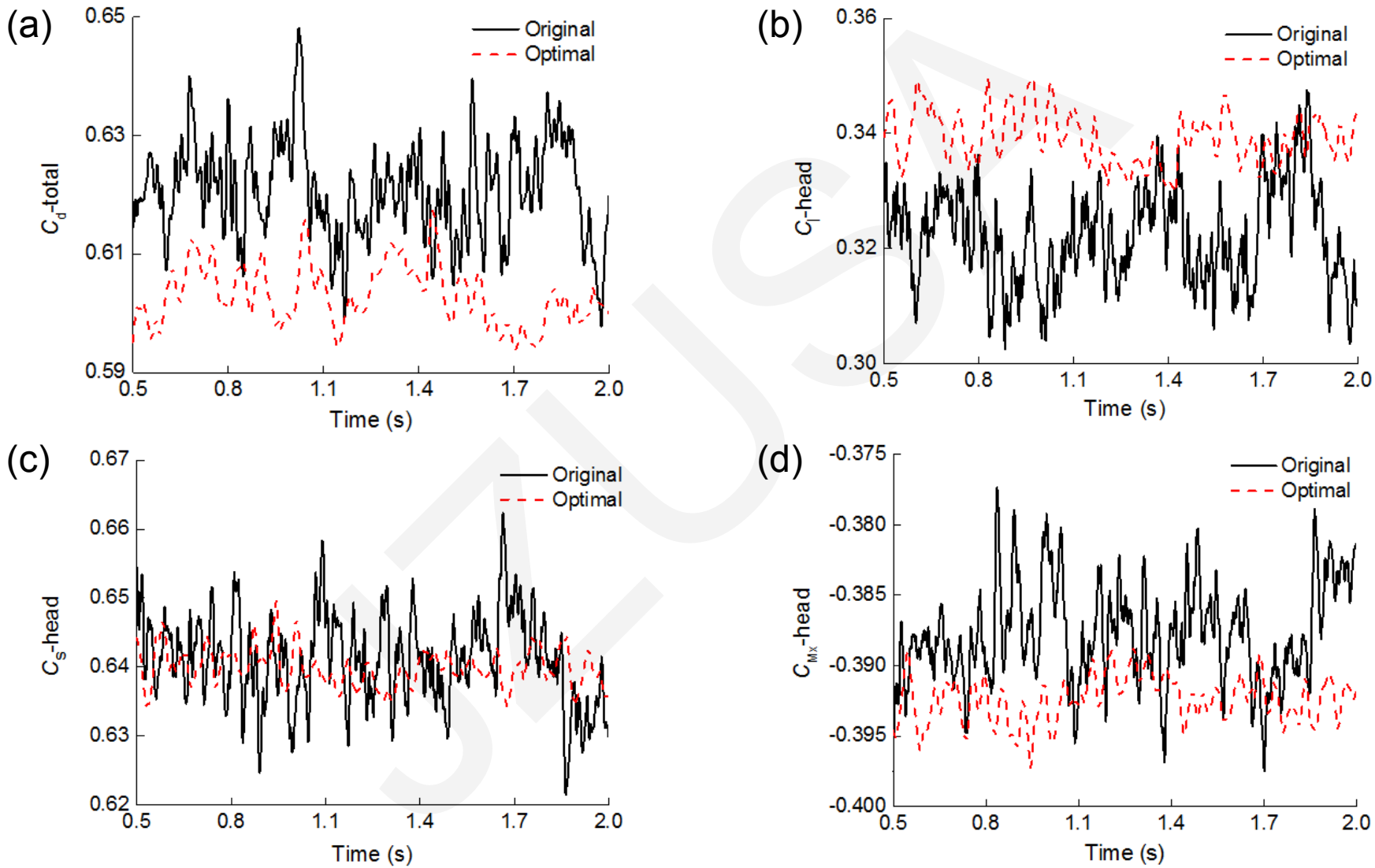


Fig. 7. Time history of C_d-total (a), C_l-head (b), C_s-head (c), C_{Mx}-head (d) in crosswind conditions before and after optimization

Conclusions

- A multi-objective aerodynamic optimization design method of a HST head shape is presented in this paper. The multi-objective aerodynamic optimization design of the HST head shape combining NSGA-II and a Kriging model was performed, taking the total aerodynamic drag coefficient (C_d) and the lift coefficient (C_l) of the tail coach as the optimization objectives. In conditions without crosswind, after optimization, the total C_d is reduced by 2.61%, and the C_l of the tail coach is reduced by 9.90%. In crosswind conditions, the total Cd is reduced by 2.98% and the side coefficient (C_s) of the head coach is slightly reduced by 0.24%. In addition, the HST with the optimal head benefits from low fluctuations of the aerodynamic loads in crosswind conditions.