Effect of low operating temperature on the aerodynamic characteristics of a high-speed train

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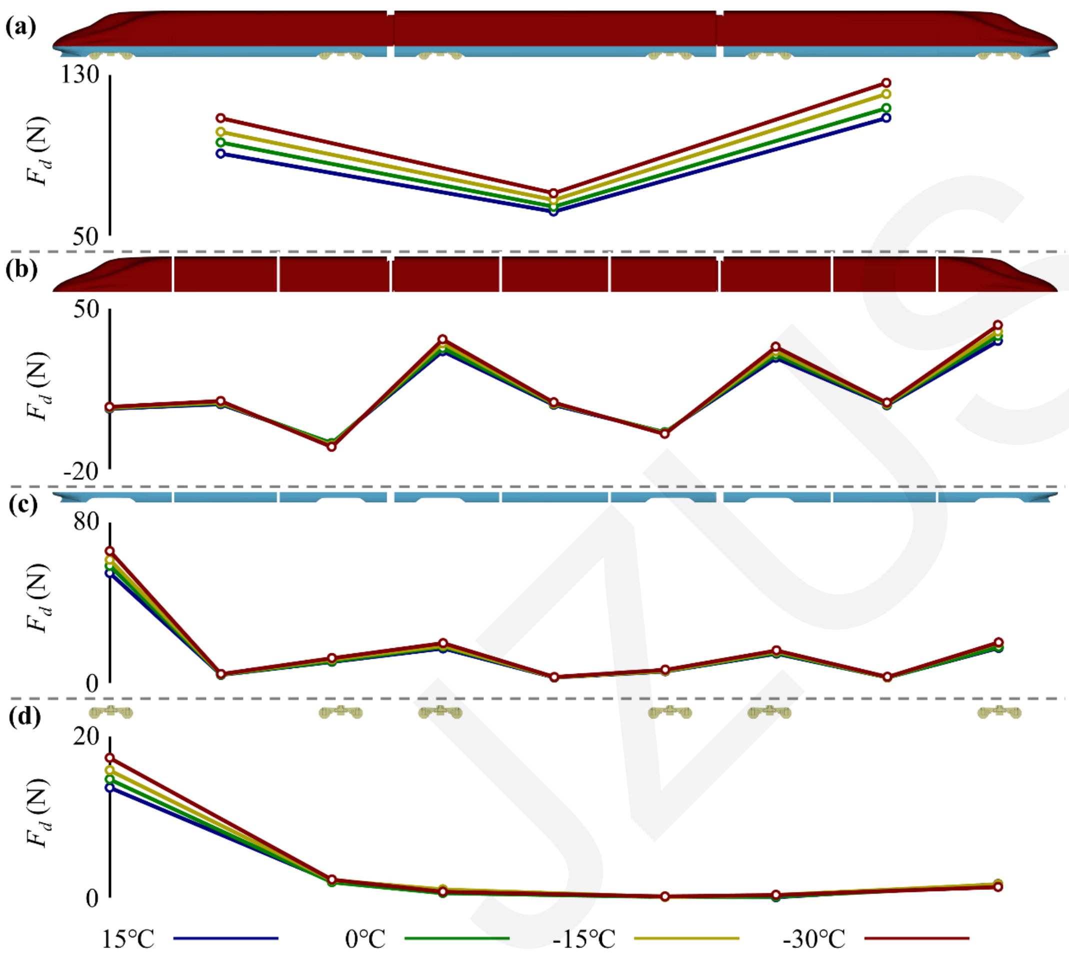
Background

In recent years, more high-speed railways have been established in snowy areas. The temperature is significantly low in winter and can even reach -30℃ and lower. The low temperature will affect the aerodynamic performance of trains.

Result and discussion



Aerodynamic drag force

- The aerodynamic drag of the whole car increases by 4.9% at 0 ℃, 10.9% at -15 ℃ and 16.9% at -30 ℃ compared to the aerodynamic drag of the HST operating at +15 ℃.

- The change in aerodynamic drag of HST at low temperatures is directly related to air density and viscosity.

Result and discussion

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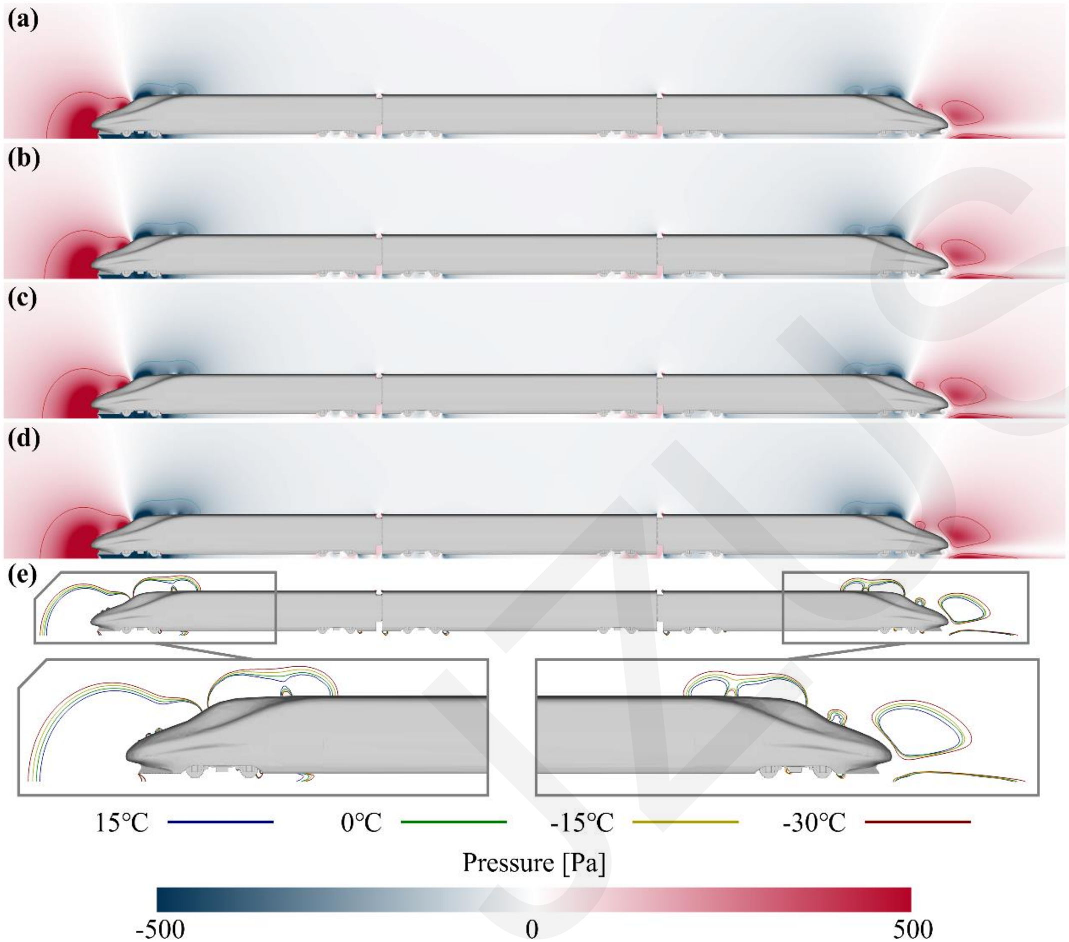

Pressure distribution

- The ambient temperature affects the pressure distribution in the flow field around the train, in which the higher the temperature the smaller the diffusion area of the positive and negative pressure distribution near the car body, and the lower the temperature the larger the diffusion area of the positive and negative pressure distribution near the car body.

Result and discussion

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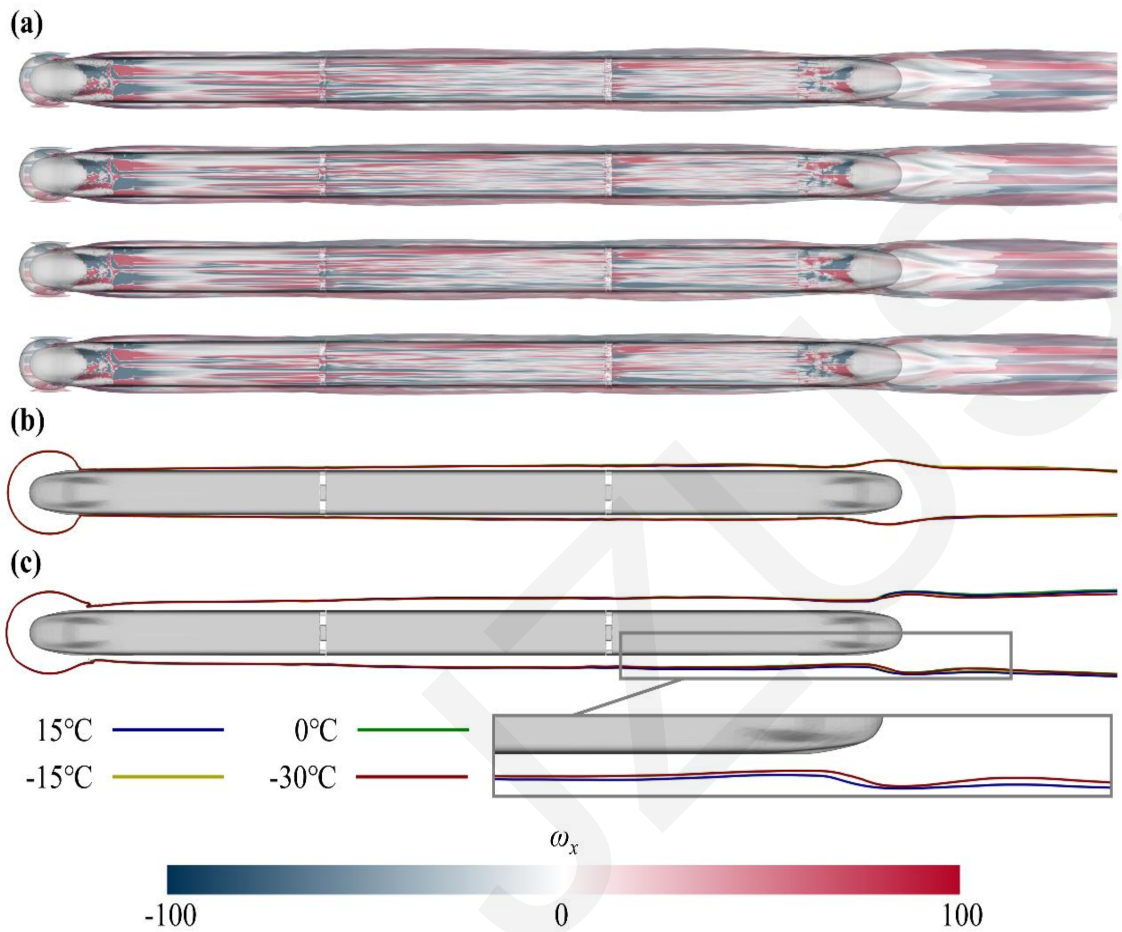
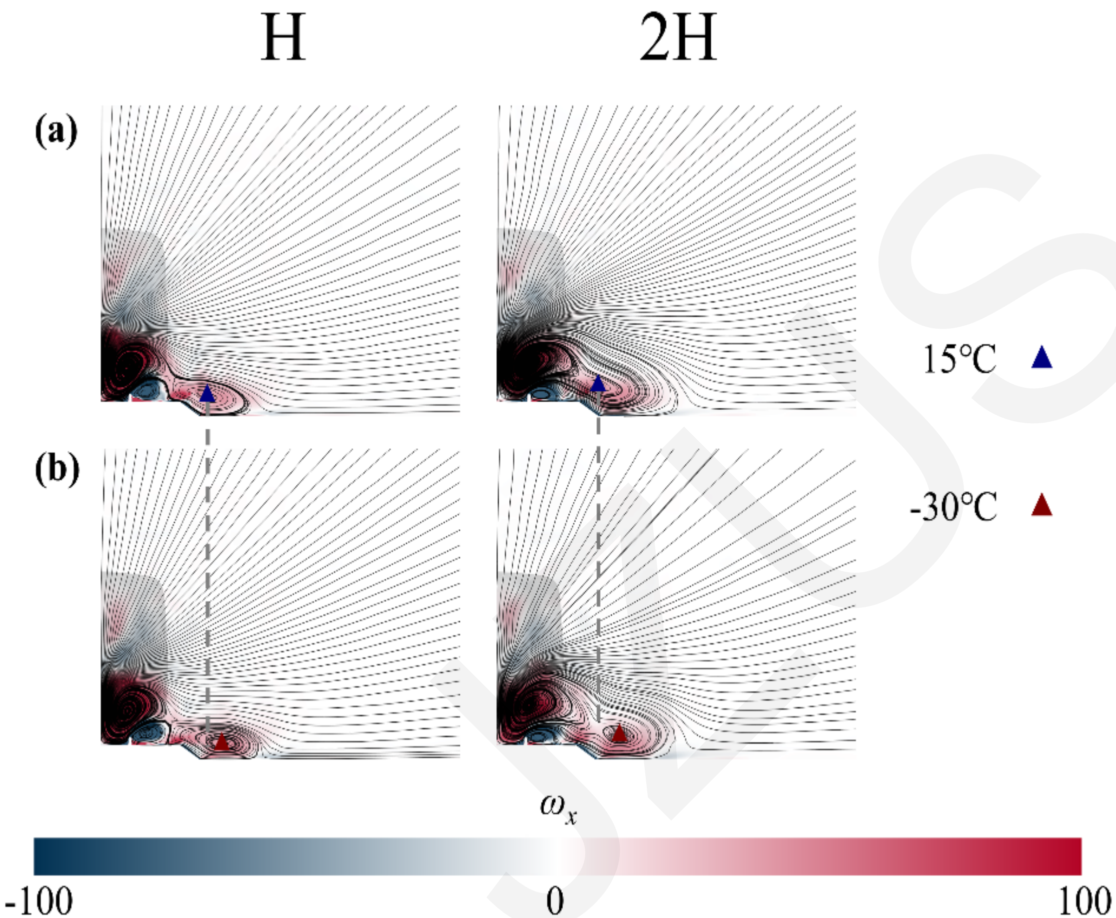


Flow round the HST

- The decrease in temperature reduces the intensity of the train-induced wind around the vehicle, leading to an inward contraction of the train-induced wind action.

- The decrease in temperature will significantly enhance the vorticity contained in the z-axis of the vortex flow, which will have a more serious impact on the wake flow at the tail of the HST.

Result and discussion



The wake flow

- The lower temperature will cause the vorticity in the wake flow of the train to increase along the direction of train operation, and the outward movement of the vortex and the core indicates that there will be more obvious vortex structures and shedding in the wake region of the HST, implying that there will be a more extensive vortex influence zone and more serious vortex influence in the tail of the HST at a lower temperature.

Conclusion

- The temperature has an effect on the operating drag force of the HST. Compared to the normal temperature of +15 ℃, the operating resistance of the HST at low temperatures increases by 4.9% (0 ℃), 10.9% (-15 ℃), and 16.9% (-30℃), respectively, mainly in hc1, hc5 and bogie1 of the head car, mc1, mc2 and mc5 of the middle car, and tc1, tc2, tc5, and tc6 of the tail car. The effect of temperature on the aerodynamic drag of HST is more serious than on the impingement and separation of surface flow.
- As the temperature decreases, both the positive and negative pressure zones in the upper body region expand significantly, and the peak value under the body increases significantly. In the bogie cavities, the windward side of the bogie, which is susceptible to airflow impact, and the rear end plate of the cavity show a significant increase in positive pressure. The pressure distribution of the flow field under the car body shows an obvious increase, and is mainly concentrated in the nose of the head car and the cowcatcher of the tail car.
- As the temperature decreases, the range of train-induced wind action around the body is significantly reduced, and the distribution area of the vorticity at the nose of the tail car produces a significant backward extension. In the lower part, the velocity of train-induced wind increased significantly with the temperature reduction and was mainly concentrated in the area susceptible to impingement flow. The airflow velocity in the bogie cavities increased significantly and was mainly concentrated in the upstream cavities.
- The wake flow of HST is affected by temperature mainly in the near region of the down-stream flow field of the car body and the bottom of the wake flow. As the temperature decreases, there is a significant decrease in the train-induced wind at the bottom of the wake flow, while there is little difference at the top. The vortex generated at the rear of the tail car expands outwards significantly, and the vorticity increases significantly too.