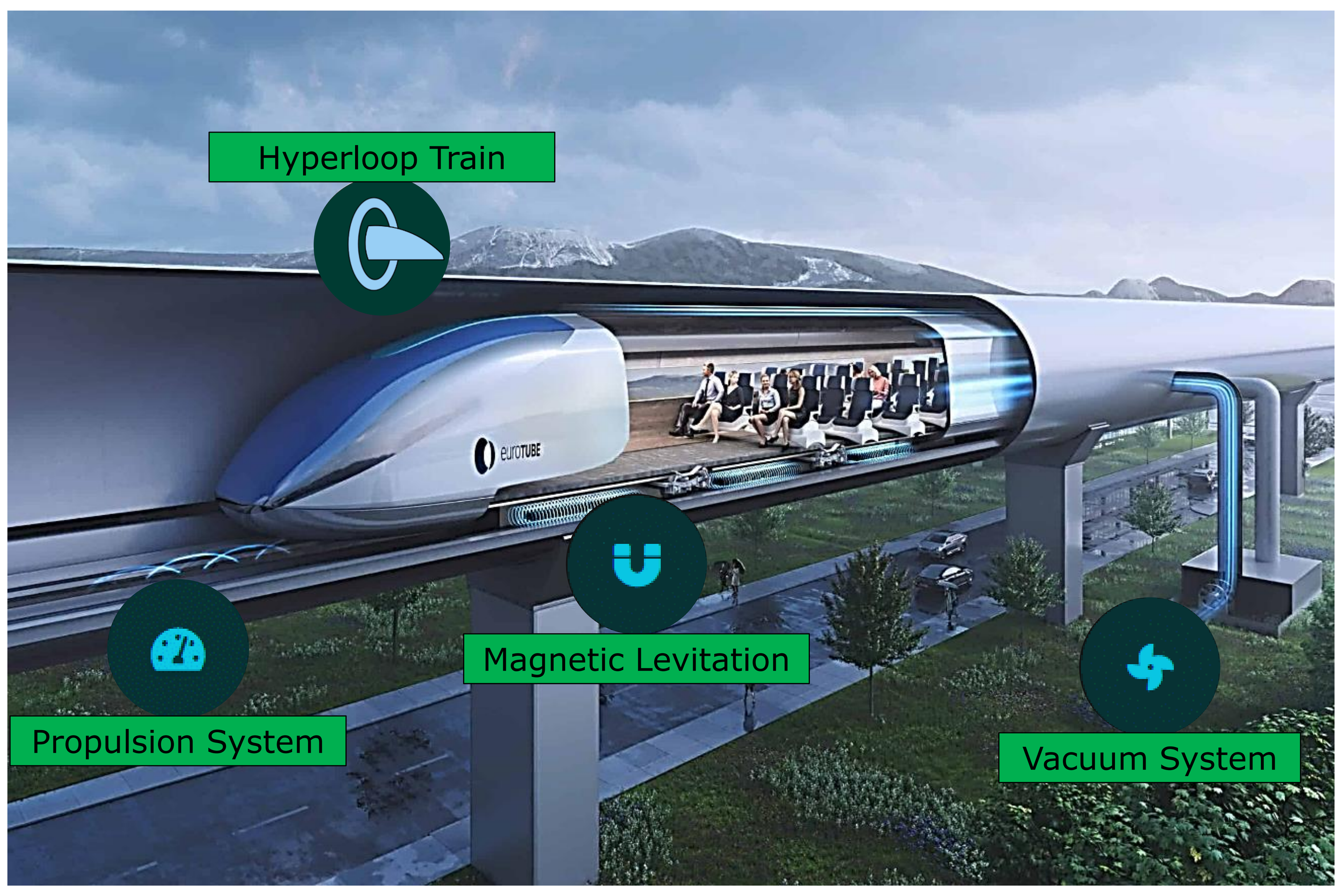
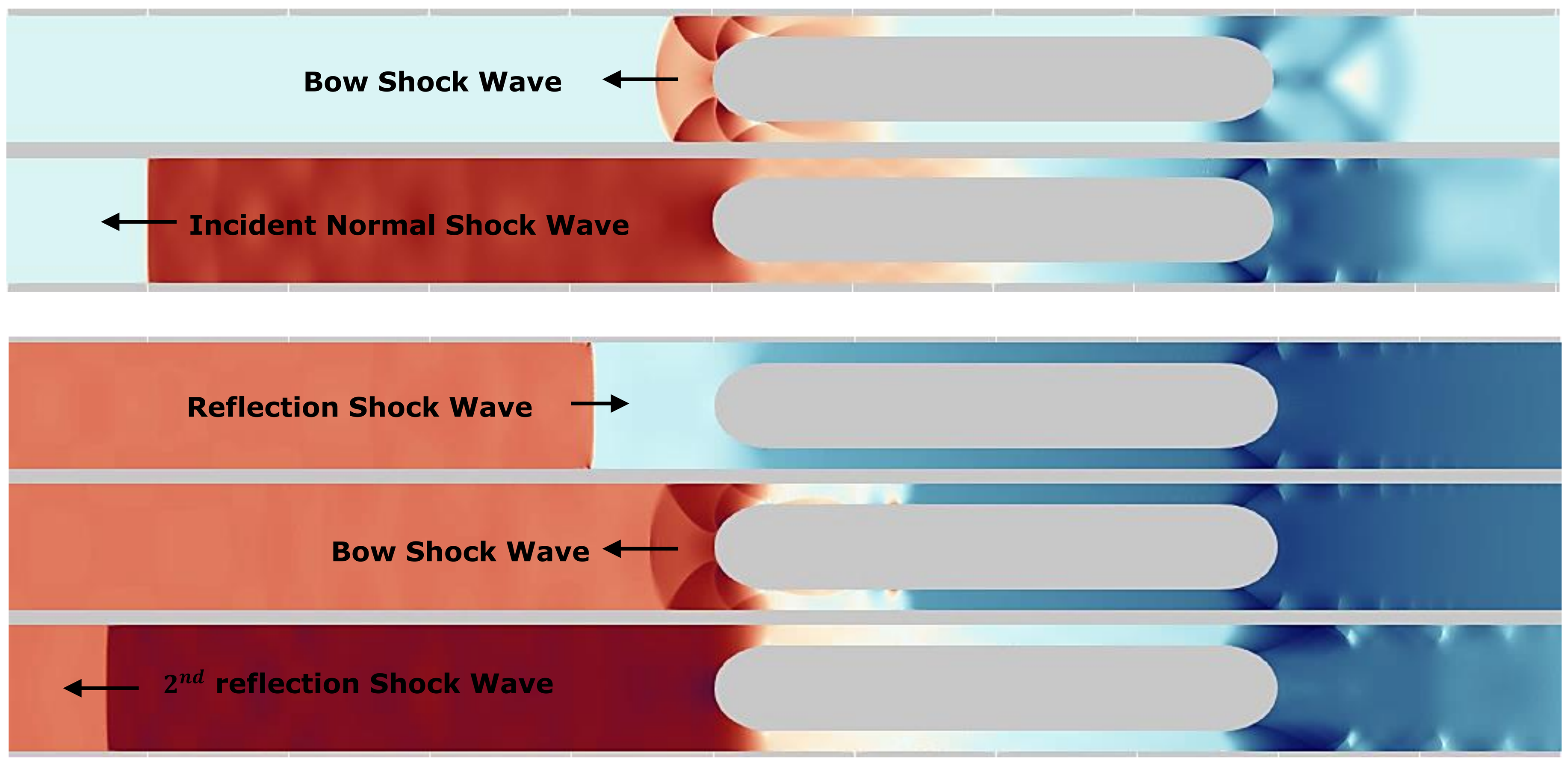
Technik & Architektur

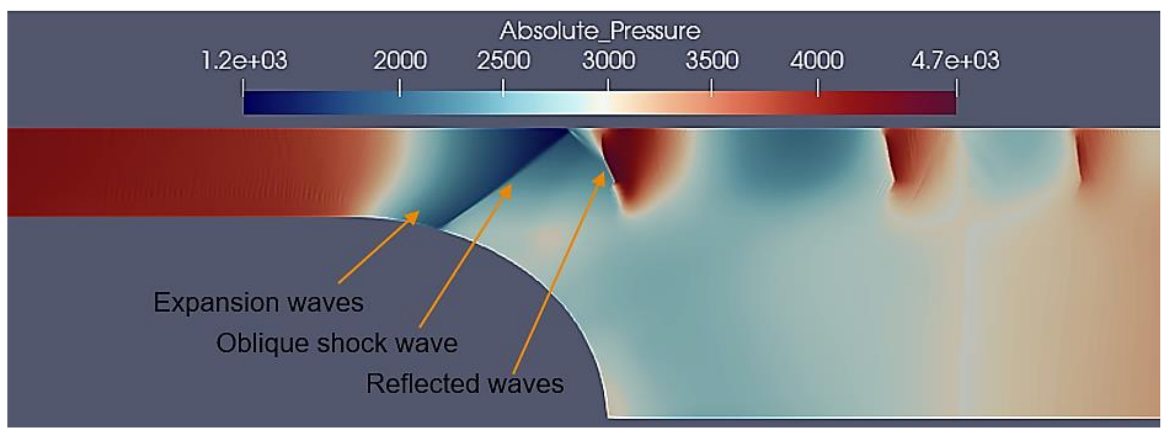
Master-Thesis Engineering-Specialization Mechanical Engineering (Fluid Mechanics)

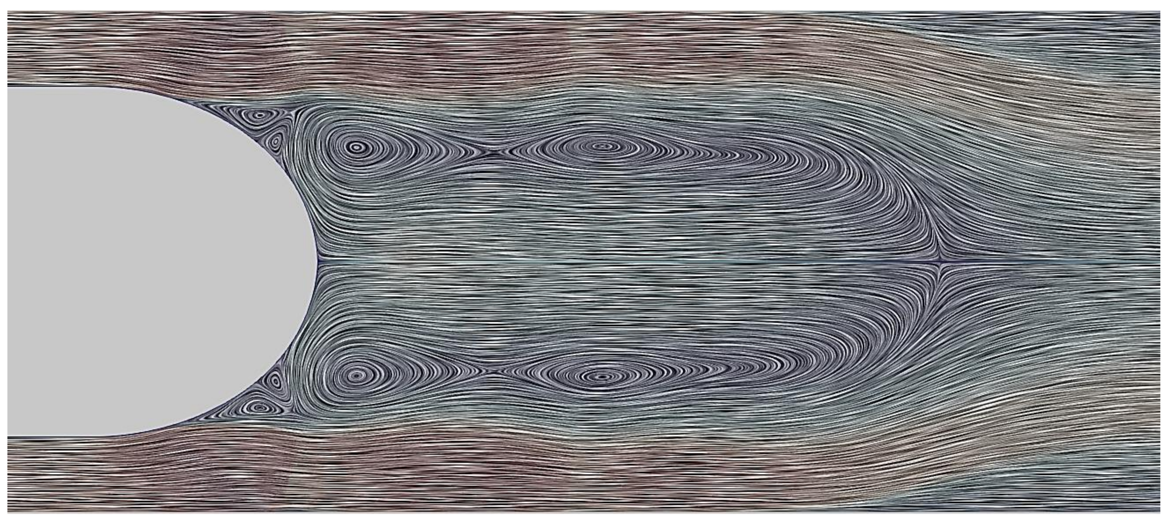
Numerical investigation of drag and vehicle instability induced by interaction between reflection shock wave and vehicle moving inside low-pressure tube.

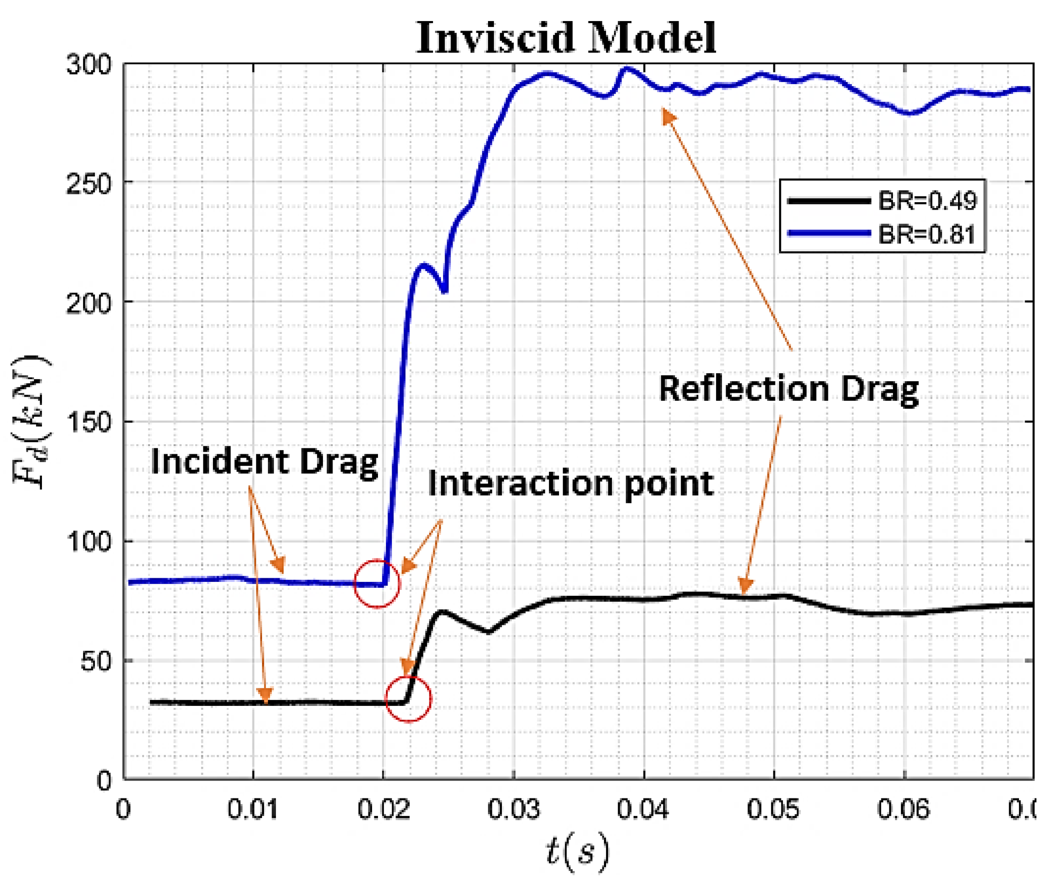


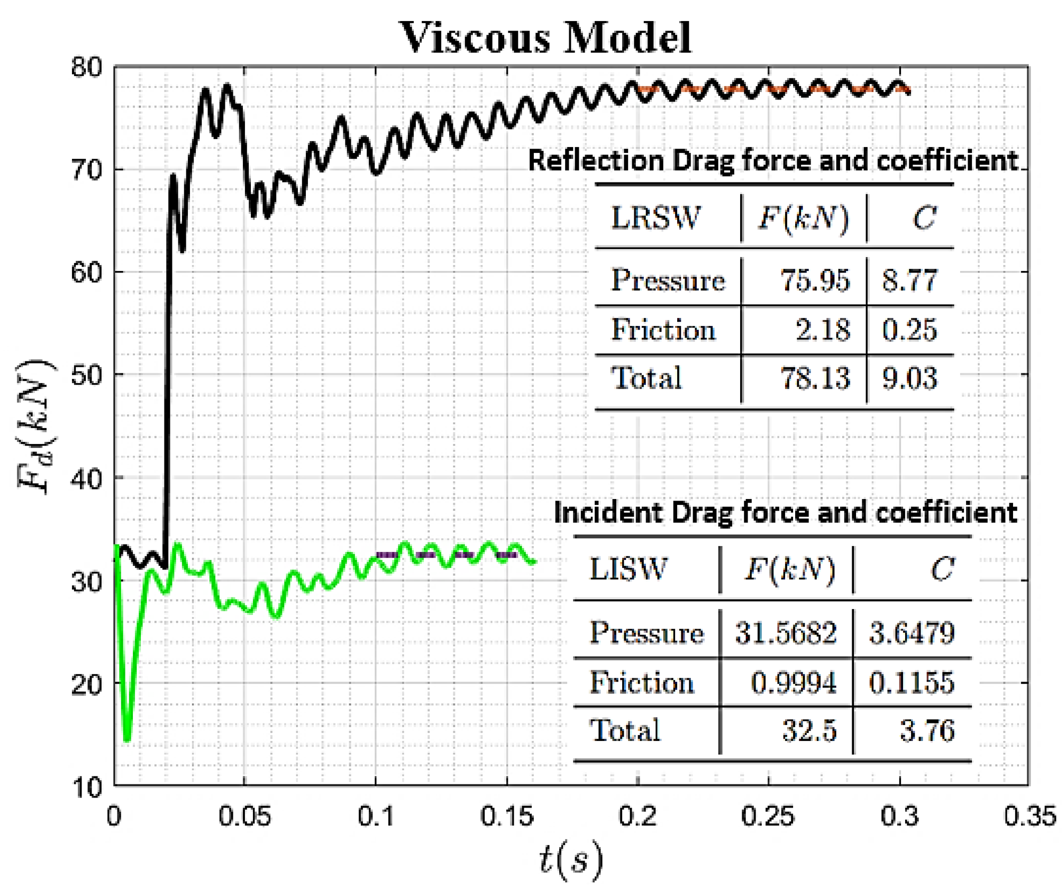
Hyperloop System (Source: www.eurotube.org)











Abstract

Hyperloop is an innovative transportation system that promises to revolutionize the way we travel. It is proposed to be high-speed transportation mode with highly efficient energy consumption. The train, which is magnetically levitated and moves with high speed inside of a low-pressure tube, is a versatile solution for various transportation needs. Although the near-vacuum condition inside of tube reduces the air friction, the compressibility effect of air, leading to generation of a normal shock wave, is being highlighted. The shock wave is formed due to chocked condition occurring at the minimum area between tube and train. This condition causes air to accumulate in front of train and increases the pressure, drag force, and instability for train. When the shock wave moves forward, it eventually reaches the tube end wall and bounces back moving towards the train. The interaction between reflection shock and train increases the pressure on the train and aerodynamic drag force.

In this thesis, we investigated the unsteady features of high-speed train's aerodynamics and quantified the drag force induced by incident shock wave and reflection shock wave.

In order to accurately capture the incident shock wave properties and drag force, a set of 2D-simulations, using inviscid and viscous models were conducted. The influence of blockage ratio on drag force, experienced by train due to incident and reflection wave, has been studied in inviscid models. A methodology was developed to capture the properties of the reflection shock wave based on the properties of the incident shock wave to ensure consistency in simulation. The drag force analysis was conducted at two stages: when the shock wave was forming and when it hit the train.

Results

The results of the analysis have indicated that the blockage ratio has a considerable influence on the drag force, as an increase in blockage ratio correlates with an increase in drag force. Additionally, due to air compression in front of train, the pressure increases, while at the back of the train, the pressure decreases due to the generation of an oblique shock wave and flow separation. The drag analysis of viscous model has indicated that the total drag mainly dependent upon pressure drag, rather than shear drag.

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MASTER OF SCIENCE IN ENGINEERING

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