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Aerodynamic Design Optimization Technique for a Tube Capsule That Uses an Axial Flow Air Compressor and an Aerostatic Bearing

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Abstract : High-speed transportation has become a growing concern. To increase high-speed efficiencies and minimize power consumption of a vehicle, we need to eliminate the friction with the ground and minimize the aerodynamic drag acting on the vehicle. Due to the complexity and high power requirements of electromagnetic levitation, we make use of the air in front of the capsule, that produces the majority of the drag, to compress it in two phases and inject a proportion of it through small nozzles to make a high-pressure air cushion to levitate the capsule. The tube is partially-evacuated so that the air pressure is optimized for maximum compressor effectiveness, optimum tube size, and minimum vacuum pump power consumption. The total relative mass flow rate of the tube air is divided into two fractions. One is by-passed to flow over the capsule body, ensuring that no chocked flow takes place. The other fraction is sucked by the compressor where it is diffused to decrease the Mach number (around 0.8) to be suitable for the compressor inlet. The air is then compressed and intercooled, then split. One fraction is expanded through a tail nozzle to contribute to generating thrust. The other is compressed again. Bleed from the two compressors is used to maintain a constant air pressure in an air tank. The air tank is used to supply air for levitation. Dividing the total mass flow rate increases the achievable speed (Kantrowitz limit), and compressing it decreases the blockage of the capsule. As a result, the aerodynamic drag on the capsule decreases. As the tube pressure decreases, the drag decreases and the capsule power requirements decrease, however, the vacuum pump consumes more power. That’s why Design optimization techniques are to be used to get the optimum values for all the design variables given specific design inputs. Aerodynamic shape optimization, Capsule and tube sizing, compressor design, diffuser and nozzle expander design and the effect of the air bearing on the aerodynamics of the capsule are to be considered. The variations of the variables are to be studied for the change of the capsule velocity and air pressure.

Keywords : tube-capsule, hyperloop, aerodynamic design optimization, air compressor, air bearing
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