Aerodynamic Levitator with Annular Jet Sealing: Concept, Geometry and Operating Principle

[Author Name]

Abstract

We present the conceptual design of an *aerodynamic levitation system* based on a circular disc that produces a sealing *air curtain* along its outer rim. Unlike hovercrafts relying on Coandă-effect skirts or drones generating lift from rotor thrust, this device uses an annular high-speed jet to confine a nearly static, high-pressure air cushion trapped between the disc and the ground. The pressurized region sustains an external load while the curtain jet minimizes leakage to the surroundings. A central air inlet compensates the residual losses, maintaining the cushion pressure in steady equilibrium. This paper describes the geometry, operating principle, characteristic parameters, and design guidelines of the system.

1 Introduction

Conventional levitation or hovering devices produce lift either by redirecting large air masses downward (drones, propellers) or by sealing a pressurized cushion with flexible skirts (hovercrafts). The present concept introduces a different principle: the lift arises from a static overpressure trapped under a rigid disc, where the leakage is dynamically minimized by a thin annular high-speed jet forming a *vertical air curtain*. The curtain acts as a fluidic barrier, reducing communication between the inner cushion and the external environment. The resulting pressure field supports the load with minimal downward mass flux.

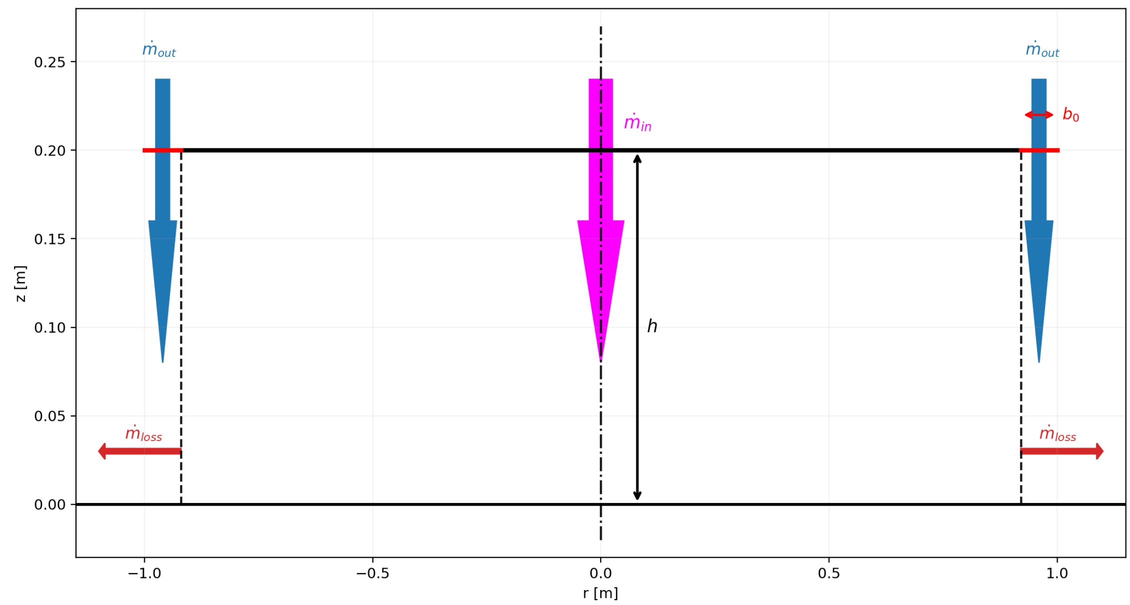

Figure 1 – Schematic of the aerodynamic levitation system: the outer annular air curtain seals the internal cushion; a central inlet compensates the leakage.

2 System Description and Operating Principle

2.1 Geometry

The system consists of a circular disc of outer radius R hovering above a flat surface at a mean clearance h, with h of the same order of magnitude as R. An annular slot of width b_0 is located near the periphery, at $r \approx R_o \simeq R$, and connected to a circular impeller or blower that feeds a downward high-speed jet of mean velocity U_0 and density ρ. The jet forms a *vertical curtain* along the disc edge, which impinges on the ground and partly turns radially outward. The region enclosed by the curtain ($r < R_i$) forms the *cushion chamber*, whose mean pressure $p_c = p_\infty + \Delta p$ is greater than ambient. A central inlet supplies a make-up flow $\dot{m}_{in}$ to compensate the residual losses $\dot{m}_{loss}$ leaking through the curtain and the side gap. Figure 1 illustrates the layout and main parameters.

2.2 Operating Mechanism

1. The annular impeller accelerates air through the peripheral slot, creating a jet with local momentum per unit circumference

$$J = \rho U_0^2 b_0 \quad [\mathrm{N/m}]. \tag{1}$$

   This jet descends nearly vertically and interacts with the ground, generating a high-momentum barrier.

2. The barrier strongly limits the outflow from the inner cushion. The rate of leakage $\dot{m}_{loss}$ decreases with increasing J, since the curtain resists entrainment and backflow.

3. The central inlet injects the make-up flow $\dot{m}_{in}$, which maintains the balance

$$\dot{m}_{in} = \dot{m}_{loss}(\Delta p,\ h,\ J), \tag{2}$$

   determining a steady cushion pressure Δp.

4. The upward lift force is then

$$F_L = \Delta p\, A_i = \Delta p\, \pi R_i^2, \tag{3}$$

   which supports the disc and the carried load.

2.3 Governing Parameters

Key relationships for estimation include:

- Jet mass flow rate:

$$\dot{m}_{jet} = 2\pi R_o \rho U_0 b_0. \tag{4}$$

- Leakage flow (without curtain, approximated as a turbulent annular orifice):

$$\dot{m}_{leak,0} \approx 2\pi R \rho C_d h \sqrt{\frac{2\Delta p}{\rho}}, \tag{5}$$

  where C_d is a discharge coefficient.

- The curtain effectively reduces the leakage by a factor depending on the non-dimensional *sealing number*

$$S = \frac{J}{\rho \Delta p h}, \tag{6}$$

  which measures the ratio between the jet momentum and the pressure-driven leakage momentum. For $S \gg 1$, the seal is effective and $\dot{m}_{loss} \ll \dot{m}_{leak,0}$.

2.4 Design Guidelines

- **Gap height h:** too large increases leakage; too small risks instability and contact. Practical ratios are $h/R = 0.05$–0.3.
- **Slot width b_0:** kept small (millimetric scale) to maximize U_0 for a given jet mass flow.
- **Jet inclination:** a slight inward tilt (a few degrees) helps pressurize the inner region and reduce entrainment, avoiding a strong Coandă effect.
- **Pressure and lift:** the equilibrium overpressure scales with $\Delta p \sim J/(h\rho)$ for strong curtains, allowing significant lift with modest power.
- **Power balance:** the jet power $P_{jet} \sim \dot{m}_{jet} U_0^2/2$ and the make-up power $P_c \sim \dot{m}_{in} \Delta p/\rho$ determine the global efficiency.
- **Stability:** small perturbations in h induce restoring pressure gradients (if one side approaches the ground, local Δp rises), yielding passive self-leveling.

2.5 Comparison with Existing Systems

- **Versus drones:** lift is not generated by downward acceleration of large air masses but by static overpressure.
- **Versus hovercrafts:** no flexible skirt or Coandă adhesion is used; the curtain provides a fluidic seal.
- **Advantages:** uniform lift distribution, reduced mechanical complexity, potentially quieter and more efficient operation at close ground distances.

3 Conclusions

The proposed aerodynamic levitator uses a jet-induced air curtain to dynamically seal a confined air cushion under a circular disc. The system decouples the functions of *sealing* (provided by the annular jet) and *pressurization* (from the central inlet), allowing the lift and stability to be controlled independently. By tuning the jet momentum, gap height, and make-up flow, it is possible to sustain significant loads with modest flow rates. Future work will focus on experimental validation, optimization of the curtain geometry, and analysis of stability and noise performance.