IJMRT: Volume (7), Issue 5, 2025
International Journal of Multidisciplinary Research Transactions
(A Peer Reviewed Journal)
www.ijmrt.in
ISSN (Print):2663-2381
ISSN(Online):2663-4007

Design and Fabrication of Contactless Conveyor using Air Pressure

Keerthi B L[1*], Chandan R[2], Keerthi A N[3], Poornachandra H[4]

[1]Assistant Professor, Adichunchanagiri University, Faculty of Engineering Management & Technology, BGS Institute of Technology, BG Nagara, India.
[2,3,4]Student, Adichunchanagiri University, Faculty of Engineering Management & Technology, BGS Institute of Technology, BG Nagara

Corresponding Author*
DoI: https://doi.org/10.5281/zenodo.15505290

Abstract

This study presents the design, fabrication, and testing of a contactless air conveyor system that employs pressurized air to achieve non-contact transportation of lightweight objects. The prototype features a perforated fiberglass sheet and a centrifugal blower, generating a thin air film to levitate and move flat objects weighing up to 100 grams. Experimental results demonstrate stable levitation at a 0.5 mm air gap, low energy consumption (55W), and suitability for hygienic applications in pharmaceuticals, food processing, and electronics. Advantages include reduced contamination, minimal maintenance, and enhanced product longevity. Limitations, such as load capacity constraints and environmental sensitivity, highlight areas for improvement. This work underscores the potential of air-based conveyors as a clean, efficient alternative to traditional systems, with recommendations for scalability and advanced control integration.

Keywords: Word Contactless Conveyor, Air Film, Non-Contact Handling, Pneumatic Transport, Material Handling.

1. Introduction

Introduction In today's fast-paced manufacturing landscape, the demand for clean, efficient, and damage-free material handling systems is critical. Traditional conveyors, such as belt and roller systems, involve mechanical contact that can cause wear, contamination, or damage, particularly for delicate products in industries like pharmaceuticals, food processing, and semiconductor manufacturing. These challenges necessitate innovative solutions that prioritize hygiene, precision, and operational efficiency.

Contactless air conveyors address these issues by using pressurized air to create a thin film that levitates and transports objects without physical contact. This eliminates friction, reduces contamination risks, and minimizes maintenance needs. The presented study focuses on the development and evaluation of a contactless air conveyor prototype designed to transport lightweight, flat objects using air pressure. The system aims to offer a cost-effective, energy-efficient alternative to conventional conveyors, with potential applications in automation and cleanroom environments.

The objectives of this project are:

To design and fabricate a functional contactless conveyor using air film technology.

To achieve stable, non-contact transport of objects weighing up to 100 grams.

To minimize contamination, friction, and maintenance compared to traditional conveyors.

To explore integration with smart manufacturing systems.

2. Literature Review

The development of contactless conveyors builds on decades of research in pneumatic transport, fluid dynamics, and non-contact handling systems. Zhong et al. (2017) investigated air film conveyors for large glass substrates, demonstrating that reduced clearance enhances lifting force and pressure distribution, a principle applied in this prototype. Brun and

Melkote(2008) developed a Reynolds-stress model for Bernoulli grippers, emphasizing airflow control for stable levitation. Li et al. (2016) designed pneumatic suckers with rotational airflow, proving effective for rough surfaces, which informs the handling of varied object textures. Fan et al. (2002) explored microhole aerostatic bearings, highlighting the role of surface finish in maintaining consistent air films. Chandra et al. (1990) used finite element analysis to optimize air hole patterns, guiding the pressure distribution strategy in this study.

These studies collectively underscore the importance of precise airflow management, hole geometry, and surface design in air-based systems. This project extends these findings by developing a low-cost, scalable prototype tailored for lightweight objects, with applications in hygienic and precision industries.

3. Methodology

3.1. Problem Definition

Traditional conveyors suffer from several limitations, including wear and tear, contamination risks, high maintenance costs, and inefficiency in handling delicate or sterile objects. The project aimed to address these challenges by designing a contactless air conveyor with the following requirements

- Non-contact transportation to eliminate friction and contamination.
- Low energy consumption for cost-effective operation.
- Compatibility with lightweight, flat objects (up to 100 grams).
- Simple and affordable fabrication for scalability.

3.1 Conceptual Design

The system employs a perforated fiberglass sheet (150 mm × 600 mm) with 138 circular holes (3 mm diameter) arranged in a square pitch pattern. A centrifugal blower (55W, 220V, 2200 RPM) generates pressurized air, creating a thin air film to levitate and propel objects. The design incorporates a stainless steel frame, a sealed air plenum chamber, and precise ducting to minimize air leakage. The hole pattern ensures uniform airflow, while the blower's static pressure (85–90 Pa) supports stable levitation.

3.3 Mathematical

Modeling Key parameters were calculated using fluid dynamics principles to ensure effective levitation and motion:

Pressure (P): $P = F/A$, where $F = m \cdot g$ (force), m is object mass, $g = 9.81\ m/s^2$, and A is object area. For a 100 g object with $A = 0.01\ m^2$, $P = 98.1$ Pa.

Air Velocity (v): $v = \sqrt{(2gh)}$, where $h = 0.003$ m (hole height), yielding $v = 0.767$ m/s.

Flow Rate (Q): $Q = A \cdot v$, where $A = 7.0685 \times 10^{-6}\ m^2$ (hole area), resulting in $Q = 5.894 \times 10^{-6}\ m^3/s$ per hole.

Hole Diameter (D): $D = \sqrt{((4Q)/(\pi v))} \approx 3$ mm, confirming the chosen hole size.

These calculations ensured the blower's pressure matched the required lift for 100 g objects, with a safety margin for lighter loads.

3.4. Fabrication

The prototype was modeled in CATIA V5 for precise component design. Fabrication involved:

Top Sheet: Perforated fiberglass (150 mm × 600 mm, 138 holes, 3 mm diameter).

Frame: Welded stainless steel for strength and corrosion resistance.

Air Plenum: Sealed mild steel chamber for pressure equalization.

Blower: 55W centrifugal unit delivering 85–90 Pa.

Fasteners: Stainless steel screws and gaskets for airtight assembly.

Steps included precision drilling of the fiberglass sheet, welding the frame, assembling the blower with aligned ducting, and sealing to prevent air leakage. The process ensured structural integrity and uniform airflow.

3.5. ExperimentalSetup

Testing was conducted in a controlled laboratory environment using lightweight objects (plastic lids, paper sheets, foam blocks) weighing up to 100 grams. The setup included:

Perforated fiberglass sheet mounted on the frame.

Blower connected to the air plenum.

Infrared sensors and timers to measure levitation height, transport time, and stability over a 600 mm path.

Table.1. Prototype Specifications

Component	**Specification**
Top Sheet	Fiberglass, 150 mm × 600 mm, 138 holes (3 mm)
Blower	55W, 220V, 2200 RPM, 85–90 Pa
Frame	Stainless steel, welded
Air Plenum	Sealed mild steel chamber
Test Objects	Plastic lids, paper sheets, foam blocks (≤100 g)

3.5.1. Tests Evaluated

Levitation height vs. blower speed.

Transport time for different object shapes (square, rectangular, circular).

Stability under varying weights (50–100 grams).

4. Results

4.1. Performance Metrics

The prototype achieved the following:

Levitation Height: Stable air cushion at approximately 0.5 mm, sufficient for non-contact transport.

Transport Time: Objects traveled 600 mm in 3–5 seconds, with square and rectangular shapes moving faster than circular ones.

Stability: Flat-bottomed objects exhibited minimal lateral drift, indicating uniform air distribution.

Energy Consumption: Continuous operation consumed 55W (0.055 kWh/hour), aligning with energy-efficient design goals.

4.2. Observations

Objects up to 100 grams levitated consistently at 85–90 Pa, with a calculated lift pressure of 98.1 Pa for 100 g.

Flat-bottomed square and rectangular objects showed high directional stability; circular objects exhibited slight instability due to uneven air cushion interaction.

External air currents and vibrations from nearby equipment slightly affected object stability, highlighting environmental sensitivity.

Lighter objects (50 g) moved faster but required precise pressure control to prevent drift.

4.3. Applications

The system demonstrated potential for:

Pharmaceuticals: Transporting sterile containers and blister packs without contamination.

Food Processing: Handling packaging materials like plastic lids and trays hygienically.

Electronics: Moving printed circuit boards (PCBs) and silicon wafers to reduce mechanical stress.

Recycling: Sorting lightweight materials such as plastic flakes and paper efficiently.

Cleanroom Automation: Supporting particle-free transport in controlled environments.

Discussion The contactless air conveyor successfully demonstrated non-contact transport, addressing key limitations of traditional conveyors. Its primary advantages include.

Hygienic Operation: Eliminates contamination from mechanical contact, ideal for sterile environments.

Low Maintenance: Absence of moving parts like belts or rollers reduces wear and downtime.

Energy Efficiency: Modest power requirements (55W) compared to conventional systems.

Versatility: Handles a range of lightweight, flat-bottomed objects with minimal adjustment.

However, several challenges were identified.

Load Capacity: Limited to 100 grams with the current blower; heavier objects require higher pressure or larger systems.

Environmental Sensitivity: External air currents and vibrations disrupted stability, necessitating controlled environments.

Shape Constraints: Optimal performance with flat-bottomed objects; irregular or curved surfaces caused uneven lift.

Speed Limitations: Air-driven motion restricts transport speed compared to belt conveyors.

These limitations suggest the need for advanced control systems, stronger blowers, and environmental shielding to enhance versatility and scalability. The prototype's success in achieving stable levitation and transport validates the feasibility of air-based conveyors for niche applications, particularly where hygiene and precision are critical.

5. Challenges and Limitations

5.1. Technical Challenges

Air Film Uniformity: Slight variations in hole alignment or blower pressure caused object tilting or instability, requiring precise fabrication.

Precision Flow Control: Manual airflow tuning was time-consuming; advanced control systems (e.g., PID controllers) are needed for automation.

Air Leakage: Small gaps in the plenum or sheet mounts led to pressure drops, necessitating high-quality sealing.

5.2. Environmental Challenges

Sensitivity to Airflow: Ambient air currents from fans or open windows altered object movement.

Vibration Effects: Nearby equipment vibrations destabilized levitated objects, emphasizing the need for isolation.

Noise Generation: The blower produced noticeable noise, potentially problematic in quiet environments like cleanrooms.

5.3. Operational Limitations

Load Capacity: Limited to 100 grams; heavier objects require upgraded blowers.

Surface Compatibility: Best suited for flat-bottomed objects; irregular shapes reduced performance.

Continuous Power Demand: Blower operation requires constant power, with no redundancy in the current design.

6. Conclusions

This study developed and evaluated a contactless air conveyor prototype that leverages air film technology to achieve clean, efficient, and non-contact transport of lightweight objects. Experimental results confirmed stable levitation and movement of objects up to 100 grams, with a 0.5 mm air gap, low energy consumption (55W), and minimal maintenance requirements. The system's hygienic operation and compatibility with flat-bottomed objects make it suitable for industries such as pharmaceuticals, food processing, electronics, and cleanroom automation.

Despite its success, the prototype revealed limitations, including load capacity constraints, environmental sensitivity, and shape-specific performance. Addressing these through advanced control systems, stronger blowers, and environmental shielding could enhance its applicability. This project contributes to the growing field of non-contact material handling, offering a scalable foundation for future innovations in smart manufacturing.

Recommendations To improve performance and broaden applicability, the following are recommended:

Load Capacity Enhancement: Use higher-pressure blowers or optimized hole patterns to support heavier objects.

Adaptive Control Systems: Integrate sensors and PID controllers for dynamic airflow adjustment based on object characteristics.

Environmental Isolation: Design enclosures or shields to mitigate external airflow and vibrations.

Material Optimization: Explore nano-coatings or porous ceramics for improved air distribution and reduced energy use.

Scalability: Develop modular designs for large-scale or multi-lane applications.

Energy Efficiency: Implement variable frequency drives (VFDs) to optimize blower operation.

Industry Testing: Collaborate with industrial partners for real-world validation and feedback.

Comprehensive Testing: Evaluate performance with diverse object shapes, sizes, and materials to refine versatility.

REFERENCES

[1]. Zhong W, Xu K, Li X, Kagawa T. Study on the basic characteristics of a noncontact air conveyor for large glass sheets. AdvMech Eng. 2017;9:1–10. doi:10.1177/1687814017697190.

[2]. Brun XF, Melkote SN. Modeling and prediction of the flow, pressure, and holding force generated by a Bernoulli handling device. J ManufSci E-Trans ASME. 2008;131:351–358.

[3]. Li X, Zhong W, Kagawa T, Liu H, Tao G. Development of a pneumatic sucker for gripping workpieces with rough surface. IEEE Trans AutomSci Eng. 2016;13:639–646.

[4]. Fan KC, Ho CC, Mou JI. Development of a multiple-microhole aerostatic air bearing system. J MicromechMicroeng. 2002;12:636–643. doi:10.1088/0960-1317/12/5/319.

[5]. Chandra CJG, Spinivas YL, Seetharamu KN, Parameswaran MA. Investigation of air film conveyor pressurized through multiple holes. Finite Elem Anal Des. 1990;6:235–243. doi:10.1016/0168-874X(90)90029-E.