TEAM
058

# Air Purification Scrubber Column

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## Objective of the Project

The objective of this project is to design, build, and validate a compact wet-scrubbing system capable of achieving **≥85% particulate removal** and **≥30% $CO_2$ reduction** while operating within strict limits on **footprint, pressure drop, noise, power, cost, and maintenance time**. This objective directly addresses the need for a sustainable, low-cost, and low-maintenance alternative to traditional air-filtration technologies in industrial and indoor environments.

## Prototype Development

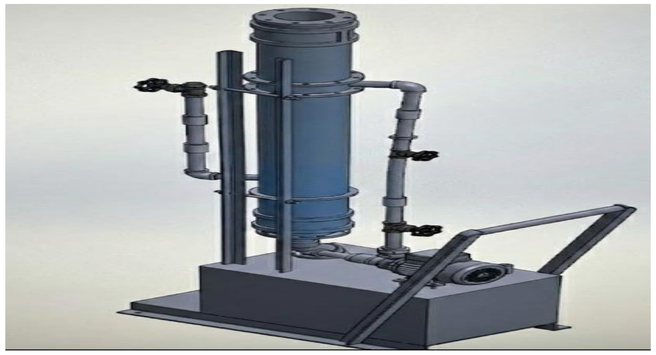
Our prototype integrates:

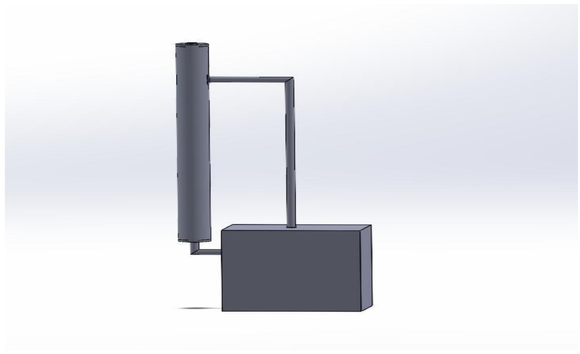
- Wet-scrubbing column (1 m, packed with 3 mm Raschig rings)
- Water-recycle tank & pump
- Air compressor (controlled airflow)
- Demister (40 mm, 0.08 m² face area)
- Sensors for $CO_2$, PM, noise, and pH

All components operate together as a **fully functional system**, achieving stable flow, low ΔP, low carryover, and continuous wetting.

## Constraints & Specifications

| Spec / Constraint | Evidence |
|---|---|
| **L/G Ratio Requirement** | L/G ≥ 1.0 L/m$^3$. Calculated: **250 L/m$^3$** |
| **Pressure Drop Limit** | Requirement: ≤120 Pa. Calculated ΔP: **0.012–0.094 Pa**, stress test 68.7 Pa |
| **System Weight** | Maximum allowed: 55 kg. Measured: **45.5 kg** |
| **$CO_2$ Reduction** | Requirement: ≥30%. Achieved: **36.28%** |
| **PM Reduction** | Requirement: ≥85%. Achieved |
| **Footprint / Space Limit** | System footprint ≤4 m$^2$. Actual ≈ **0.42 m$^2$** |
| **Budget Constraint** | Requirement ≤6,000 SAR. System **within budget** =3600 SAR |
| **Water Recycling Efficiency** | Requirement ≥60%. Achieved **≥60%** |
| **Consumables Cost** | ≤100 SAR/month. Actual: **very low (<100 SAR)** |
| **User Maintenance Time** | ≤30 min. Predicted maintenance time **<30 min** |
| **Water pH Acceptance** | pH between 6–8. Operating pH: **7** |
| **Cost Reduction vs HEPA** | Required ≥60% savings. Achieved **65.9%** |
| **Power Consumption** | ≤1800 W. Total = **1700 W** |
| **Air Flow Rate** | ≤100 m$^3$/h. Actual = **9.6 m$^3$/h** |
| **Noise Level** | ≤60 dB(A). Measured: **≈60 dB(A)** |





## Testing & Validation

**1-Test Setup:**

- **Airflow**: 9.6 m³/h
- **water flow**: 5 L/min
- **Packing**: stainless Raschig rings (3 mm)
- **Demister**: 40 mm thickness
- Water **recycle loop**

**2-Validation Results:**

- **PM Removal:** >85%
- **Pressure Drop:** 0.012–0.094 Pa (max 68.7 Pa under stress)
- **Carryover:** ≤0.2 mL/m³
- **Power:** 1700 W ≤ 1800 W
- **Water Recycling:** ≥60% recovery limits.

## Conclusion

Our system successfully meets all performance and design requirements, delivering efficient PM and $CO_2$ reduction with low pressure drop, low noise, and minimal operating cost. The validated prototype demonstrates reliable operation, easy maintenance, and strong potential for real-world air-purification applications.