Experiment No 4

Objective: - Performance analysis of micro-axial flow fans used in cooling electronics.

Prerequisites: -

1. Concept of axial fans.
2. Self-Reading before Coming to The Laboratory:
    - What are Fan Laws?
    - How to organize experiments to verify Fan Laws?
    - Prepare Brief Planning and show it to the instructor before starting the experiments.

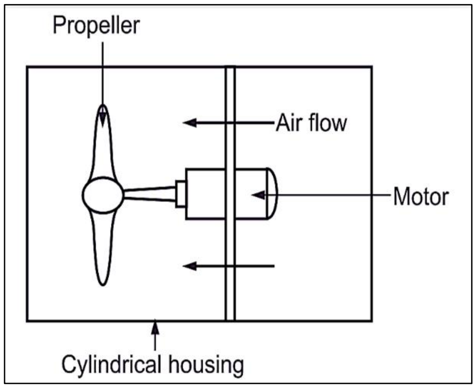
Minute details about the practical Setup:- (or the theoretical brief background)

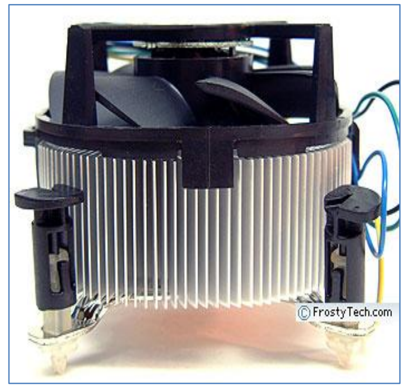
Micro-axial fans are compact air-moving devices that operate on the principle of axial flow, where air is drawn in parallel to the fan shaft and expelled in the same direction. Due to their small size, high efficiency, and ability to deliver a steady airflow at low to moderate pressure differences, they are widely used in electronics cooling, laboratory experiments, and compact ventilation systems.

In thermal engineering applications, micro-axial fans are extensively used for forced convection heat transfer, particularly in cooling of electronic equipment, laboratory-scale heat exchangers, and compact enclosures. Their performance is characterized by parameters such as:

- Volumetric flow rate (Q): Typically ranging from a few CFM (cubic feet per minute) up to ~100 CFM for micro-scale fans.
- Static pressure rise (ΔP): Usually in the range of 10–200 Pa, suitable for low-resistance cooling applications.
- Power consumption: Generally, less than 10 W, making them energy efficient.
- Efficiency: Around 40–60%, depending on blade geometry and operating speed.
- Operating speed: High rotational speeds (2,000–10,000 RPM) allow effective air circulation in small volumes.

The pipe and orifice diameters for three different fans are mentioned on the physical setups themselves.





Fan laws:

1. Volume flow:

$$q_{v2} = q_{v1} \times \left(\frac{n_2}{n_1}\right)^1 \times \left(\frac{d_2}{d_1}\right)^3$$

2. Pressure:

$$p_2 = p_1 \times \left(\frac{n_2}{n_1}\right)^2 \times \left(\frac{d_2}{d_1}\right)^2 \times \left(\frac{\rho_2}{\rho_1}\right)^1$$

3. Absorbed power:

$$P_{R2} = P_{R1} \times \left(\frac{n_2}{n_1}\right)^3 \times \left(\frac{d_2}{d_1}\right)^5 \times \left(\frac{\rho_2}{\rho_1}\right)^1$$

4. Efficiency %:

$$\frac{q_v \times p_t F}{10\ P_R}$$

Nomenclature for symbols used in this page:-

qv = volume flow of air, m^3/sec
n = rotational speed of fan
d = diameter of fan
p = pressure developed by the fan
p = density of air, kg/m^3
PR = power absorbed by the fan, kW

Experimental Procedure/what you should aim at: -

- Draw a neat sketch with all the major dimensions of the test rig and details of all the instruments available on the test rig.
- Measurement of speed and power consumed by the fan.
- Measurement of static pressure at inlet and exit of the fan for various flow rates.
- Carry out all the measurements to verify fan laws as in table 1.
- Draw graphs corresponding to
    1. The fan performance curves i.e. Static Pressure Vs Flow rate for various regulated speeds
    2. Pressure difference vs Flow rate at each RPMs speed.
    3. Hydraulic power vs Flow rate at each RPMs speed.
- Repeat this for all three fans

S. No.	Valve opening	Motor speed	Pressure	Flow rate	Temperature
1	Full open				
2	$1/4^{th}$ opening				
3	½ opening				
4	$3/4^{th}$ opening				
5	Full closed				

What next (Things you can ponder over):-

1. Why did I do this whole experiment?
2. What are the different manufacturing companies involved in making fans?
3. How does a blower score over fans and where do fans have upper hand?

**Submission of Report:**

- A single report per group.
- All are equally responsible for the preparation of the report.
- Should answer the question on your report.
- Each Report will be evaluated for 10 points.

**References:-**

1. Turbines, compressors and Fans by S. M. Yahya.