Fabrication and Performance Analysis of Electric Duct Fan with After Burner

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ABSTRACT

EDF jet Engine is the combination of Electric Duct Fan and After Buner. EDF jet Engine uses the Hybrid system. The EDF uses 2200kv Brushless Motor to run the propeller and After Burner uses the fuel to increase the thrust of the EDF Jet Engine. In this Paper we test Thrust, Air Flow, RPM and Velocity of the EDF Jet Engine.

An EDF (Electric Ducted Fan) jet engine is an efficient and quiet form of propulsion for model airplanes and drones, using lightweight fan blades to draw air in, accelerate it through the ducting, and expel it out the back. This process generates thrust while providing a realistic, scale-like appearance. The performance of an EDF jet engine is determined by several factors, including the size and shape of the ducted fan, the number and design of the fan blades, and the power output of the electric motor. EDFs are typically rated in terms of their diameter (in millimeters) and number of fan blades, such as a 100mm 12-blade EDF.

Afterburner jet engines are designed to provide additional thrust in situations where high acceleration or speed is required by injecting fuel into the exhaust stream and igniting it. This allows the aircraft to boost its performance during takeoff and evasive maneuvers, although this will not deliver a scale-like appearance. Both types of jet engines have important roles in model aviation, delivering reliable performance with minimal environmental impact.

This abstract will discuss the construction, working principle, advantages, and disadvantages of afterburner jet engines. Afterburners are an important component of military aircraft and have been used extensively in fighter jets and some commercial aircraft, such as the Concorde. Understanding the construction and working of afterburner jet engines is essential for those involved in aircraft design and maintenance, as well as aviation enthusiasts.

Keywords: EDF, After Burner, Thrust, Airflow, Latest Measurement.

1. INTRODUCTION

EDF Jet Engine is the Hybrid Air Breathing Propulsion means combination of the Electric and Jet propulsion system, the electric motor take power from battery to drive the Propeller for air intake.
The problem in the existed aircraft and the propulsion system is emission of LTO NOx and large Noise during landing or Take-off, field length and Performance of fuel burn is not satisfied the future need of NASA goals. To overcome this aviation industry, demand the Hybrid Air breathing propulsion system is best potential way to meet these goals.
Conventional jet engine takes time to increase and decrease the thrust whereas Hybrid jet engine can change speed almost instantly because we can control the speed of brushless motor speed instantly.

The aim and objective of an EDF (Electric Ducted Fan) jet engine are to provide a lightweight, efficient, and relatively quiet propulsion system for model airplanes and drones.

- High performance: EDF jet engines are designed to provide high thrust-to-weight ratios, enabling model airplanes and drones to achieve high speeds and perform agile maneuvers.
- Efficiency: Another objective of an EDF jet engine is to be efficient in terms of power consumption and thrust output. EDFs are known for their high efficiency and can provide a lot of thrust for relatively little power consumption. EDF jet engines are designed to be highly efficient, maximizing the amount of thrust generated for a given amount of power input. This efficiency is achieved by optimizing the ducted fan's design and minimizing energy losses in the system.
- Lightweight: EDF jet engines are designed to be lightweight, which is critical for achieving high speeds and agile flight maneuvers in model airplanes and drones. The use of lightweight materials, such as carbon fiber and plastic, is common in EDF construction.
- Relatively quiet: Compared to traditional gas turbine engines, EDF jet engines are relatively quiet, making them ideal for use in residential areas and public spaces where noise pollution is a concern.
- Agile flight maneuvers: The thrust provided by an EDF jet engine is typically very responsive, allowing the aircraft to perform agile flight maneuvers, such as loops, rolls, and other acrobatic maneuvers.

2. EDF JET ENGINE DESIGN AND ANALYSIS

We start with the body, which holds the EDF and After System. We used a metal sheet as our jet engine body due to its heat resistance capabilities. Next, we move on to the flame tube. This tube works to contain the flame and create turbulence that allows air to slow down, thus enabling combustion. To get proper turbulence, we cut and bent the tube vertically so fins were created. Once this was done, we needed a fuel line; for this we used a 2-feet copper tube for its heat resistance capabilities.

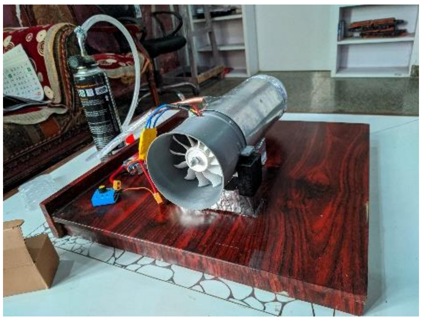

Fig 1: EDF JET ENGINE

the copper tube was then bent using fire so it produced one continuous tube to direct fuel into the flame tube without any disruption. Then, four 1 mm holes were drilled in order for fuel distribution inside the flame tube. For ignition, the glow plugs or incandescent plug method is used in diesel engines – passing an electric current through a filament that heats up similar to a light bulb. With this system there is no issue of spark occurring inside unburnt fuel mixture which can causes explosion inside combustion chamber resulting in malfunctioning of Jet Engine.

3. THEORETICAL CALCULATION OF EDF JET ENGINE

Propeller Measurement

EDF Duct Diameter = 100mm

Inner Hub Radius = 17.5mm

Entire Propeller Radius = 48.5mm

Starting with Impeller, each blade is set to an angle of attack of 45°.

In this EDF at the hub the radius is 17.5mm, which means in one revolution the blade profile at the hub will travel a distance of 110.5mm.

Now at the tip of the blade the radius is 48.5mm, which means each revolution the blade profile at the tip of the blade will travel a distance of 320mm.

45/20 = 25
That means the tip propeller has 25° less angle than the Hub.

Velocity
Area Of Circle = $A = \pi r^2$
A = 3.14 * (50)2 = 7853.98
Newton Second Law: - F = ma
Where a = v/s
Therefore F = m. v/s
No Velocity change because the EDF is Stationary. What does change between however is the mass, as the propeller runs it moves more and more air mass through it.
So instead of calculating F = m. v/s (Change in Velocity)
We use F = m/s. V (Change in mass)
So previously we calculated the pitch of propeller which is 110.5mm or 0.1105m.
To find velocity we have to first find the RPM of the EDF.

RPM
RPM = MOTOR KV * BATTERY VOLTAGE(4S)
RPM = 2000KV * (4*3.7)
RPM = 20000
RPS = 20000r/m = 333.33r/s
Velocity(V)= 20000r/m * 0.1150m/s
V = 333.33r/s * 0.1150m/s
V = 38.33m/s

Air Flow
First, we have to find volume of air moved each second.
The area of the EDF can be calculated by Subtracting the Hub area from the entire Fan area.
πr^2
r1 (Radius of entire fan area) = 0.0485m
r2 (Radius of Hub Area) = 0.0175m
Area = π (0.0485 – 0.0175) = 0.09734m2
And as for the length we already figured out that we are moving air at velocity of V = 38.33m/s
Volume = 38.33m/s * 0.09734m2
Volume = 3.73m3 /s
now we have to find mass of the air by volume. mass of air changes all the time.

Thrust
Taking Mass of air = 1.225kg/m3

Change in mass/s = 3.73m3/s * 1.225kg/m3 = 4.5 kg/s

F = m/s * v
F = 4.5 * 38.33m/s
F = 172.485 kg m/s
THRUST = 12 kg (For Ideal Condition)

4. RESULT AND DISCUSSION

We have done theoretical calculation as well as practical experiment and got the overall performance of 84%. In theoretical calculation and practical experiment, we have calculated Thrust, Air Flow, Propeller RPM, Velocity, Temperature at the Nozzle. Below is the comparison table of theoretical values with experimental values.

SR. No.	Description	Theoretical Value	Actual Value
1	THRUST	12kg	10.1kg
2	AIR FLOW	3.73m3/s	3.45m3/s
3	RPM	20000r/m	18502r/m
4	Velocity	38.33m/s	35.46m/s

Fig 2: Front View

5. CONCLUSION

A Prototype of EDF with after burner have been fabricated and detailed comparison of parameters is done. The Thrust of the Electric Duct Fan Jet Engine was first priority, which is successfully done. Electric Duct Fan with After Burner is High performance, Efficient, Lightweight, Relatively quiet, and can perform Agile flight maneuvers better than conventional jet engine.

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