

KARNATAKA STATE COUNCIL OF SCIENCE AND TECHNOLOGY

**DAYANANDA SAGAR UNIVERSITY
DEPARTMENT OF AEROSPACE ENGINEERING**

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TITLE OF PROJECT

THRUST VECTOR CONTROL

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KEYWORDS

- 1) Thrust Vectoring**
- 2) 3D printing**
- 3) Flight Computer**
- 4) Sugar Propellant**
- 5) Rocket**
- 6) Rocket Candy**
- 7) Servo Mechanism**
- 8) Gimbal**
- 9) PID Controllers**

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INTRODUCTION

In addition to providing thrust, a propulsion system has to be able to provide moments to control the aircraft's attitude and flight path. By controlling the vehicle's thrust direction, it is possible to control its roll, yaw and pitch motions.

The ability of an aircraft, rocket or any other spacecraft to manipulate the direction of thrust from its engine to control the attitude or angular velocity is called Thrust vector control. The main reasons of using TVC are to control the flight path or its trajectory, to change the attitude of the aircraft, to bring back the aircraft to its original position after it is disturbed by other external forces.

1.1 Theory

Every rocket will have its own path of flight as per its specified mission. Whenever a rocket is launched and is travelling with high velocity, there are high possibilities that it may encounter some external disturbance/forces due to adverse atmospheric conditions. These unwanted forces may create a rolling moment about the rocket's center of gravity and may lead to tilting of the rocket body, which makes the rocket deviate from its path mission leading to a mission failure. This problem can be achieved by using TVC, where TVC helps in maintaining the rotational equilibrium of the rocket, by providing counter acting moment to the moments produced due to external disturbances.

Another usage of TVC is exact opposite to its primary usage, that is to intentionally produce a moment about the rocket's center of gravity and change the mission path as required. Another application of this is used in missiles, to change its flight path when it is locked on to a target.

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AIM, OBJECTIVE, METHODOLOGY

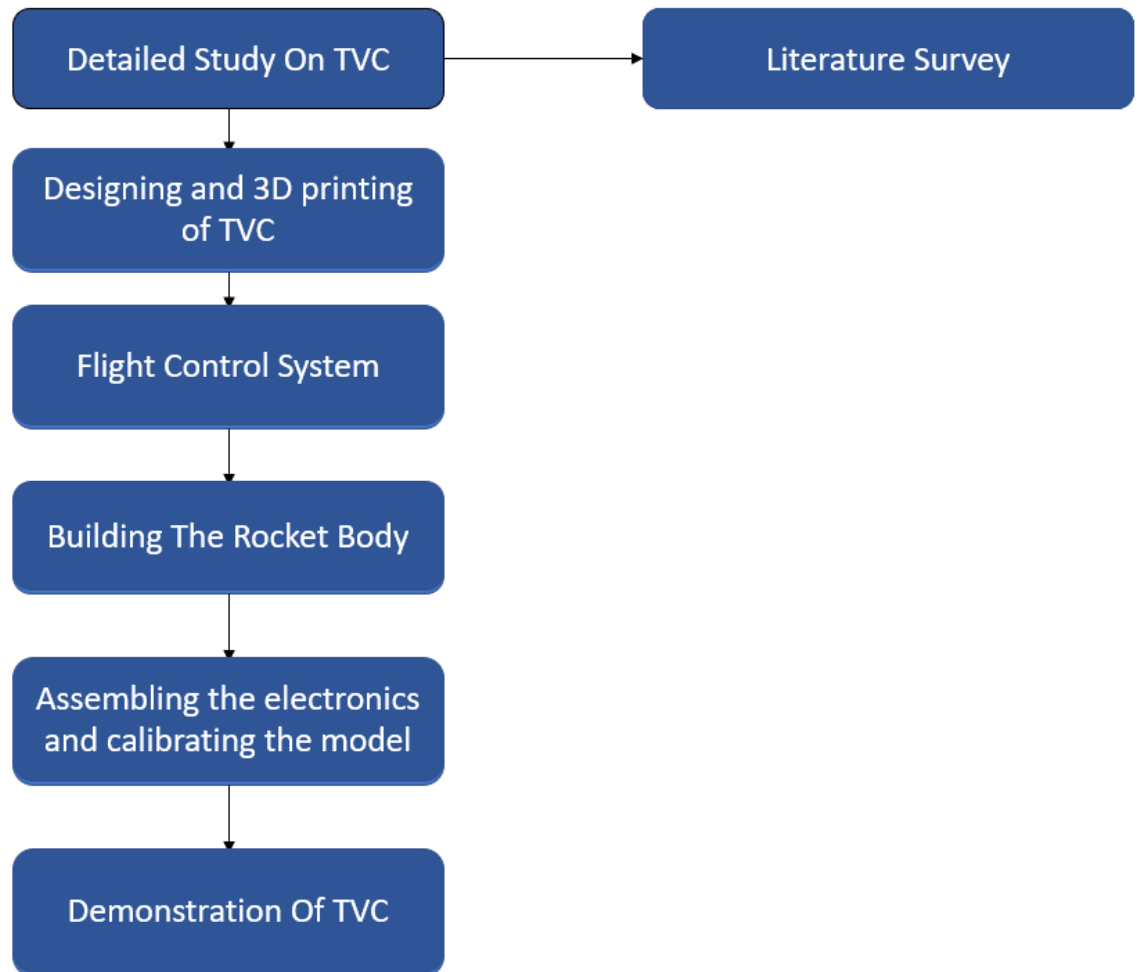
3.1 Aim

To design and build a prototype of a thrust vector-controlled rocket

3.2 Objective

1. Understanding the working and mechanism of TVC
2. Designing and 3D modelling of TVC mount
3. 3D printing of the TVC mount
4. Developing Flight Control System
5. Building the rocket body
6. Assembly and calibration of prototype model
7. Demonstration of TVC

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3.3 Methodology

Our project will be initiated with a detailed study on TVC, types of TVC and materials. Once the literature survey is done, it is proceeded to designing and 3D printing. Autodesk Fusion 360 is used for design and modelling of TVC, and it is 3D printed using PLA material with necessary input parameters. Next step will be building the flight computer using Arduino and gyro sensor. Once the model and flight computer is ready, they are assembled and calibration is performed to make sure the sensors and controllers are working fine. After this, we reach the final phase where the model is calibrated and is responding to orientation change.

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DESIGN

Design

2D Drawings

TVC Pipe

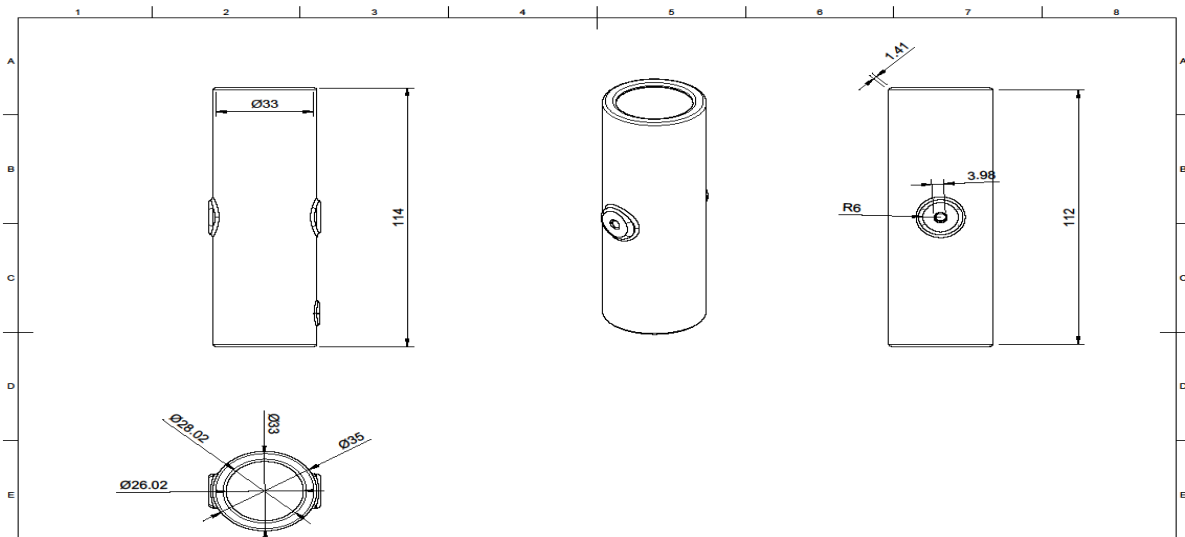


Figure 1 TVC PIPE

TVC pipe is the part of TVC mount which acts as the nozzle. The propellant is filled in this pipe, which when ignited, thrust is produced

4.1.2) Outer Gimbal

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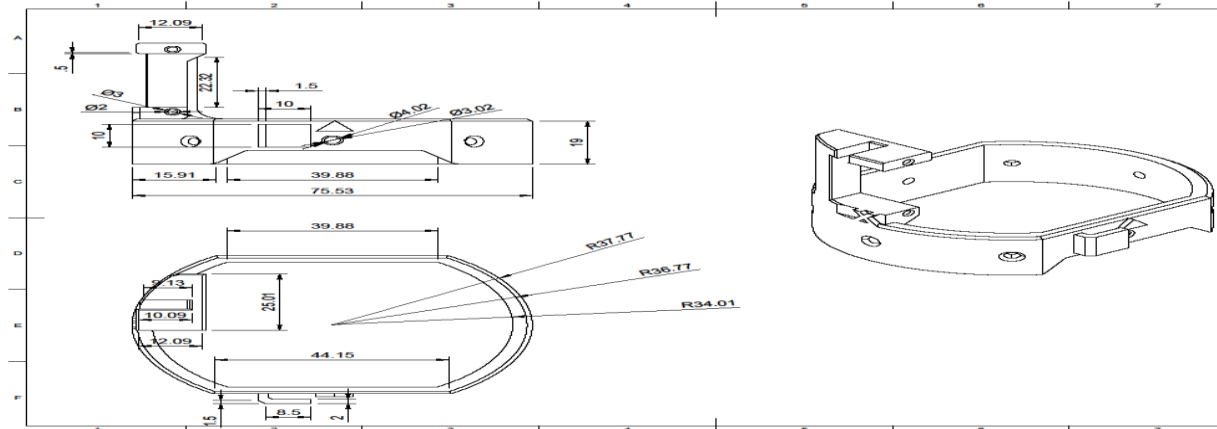


Figure 2 OUTER GIMBAL

Outer gimbal is the mechanism part which deflects the pipe/nozzle in X axis. This outer gimbal is integrated with a servo motor which moves the nozzle in X Direction.

4.1.3) Inner Gimbal

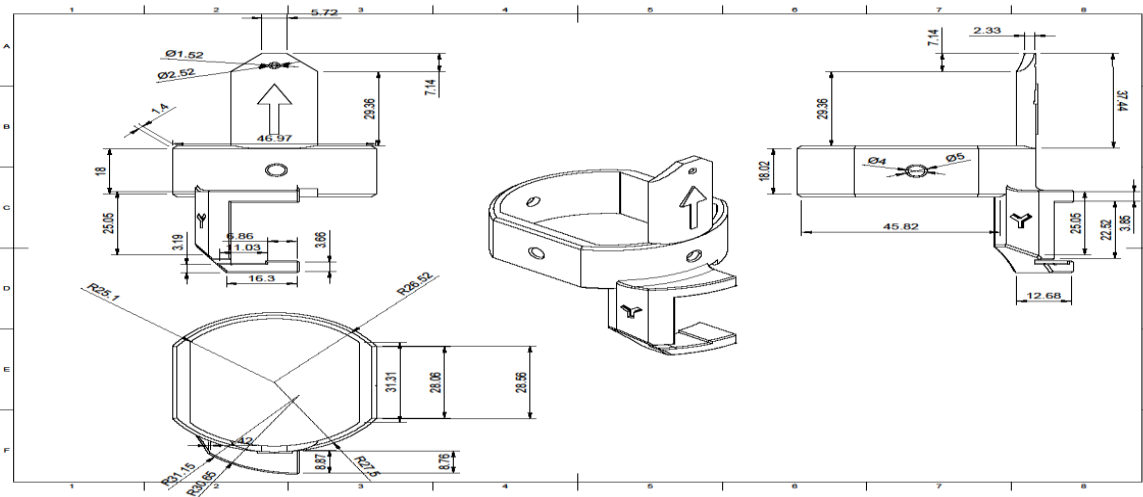


Figure 3 INNER GIMBAL

Inner gimbal is the mechanism part which deflects the pipe/nozzle in Y axis. This inner gimbal is integrated with a servo motor which moves the nozzle in Y Direction.

3D DESIGN AND MODEL

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4.1.4) TVC MOUNT

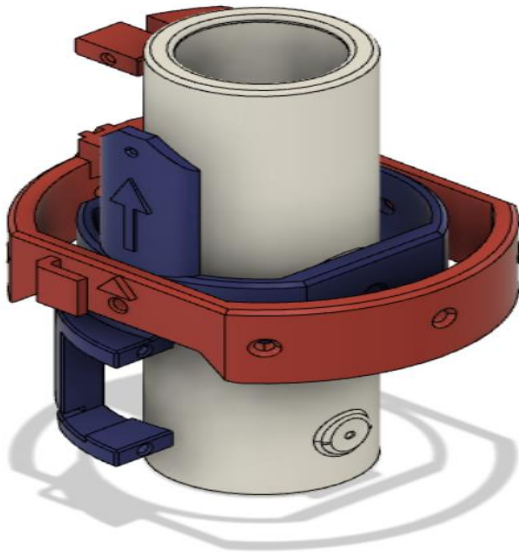


Figure 4 TVC MOUNT

4.1.5) Rocket Body

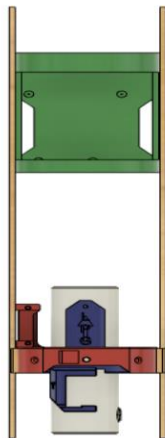


Figure 5 ROCKET BODY

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RESULT AND CONCLUSION

Results

Successfully designed the 3D printed prototype of TVC mount and flight computer assembly. Optimized calibration of flight computer after number of iterations and fixing of optimized gain values for PID controllers. Successful testing of propellant and TVC mechanism

Conclusion

Thrust vector control is a method to control the trajectory and attitude of an aircraft. The method we use to control the thrust vector is by using a gimbal mechanism. Two servo motors are used to control the thrust vector in X and Y axes. A flight computer 'ARDUINO UNO' is used to control the deflection of the thrust. A 9V battery is used to power the 2 servo motors.

The propellant we used was potassium nitrate and powdered sugar which was then pounded to make the propellant. It was also melted and then poured into the booster. Thrust vector control mechanism was successfully demonstrated. The calibration of the flight computer was done well and the thrust vector was controlled as per requirements. The deflection of the rocket and the deflection of the thrust vector(nozzle) is matching and the rocket is able to come back to the original position.

Scope For Future Work

3D printing is being used to create lightweight and compact TVC systems for small drones and UAVs. 3D printing is being used to create TVC systems for spacecraft that need to make precise adjustments to their trajectory during flight. These systems can be designed to withstand the extreme temperatures and pressures of spaceflight, and can be optimized for weight and performance.

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