SEDSIC’ 07

ROCK-IT (Rocket Design Competition)

Report

by

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1. Introduction

A **water rocket** is a type of model rocket using water as its reaction mass. They are a heap of fun. Their performance is amazingly good. They are certainly the fastest and most spectacular of any of the toys. And they drive you to continually improve the rocket so that it goes higher, or comes back with a parachute. This culture is new in INDIA. Water Rockets can be made at home with no special equipment and are cheap as well.

2. Problem Statement

Design, build, and launch a water jet rocket .It should return its payload (a raw egg) to Earth safely.

3. Specification of the Requirements

1. The protection for egg should have maximum thickness of 5mm.

2. The result must be a space transportation vehicle capable of carrying a payload (the egg).

3. The team is also supposed to develop their own launchpad.

4. The rocket must launch as one complete unit, but may come down as separate pieces.

5. The maximum working pressure of the rocket is 8atm(0.8megapascals)(120psi).

6. The weight of the rocket should not exceed 1000 gms (dry weight).

7. The dimensions of the nozzle should be standard nozzle as mentioned on site.

4. Proposed solution

Basically, a water rocket is a plastic bottle (mostly used standard plastic coke or pepsi bottle that isfilled half way with water, pressurize with air, and invert. Standard Football foot pump available in market can be used for pressurizing the air.When pressure is released, the pressurized air forces the water out which propels the rocket.

For releasing the pressure a mechanism is built using wire ties which hold the bottle in place before launch and once support is removed rocket takes off. The payload is placed at the top of the rocket and the design of this top part is such that the slight drag on this part acts during the motion which holds the top part with on the bottom part.This drag holds the top half in its position. When the velocity of the rocket decreases, then it becomes unstable. And top part gets separated from the bottom part. The parachute in the top part then opens up and it lands slowly to earth.

5. Methodology

Arrange the following materials:

For the launcher:

1. Pipe with outer dia slightly less than the internal dia of the plastic bottle used.
2. Cable ties
3. A wire coat hanger
4. 40mm dia PVC pipe.
5. Cork
6.Valve
6. A stand.
7. Rope.
8. PTFE tape.
9. Glue

For Rocket:

1. 2liters cold drink pet bottles-2
2. Football pump for pressurizing the rocket.
3. Synthetic cloth for parachute
4. Elastic membrane

Launcher:

1. Take a pipe with outer dia 22mm(=inner dia of bottle) and Cut a slot at a distance of 20cm from an end.

2. Place some cork or rubber material or PTFE tape over it to prevent any leakage.
3. Fix the cable ties around the pipe using bond glue such that they just fix over the bottle neck ring.

4. One end isattached to the pump via valve. This valve is attached to the pipe by using a cork. In this cork hole is drilled at the centre less than the outer dia of valve. Because of the threads on the valve it is fixed to the cork and cork can be easily screwed to the pipe having internal threads.

5. Cut a slit down the full length of the longer, 9cm long piece of pipe.

6. Spread the slit in the longer pipe so that it pushes over the shorter one. The top part of the longer split tube is the right diameter to lock the cable ties in place around the bottle neck, while the rocket is being pressurized.

7. Slide the collar up over the pipe to make sure it fits OK

8. Now we drill two holes of some (small) diameter near the bottom end of the inner pipe of the lock collar. Take a wire coat hanger and cut it to size using a pair of wire cutters. Bend the wire coat hanger into the shape and carefully push the hooked ends of the wire into the holes in the collar (as shown below).

9. A spring mechanism is designed to hold the locking collar in place before launch, whilst the rocket is being pressurized. We cut it from the middle of a small half litter pet bottle. We then cut two holes, just large enough (22mm) for the launch pipe to go through. Slide the locking collar back onto the launch pipe and slide the retaining spring behind it.Now we fit a T-type collar at the open end of pipe with one of its ends closed. The other end is fitted with a rubber cork consisting of a one way valve through which we can pressurize the bottle.Now we fix the launcher pipe to a stand which can support the whole setup.

Rocket making

1: Cut a 2 litre bottle into 3 pieces such that middle one is bigger in length then other two.
2. Put the middle one over the second bottle such that somepart of the cut bottle piece is above the other pepsi bottle (inverted). The purpose of putting this piece is to give additional strength to the bottle to safeguard it for explosion.Also we place an elastic membrane over the top of this cut bottle piece. This membrane would provide suport for the payload to be kept over it.

3. The top of the rocket is made from the top part of the bottle cut. We make an arrangement for the payload to sit inside this part. The membrane at the lower part(explained above) safeguards the payload(egg) from shock..

4. Cut the cylindrical fin section from the new PET bottle to the struts with the duct tape. The rocket is complete and should now look something like the one shown in the figure. Note that the longer and further back that you make the fin the more stable will be. Also if the curved fins are used it provides more stability by rotating about an axis that is moving-Gyroscopic motion.

6. Design

The water rockets are generally designed for maximum time of flight. Here designing each part is very important. Also each part has to be attached properly. Because at higher pressures leakage might start or it may explode. The performance of the water rocket is dependent on the following factors:

- Total weight of rocket
- Surface friction

- Empty volume of the rocket
- Ratio of water filled and total volume of rocket
- Weight of payload
- Area of efflux(this would decide the flow rate)
- Initial peak pressure
- Number of stages
- Parachute opening mechanism- ideally it should open at topmost point
- Diameter of rocket

7. Expected performance

Maximum height=65 meters
Maximum speed=50m/sec
Time of apogee=3secs
Speed at touch down=3m/sec
Total time of flight= 8 sec

8. Implementation procedure

Payload Launch
The water is inserted in the bottle to half of its capacity(presently we are trying to test it with 3 bottles, 6 litres capacity). Then the bottle with water is placed over the launch pad. Here the launch pad is slightly tilted to avoid the fall of water. The bottle is held in its place by the cable ties, which are locked using locking collar. The parachute is placed over the top of the rocket now with its conical cap at the top. Now the hose of the pump is attached to the valve used in the launching pad. The string for triggering the launch is looped over a pulley and taken to a safe distance. Then the bottle is slowly pressurized to the required pressure. The string is pulled gently which opens the lock of ties and the rocket is launched.

Parachute Deployment
We are using the 'nosecone off at apogee' method. This method relies on the tilting effect of the rocket at apogee for the nosecone to come off and the payload too (due to inertia). During the early stage of the flight, the nosecone is held in place by the drag force and acceleration.

Paylodad Safety
The payload is supported by elastic membrane on one side. This membrane prevents any damage to the egg. Parachute is used for its safe comeback.

9. Safety measures:

Water rockets are dangerous because they involve compressed air at very high pressure. There is enough energy stored to seriously injure if it explodes. And the rocket flies with enough speed to break bones if it should become unstable in flight and head back to earth.

- The pump used for pumping air is sturdy. It has got in-built pressure gauge so that we know that how far it is pumped.
- The length of connecting pipe for pressurizing is increased to 5 mts. So that if any casuality happens then the damage is reduced.
- 2-litre bottles available in market can withstand pressure as high as 150 bars or even more. But the official recommendation is 90 bars. Keeping that in mind we have given extra covering to bottle by inserting the part of bottle inside the other bottle.
- We are using a launch pad that can trigger the rocket from a distance of 5 mts.
- The launch pad base is made wide and heavy so that there is no possibility of its fall while triggering or take off of rocket.
- The material used for making launching pad has much more strength than needed so that it rules out the possiblity of its explosion.
- Each time before launch the cork used for holding valve is checked to ensure that cork is not losse.