

IMPROVING THE DESIGN OF BRAKING IN HYPERLOOP SYSTEMS

MFG5 | Adeesh Bansal | BEng (Hons.) Mechanical Engineering | Supervisor: Dr. R Heinemann

Introduction

Hyperloop is a maglev train that propels the pod in a vacuum tube at supersonic speeds (Fig. 1). Magnetic brakes are primary, however mechanical brakes, which induce a braking force onto the track, are required as redundancy. [1]

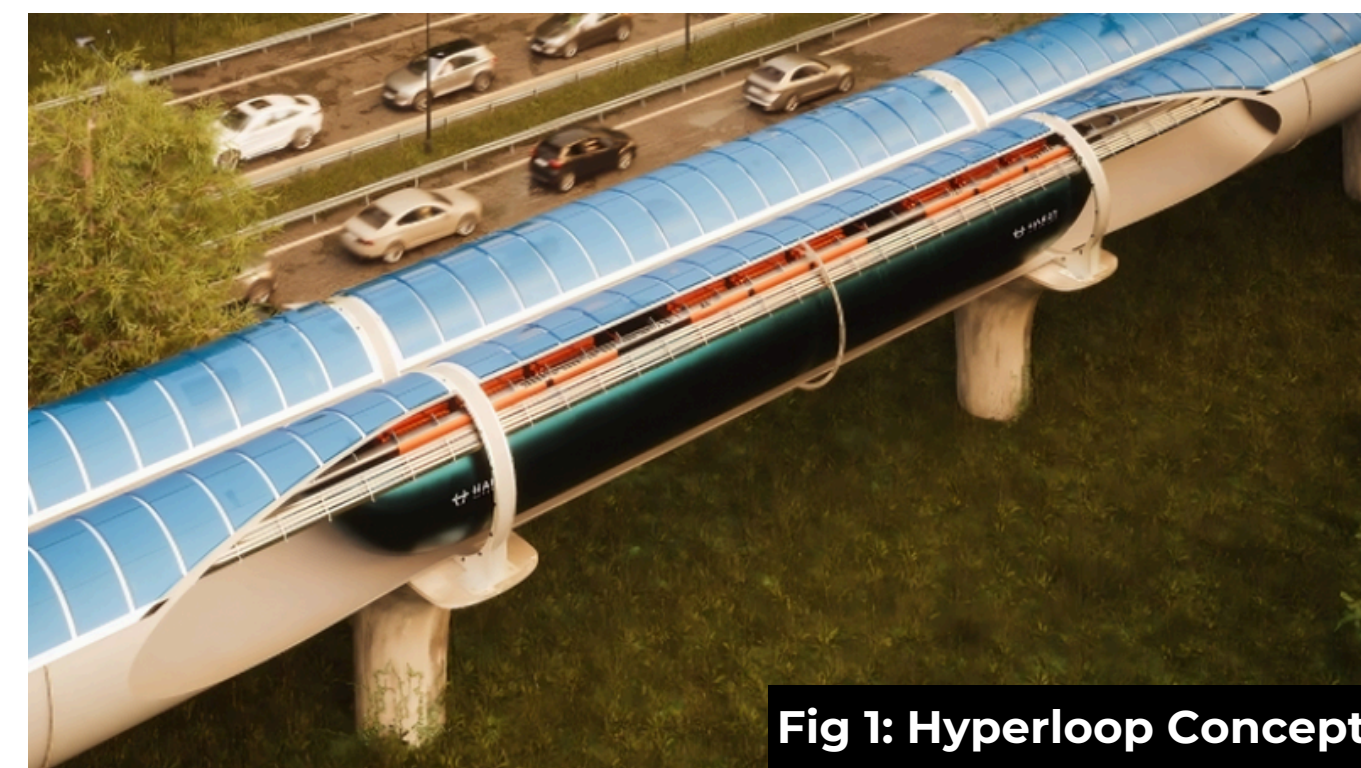
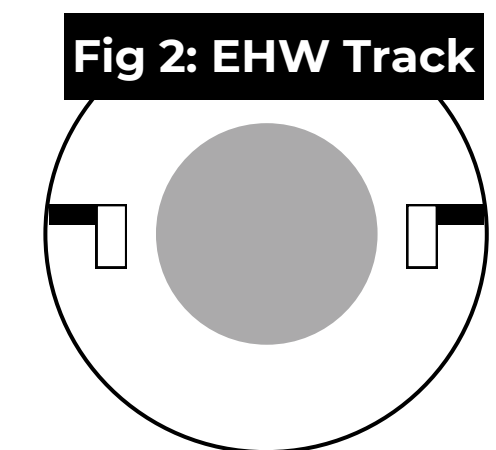


Fig 1: Hyperloop Concept

European Hyperloop Week (EHW) provides a structure for academics to present Hyperloop related findings annually. [2]

Motivation



EHW operates at a scale smaller than a full passenger pod, thus there are no braking systems designed for full scale use.

Emergency Braking Systems (EBS) must conform to the track dictated by EHW (Fig. 2) [3]. The track has been changed recently, thus presenting various possible braking designs.

Aim

To design an EBS for a full scale Hyperloop pod.

Objectives

- Analyse previous EBS concepts.
- Determine a design framework.
- Develop a conceptual design based on the optimal configuration.
- Recursively, improve concept with simulations and literature research.

Design Framework

The literature revealed a design framework. Potential energy is stored with a **retention mechanism**. Upon power loss, it generates a normal force on the track[5],[6]. Figure 3 is an ideal example of this. After this, one must select a configuration.

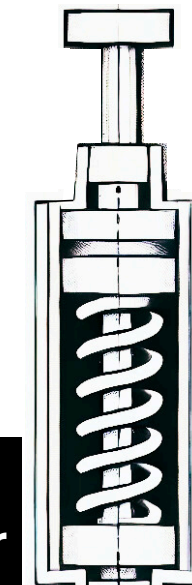


Fig 3: Spring Loaded Cylinder

Comparing Configurations

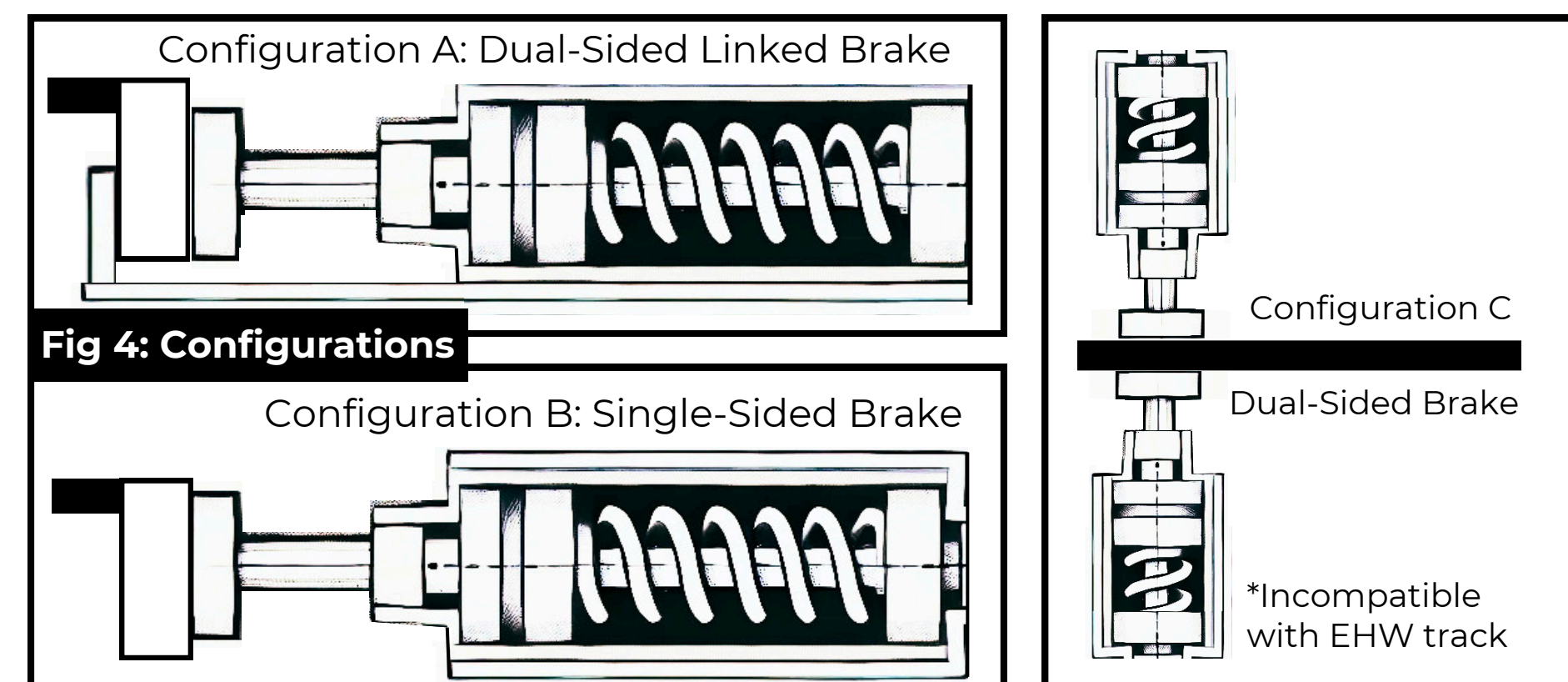


Fig 4: Configurations

A has the least maintainability due to its rear pad linkage, and C falls short due to its incompatibility with the track.

Criteria	Weight	Score	Configuration A	Configuration B	Configuration C
Wear	2	Score	3	1	3
		Weighted	6	2	6
Compatibility	4	Score	4	5	1
		Weighted	16	20	4
Performance	5	Score	3	3	5
		Weighted	15	15	25
Predictability	2	Score	4	4	5
		Weighted	8	8	10
Maintenance	6	Score	3	4	4
		Weighted	18	24	24
Compactness	4	Score	3	4	2
		Weighted	12	16	8
Total			75	85	77

Fig 5: Decision Matrix

Initial Calculations

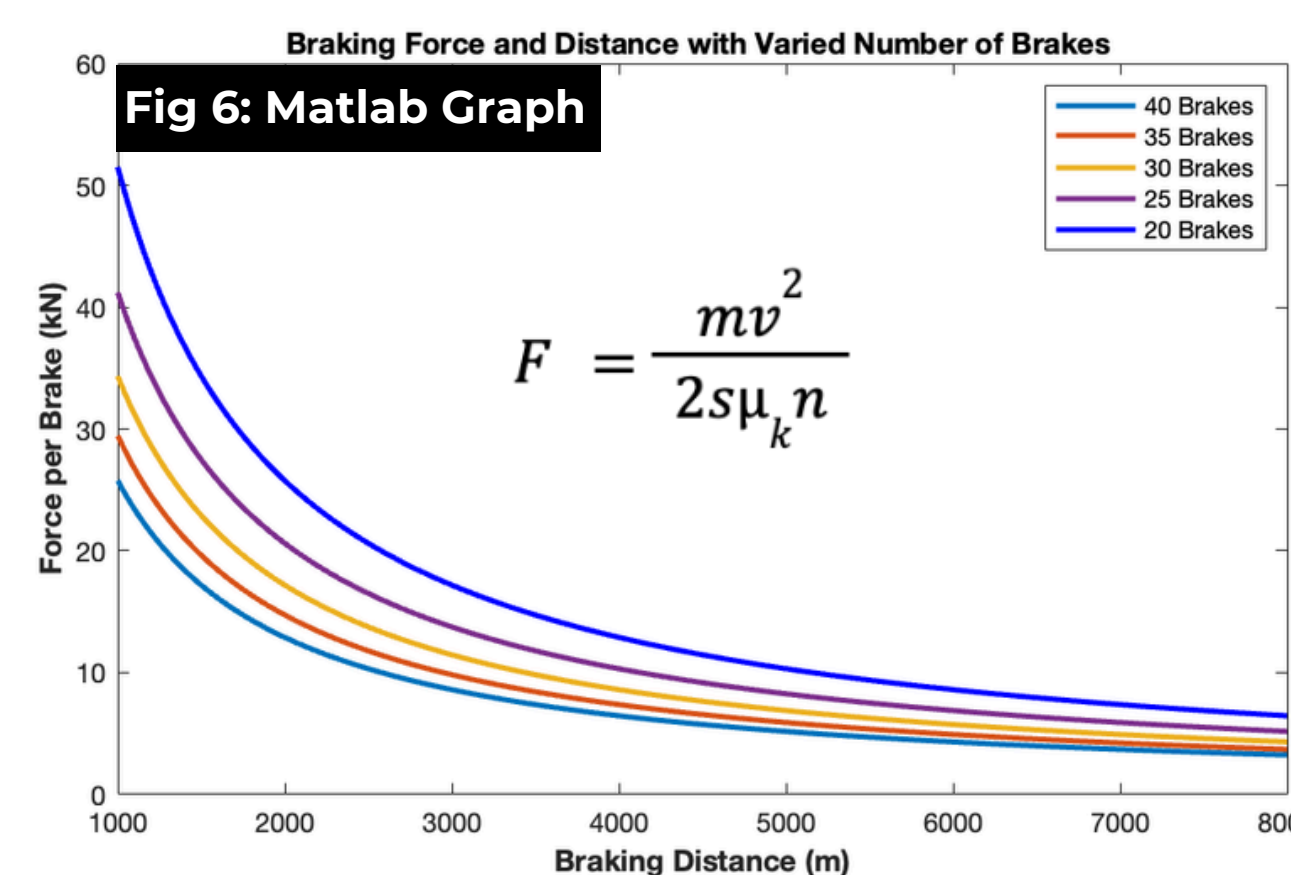


Fig 6: Matlab Graph

Initial calculations (Fig. 6) are completed after selecting a configuration. This establishes a braking force range to aid the concept stage. [7]

mass = 100 kg
velocity = 278 m/s
 μ_k (Friction Coefficient) = 0.75
n = number of brakes

Conceptual Design

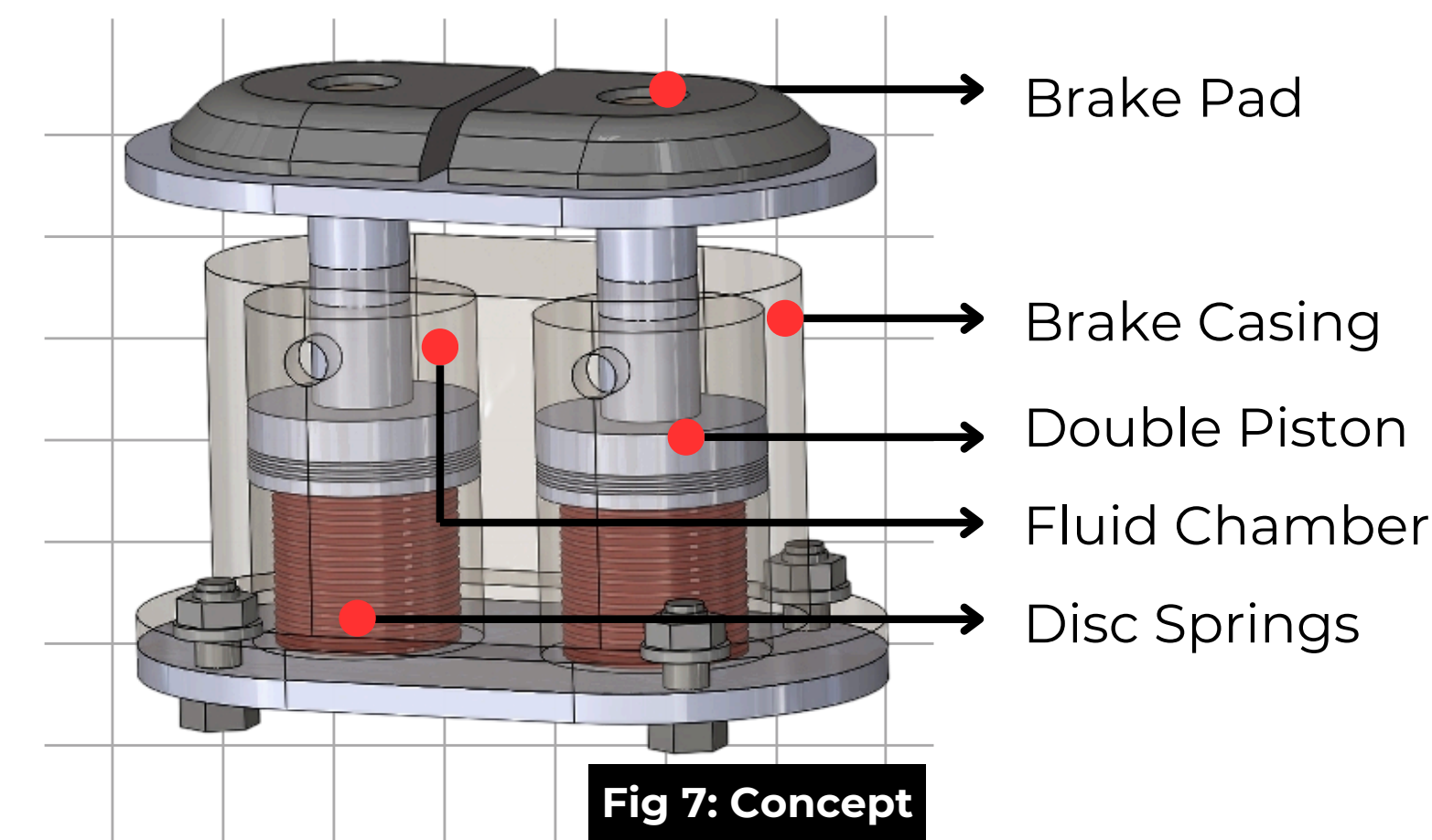


Fig 7: Concept

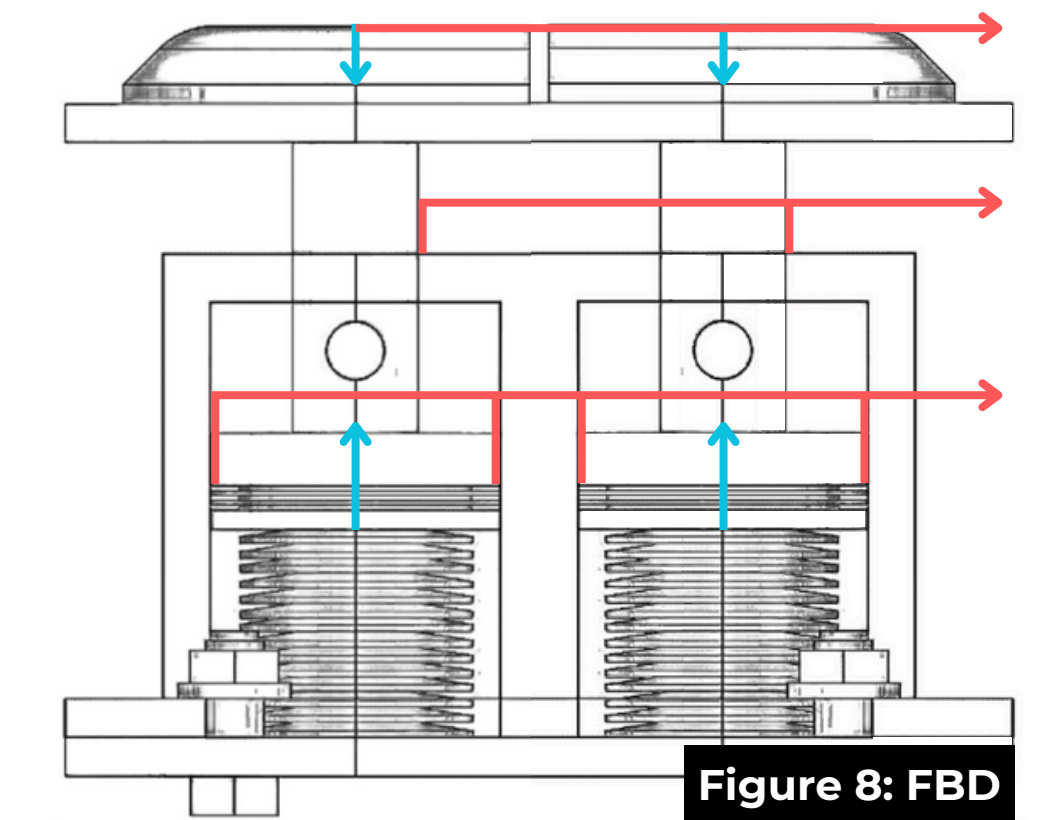


Figure 8: FBD

Design Changes

Flanged bushing (Fig. 10) added at interface of casing and pistons in order to distribute the compressive stresses visualized in the FEA (Fig. 9).

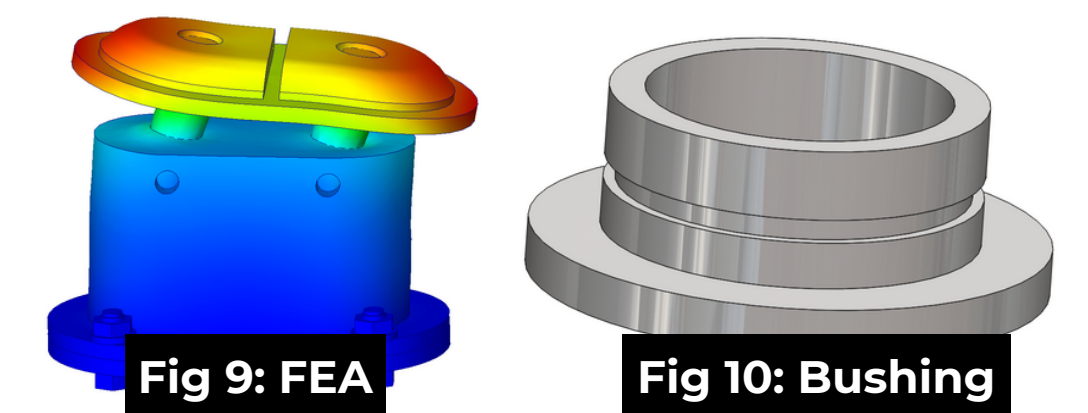


Fig 9: FEA

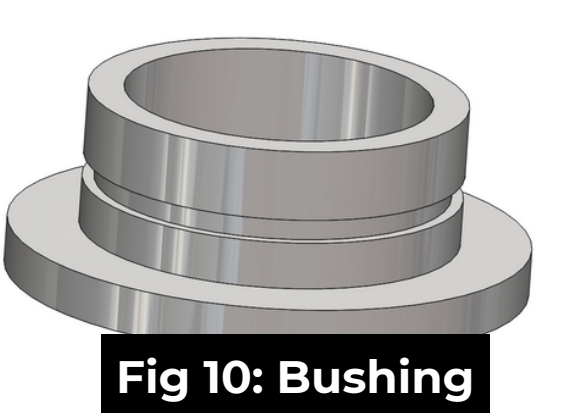


Fig 10: Bushing

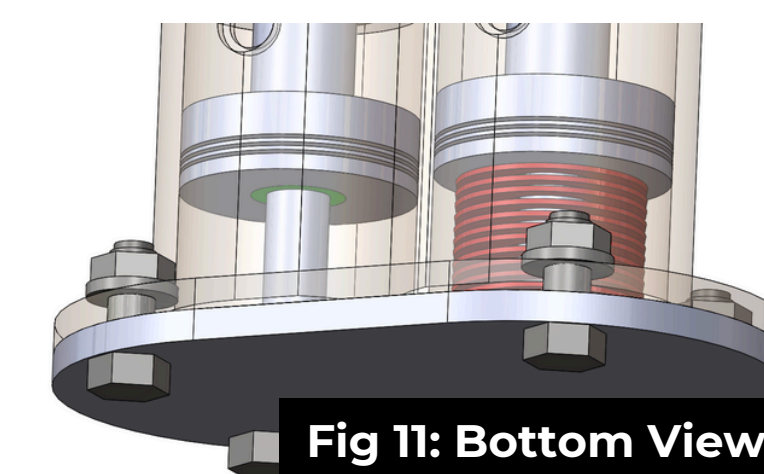


Fig 11: Bottom View

In order to further reinforce the piston and constrain the oscillations of the springs, the piston was made hollow from the bottom and attached to a linear rail (Fig. 11). Other changes include decreasing the distance between pistons and case profile to reduce mass.

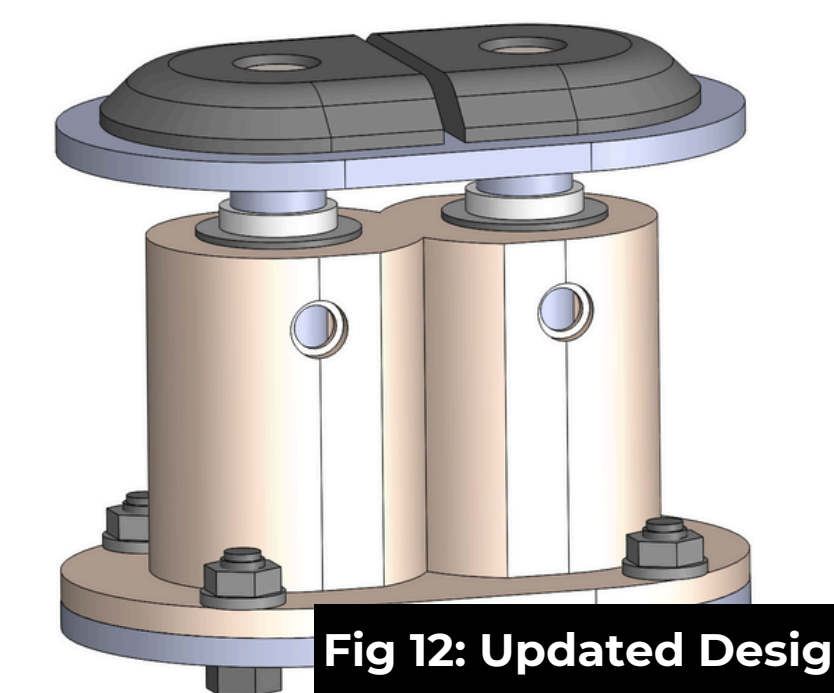


Fig 12: Updated Design

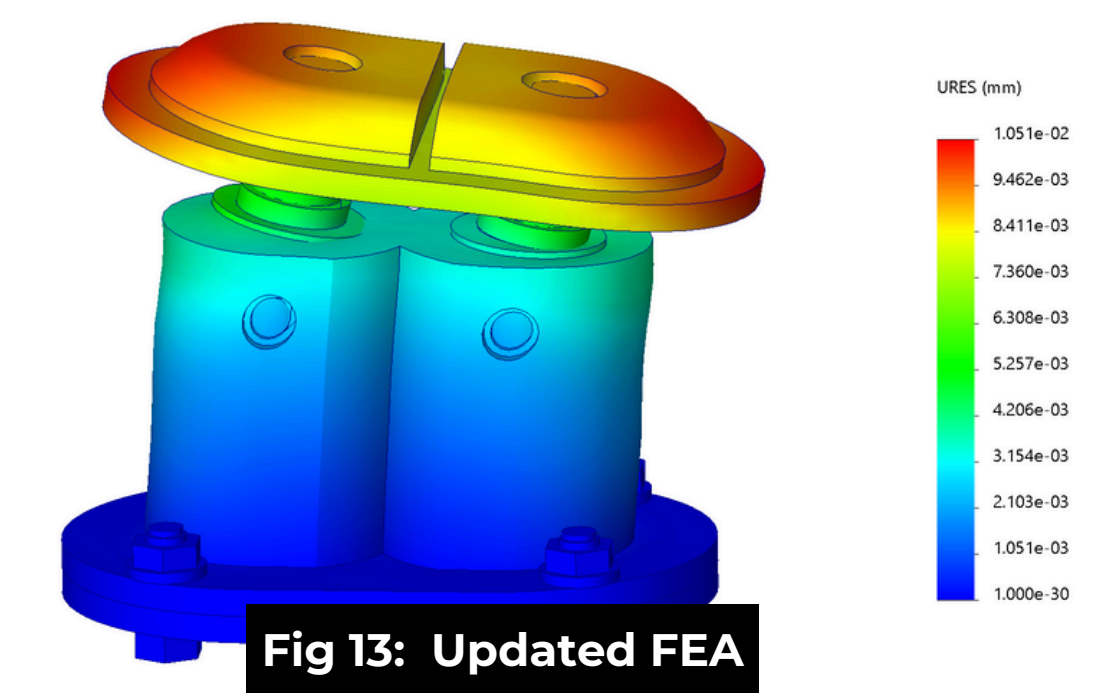


Fig 13: Updated FEA

Future Work

- Expand on the existing Matlab code to optimize for number of brakes, rod dimensions and piston diameter.
- Select materials for brake pads, bushings and other parts of the assembly based on the review of literature.
- Design a pneumatic circuit that is suitable for the system.
- Produce a final design with an implementation plan.

References

