ME232: Kinematics and Dynamics of Machines (KDoM)

Cam Follower in Packaging

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ME232 Kinematics and Dynamics of Machines

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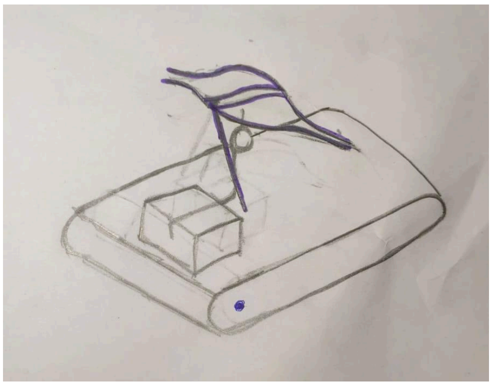
Section 2: Abstract

Purpose



Sealing countless boxes by hand is slow, tiring, and error-prone. Automation offers a solution, transforming a laborious task into a streamlined process. Modernized assembly lines are fast, repetitive, and designed for efficiency. Machines equipped with cam followers provide solutions to these requirements. These ingenious mechanisms convert circular motions into precise back-and-forth movements, allowing a uniform and accurate tape application on every box. This improvement not only saves time and effort on the assembly line but ensures consistent, high-quality seals, protecting every package that rolls down the line. Automation brings efficiency and precision to repetitive tasks, making modern assembly lines faster and more reliable.

Methodology

As a conveyor belt starts moving, a steady stream of boxes glides across its surface. Above all this, a roll of tape hangs. As a box travels the conveyor's path, the tape descends, adhering firmly to its top. Nearing the box's end, a cylindrical cam, its rotation powered by the line, partners with a sharp-edged follower. This dynamic duo oscillates with precise timing. As the follower reaches the tape's edge, a clean cut – the tape snips and prepares the roll for the next box. This synchronized movement ensures a continuous flow of perfectly sealed packages.

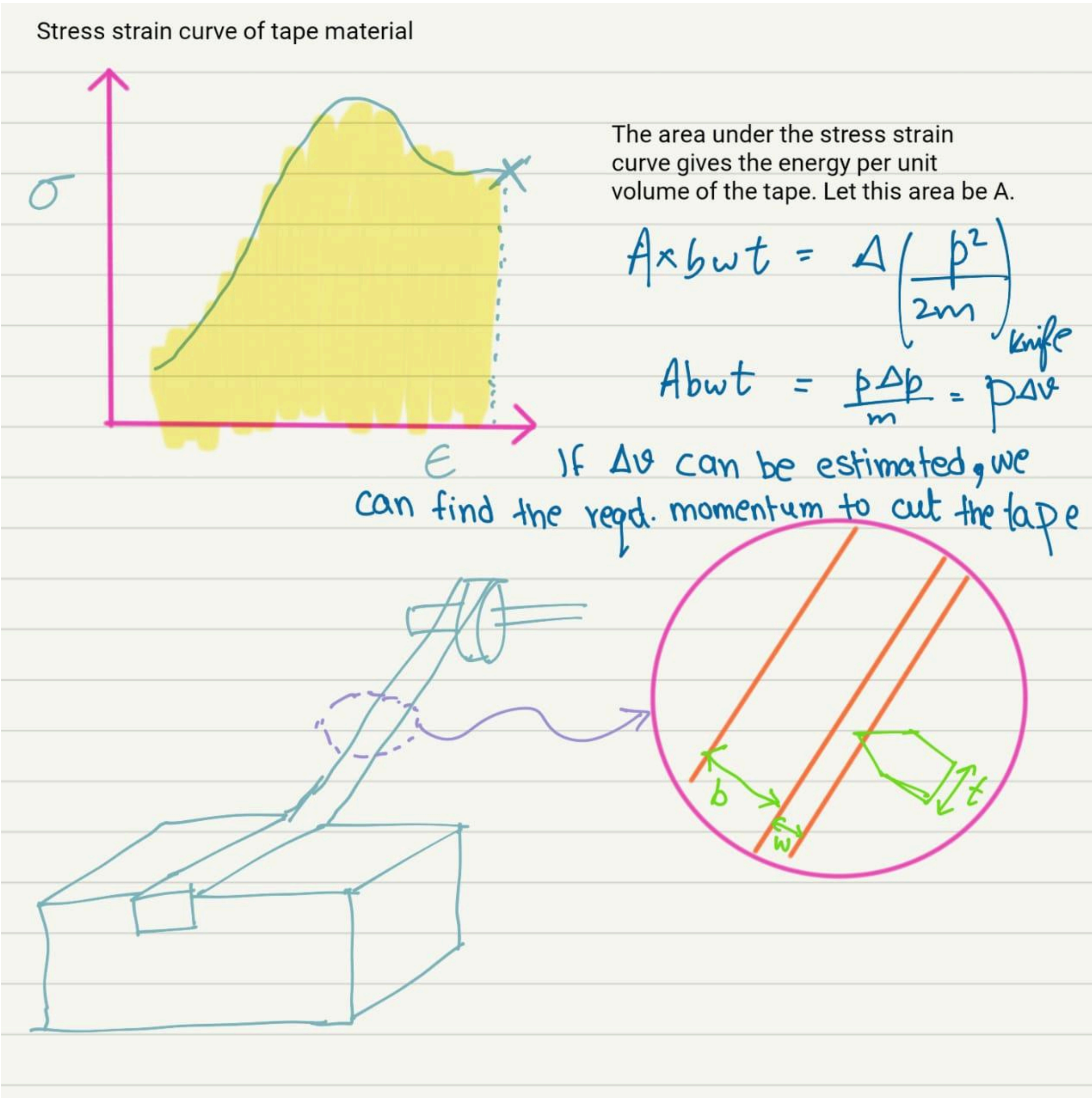
Another important calculation was done using the stress-strain curve of the tape material. The total energy to cut the tape till its ultimate tensile strength was given by the decrease in kinetic energy of the follower knife. If we can find the decrease in momentum of the follower knife, we can estimate the required momentum to cut the tape. The relation to finding the force to cut can be found out by the reference [1].

Key Findings

Our project unveiled the interplay between iteration, simplicity, and precision in a mechanical design. We refined a mechanism for a seemingly basic task – box taping. Each iteration became a step in a captivating dance. We relentlessly pursued a solution, trying to strip away unnecessary complexity. Intricate designs gave way to the beauty of minimalism, culminating in a cam and follower – a testament to the power of iteration. This project underscored that the most efficient and reliable solutions often lie in the careful orchestration of these three principles, shaping not just box taping, but the future of countless mechanical marvels.

Conclusions

Our experimentation revealed an interesting connection between cam length, follower speed, and overall system efficiency. As the cam length increases, the travel distance of the knife-edged follower also increases. This translates to a faster cutting motion, allowing for quicker tape application on a larger number of boxes in a shorter time frame. However, this benefit comes with a trade-off. A longer cam necessitates a larger overall mechanism, making it bulkier and potentially cumbersome to integrate into existing assembly lines. This increased size can also introduce challenges in terms of maintenance and maneuverability. Finding the optimal cam length therefore becomes a balancing act. We must balance achieving the desired tape application speed and maintaining a compact design that seamlessly integrates into the production line. This highlights the importance of considering not just functionality but also practical limitations during the design process.



Section 3: Mechanism Description

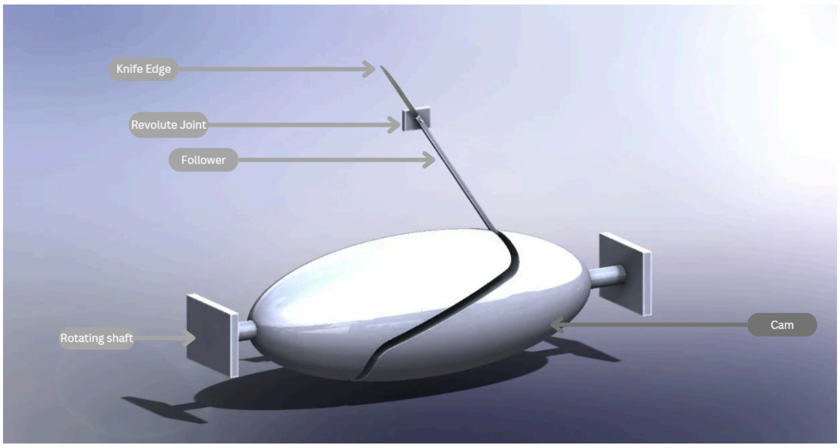
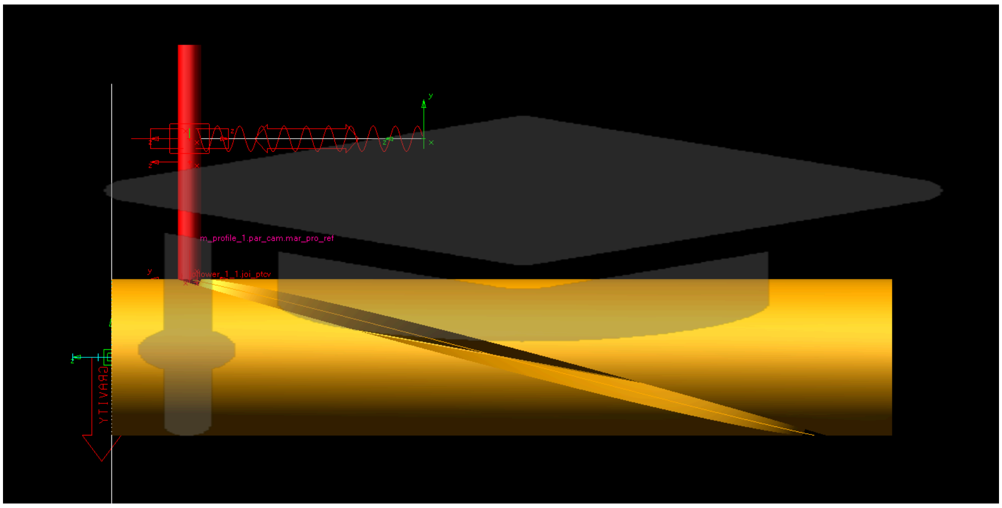
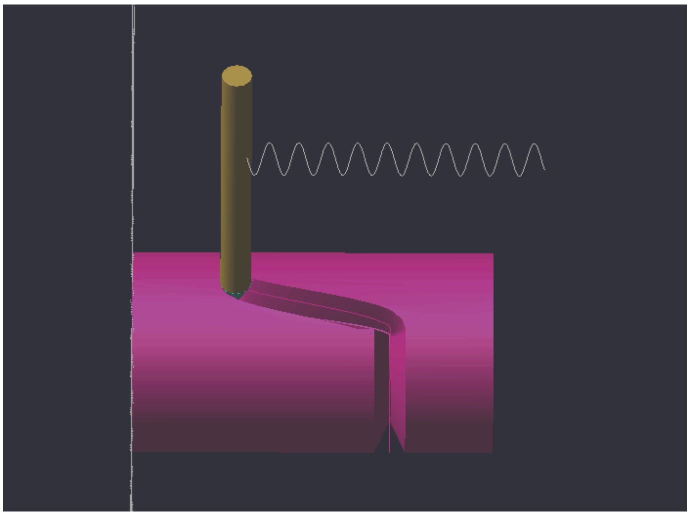


Image of the CAD model



Kinematic sketch of mechanism-1 from ADAMS



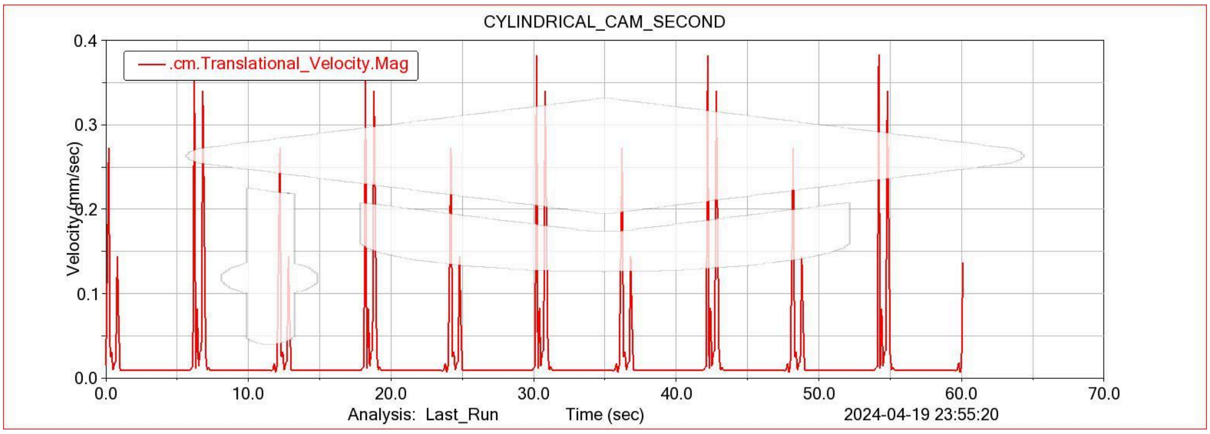
Kinematic sketch of mechanism-2 from ADAMS

Details of Cam System mechanism-2 :

Cam:	
Length	350mm
Follower displacement	150mm
Degrees of rise and fall	30
Radius	100mm
Groove width	30mm
Groove depth	30mm
Follower:	
Geometry	Knife-edged
Motion	Translational
Arrangement	In-line
Arm length	300mm
Arm radius	14.85mm
End height	300mm
Spring:	
Spring Coefficient	100
Damping coefficient	1.0
Length at preload	300mm
Preload	0
Natural length of spring	300mm

Weight of entire mechanism (CAM, Follower arm, and knife-edged end):
Mass = 1kg
Ixx = Iyy = Izz = 10

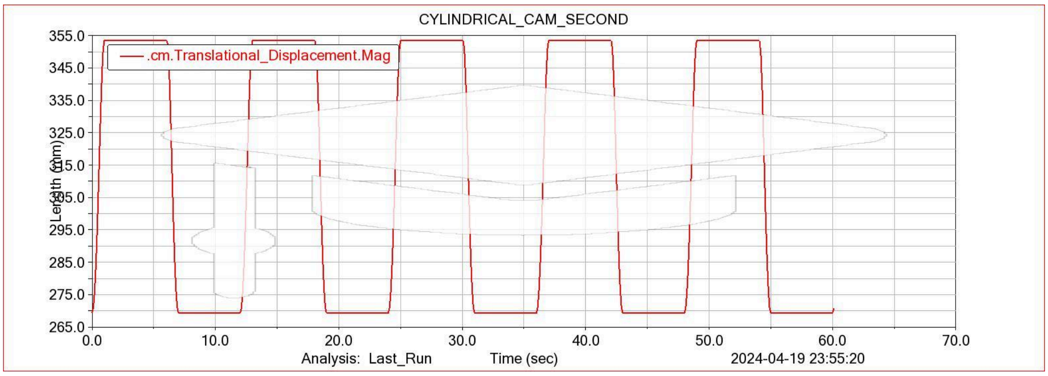
Follower velocity



Maximum velocity = .37 mm/sec

V_CM of CAM is negligible but not zero, showing that the Force exerted by the Follower over the CAM is imparting momentum to it.

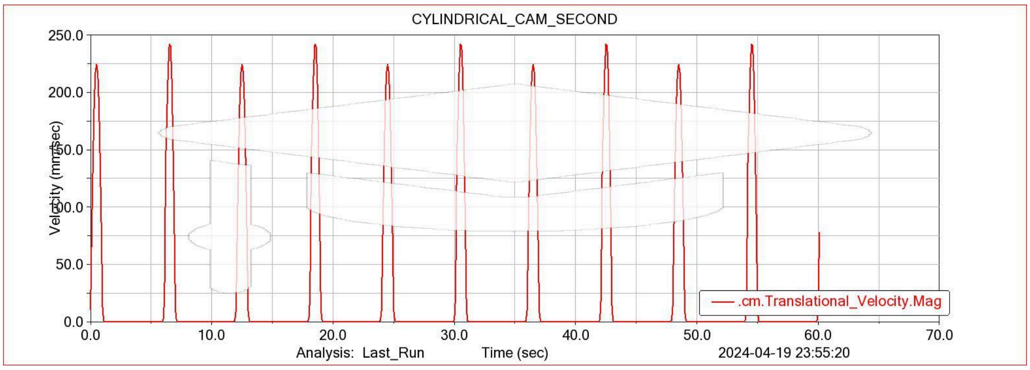
x_cm_ARM



Maximum displacement= 48.75 mm

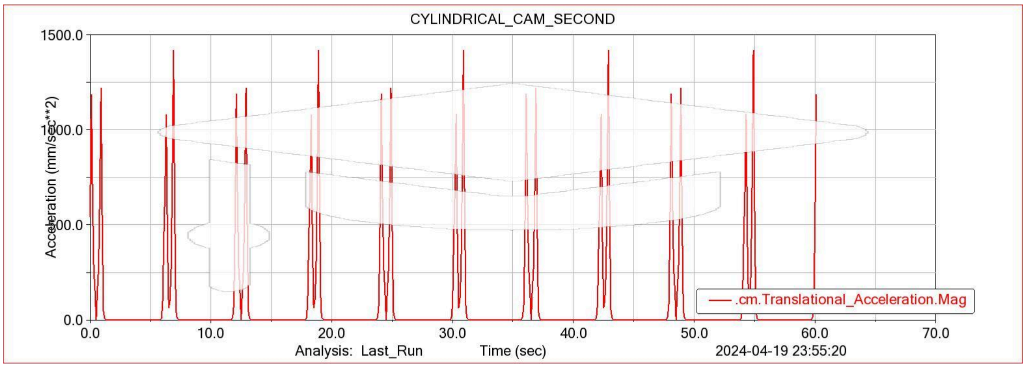
D=30 degree

v_cm_ARM



Maximum velocity= 230 mm/s

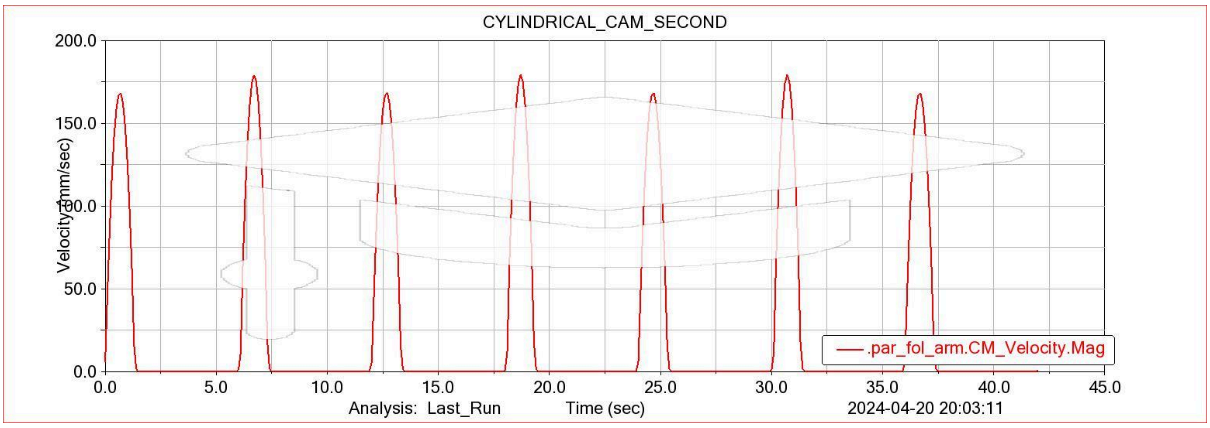
a_cm_ARM



Maximum acceleration= 1375 mm/s^2

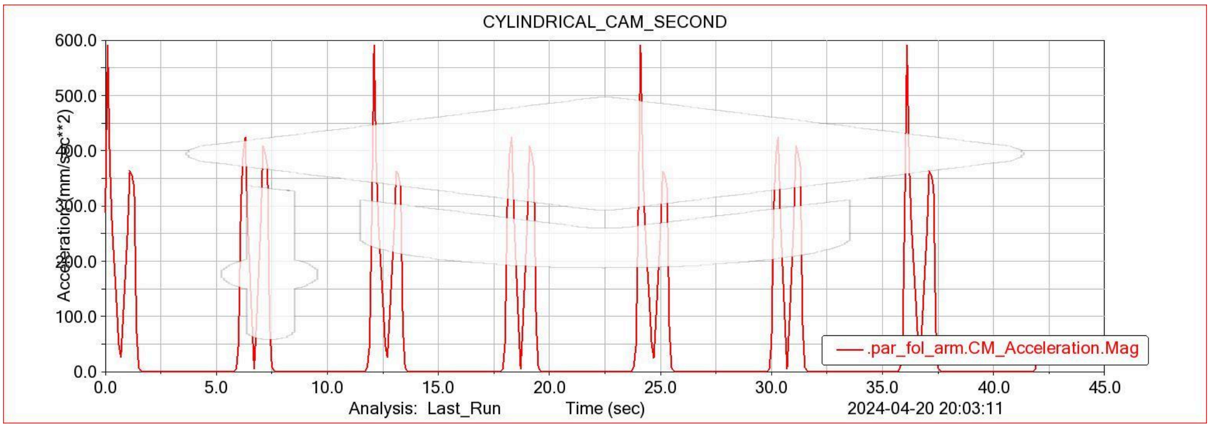
D = 40 degrees

v_cm_ARM



Maximum velocity = 175 mm/sec

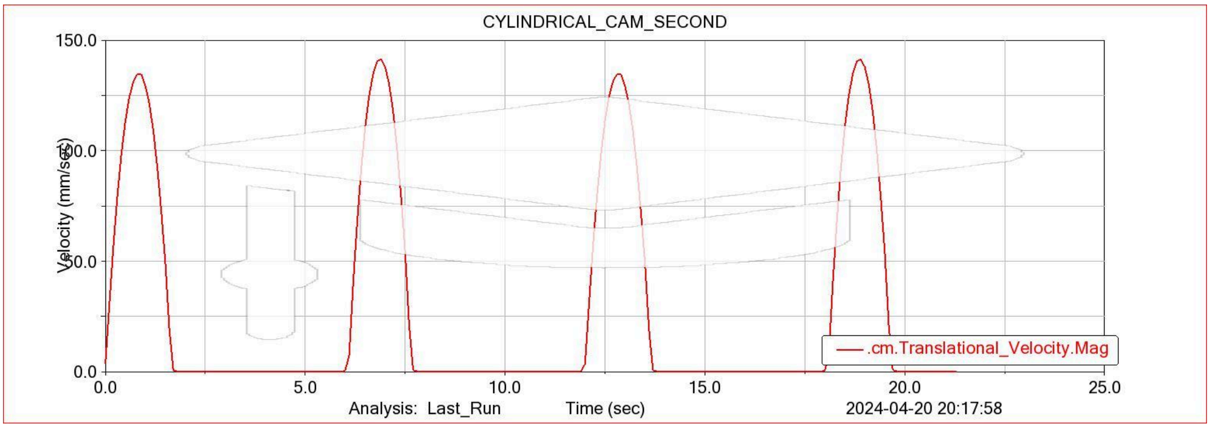
a_cm_ARM



Maximum acceleration = 600 mm/sec^2

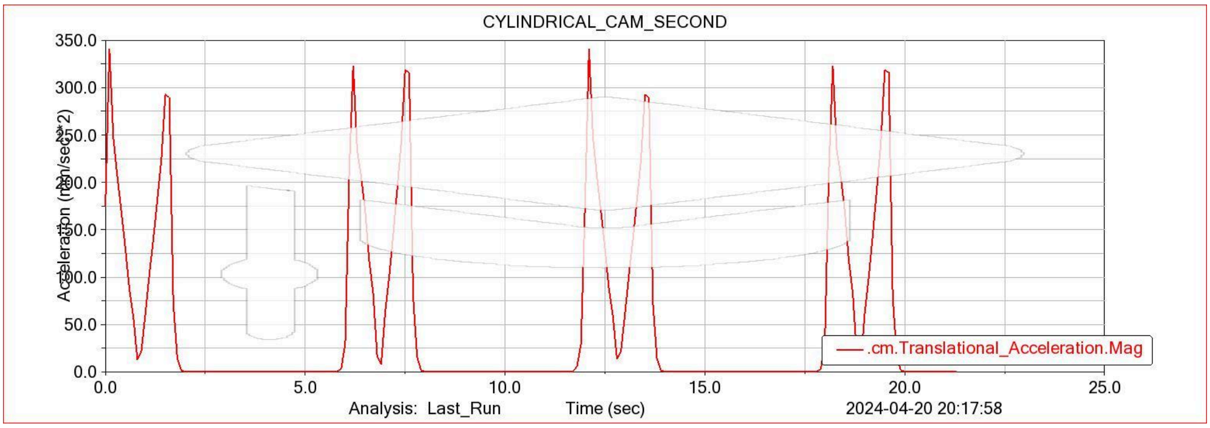
D = 50 degrees

v_cm_ARM



Maximum velocity = 137.5 mm/sec

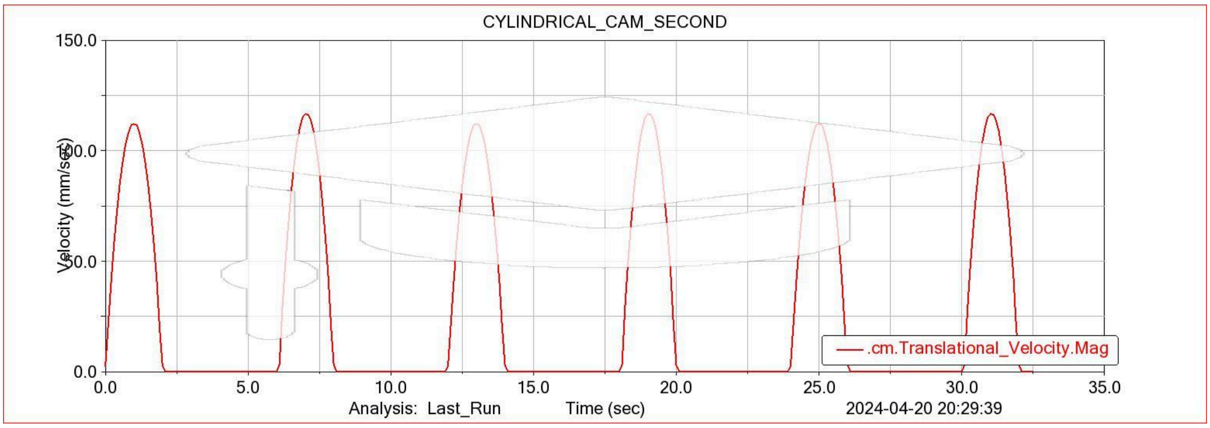
a_cm_ARM



Maximum acceleration= 337.5 mm/sec^2

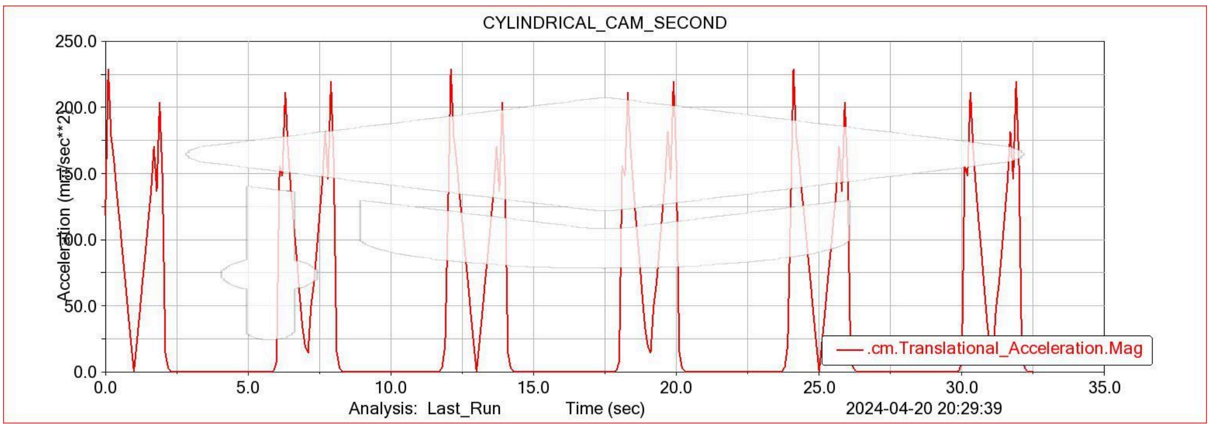
D = 60 degrees

v_cm_ARM



Maximum velocity = 112.5 mm/sec

a_cm_ARM



Maximum acceleration = 225 mm/sec^2

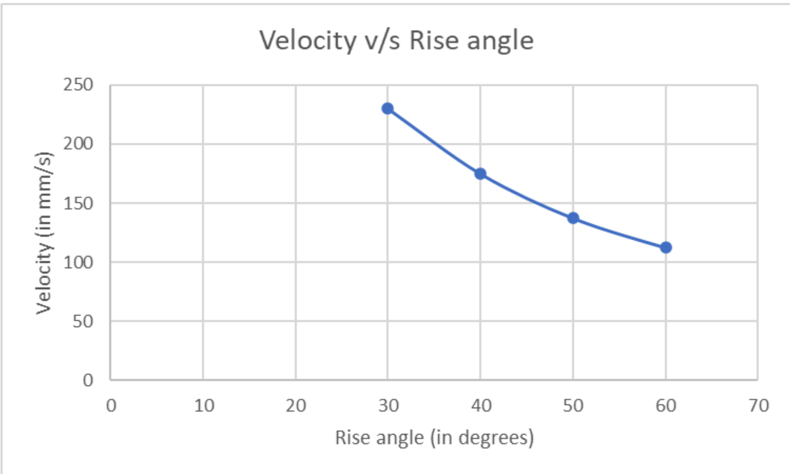
Section 4: Results & Discussions

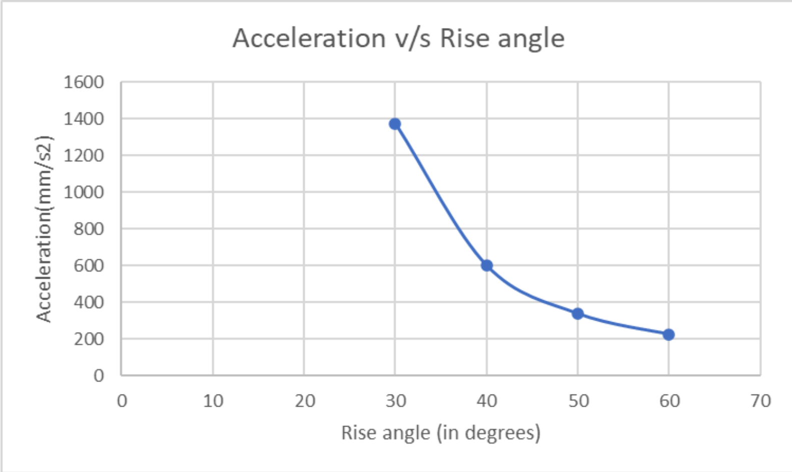
I. Relation with the CAM rise angle

The findings suggest a clear correlation between the rise angle of the CAM and the translational velocity of the follower's end. As the rise angle increases, there is a noticeable decrease in the translational velocity at the end of the follower. This observation underscores the significance of rise angle in influencing the movement dynamics of the system.

The analysis delves deeper into the behaviour of the follower's end point by examining both translational velocity and acceleration magnitude. By scrutinising these parameters, a comprehensive understanding of the system's performance under varying rise angles is achieved.

The rise angle couldn't be further reduced in the ADAMS software because the groove can't make such a sharp turn. After all, its width is a hindrance in making the turn for the follower.



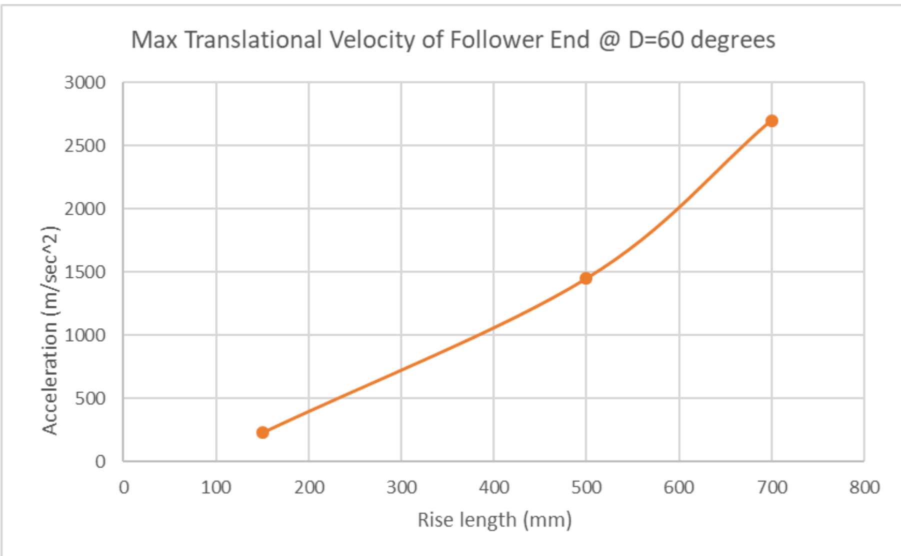


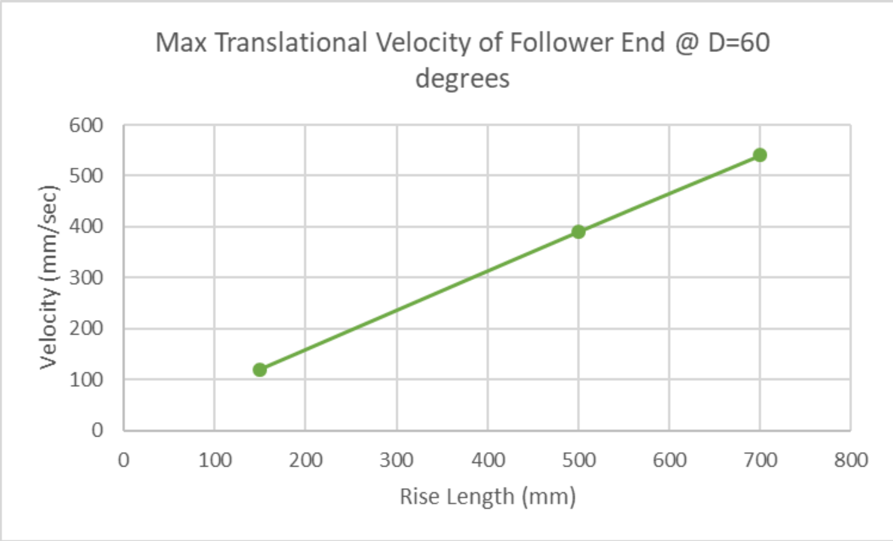
II. Relation with the follower rise length

In addition to the influence of the rise angle of the CAM, it is evident from the analysis that the length of the CAM cylinder also plays a significant role in affecting the velocity and acceleration parameters of the system. As the rise distance or CAM length increases, there is a notable increase in both translational velocity and acceleration.

By extending the CAM length, the system experiences heightened velocity, at the middle of the follower. The follower end point acceleration's magnitude is also increasing at the extreme point of the CAM.

The translational velocity follows a linear trend with the *rise distance*.
The translational acceleration magnitude graph is changing its nature and shape very abruptly with the change in rise length.





Section 5: Conclusion

The conclusions drawn from the results of the ADAMS simulation project offer valuable insights into the dynamic behaviour of the system under investigation, particularly in relation to the CAM rise angle and follower rise length.

The study shows a clear link between CAM rise angle and follower end velocity: as the angle increases, velocity decreases. The analysis also considers acceleration, offering a holistic view of system performance. However, there are limits to reducing the angle further due to groove width constraints.

Additionally, increasing CAM cylinder length boosts both velocity and acceleration, especially at the middle and ends of the follower. A linear relationship between velocity and rise distance is observed.

Overall, these conclusions emphasize the complex interplay between CAM geometry and system dynamics, providing valuable insights for optimizing system performance and informing future design decisions. Further research and experimentation may be necessary to explore additional parameters and refine our understanding of the system's behaviour.

Section 6: References

1. Optimization of the knife profile shape for resource-saving primary fish processing
2. Effects of knife edge angle and speed on peak force and specific energy when cutting vegetables of diverse texture Cutting force and specific energy for vegetables 23
3. Complete Can Beverage Production Line

Section 7: Individual Contribution

Group member	Contribution
Pranjal Girhepunje	● Ideation of flower-cam for bottle cap mechanism and inputs in final ● CAD modelling for flower-shaped cam ● ADAMS- design of flower cam mechanism ● Calculations in the report
Tanishka Meshram	● Ideation inputs for bottle cap and tape cutting mechanism ● ADAMS- design of disk-shaped cam ● Simulation of the disk-shaped cam follower ● Research on the topic of cutting tape for accurate ADAMS design
Adarsh Prajapati	● Ideation for the tape cutting mechanism ● ADAMS- design of the mechanism2 of cylindrical CAM ● Simulating cam followers ● Analysis of position, velocity and acceleration of the follower and did the mathematical calculations for the stress-strain curve, and energy dissipation