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An Application of Elliptical Trammel For The Purpose of Bottle Shaking

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Abstract
This presented article is an approach towards the use continuous motion of double sliders of crank chain mechanism which is automated by applying AC motor and gear arrangement as a Bottle shaking Machine. This is an elliptical trammel mechanism in which two sliders moves in to two slots, imparting perpendicular motion to each other. A connecting rod is used to connect these two sliders and make the motion constrained. The slotted Lever is mounted part within the mechanism. Two sliders, a crank and a connecting rod are the various components of mechanism and relative motions of these components are described having degree of freedom as a unity. Design of mechanism has been performed on the basis of their dimensions and deformation. Analysis of various components of the mechanism has been carried out. Thus this an elliptical trammel from which the approximate straight motion of sliders is being used for shaking purpose of bottles.

Keywords: *Double sliders, crank, elliptical trammel, gear, bottle shaking.*

INTREODUCTION

In engineering education, generally two concepts of kinetics and kinematics are used arbitrarily as it is not physically possible to separate it. First one to consider the motion and then consequentially investigate the forces acting on it. For a motion generated mechanical system, one of principal aim is of kinematics so as to create (design) desired motion of mechanical parts and then to compute the positions, velocities and acceleration of the rotating or reciprocating elements of the system.[1]A mechanism is such a body that transmits or transforms the motion developing some forces and can be transmitting very low power. It is little-bit difficult to differ the machine and mechanism. Some examples of mechanisms such as tongue, pencil sharpener, folding chair. Some examples of machines that possess motion are punching machine, nut cutter, a bank vault door, food blender. There cannot be any crystal clear line to differ it. They differ in degree rather than in kind. So simply a mechanism is a system of elements arranged to transmit motion in predetermined fashion and a machine is a system that transmits energy after motion. [1]

In a planner mechanism, a frame is a fixed link and other links act as rotating or transmitting links. The rigid link which rotates in full circular form called as crank and this circular motion is transmitted in reciprocating motion or vice-versa. The Following are the listed inversions of double slider mechanism.

I) Elliptical trammel II) Scotch yoke mechanism III) Oldham's coupling
An elliptical trammel is a simple mechanism which can trace exact elliptical path. It consist of two sliders which

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confined to perpendicular channels or rails and a rod which is attached to the sliders by pivots at fixed positions along the rod. The use elliptical trammel device to cut out the significant elliptical shapes changing the sizes automatically by using the motor and rack and pinion arrangements [6]

A mechanism that generates the shape of an ellipse because of the motion of two sliders are restricted ("trammeled") to perpendicular channels or rails, and a rod which is attached to the sliders by pivots at fixed positions along the rod. As the sliders move to and fro each along its channel, the extended end of the connecting rod moves in an elliptical path. During the motion, a fixed point on the segment traces an ellipse with one quarter of the ellipse in each quadrant and traces a complete graph as an ellipse, thus a mechanism for drawing an ellipse.[1]

Dynamic analysis of forces with the help of different software based methods like MSC ADAMS has been done to ensure the working of mechanisms for particular applications.[5]The major and minor axes of an ellipse are the distances between the end of the rod and the two pivots. An elliptical trammel can intend, to draw, to cut, or to machine ellipses, e.g. in wood or other sheet materials. The kinematic analysis is also studied to find out the position and motion aspects of the mechanism [6].The size and shape of the ellipse can be varied. As we have seen in the review papers, lot of expert have tried their views and working principles as needed for them in their own experiment. It is seen that it can be used as tool changing apparatus[4],other application is Stiller-Smith Mechanism had also been obtained by changing rotational characteristics of the slider of the trammel[1].The elliptical trammel mechanism can have various applications as it can be made in various gestures. The utilization of motion of elliptical trammel has been successfully shown with a floating crank.[3]One has given a nice comparative study for eight cylinder I.C. Engine and was found significant. [2]The elliptical trammel mechanism has various applications as it can be made in various gestures. In this mechanism we are going to show a single application of using a normal elliptical trammel to run as a mechanism for straight motion of slider in the slots so that we can get a required stroke length for bottle shaking purpose. In this way it will be possible to find the use of elliptical trammel in simple way. Thus the device made was enough capable to achieve the objective of shaking the bottles. if this mechanism can be used as small scale apparatus, then it is surly a great gesture in major value graded mechanisms.

Inversion of elliptical trammel:
Different mechanisms obtained by fixing different links of a kinematics chain are known as its inversions. It is a closed kinematic chain which consists of double slider, a coupler and a frame. It has two sliding and two revolute joints. Elliptical trammel mechanism is one of the inversions of a double slider crank linkage. It can be used for tracing an ellipse.
Link 1 – Frame
Link 2 - Slider-I
Link 3 - Coupler
Link 4 - Slider-II

Pair A- Sliding pair, link 1 and link 4
Pair B- Turning pair, Link 1 and link 2
Pair C- Turning pair, Link 2 and link 3
Pair D- Sliding pair, Link 3 and link 4

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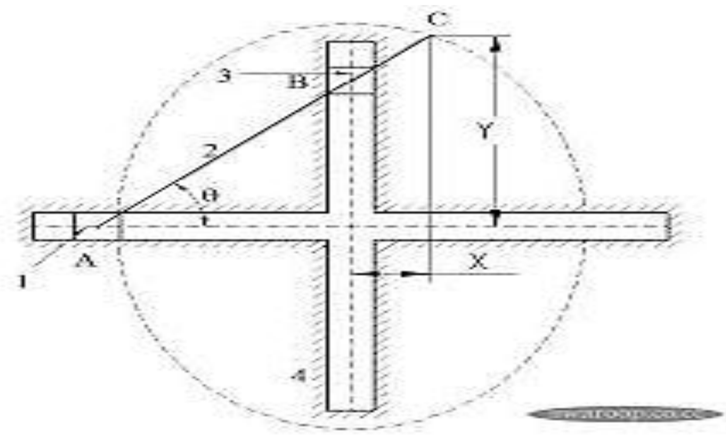

Figure 1: *inversion of elliptical trammel.*

MATERIALS AND METHOD

The fabrication of trammel has been done and the mechanism is automated with the help of AC motor, the gear box and a chain drive attached to it. The fabricated device is capable to achieve the required application. The various components are as : A steel frame having two slots for sliders, connecting rod of 800 mm length, a crank ,a gear box for reducing velocity ratio and a AC motor (0.4KW) steel connecting rod used for a connection between the two sliders. In this device a AC motor was connected to the gear box with the help of coupling. the ratio of velocity is 70:1. Gear box and shaft are connected to each other with the help of chain. Then the rotating shaft is connected to the crank. Two pinions are mounted on crank. Balancing was done to avoid the forces, out of balance couple and the excessive vibrations. Further to automate the mechanism, this arrangement has been connected with power supply to the motor and motor shaft is coupled with gear box. The complete assembly of the device has been shown in Fig.1. Further, kinematic analysis or position analysis of the device has been performed by MATLAB software and velocity and acceleration graphs have been plotted for each 30^o crank angle and the distance moved by both the sliders.

Figure 2: *Front sides and Back side view of fabricated device*

RESULTS AND DISSUCTION

The fabricated model of elliptical trammel had been driven by Ac motor. A gear box is attached to the motor shaft with the help of flexible coupling. The velocity is reduced with the help of gear box and the motion is transferred to some vertical distance by chain drive to the crank. The crank length of 400 mm is calculated and the rotation to the crank is transferred by attaching spur gear on the crank. The crank is attached at the center of connecting rod.

The bottles were clamped at place of both sliders and the distance moved by these two sliders Vs. angle traced were calculated. The velocity graph and the acceleration graph is plotted separately. Figure 3 to figure 6 shows the different cases of the graph plotted. Thus the two motions of sliders is used for bottle shaking purpose.

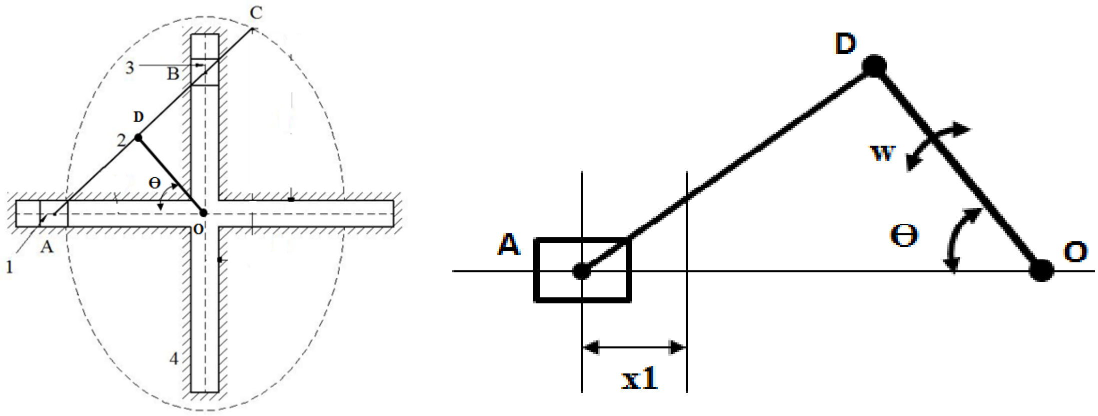

Figure 3: *Elliptical Trammel Mechanism and slider 1 (horizontal).*

The equations of displacement, velocity and acceleration for slider 1 (horizontal slider) is modeled, considering the link OD as crank, link AD as connecting rod, and link1 as slider1.

* Displacement equation is x1 = r (1 - cos θ) (1)

* Velocity of slider is v1 = rω (sin θ+ (sin (2θ)/2n) (2)

* Acceleration of slider is a1= rω2 (cosθ + (cos (2θ)/n (3)

Where, r is crank length, ω is angular velocity of crank OD, θ is angular displacement of crank in radians, Graphically, for one rotation of crank, the variation of displacement, velocity and acceleration of slider 1 is shown as under:

Table 1*: Variation of displacement of slider1.*

Sr. No.	θ (degree)	Displacements(m)
1	0	0.000
2	30	0.048
3	60	0.180
4	90	0.360
5	120	0.540
6	150	0.672
7	180	0.720
8	210	0.672
9	240	0.541
10	270	0.361
11	300	0.181
12	330	0.049
13	360	0.000

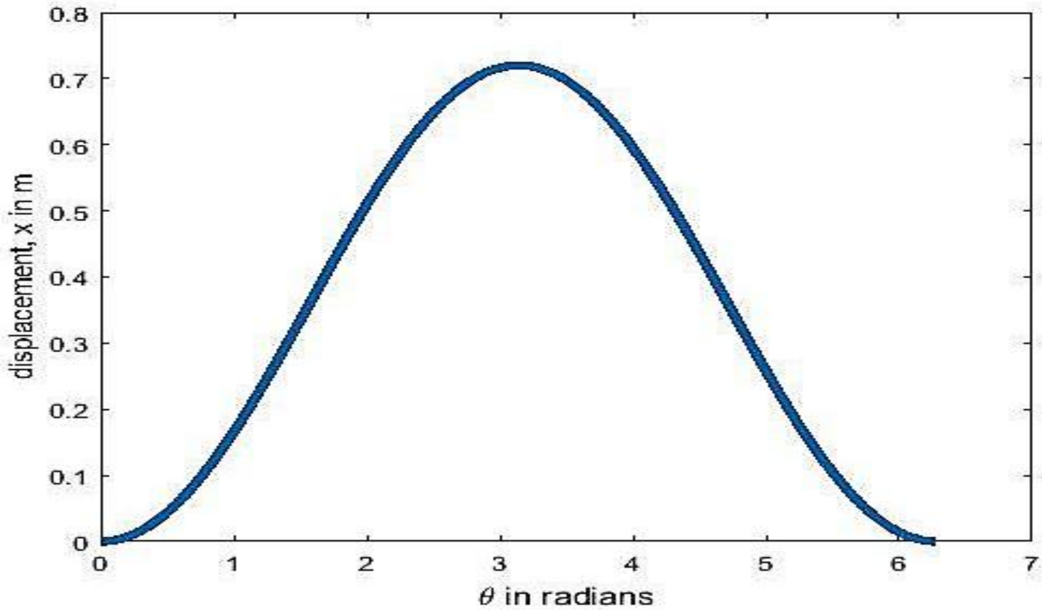

Figure 4: *Displacement graph.*

Table 2: *variation of velocity of slider 1.*

Sr. No.	θ (degree)	Velocity (m/s)
1	0	0.000
2	30	2.059
3	60	2.592
4	90	1.456
5	120	-0.072
6	150	-0.606
7	180	-0.003
8	210	0.605
9	240	0.079
10	270	-1.446
11	300	-2.589
12	330	-2.068
13	360	-0.014

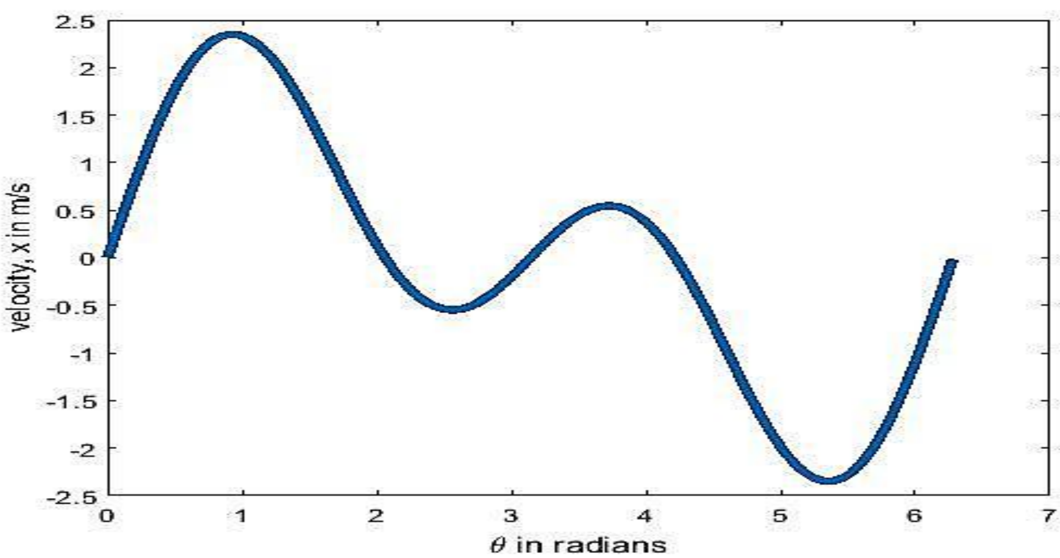

Figure 5: *Velocity graph.*

Table 3: *Variation of acceleration of slider.*

Sr. No.	θ (degree)	Acceleration(m/s2)
1	0	18.293
2	30	11.300
3	60	-3.265
4	90	-12.421
5	120	-9.164
6	150	1.107
7	180	6.558
8	210	1.166
9	240	-9.111
10	270	-12.439
11	300	-3.349
12	330	11.222
13	360	18.292

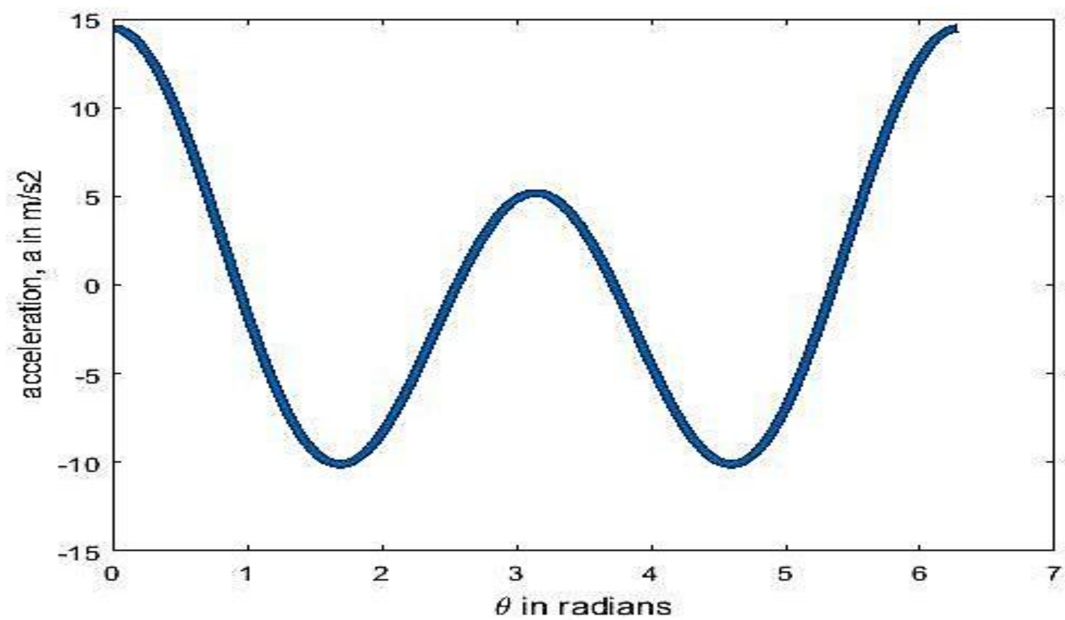

Figure 6: *Acceleration graph.*

In a similar way, The equations of displacement, velocity and acceleration for slider 2 (vertical slider) can be modeled by considering the link OD as crank, link BD as connecting rod, and link 3 as slider 2.

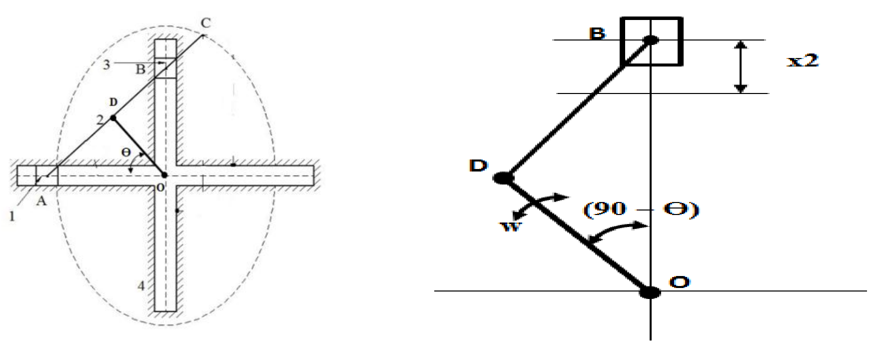

Figure 7: *Elliptical Trammel Mechanism and slider 2 (vertical).*

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The equations of displacement, velocity and acceleration for slider 2 (vertical slider) can be modeled similarly as
Displacement equation is x2 = r (1 - cos (90 - θ) (4)
Velocity of sliderv2 = rω (sin (90 – θ) + (sin (2(90 - θ)) / 2n) (5)

Acceleration of slidera2 = rω2 (cos (90 – θ) + (cos (2(90 -θ))/n) (6)

Graphically, for one rotation of crank, the variation of displacement, velocity and acceleration of slider 2 is shown as under:

Table 4: *Displacement variation of slider 2.*

Sr. No.	θ (degree)	Displacements(m)
1	0	0.360
2	30	0.180
3	60	0.048
4	90	0.000
5	120	0.048
6	150	0.180
7	180	0.360
8	210	0.540
9	240	0.672
10	270	0.720
11	300	0.672
12	330	0.541
13	360	0.361

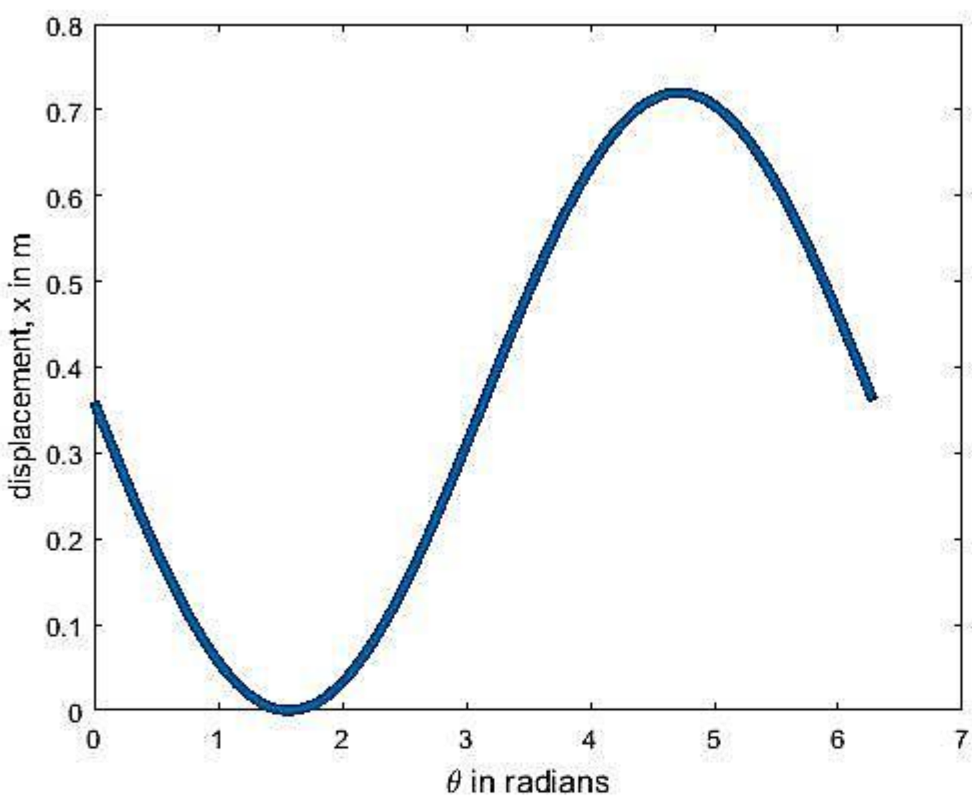

Figure 8: *Displacement graph.*

Table 5: *variation of velocity of slider 2*

Sr. No.	θ(degree)	Velocity (m/s)
1	0	1.456
2	30	2.592
3	60	2.059
4	90	0.000
5	120	-2.059
6	150	-2.592
7	180	-1.456
8	210	0.072
9	240	0.606
10	270	0.003
11	300	-0.605
12	330	-0.079
13	360	1.446

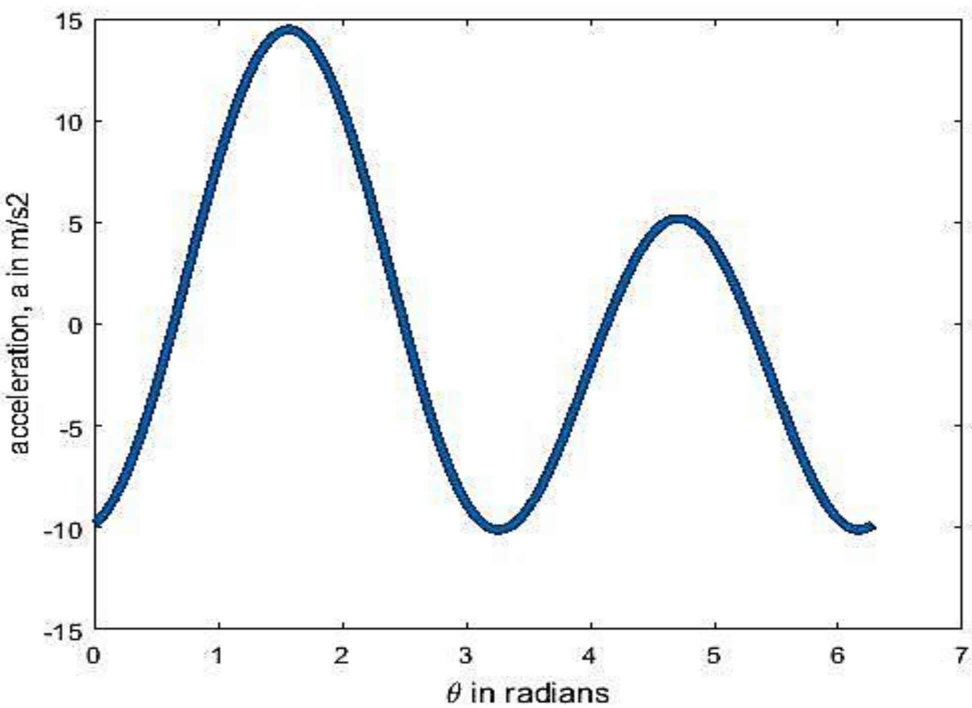

Figure 9: *velocity graph.*

Table 5: *variation of acceleration of slider 2.*

Sr. No.	θ(degree)	Acceleration
1	0	-12.421
2	30	-3.265
3	60	11.300
4	90	18.293
5	120	11.300
6	150	-3.265
7	180	-12.421
8	210	-9.164
9	240	1.107
10	270	6.558
11	300	1.166
12	330	-9.111
13	360	-12.439

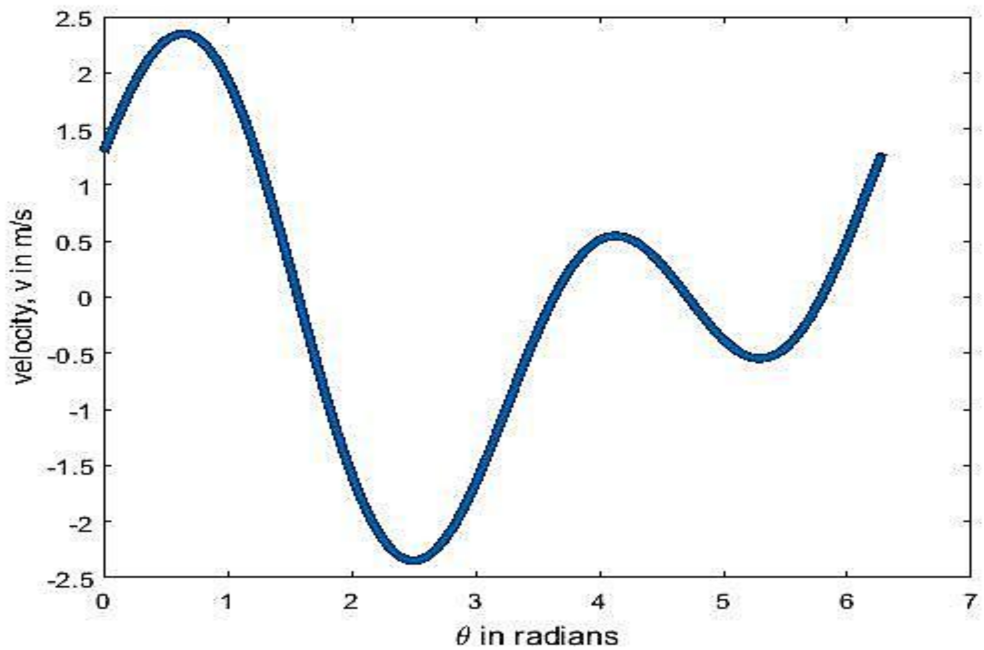

Figure 9: *acceleration graph.*

CONCLUSION

This is an inversion of double slider mechanism in which the motion is trammeled in particular path. It has two rotating and two sliding joints. The motion is automated with the help of AC motor and the shaking of bottles was done. The travel of motion is perpendicular to each other and the stroke length of 800 mm was designed. The findings are listed below:

FINDINGS FROM THE DISPLACEMENT DIAGRAM

1. When crank angle is at 0 degree there is zero displacement
2. When angle turns half the cycles there is minimum distance traveled which is around 800 mm, which is our required stroke.
3. Again at the end that θ is 360^o the displacement will be zero

FINDINGS FROM THE VELOCITY DIAGRAM

4. When crank is at 0 degree then the graph shows that the velocity of slider is around 1.4 m/s.
5. Velocity of slider reaches to maximum of 2.59 m/s, when crank angle is around 60 degree and it reaches to maximum -2.589m/s, when crank angle turns 300 degree.
6. When crank angle 225 degree it reaches to maximum velocity of 0.5 m/s.
7. When crank angle is 270 degree the velocity is -0.5 m/s.
8. When crank angle is 360 degree the cycle will get repeated with the velocity of 1.5 m/s.

FINDINGS FROM THE ACCELARATION DIAGRAM

9. From the graph it is found that the acceleration is -10 $m/s^2$when crank angle is 90 degree and reaches to 5 m/s^2 when crank angle as moved to 180 degree.
10. The maximum acceleration is reached whenθ is 0 & 360 degree.
11. This is all about horizontal slider and similar graphs are taken for the vertical slider.
12. The displacement of the vertical and horizontal slider is same, where we get maximum stroke length which is our required length of shaking of bottle.

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