EXPERIMENTAL ANALYSIS OF TWO STAGE MECHANICAL OSCILLATOR

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Abstract— **an experimental analysis of a two stage mechanical oscillator has been provided in the following paper. A two stage mechanical oscillator acts as a mechanical amplifier multiplying the input energy provided at the input side to provide an amplified output. A two stage mechanical oscillator is a simple mechanism consisting of a see-saw arrangement i.e., massive lever pivoted on a support. On one side of the lever hangs a pendulum with a bob of mass, m. Input energy to the mechanism is provided by raising the pendulum to a height h, and then releasing it. The pendulum oscillates about the pivot point due to the unbalance on the input side as a result of oscillation of the pendulum about the pendulum's pivot point. Due to the unbalance the other side of the lever also undergoes to and fro motion about the pivot point, which can be coupled to generator, motors, mechanical presses etc and hence act as the output side of the mechanism. The oscillations continue until damped due to various factors like frictional and inertial resistances. Therefore, in theory the above mechanism can provide efficiency over unity. An experimental analysis is done calculating energies provided at the input and output side to measure the efficiency of the mechanism.**

Keywords—Centrifugal force, Centripetal Force, Oscillator, Pendulume, efficiency

I. INTRODUCTION

In this work, two stage mechanical oscillator developed by the famous scientist vellijiko milkovic is fabricated using GI links, bearings and the efficiency of the mechanism was to be measured by measuring energy at both input and output side. Jovan Marjanovic in his paper titled "Recommendations for construction and efficiency measuring of Two Stage Mechanical oscillator,2012" describes briefly how to construct vellijiko's two stage mechanical oscillator and to measure its efficiency as well as various forces acting on the mechanism. A mathematical pendulum is an idealization, working on the assumption that:

- The rod or cord on which the bob is hanged doesn't have a mass, is inextensible.
- Motion in 2-D, i.e. the bob does not trace an ellipse
- The motion does not lose energy to friction
- Air resistance is non-existent

A mathematical pendulum is defined as:

"A body suspended from a fixed point so that it can swing back and forth under the influence of the gravity. A simple pendulum consists of a bob (weight) suspended at the end of a string. The periodic motion of a pendulum is constant, but can be made longer or shorter by increasing or decreasing the length of the string. A change in the mass of the bob alone does not affect the period".

In modern mechanics, analysis of the pendulum movement takes assumptions that the movements are very small oscillations (less than 5o), while the movement of the pendulum at higher amplitudes is quite insufficiently explored, both theoretically and practically.

During the oscillation of the pendulum, kinetic and potential energy are transforming one into the other, and the forces change their magnitudes and directions. Because of the centrifugal force in the lower position, the resultant force acting on the pendulum culminates (due to the maximum speed of the movement), and the effect of the force of gravity is in its maximum, so that the pendulum moves down and then moves upward in the direction of vertical plane. Surplus of energy, due to these inertial forces and gravitational potential can be explained by the additional acceleration due to gravity potential.

The effect of creating the free energy is defined in this study as the difference between the energy which is the machine transfers to the user system by the lever and the energy which is input from the environment in order to maintain the oscillation of the pendulum. Appearance of the free energy is not in accordance with the energy conservation law. The effect of creating the free energy results from the difference between the work of the orbital damping forces of the lever and the work of the radial damping force of the pendulum motion. This effect enables increase of the input energy. The coefficient of efficiency of the machine can be more than one.

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II. WORKING PRINCIPLE

The study of a swinging pendulum relates to all three laws of Motion. Once in motion, the pendulum remains swinging until friction at its pivot point and air drags slow it down. Its back and forth motions describe a complex set of acceleration and decelerations produced by the action of gravity on the mass of the pendulum. And finally, the centrifugal force produced by the angular momentum of the pendulum at the bottom of its swing is perfectly balanced by the constrained centripetal force in the arm the pendulum is hanging from.

The Two-Stage mechanical oscillator is most easily described as a balance beam with a pendulum hanging on one side and a fixed weight attached to the other side. When the pendulum is not swinging the two sides are balanced for both weight and mass and the beam is at rest. As soon as the pendulum is put in motion and Begins to swing back a and forth, the balance beam begins to gyrate up and down at twice the frequency of the

Pendulum's swing. Once in motion, the pendulum's swings described by a set of conserved forces and will only slow down due to the pivot point friction and air resistance .The up and down gyrations of the balance beam are, however, another matter entirely.

With the pivot point of the pendulum now free to move, the centrifugal force of the downward swing is free moveable beam, while the countering centr remains a constrained force within the arm the hanging from. This remarkably simple, arrangement, liberates useable force that Can be harnessed to produce real work at the other end of the beam, that is not countered by an "equal and opposite" reactionary force in the machine. So, when the pendulum swings down, it lifts the weight on the opposite side of the balance beam, thereby accomplishing real work, (Work: Force x Distance) measured in Newton-Meters. When the pendulum reaches the top of its swing, it experiences a brief moment of weightlessness, as It reverses the direction of its swing. At that moment, the side of the balance beam with the fixed weight on it becomes heavier, and it drops with a large force indicative of the unbalanced condition, each time the pendulums wings back and forth once, the weight is lifted and dropped twice. Neither the lifting of the weight, nor its dropping, nor the removal of work from the movement of the beam, impress any forces on the pendulum that act to damp out its free oscillation.

of the physical pendulum

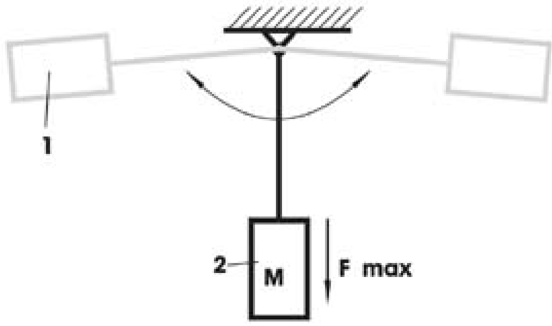

Figure 1: Difference of the potential energy during oscillation

Previous Experiences Of Energy Measuring

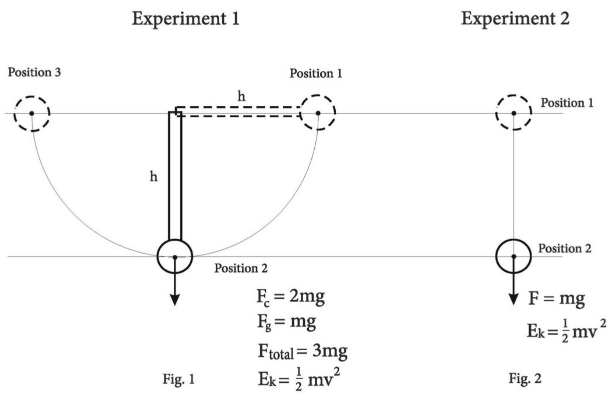

Fig 2 : Forces acting on the bob of pendulum during top and bottom positions, during it's swing.

Experiment 1

Fig. 2 describes the experiment where the weight of that pendulum with mass m free falls from position 1.
If we disregard the friction force and air resistance, the pendulum will interminably move in the semicircle trajectory from position 1 to position 3, as shown in Fig. 1.If the pendulum arm has length h, potential energy of the pendulum body in position 1 is:

E_p = mgh………….. (1)

Pendulum weight in position 3 has the same potential energy. In position 2, total potential energy of the weight from position 1 turns to kinetic energy:

E_k=mv^2/2………... (2)

i.e. weight with mass m will have the following speed in position 2:

v = 2gh…………………… (3)

Now, let us look at the situation where this two-stage mechanical oscillator is set so that the pendulum moves only when total centrifugal force approximately equals 3mg.

In this experiment, radius of the semicircle trajectory of the pendulum weight r has length h, so that the pendulum weight in position 2 is influenced by centrifugal force with the approximate value:

F_c =mv^2 /r=2.m.g.h/h=2mg.... (4)

In addition to centrifugal force, the weight in position 2 in influenced also by gravity:

F_g = mg……………………… (5)

so that the total force exerted on the weight in position 2 equals to:

F_{total} = F_c + F_g = 2mg + mg = 3mg...(6)

I am mentioning that this approximate amount of the force will take effect because the mechanism is set in such a way that the lever starts to move only when the centrifugal forces reaches approximate value of 3mg.

Experiment 2
Let us look at the second experiment, described in Fig. 2:
We have let the same weight into the free fall from height h. Freefalling weight after distance h will have the kinetic energy:

Ek =mv^2 /2…………………………….. (7)

And will be influenced by gravity at that position:

F = mg………………………………….. (8)

When we compare these two situations, we can see that the weight has the same kinetic energy in both situations:

E_k =mv^2 /2…………………………….... (9)

in position 2 both in experiment 1 and 2, and that energies needed to lift the weight to height h are the same in both cases:

E_p = mgh……………………………….. (10)

but the force exerted on the weight vertically downwards in position 2 of the experiment 1 equals to:

F_{total} = F_c + F_g = 3mg……………… (11)

and in the experiment 2, force exerted on the weight vertically downwards is:

F = mg ……………………………….. (12)

in all positions of the trajectory, including position 2. Is it not true that the weight in position 2 of the first experiment is in energetically more favorable situation than in the same position in the second experiment.

It is important to note that we are not supporting over unity claim for the oscillator where its pendulum was initially raised to some height and then left to swing until it stops.
Our idea is that after initial rising of a pendulum it is necessary to keep adding a little energy to a pendulum to keep it swinging. Because two stage oscillators are supposed to be used for long period of the time, energy spent for initial rising can be disregarded. The same logic is for Diesel engines where it is necessary for them to achieve working temperature before measuring its efficiency. Nobody would also include energy spent for magnetization of permanent magnets in an electric motor for calculation of efficiency ratio of his electric motor.
It is necessary to measure small energy continuously added to maintain pendulum swinging. Note also that output force on the lever side is variable and change from zero to a maximum defined by its mass. The reason for it is variable force of the pendulum which exert pulling the lever on opposite side. This makes mathematics complex and precise tools for measuring variable force are necessary for calculation of efficiency ratio of a two stage oscillator.

III. DESIGN AND FABRICATION OF TWO STAGE MECHANICAL OSCILLATOR

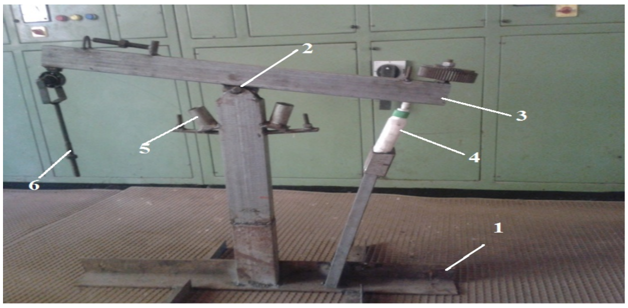

Fig.3: Experimental Setup
1.Base, 2.Ball Bearing,3.Links,4.Discharge Setup,5spring,6.Pendulum

Specifications of two stage mechanical oscillator

As in the photo, there is a pendulum attached on horizontal link. It is attached to the link using an iron rod. A main ball bearing is provided at the centre for oscillating the links. A discharge setup is made on the right side. These are all attached on a base. Shown. 2 small springs where attached on 2 sides (as shown in fig.) for proper oscillation.

IV. EXPERIMENTAL SETUP

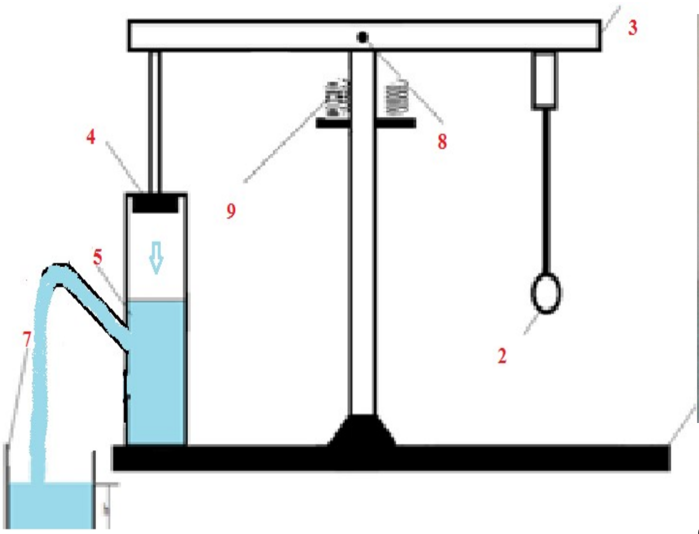

Fig.4: Design of the Experimental Setup
1. Base, 2.Pendulum, 3.Links, 4.Piston, 5.Water In Cylinder, 6.Pipe, 7.Measuring Tank, 8.Ball Bearing
9. Spring for Increasing Oscillations

Efficiency of Two Stage Mechanical Oscillator

Fig 5: Height of rise of pendulum

To measure the input energy
I/p=mgh…………………….. (13)
Where m-mass of pendulum
g- Acceleration due to gravity
h-height of rise of pendulum

Fig 6: Discharge measuring setup

Output energy of 2 stage mechanical oscillator is measured by measuring the discharge from the discharging setup provided in the left part of the setup. The initial mass and final mass (after discharge)of discharge setup say hand wash is measured.

Total discharge Q = (initial mass of discharge setup-final mass of discharge setup)/ (density of water p x time taken for discharge t)……………………………….. (14)

Now output power =m .g. H……………… (15)

Where m-net mass of water discharged

Q-discharge

g- Acceleration due to gravity

H-total head of water =head of delivery pipe H_d + velocity head H_v

$H_v=v^2/2g$ ……………………………….. (16)

Where v-velocity of flow=Q/a

a=area of delivery pipe

V. EXPERIMENTATION

Observations

Procedure

The experiment was done by swinging the pendulum freely for 10 seconds. Due to the action of ball bearings the links will oscillate and water will be discharged from the discharge setup by pressing it. The water flow rate was measured by checking the final and initial weights of the discharge setup.

Sl no.	Height of rise of pendulum (m)	Time taken for discharging,t (s)	Input energy (joules)	Initial mass of hand wash (g)	Final mass of hand wash (g)	Net mass of water discharged (g)	Discharge Q ($m^3/s x 10^{-6}$)	Velocity of flow in (m/s)	Velocity head (m)	Total head (m)	Output energy (joules)	Efficiency (%)
1	0.22	10	1.07	227.43	181.73	45.7	9.14	5.172	1.363	1.4	0.656	60.79
2	0.18	8	0.88	181.73	145.96	35.77	8.943	5.06	1.305	1.4	0.493	55.84
3	0.16	10	0.78	145.96	111.36	34.6	6.92	3.916	.782	0.8	0.299	38.08
4	0.14	6	0.68	111.36	84.16	27.2	9.06	5.131	1.341	1.4	0.385	56.04
5	0.12	6	0.58	84.16	57.71	26.45	8.817	4.989	1.268	1.3	0.355	60.30

TABLE 1 Experimental observations of output at various height of rise of pendulum

Sample Calculation

Set for maximum efficiency

Height of rise of pendulum = 0.22m

Time taken t = 10 s

Mass of pendulum bob = 500g

Input energy (I/P) = mgh

=0.5x9.81x.22

= 1.079J

Initial mass of discharge setup, m_i =227.43g

Mass after discharge,mf =181.73g

Net mass of water discharged m $= m_i - m_f$

= 227.43-181.73

= 45.7g

$= 45.7x10^{-3}$kg

Area of discharging pipe $= 3.14.d^2/4$

= 3.14x.0015x.0015/4

$= 1.76x10^{-6}$

Discharge Q = m/density (p).t

$= 45.7x10^{-3}/1000x10$

$= 9.14x10^{-6} m^3/s$

Velocity of flow v = Q/a

$= 9.14x10^{-6}/1.76x10^{-6}$

= 5.172m/s

Velocity head H_v $= V^2/2g$

$= 5.172^2/2x9.81$

= 1.363m

Total head H $= H_v+H_d$

= 1.363+0.1

= 1.463m

Output energy = mgH

$=45.7x10^{-3}x9.81 x 1.463$

=0.656J

Efficiency = (O/P) x 100 / (I/P)

=0.656x100/1.079

= **60.79%** -Max efficiency obtained

The maximum efficiency obtained is **60.79%**.The efficiency never exceeds unity.

Characteristic Curves of Two Stage Mechanical Oscillator

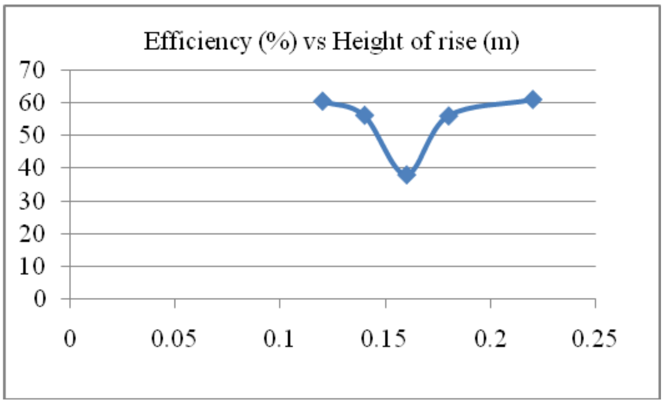

Fig 7: Variation of efficiency with height of rise of pendulum
X axis-height of rise in meters m
Y axis-efficiency of two stage mechanical oscillator in percentage %

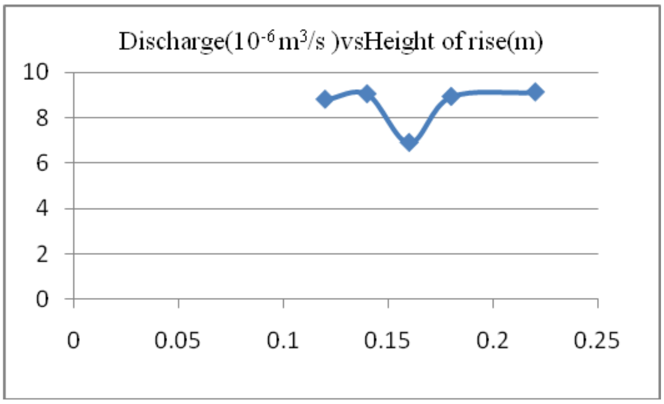

Fig 8: Variation of discharge with height of rise of pendulum
X axis-height of rise in meters m
Y axis-discharge produced in 10^{-6} m^3/s

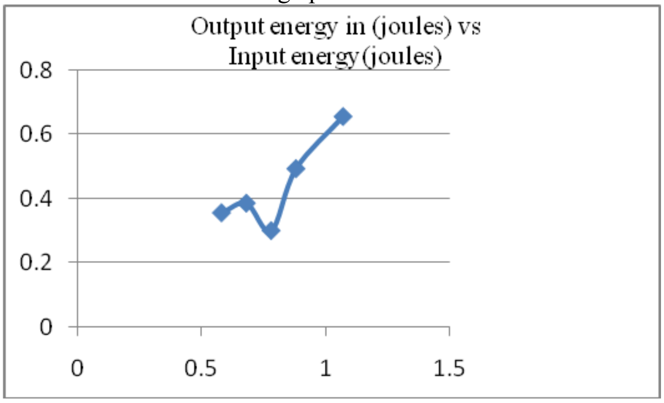

Fig 9: Variation of output energy with input energy
X axis-input energy in joules
Y axis-output energy in joules

Variation of efficiency with height of rise of pendulum and variation of discharge with height of rise of pendulum was found to be nearly constant. But the third reading corresponding to 0.16m height of rise of pendulum shows a dip. Output energy increases linearly with input energy. Still the third reading shows a deflection from the common behavior of the graph. Anyway the efficiency never exceeds unity.

VI RESULTS AND DISCUSSION

The experiment was performed with a goal to analyze events of large amplitude of oscillations of the pendulum, which modern mechanics and physics have not sufficiently explored, and that this should not be an obstacle for further investigations by persons interested in this field.

The maximum efficiency obtained was 60.79% which is less than unity. It may be due to friction in the bearing losses due to discharge setup etc.

A very interesting phenomenon, concerning the distance passed, was noticed after varying distance "*D*", which brings us to the conclusion that *greater oscillations give greater movement and also generate a greater amount of energy* and that the gravitational force seems to "*add*" some energy to the system. This comment should be accepted with caution because the scientific community generally accepts the law of conservation of energy. But the experiment shows that it's evident that our gravitational force "*helps*" us to achieve greater movement of the pendulum system in both cases (*sliding and rolling*)

VII CONCLUSIONS

The free energy of the machine based on oscillation pendulum-lever system, is defined in this study, as difference between the resulting energy of the machine and the energy input from the environment in the same time interval. Existence of the free energy defined in this way is not in accordance with the energy conservation law, and has not been verified experimentally and it cannot be explained. Either way, the mechanism finds application in converting oscillatory motion to linear motion.

In the proposed method of measuring, it appears that the quotient of efficiency is smaller than one, then this machine is not an over unity machine. The efficiency of the system may be further improved by reducing various losses such as friction losses. For e.g. Use of ceramic bearings instead of steel bearings can give better efficiency and smooth working.

Like in any experiment, it is possible to improve a certain segments, so it was also noticed that in this experiment certain improvements can be made in the form of exclusion of the errors caused by the human factor, which is mostly related to the introduction of automated (robotic) energy transfer system to a pendulum, which would provide greater reproducibility of results and greater accuracy. It is also necessary to expand the analysis of large amplitude oscillations to find a critical point at what it is profitable to invest energy.

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