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A BRIEF STUDY ON PENDULUM BASED PUMP

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Abstract-A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. Pendulum is a simple body which moves freely until any damper is present. Hence, if the oscillation is forced, then it is possible to gain continuous movement. Our objective is to create the vibration with application of minimum energy as possible. If we can manage to give the pendulum north and south pole of magnet and arrange another pair of magnet of same polarity as shown in picture below, then we can attain a forced vibration of pendulum with minimum energy as possible. By link mechanism, we can attain linear motion from oscillatory motion and can use that to operate a pump or compressor. So the energy consumption of this system will be lowest. From the above reviews, we took idea of magnetic pendulum, theories associated with balancing the pendulum and mechanism of simple reciprocating. By utilizing the concepts, we proposed to create a zero energy pump.
Keywords- Reciprocating pump, Basic Pendulum, Magnetic Pendulum and Two Bar Mechanism.

I. INTRODUCTION

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps. Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for watercooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers. Pendulum is a simple body which moves freely until any damper is present. Hence, if the oscillation is forced, then it is possible to gain continuous movement. Our objective is to create the vibration with application of minimum energy as possible. The basic concept of this is to use the oscillatory motion of simple pendulum and converting this motion into linear motion of piston movement.

The basic law applied for a magnet is “opposite poles repel”. If we can manage to give the pendulum north and south pole of magnet and arrange another pair of magnet of same polarity as shown in picture below, then we can attain a forced vibration of pendulum with minimum energy as possible. By link mechanism, we can attain linear motion from oscillatory motion and can use that to operate a pump or compressor. So the energy consumption of this system will be lowest.

The ever increasing demand for energy has led to the formation of various advanced resources which produces a certain part of the required energy. One principal consumer of a large amount of energy is our household itself. Large amount of electrical energy is wasted in pumping water, irrigation purposes etc. It is in this context the importance of pendulum pump arises, by the use of which a large amount of energy can be conserved and the conserved energy can be used for various other purposes. The main importance of a pendulum pump is that the initiation energy for starting The process of pumping, swinging of the pendulum, is considerably minimum when compared with the work required to operate hand pumps. Typical hand pumps require sufficiently large effort and an average person can use the pump continuously only for a short time, but the pendulum pump requires only minimum of the effort, because it is only required to oscillate the pendulum and can maintain these oscillation for several hours, without any fatigue. The advantage of this invention compared to present hand pump solutions are: less force to start the pump, less water consumption, and both arms can be used to fetch the water. Renewable energy technologies are essential contributors to sustainable energy as they generally contribute to world energy security, reducing dependence on fossil fuel resources, and providing opportunities for mitigating greenhouse gases. The International Energy Agency states that: Conceptually, one can define three generations of renewables technologies, reaching back more than 100 years.

II. A DETAILED LITERATURE REVIEW ON ENERGY GENERATION USING PENDULUM

Lin et al.[2013][1] from The State Key Laboratory of Fluid Power Transmission and Control, Zhejiang University, China were acquired experimental data from the semi-physical test rig and analysed validate the energy transmission strategy of dual-medium pressuriser. An onshore pendulum WEC test rig is built to validate the above proposals. A hydraulic cylinder is substituted for the wave that exerts force on the pendulum. Although the force and the output power in the simulation are somewhat different from those in the test results, the overall tendency is the same, and the dual power stroke in one period is clearly shown.

Rahul Singh and Vijay Kumar [2014][2] from Dept. of Electronics and Communication Indian Institute of Technology, Roorkee, India presented an approach for the swing up and stabilization of a rotary inverted pendulum (RIP). RIP system is an unstable, multivariable, under actuated and highly nonlinear in nature. RIP consists of a pivot arm, the pivot arm rotates in a horizontal plane by means of a servo motor. The opposite end of the arm is attached to the pendulum rod whose axis is along the radial direction of the motor. The task is to design a controller that swings up the pendulum, and keeps it in upright position. Swing up action is based on the energy principle whereas stabilization uses Takagi Sugeno Fuzzy controller. A mode controller is used to decide which control action is to be implemented. Mode controller is basically a condition check on the angle of the pendulum rod. Finally MATLAB SIMULATION results reflect the performance of the RIP system with the stated control actions.

R. Ortega [2013][3] from Depto. deMatemática Aplicada, Universidad de Granada, 18071 - Granada, Spain presented the stability of the equilibrium of a pendulum of variable length in terms of the third approximation. In contrast, the traditional linearization procedure is not always faithful. Alternative characterizations of stability are also presented. They are based on degree theory and on the algebraic structure of the symplectic group.

V.P Mitrofanov1 and N.A Styazhkina [2013][4] from Department of Physics, Moscow State University, 119899, Russia made a study of an external electric field influence on the pendulum damping. The electric field was applied between the conducting surface of the pendulum and the nearby electrode. The experiments were carried out in atmospheres with various values of relative humidity and in vacuum. The losses are found to be dependent on the surface-adsorbed water as well as the manner of surface treatment of both the pendulum and the electrode.

Violaine et al.[2014][5] from UMR 6233 ISM Marey, Université de la Méditerranée, 163, avenue de Luminy, Francemade analysis of the mechanical constraints operating suggested that the gymnast should be considered as a pendulum of variable length. Increasing and decreasing pendulum length at appropriate phases of the swing effectively allows energy to be injected into the system, thereby compensating the energy lost to friction.

W. Szyszkowski and D.S.D. Stilling [2014][6] of Mechanical Engineering Department, University of Saskatchewan, 57 Campus Drive, Saskatoon, Canada studied the damping effects that are generated in a frictionless oscillating physical pendulum by a continuous motion of an auxiliary mass. The analysis presented shows how a mass sliding in a periodic pattern along the rotating member affects the system oscillations. The resulting rotational motion of the pendulum is not exactly periodic. Therefore, the mass motion should be continuously synchronized to control the phase angle. If the mass motion period is not adjusted properly (if kept constant, for example) then undesired "beating" effects would result over extended oscillations of the pendulum.

Dian-Hong et al.[2013][7] from department of Mechanical and Electronic Engineering, China University of Geosciences, Wuhan 430074, PR China, amplified the geomagnetic influence on torsion pendulum experiment by producing an additional horizontal magnetic field, and obtained the dissipation, which is proportional to B2 in the disc shaped torsion pendulum experiment. The geomagnetic influence should be considered due to the inelasticity correction in G measurement in high Q-factor torsion pendulum experiments.

Sergey V. Kapranov and Guennadi A. Kouzaev [2013][8] from Department of Electronics and Telecommunication, Norwegian University of Science and Technology, Norway considered the motion of a dipole in external electric fields in the framework of nonlinear pendulum dynamics. A stochastic layer is formed near the separate rix of the dipole pendulum in a restoring static electric field under the periodic perturbation by plane polarized electric fields. The width of the stochastic layer depends on the direction of the forcing field variation, and this width can be evaluated as a function of perturbation frequency, amplitude, and duration.

Tao Hana et al.[2013][9] from Department of Mechanical and Industrial Engineering, University of Illinois at Chicago, United States observed a pendulum-like motion of the usually straight electrified jet experimentally and theoretically modeled. Pendulum-like motion arises due to repulsive Coulomb force between the straight electrified jet and the charges accumulated on the collector. This electrical force repels the similarly charged landing jet segment in the collector plane. The motion is transferred to the whole jet via elastic stress sustained by the jet. The initially straight segment of the jet is arched. The pendulum-like motion has frequencies of the order of 10–102 Hz.

Denise S.D. Stilling and Walerian Szyszkowski [2014][10] from Mechanical Engineering Department, University of Saskatchewan, Saskatoon, Canada examined the control of angular oscillations or energy of a system through mass reconfiguration using a variable length pendulum. The interaction between the sliding and angular motions can be used to control the angular oscillations of a system. Simple rules for generating either attenuation or amplification of the oscillations by sliding a mass can be derived by analysing the energy balance or the Coriolis forces.

A.-L. Hayter et al. [2013][11] from AFRC Institute of Food Research, Norwich Laboratory, UK described the use of the IFR portable pendulum, with further instrumentation, for assessment of the mechanical properties of solid foam structures. These data, obtained under high strain rate conditions of impact, provide an alternative to the use of low strain rate texture measuring apparatus based on tensile testing devices. The instrumented pendulum records the transient penetration of a hammer into the sample using an angular displacement transducer.

III. EXPERIMENTAL PROCEDURE

3.1 Design of parts by modelling software

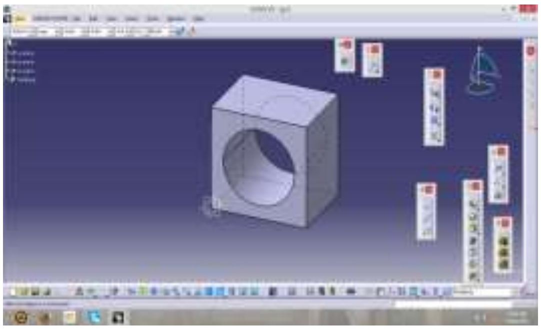

Fig - 1: Front part of reciprocating pump

It is the main part of the device which will carry the piston of length 25mm inside it. It has dimensions of 47x47x47mm with a hole of 31mm diameter inside throughout it's length.

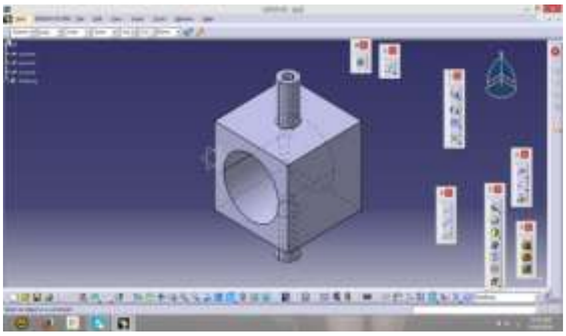

Fig – 2: Back part of reciprocating pump

It is also an important part of the device, functioning the same operation as front part. Apart from that, it has inlet and outlet port. It has a dimension of 40x40x40mm with inlet & outlet ports having outer diameter 10 mm and inner diameter 5 mm. The main body has hole of diameter 31 mm with length 30 mm.

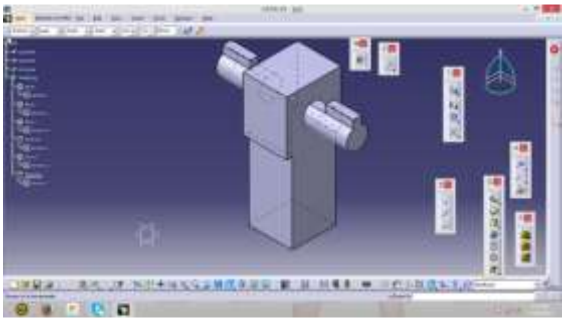

Fig - 3: Stand for carrying transmitting wheels

It is used to support the transmitting wheels. It consists of a base plate and shaft. The shaft is inserted in a ball bearing for smooth operation. The ball bearing is fixed in the base plate. The base plate is also used to hold the pump.

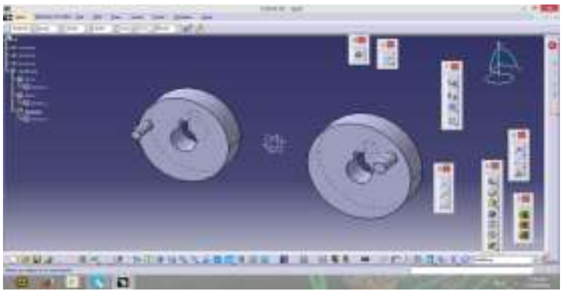

Fig – 4: Power transmitting wheels

These are used to transmit the power from pendulum to the piston. One wheel is connected to the piston and other wheel with the pendulum arm.

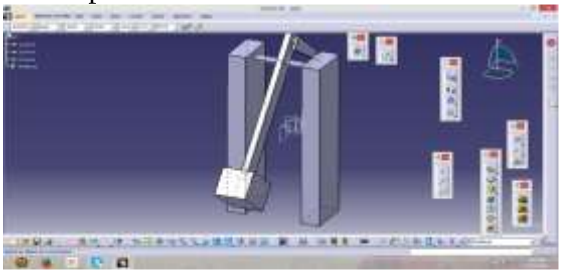

Fig - 5: Pendulum attachment with stand

It is the power supplying unit for the system. The pendulum arm is pinned at an offset from the top. The top part consists of an arm which is connected to one of power transmitting wheels.

2.2. Operation

The operation process of this pump is similar to that of a reciprocating pump except the power transmission part. As we saw above, the pump is driven by a pendulum and various joining parts. The mechanism is as follows:-

- The pendulum is kept on a steady stand hanging. The arm of pendulum is made offset beyond the fulcrum position.
- The offset portion of the pendulum arm consists another arm, which is further connected to the power transmitting lever.
- Both the power transmitting wheel and lever are connected via a shaft. The whole attachment rests upon a single stand. Both power transmitting parts have provision to rotate simultaneously.
- The power transmitting wheel is connected to the piston via connecting arm. The pump is attached at a distance.
- As the pendulum starts oscillating, it's oscillating motion is transferred to the power transmitting lever where it converts into rotary motion. This rotary motion is transferred to the wheel due to the interlinking between them.
- The rotary motion is supplied to the piston where it converts into linear motion due to link mechanism. Hence the suction and compression goes on in the pump.
- A provision for oscillating the pendulum continuously can be done by setting up magnetic field. Hence there will be continuous operation of the pump.

III. RESULTS AND DISCUSSION

The prepared model was not satisfactory as expected. But it was able to deliver a suction at the ports. As the source was not enough to drive pump here, so optimizing the source will help to get better results. Also it is possible to vary the source to get better results. Some of the variation is proposed below.

In the above concept, the power from pendulum is supplied to the first wheel. If the pendulum is taken out and a lever is attached to the wheel, then it is possible to drive the wheel by hand. The rest operation will function the same as above.

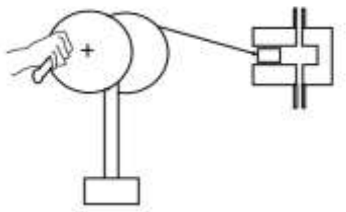

Fig – 6: Rough model of above method

Or by completely removing the pendulum system and first transmitting wheel, we can attach a pedal system with sprocket wheel for easier operation. This will be more convenient than the first method and will be easier to handle also.

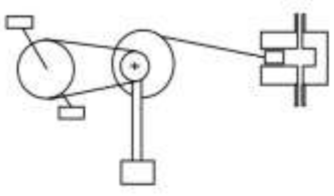

Fig – 7: Rough model of above proposed method

VI. CONCLUSION

We utilised the above concept and prepared the corresponding model. The model wasn't as satisfactory as expected, but it showed that the above concept can be modified further and can be successful too. The concept can have many variance as described above, thus increasing the chance of success. As a product, it has a higher potential of saving energy if compared with modern days.

Since this concept does not utilise any kind of electrical source, it will be a useful device which can be used in countryside area or in the agriculture field where electricity is not easily available. Also the output in this concept is more as compared. So it will be a beneficial device.

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