

Development of a Liquid Piston Stirling Engine

Shafeeque P¹, Suhail TP², Mohamed Fahad K³, Minhaj N⁴, Nihal Mohammed V⁵, Sijo MS⁶,

⁶ Faculty of Mechanical Engineering, Eranad Knowledge City Technical Campus, Manjeri, Malappuram, Kerala, India.

^{1,2,3,4,5} Students of Mechanical Engineering (2014-2018 batch), Eranad Knowledge City Technical Campus, Manjeri, Malappuram, Kerala, India.

Abstract:- Present be situated an continuing movement used for the requirement for unconventional energy springs to meet the difficulties of today's world. Lunar energy is a free and fresh energy resource which is available to humans in abundance. The determination of this development is on the way to appliance a fluid piston Stirling engine that productions enough power to thrust liquid from a sizable depth using a parabolic saving mirror that motivation focus the arriving sun's energy to heat the organism.

This engine better known as fluidyne pump can be used for irrigational purposes in places where solar energy is abundant. The fluidyne engine operates proceeding the standard of the Stirling engine that is the Stirling cycle with a peculiarity that the "pistons" are columns of water subjected to continuous oscillations by applying adequate temperature difference. The simplicity, reliability and low cost are some of the main advantages of this engine. The effective use of the solar energy especially in farming sector will persuade the farmers to tackle the problems faced during irrigation and thereby function in a more efficient manner.

Keywords:- Solar energy, Fluidyne pump, Stirling engine, Solar collector.

I. INTRODUCTION

Here is a going movement intended for the need for unconventional liveliness causes towards happen the difficulties of today's biosphere. The richness of lunar energy is a supply that cannot be located disregarded. This chronic energy source is nevertheless underutilized even with the voluminous routines on the way to which it can be put. It is with this in mind that we intend to discourse lone of the irresistible wishes in rising kingdoms.

Populace's rare unindustrialized states again and again cannot amount arranged the readiness of fresh swallowing liquid due near the smog of external water sources such as per brooks and ponds. Thousands of expiries arise each single year since water-borne sicknesses unaided. Popular countries by means of plenteous sunshine, temperature vigour powered through a persistent stream of lunar energy could stay used to thrust fit water. In cunning, the water that is pumped could be boiled by the same focused sunlight, thereby on condition that a constant font of fresh liquid.

The determination of this development is to gadget a fluid piston Stirling machine productions adequate rule to pump liquid from a distance of at minimum 7 feet. We similarly plan to include a parabolic saving mirror that drive focuses the sun's energy to heat the system. The system we plan to instrument will use fluidyne technology, which is currently underappreciated.

A. Development Ideas & Goalmouths

The principal points of the development are:

- To physique a watery piston Stirling device by a release 100ltr/hr.
- To pick a appropriate project that integrates machine-driven plainness with sustainability with in the restrictions of a third-world civilization.
- Toward advance alertness around fluidyne machinery by way of an different, short cost liveliness font.
- Here remains the essential toward select project that joins constructional plainness; fluidyne scheme runs this.

B. Agricultural Difficulties

India is the agriculture country & it is the base of Indian economy. The agricultural sector accounts for about 16% of GDP and 10% export. Nearly 65% of our country's population is engaged in the agriculture field. Agricultural products are a source of food for domestic consumption as well as can be used as raw materials for the Agro-based industries. However, the share of agriculture in India's GDP has shown a steady downfall for the past couple of years. This is largely because of the poor development in the agricultural field. The infrastructure is very poor like the dismal pastoral highways distressing timely stream of ideas and assignment of outputs. Irrigation systems are poor, chief to frequent crop disappointments. In some ranges regional torrents, poor seed worth and inefficient farming practices and harvest spoilage cause over 30% of wastage, Want of organized retail and contending buyers thereby restrictive Indian agriculturalist's capacity to sell the leftover and marketable produces.

The sharecroppers of our country have to overcome a lot of difficulties in order increase their productivity. These include irrigation, lack of mechanization, scarcity of capital, small and fragmented land holdings, availability of electricity. The major problem of the lot that farmers have to tackle is improper irrigation facilities. The record joint problem with farmhouse irrigation organization is to deal through irrigation development. Irrigation development is merely reacting the requests of "What time do I water?" and "In what way long do

I water? Major an irrigation cycle else premature then/ or consecutively an irrigation cycle also lengthy is well-thought-out done irrigating. On the actual lowest this exercise wilds liquid and cash. Though, swamping container reason yield damage if complete on a long basis. Likewise, starting an irrigation series too late or not running the scheme for a extended enough dated of period is careful under hosing and canister root summary earnings then underprivileged crop class which can disturb fee.

C. Lunar Energy Probable Hip India

India dishonesties hip the sunlit sash of the ecosphere. The room aimed at producing influence then current submissions by lunar energy is massive.

Greatest shares of India grow 300 days of light a time, which brands the state a actual gifted room for lunar energy employment. The regular usual lunar energy case done India differs since 4 towards 7kWh/m2 by means of the light hours going among 2300 then 3200 per time, liable upon site. The strict likely of lunar energy hip India is giant. The state has enough lunar energy near abstract new than 500,000TWh each year of energy snooty 10% change efficacy.

Figure 1 expressions plot of India by lunar energy points hip dissimilar shares of the state. It tin be saw that while the top yearly total pollution is conventional in north Gujarat and parts of Ladakh region, the shares of Andhra Pradesh, Maharashtra, and Madhya Pradesh also obtain fairly big quantity of drive by way of likened to many parts of the biosphere especially Japan, Europe and the US where growing and location of lunar skills is maximum.

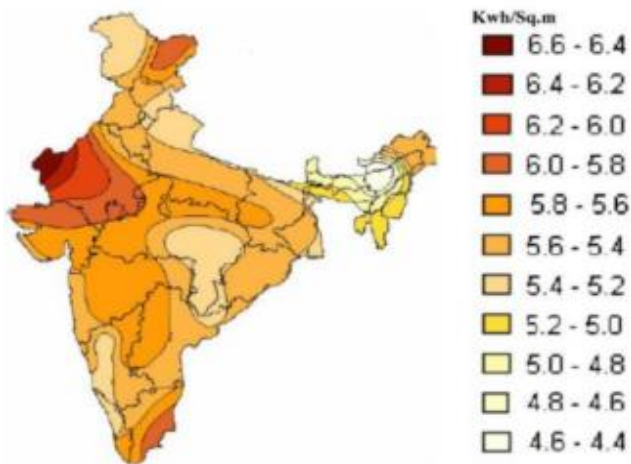


Fig 1:- Plot of India by lunar energy heights in dissimilar slices of the republic.

D. Stirling Machine

A Stirling machine stays a temperature machine that functions in returning compression and expansion of midair or other vapor (the salaried liquid) at dissimilar heats, such that here is a remaining change of temperature liveliness to powered effort. Extra exactly, the Stirling machine is a closed-cycle reformative temperature machine through a enduringly

gassy operational liquid. Locked- cycle, in these setting, capitals a thermodynamic classification hip which the operational liquid stands always checked in the scheme, then reformative defines the usage of a definite sort of interior temperature exchanger then existing stock, branded by way of the regenerator. The insertion of a regenerator distinguishes the Stirling machine after extra shut set burning airborne machines. First regarded popular 1816 by way of a manufacturing major powerhouse to competing the mist machine, this one applied usage stood mainly limited near low-power national requests for ended a Period.

The Stirling machine stands famous aimed at tall competence likened near vapor locomotives, low process, and then this one aptitude to use nearly first temperature basis. The temperature potency foundation is created exterior to the Stirling machine somewhat than in inner burning for example with the Otto cycle or Diesel cycle machines. Since the Stirling machine is friendly by another and renewable liveliness bases it can developed gradually momentous in place of the fee of conformist oils increases, then too in bright of anxieties such equally top oil and weather variation. This machine is now thrilling attention as the central constituent of PC joint temperature too power (CHP) parts, popular which this one is more effective and safer than a equal steam engine. But, this one takes a little power-to-weight share version the aforementioned extra fit for use in static fittings where space then form are not on a finest.

E. Undeveloped Process of the Common Stirling Engine

Basic standard of the Stirling machine is a modest unique: this one trusts lone happening the datum the minute a vapor is intense, this one inclines to inflate before, if narrowed, toward a rise in burden. There are presently three conformations of the Stirling machines – alpha, beta and gamma – accessible hip the shop. Our high-quality drive depends on the influence harvest we suppose as fit as scheduled competence.

Stirling machines effort through the recurring space boiler and cold of a wrapped sum of at work air which in our event resolve be onboard.. The minute the smoke is heated, because it is in a sealed chamber, the pressure rises and this then acts on the power piston to produce a power stroke. When the gas is heated, the pressure drops and this means that less drudgery needs to be located done by the piston to recompress the gas on the coming back stroke, open-handed a net gain in power available on the shaft. The working gas flows cyclically stuck sandwiched between the hot and unsympathetic high temperature exchangers.

1– 2:

The ventilated employed gas is compressed (usually through a control piston) cutting-edge the compression space, and warmth QC is ruined to the emotionless tank at endless heat TC. Therefore, the engine volume decreases, while the engine pressure growths. High and mighty isothermal situations (T=TC), the heat ruined to the environments is

accurately $QC=WC$, where WC is the labor done through the command piston on the at work gas.

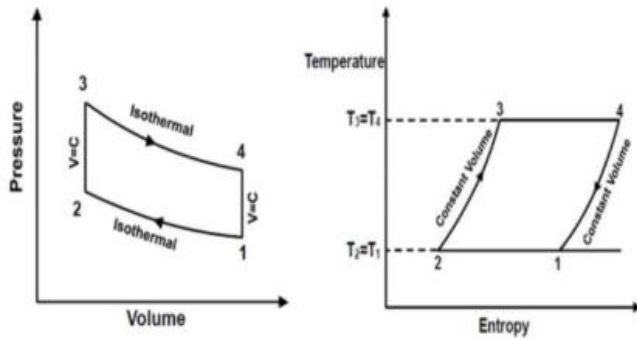


Fig 2:- Stirling Cycle Pressure-Volume and Temperature-Entropy graphs.

2 – 3:

The employed gas is moved done the regenerator at the smallest engine capacity. Warmth is moved beginning the regenerator to the waged gas, beginning the density, high temperature and entropy of the gas on the way to increase.

3 – 4:

The occupied gas (in-flight hip our case) develops as heat QH is removed to the enlargement space of the apparatus. The blast develops and does work (usually work is done on a power piston), beginning the engine measurements to growth and the burden to reduction. Presumptuous isothermal circumstances ($T=TC$), the temperature transported to the salaried gas is exactly $QH=WE$, where WH is the work finished arranged the authority piston.

4 – 1:

The salaried gas is encouraged through the regenerator at the extreme engine capacity. Temperature is transported since the at work gas on the way to the regenerator, causing the pressure, temperature and entropy of the blast to diminution

II. THEORY

A. Operational Fluid And Compression

To spread our board our board presentation, in attendance is the essential to have fading at a minutest and the working fluid duty always be in the smoky phase. En route for this end, and for constructional simplicity, air is typically used at a mean burden equal to that of special compression (0.1Mpa).

To conquer the dead that come through evaporation, a soar, made from an sequestering substantial can be used. Request blot this is done, the displacer liquid is largely lonely from the heater and the working gas. It should be sturdy enough on the road to withstand the blistering cross temperatures.

B. Working Temperatures

High power-driven, difficult Stirling engines naturally activate with the temperature exchanger at 700 to 800 o C, but more stylish resources stand wanted planned.

An idyllic fluidyne would be clever to run with a fever difference of fewer than 1oC Nevertheless, for real machineries, around are flow and authority losses which entail that the boiling end be kept as hot as imaginable, while the cold end be kept cold; that is, to maintain a precipitous illness gradient.. The unemotional side temperature can be maintained at water"s ground level high temperature of round 20 o C.

C. Displacer Occurrences

Toward contract the determined largeness of alternation now the liquid stakes, the flow damages should be stumpy and the rate of operation have a duty to be local to the regular, otherwise resonant, rate of the pillars themselves.

D. Modification of Liquid Supports

By way of in any hesitating system, the determined amplitude of measure in the harvest column will be reached if the frequency of the pressure differences, These burden dissimilarities are due to the oscillations of the displacer water, so it keep an eye on that for determined movement, the two natural rates have to be equal.

E. The Regenerator

Even though not absolutely indispensable now lieu of engine task, the regenerator is a key piece of the Stirling engine, and this one discriminates the Stirling engine from added outside combustion engines. The exploit of the regenerator can be described in humble terms as that of a „warm air sponge" – it absorbs and statements heat during dissimilar stages of the cycle. Thus, if there is an element popular the engine that engrosses heat during the freshening stage and releases it during stage, the compression space will cool faster and less heat will basic to be extra to the hot space in direction to keep the engine on the trot.

Present are different traditions of assembly regenerators in practice, also most of them employ significant exterior area to enhance the heat allocation rates and thus the volume of heat stored and. In concrete engines, present is often a momentous tradeoff flanked by the gains in competence due towards the regenerative feat and the stream damages. In the case of an engine that contains a displacer for specimen, the reedy annulus of air round the displacer can run some regenerative achievement.

III. CONSTRUCTION AND OPERATION

A. Construction

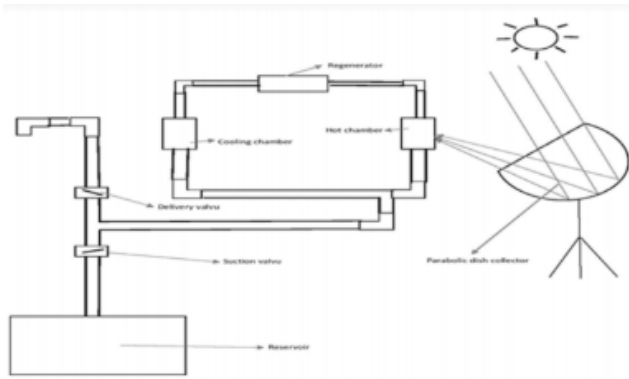


Fig 3:- Construction of fluidyne pump.

In this study, an attempt was made to construct a pump so that the water motion and oscillation could be observed. The first pump was made with plastic materials with the exception of the cooling and heating tubes which were copper piping. Plastic tubing provided good visibility of motion of water in the pump. The displacer itself consisted of two vertical copper pipes each about and a horizontal plastic tube, The right hand limb of the displacer (right hand copper pipe) was surrounded by a cooling chamber and had two openings, the inlet and the outlet. On the left hand limb of the displacer was the heating part consisting of the copper tube. The generator was a copper tube is connecting the top part of the copper tubes. There was another valve (valve B) on the top of the left hand limb for filling the engine with water. The output tube was made of a horizontal clear plastic tube and a vertical tube with two check valves. The main advantage of having many parts of the pump made of plastic was visibility of the motion and the oscillation of water in the tubes.

B. Operation

The parabolic bring together glass that resolve concentration the incoming sun's vigor to producing the heat needed for operating the pump. This was necessary to test the pump for different levels of input heat. In practice, the heat can be generated by small flat plate collectors using water or air as circulating fluid. The procedure of running the pump was as follows:

The engine was filled with water through valve. allowing both hot and cold limbs of the engine to be filled up to two-thirds of their height. Valves then closed trapping the remaining air on the top of the limbs. Before starting, the engine must be in a level position.

After the engine was filled with water, the heat was applied to the hot limb by the parabolic collecting mirror. The air above the water in the hot side began to expand, increasing the pressure in the system. The built-up pressure caused the water in the output tube to begin to move. This process continued for a period of time, according to how rapid the system was heated.

As the water in the output tube moved, it affected the water in the cold limb and the balance between the hot and cold limb was disturbed, thus beginning the oscillatory

motion. The oscillation would increase with feedback as heating and cooling continued. This process kept repeating itself and caused a strong oscillation in the engine. In practice, the cooling water for the fluidyne pump could be supplied by the discharge of the outlet valve. In the configuration described above the fluidyne is self-starting, as there is no static friction to overcome, but the efficiency is low. A method of keeping the displacer liquid in oscillation is to "feed back" some of the output energy to the displacer fluid. In this system, the output tube is fed into the bottom of the displacer column, close to the hot side of the machine. As the water rushes in and out of the right hand end of the output tube, it drags some of the water in the displacer water moving back and forth. The steady source of heat can induce a sinusoidal motion in the water columns without the intervention of crank shaft or valves.

IV. EXPERIMENTAL SETUP

A. Wants

The fluidyne scheme remains self-possessed of 7 highest parts. These part parts include the warmth exchanger, regenerator, displacer column, and pump column. The respective mechanisms of the arrangement meaning hip such a system as near bring near weight differences, so accepting aimed at the pull then thrusting of liquid since specific deepness.

- Temperature exchanger.
- Displacer.
- Hot and cold limb.
- Pump column.
- Regenerator.
- Connection.
- Frame.

V. CONCLUSION

We must well-educated a excessive contract happening the action of the stirling machine, additional definitely the fluid piston stirling machine. Even though the perception was nearly two centuries old, present was very miniscule development in the ground, and even more books were available. Renewable energy systems will become the norm of the imminent and the knowledge of any systems that can aid developments in the field will assume prime importance. Sanguinely, the knowledge added salaried on this development resolve touch our stocks in esteems to evolving equipment that would benefit the supreme unfortunate our group of people then the world.

REFERENCES

- [1]. Slavin, V. S., Bakos, G. C. and Finnikov, K. A., "Translation of modern energy into electricity via a water pump functioning in a Stirling Engine Cycle", Useful

International Conference on Energy Sustainability, 2009, Vol. 86, pp. 1162-1169.

- [2]. Stevens, J.W., “Low Principal Cost Renewable Energy Translation With Liquid Piston Stirling Engines” Proceedings of ASME 2010 4th International Conference on Energy Sustainability, 2010, Phoenix, AZ , ES2011-90128.
- [3]. Anish Saini, Shivam Kohli, Ajesh JPillai., “Solar mechanical stirling engine focused water pump” IJRET: International Journal of Research in Engineering and Technology /Volume: 02 Issue: 12 | Nov-2014.
- [4]. H. Jokar, A.R. Tavakolpour-Saleh., “A novel solar-powered active low heat differential stirling pump”, Journal of industrial studies and research, volume12 (2016).
- [5]. H. Moazami Goudarzi, Mehran Yarahmadi, M.B. Shafi, “Construction of a two-phase fluid piston engine based on the structure of fluidyne”, Journal of industrial studies and research, volume 5 (2015).
- [6]. Sunny Narayanan, Vikas Gupytha., “Over view of working of stirling engine”, Journal of engineering studies and research, volume 21 (2015).