iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 9 **Issue:** VI **Month of publication:** June 2021

DOI: https://doi.org/10.22214/ijraset.2021.35230

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

Design and Development of Light Weight Stirling Engine by using Compressor

Mr. Pratik Prakash Chavan[1], Mr. Saiprasad Sunil Ganbavale[2], Mr. Abhinandan Sharankumar Phulari[3], Mr. Birudev Narayan Kolekar[4], Mr. Omkar Dattatray Bhurake[5]
[1, 2, 3, 4, 5]*Annasaheb Dange College of Engineering & Technology, Ashta*

Abstract: From the nineteenth century, the mechanical transformation needs an incredible nuclear power creation. The pre-owned advances have a few specialized issues making hurt people and harming materials. There are numerous ways by which altering existing methods will assist with diminishing the uses. The work proposes the best approach to assemble and use the minimal expense Stirling motor for the efficient power energy application. A protected outside burning motor was the creation proposed by Robert Stirling to save human existence and materials. This motor is imagined for working with various temperatures without start inside by squander heat recuperation. It is worked by cyclic pressure and extension measure. The plan interaction includes the plan of chambers, heat expansion, dismissal, proficiency, power yield and some more. This motor is agreeable for individuals since it is very, less loud and minimized in size and alpha motor has more noteworthy proportion contrasted with different sorts. It is elective fuel hotspot for other fuel. This is efficient power energy application. This present's development and execution trial of an alpha-type Stirling motor.

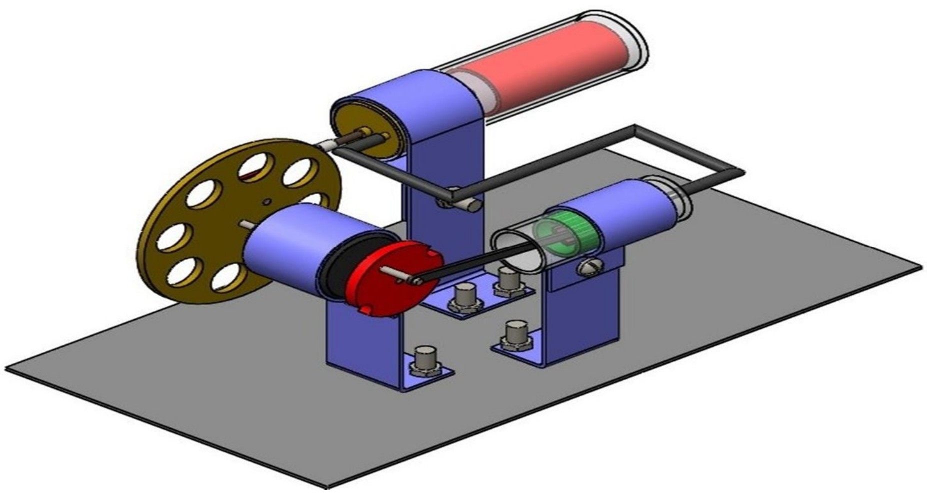
I. INTRODUCTION

The modern unrest in the nineteenth century prompted both an incredible need to supportive of duce nuclear power and a few ecological mishaps. After the oil blasts and the increment of oil cost numerous businesses shut and the mechanical regions become contaminated regions. Every one of these occasions prompted an increment in mindfulness about natural issues. Additionally, governments turned out to be more engaged with environmental change issues. Thus the resumption of interest in elective arrangements. A Stirling motor is a warmth motor working by cyclic pressure and development of air or different gas, the functioning liquid, at various temperature levels to such an extent that there is net change of warmth energy into mechanical work. Stirling motor works by changing over heat into mechanical yield and the liquid that accomplishes the mechanical work, called the functioning liquid, is ordinarily encased inside the motor and isn't blended in with some other material. Warmed working liquid grows and pushes the cylinders in the hot and cold chambers. The re-generator retains a portion of the warmth of the functioning liquid during extension, as the gas travels through the hot volume to the cool volume. During pressure, the cylinders move the other way and the functioning liquid is compacted. While passing toward the hot volume, the cooled working liquid assimilates the put away warmth in the re generator. The hot and the chilly cylinders move with a stage distinction, controlled by the wrench component. The hot and cold volumes comprise of two sub-volumes. The district where the cylinders move is called cleared volume, and the leeway of the chambers and lines between chambers are called dead volume. Essentially, there are three significant sorts of Stirling motors that are recognized by the manner in which they move the air between the hot and cold sides of the chamber, known as alpha, beta and gamma. The area of the hot and cold volumes decides the motor kind. The motor is an Alpha-type, with two separate chambers for the hot and cold volumes. In a Beta-type motor, the hot and cold volumes are situated in one chamber and isolated from one another by a displacer. The displacer is associated with the wrench instrument for supporting the exchange of working liquid between the hot and cold volumes. Gamma-type motor, which is like Beta-type, has its cool volume and pressure cylinder in a moved chamber. Stirling motor, which was created by Robert Stirling in 1816, is fit to run with any sort of energy including waste warmth. Stirling motors draw consideration in light of their high warm productivity. As outer ignition motors allowing close control of the burning cycle, their qualities of low discharges, high productivity, dependability, broadened administration stretches, low commotion. The productivity of a Stirling motor can arrive at Carnot proficiency hypothetically. In addition they need lower support cost and they can run with various types of fuel source. Albeit the hypothetical warm effectiveness of Stirling cycle is sufficiently high contrasted with Carnot cycle, heat move obstruction, and energy misfortunes, for example, gas spillages and warmth misfortunes can be seen for genuine Stirling cycle bringing about lower warm proficiency. As Mix ling motor works with a temperature distinction, boundary ought to be more noteworthy than one without an upper bound. Lower limits of the dead and regenerator volume proportions are zero, which implies there is no dead or regenerator volume in the motor. In the other limit case, where the framework comprises of just dead or regenerator volume (with no cleared volume). The lower limits for the proportion of hot cleared volume to cleared volume and hot dead volume to dead volume are zero and the upper limits for the two of them are one. In our venture, we built the alpha kind Stirling motor since it has pressure proportion less support. We are utilizing air as a functioning medium, so there is no danger because of spillage of liquid and it guarantees minimal expense as air is accessible anyplace. Nonetheless, the utilization of air as the functioning liquid in Stirling motors enjoys extraordinary benefits, for example, bountiful, promptly accessible and for nothing with the exception of pressure cost. Alpha sort Stirling motor comprises of two chambers with one cylinder in each. These chambers are associated by interfacing line. At that point, the subsequent chamber is associated with flywheel and flywheel is connected to the electric engine. Driven light is associated with the electric engine. As warmth is given to the principal chamber, because of cyclic pressure and extension measure between two chambers, cylinder in both the chambers begin moving and development of cylinder is then given to the flywheel then to electric engine and because of this Drove which is joined to the engine flickers. Consequently, the warmth energy is changed over into mechanical energy to deliver power.

II. STATEMENT

Development of light weight Stirling Engine to produce electrical energy to avoid problems occurring due to internal combustion and to improve cost per unit energy generation.

III. STIRLING ENGINE



The Stirling motor was designed in 1816 by Scottish minister Robert Stirling, before the Diesel motor which is imagined in 1893, the petroleum motor which is created in 1860 and the electric engine concocted in 1869. The investigation of Stirling advances has begun from 1816 and kept on being improved till late many years. Stirling motor is a kind of warmth motor that can be controlled by any warming source like waste warmth, sun oriented, and so on Hypothetically, the ideal pattern of Stirling motor has a warm proficiency as equivalent as Carnot cycle. Nonetheless, the genuine Stirling motor models show a little warm proficiency .Stirling motor is an outer burning warmth motor where warmth is given external the chamber. It works by constant cyclic pressure and development of air or some other gas, the functioning liquid, is exposed to various temperature levels so that there is a net transformation of warmth energy to mechanical work.

IV. MATERIAL SELECTION

Among every one of the necessary materials Copper has high liquefying point and warm conductivity which is essential for motor and furthermore the warm extension of copper is less so the motor can be worked at high temperature for long time. In any case, the texture cost is excessively high and hardness is low rather than different substances in aluminum the warm conductivity is high, weight is significantly less anyway material energy is substantially less as opposed to copper. Warm expansion is high so it can't be worked for long time at high temperatures. In pure metal oxidation opposition is inordinate rather than various materials also it has higher power as opposed to aluminum however the charge of the material is exceptionally high. The dark cast iron has exorbitant energy cost of the material is likewise low however it has low warm conductivity and low dissolving point so it can't look up to inordinate temperature for long time The material we picked is slight metal despite the fact that warm conductivity is lesser it is scarcely close to the copper and the warm development is lesser when contrasted with aluminium.it likewise has extreme liquefying point, expense of the slight metal furthermore less contrasted with copper the first disadvantage of the utilization of slight steel is that it responds with climatic air so it adequately underneath goes oxidation response. This can be incorporated with the guide of applying chromium coat over the steel surface. This additionally builds conductivity of the material.

Sr.No.	Components	Material
1	Displacer Cylinder	Mild Steel
2	Displacer Piston	Aluminium
3	Power Cylinder	Mild Steel
4	Frame	Aluminium
5	Connecting rod	Steel
6	Flywheel	Cast Iron
7	Power Piston	Aluminium
8	Clamp	Iron
9	Transfer tube	Mild Steel
10	Bearing	Stainless Steel

V. DESIGN OF ENGINE COMPONENT

A. Design of Frame
The edge is utilized to help cylinder chambers, flywheel associated shaft and other pivoting parts. The body was developed the use of aluminum plate which is simpler to machine and light weight. Casing is offered to its structure with the assistance of machine and roundabout openings are bored with the guide of capacity of boring machines. Direction are outfitted inward the backings to hold flat shaft.

B. Design of Cylinder
The cylinder can be developed of cold moved steel to make certain its warm properties for the hot chamber get together. This plays a significant capacity as if there should arise an occurrence of resistances between the cylinder and chamber dividers. To have a compelling property the floor finish ought to be extreme with the goal that misfortunes will be least, yet due to machining complexity it's legitimate to purchase a machined item which suits the plan necessities.

C. Design of Chambers
Two chambers (Hot and cold chambers) are of same measurement. It very well may be manufactured utilizing cold producing or projecting. Because of extreme surface completion standards it is fashioned then completing activity is performed through inner processors.

D. Design of Displacer Cylinder
As Stirling motor is an outer warmth motor. The warmth source that will be outfitted moreover assumes a part. Warmth can be from (sun oriented energy), Modern wastage through fittings, geothermal energy, atomic squanders.

E. Design of Move Tube
Lines Cylinders are the rounded segment or empty chambers that are in roundabout segments just as different structures to pass on the substance which can stream like fluid and gases. Every one of the functioning liquid moves through that exchange tubes.

F. Design of Associating Pole
The interfacing bar is the transitional part between the cylinder and the Driving rod. Its essential capacity is to communicate the push and pull from the cylinder pin to the wrench pin, along these lines changing over the responding movement of the cylinder into turning movement of the wrench.

VI. STIRLING CYCLE

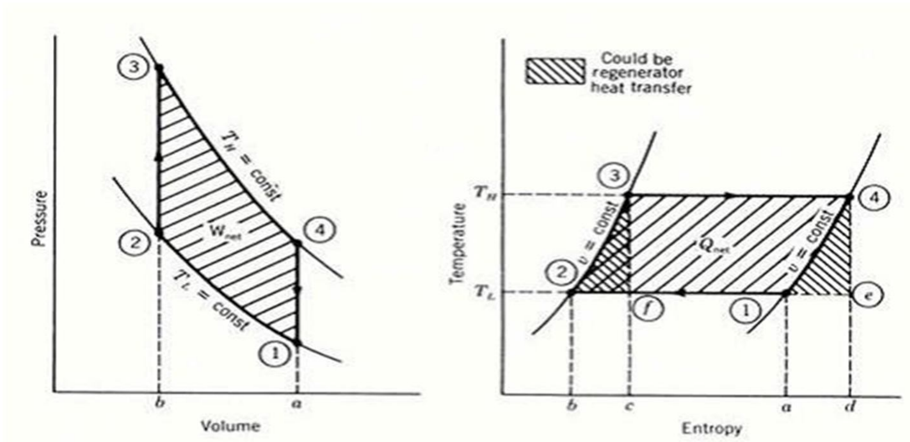


Fig: Stirling Cycle

The following are the processes that are involved in Stirling cycle:

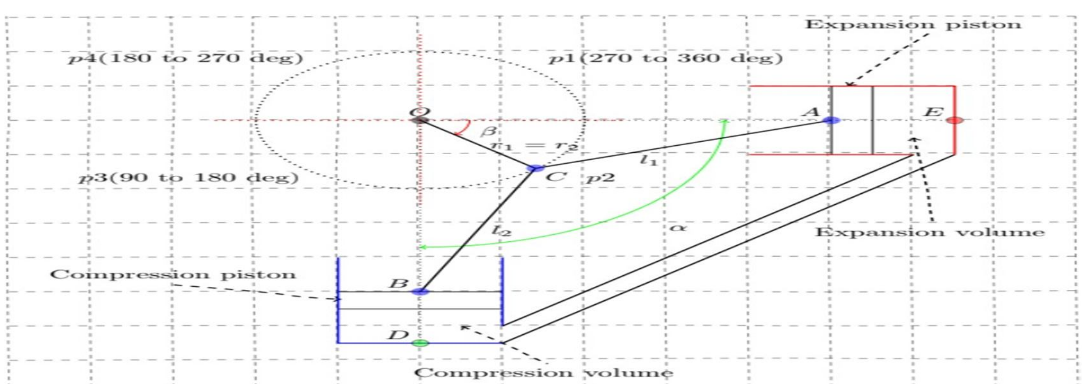
Process 1-2: Isothermal pressure at steady temperature air (working liquid) is packed Q (1-2) =area 1-2-b-an on T-S chart Work is done on the functioning liquid. W (1-2) =area 1-2-b-an on P-V graph.

Process 2-3: Isochoric heat option at consistent volume heat is added to the hot chamber. Q (2-3) = region 2-3-c-b on T-S outline Work done [W (2-3)] is zero.

Process 3-4: Isothermal development at steady temperature working liquid is extended Q (3-4) = region 3-4-d-c on T-S chart. Hot air extends Work is finished by the functioning liquid W (3-4) = region 3-4-a-b on P-V chart.

Process 4-1: Isochoric heat dismissal Warmth is dismissed at steady volume. Q (4-1) = region 1-4-d-an on T-S graph

Fig: Engine Configuration with Crankshaft Drive



VII. CALCULATION

Nomenclature:

Qh = Heat addition, Qc = Heat rejection , Th = Higher temperature ,

Tl = Lower temperature, W= Work done, P= power , T= Torque

According to 1'st law of thermodynamic

Qh + Qc + W = 0 (1)

500 + Qc + W =0

According to 2'nd law of thermodynamic QH/TH + QC/TC = 0 (2)

500/600 + Qc/300 = 0

Therefore, Qc = -250J (3)

Putting (3) in (1) 500-250+W=0 Therefore, W= -250J Efficiency = —W— / QH Efficiency = 250/500

Efficiency = 0.5 (thermodynamic)

By taking, Radius = r = 0.28 (+/- 0.1)m Height = h = 18 (+/- 0.1)cm

Swept volume= (3.147/4.D*2.L)

= (3.147/4*0.056*.14025)

= 349.4510−6M 3

Clearance volume = 5 percentage of swept volume = 5 ∗ 349.45 ∗ 10−6

V 2 = 17.47 ∗ 10−6M 3

Volume of air admitted (V 1) = Swept + Clearance V 1 = 349.45 ∗ 10−6m3 + 17.47 ∗ 10−6m3

V 1 = 366.92 ∗ 10−6m3

Compression ratio(r) = V 1/V 2

= (366.92 ∗ 10−6/17.47 ∗ 10−6) = 21.005

1− 2: isentropic process T 2/T 1 = (V 1/V 2)(r − 1)

= (366.92 ∗ 10−6/17.47 ∗ 10−6)(1.4 − 1) = 994K

According − to − ideal − gas − equation : P 1V 1 = mRT 1

Mass of air(m) = 0.001kg, Temperature of air = 300K

P 1 ∗ 366.92 ∗ 10−6 = 0.001 ∗ 0.287 ∗ 300

P 1 = 0.23 ∗ 106kPa P 2/P 1 = (1/r)

P 2 = 1/(21 ∗ 1.4) ∗ (0.23 ∗ 106) = 3.24 ∗ 106Pa

2− 3 : Constant Volume Process V 3 = V 2

P 3 ∗ V 3 = mrT 3

P 3 ∗ 17.47 ∗ 10−6 = 0.001 ∗ 0.287

P 3 = 25.02 ∗ 106

Supply − Heat − temperature − (T 3) = 1523K

Heat supplied = m ∗ Cv ∗ (T 3 − T 2) = 0.001 ∗ 0.707 ∗ (1523 − 994.7)= 0.43kJ/Kg

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 9 Issue VI Jun 2021- Available at www.ijraset.com

3− 4: isentropic − process P 3/P 4 = r

P 4 = 1 ∗ 25.02 ∗ 106/ (211.4) = 35.2 ∗ 104Pa

4-1: Constant volume process T4 /T1 =P4/P1= (35.2*104/0.23 ∗ 106) ∗ 300 = 459.13K

Heat Rejected = m ∗ Cv ∗ (T 4 − T 1) = 0.001 ∗ 0.707 ∗ (459.13 − 300) = 0.2kJ/Kg

Work done = Heat Supplied – Heat Rejected = 0.22kJ/Kg

Percentage Efficiency = (work done/Heat supplied) = (0.22/0.42) ∗ 100

Percentage Efficiency = 52.3

Performance − calculation Power = 2NT/60 KW

Torque = Force * Radius

Force = Pressure * Area

Area=3.147 *D*L = 3.14 * 56.25 * 140.625 = 0.0248m2

Pressure = 2bar

Force = 2 ∗ 105 ∗ 0.0248 = 4.923KN Torque = 4.923 ∗ 0.035 = 0.172KN – m

Power = (2 ∗ 3.147 ∗ 200 ∗ 0.172)/60 == 3.6KW.

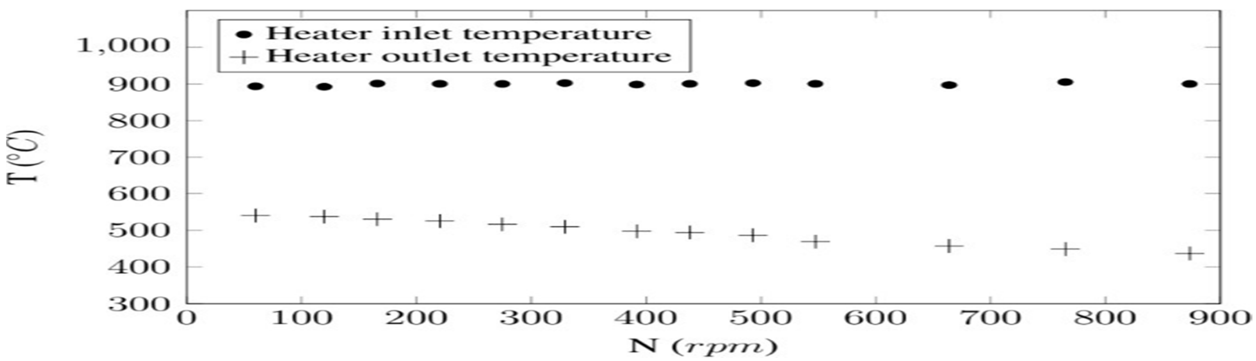


Fig: Temperature Vs Speed

After Calculations are done the performance graph of engines with different speed ranges with variation of temperature are shown below:

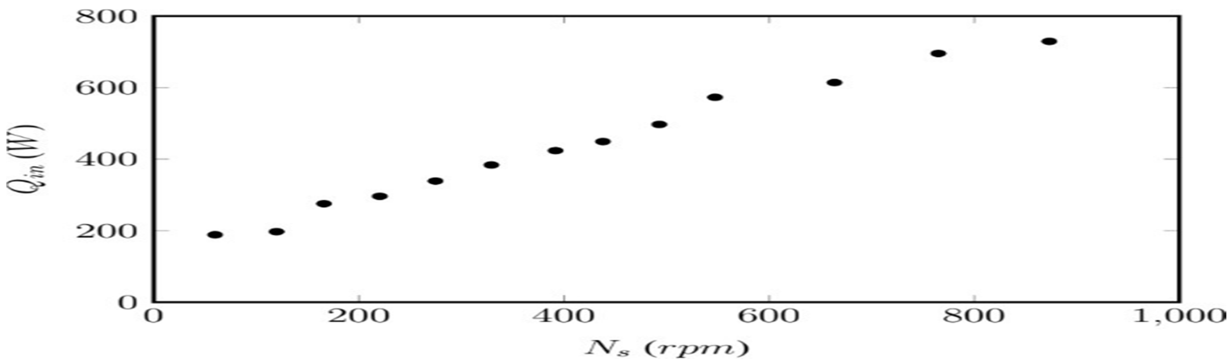


Fig: Heat Transfer Vs Speed

VIII. ADVANTAGES

A. There is no development in the air like in the event of I.C. motor, ignition motor, burning is outside the chamber.
B. The large number of conceivable hot sources burning of different gases like residue squander sun powered or geothermal energy or thermal power.
C. It is capacity of temperature of hot and cold source. As it is feasible to make it work in cogeneration, the general productivity can be high.
D. The natural fitness to react the ecological prerequisites on air pollution.
E. A significant life time due to its rusticity.

IX. LIMITATION

A. Problem of sealing are difficult to solve as soon as one wishes to have high pressure operation.
B. The efficiency is less than other engines.
C. Cannot be used for high capacity plants.

X. APPLICATION

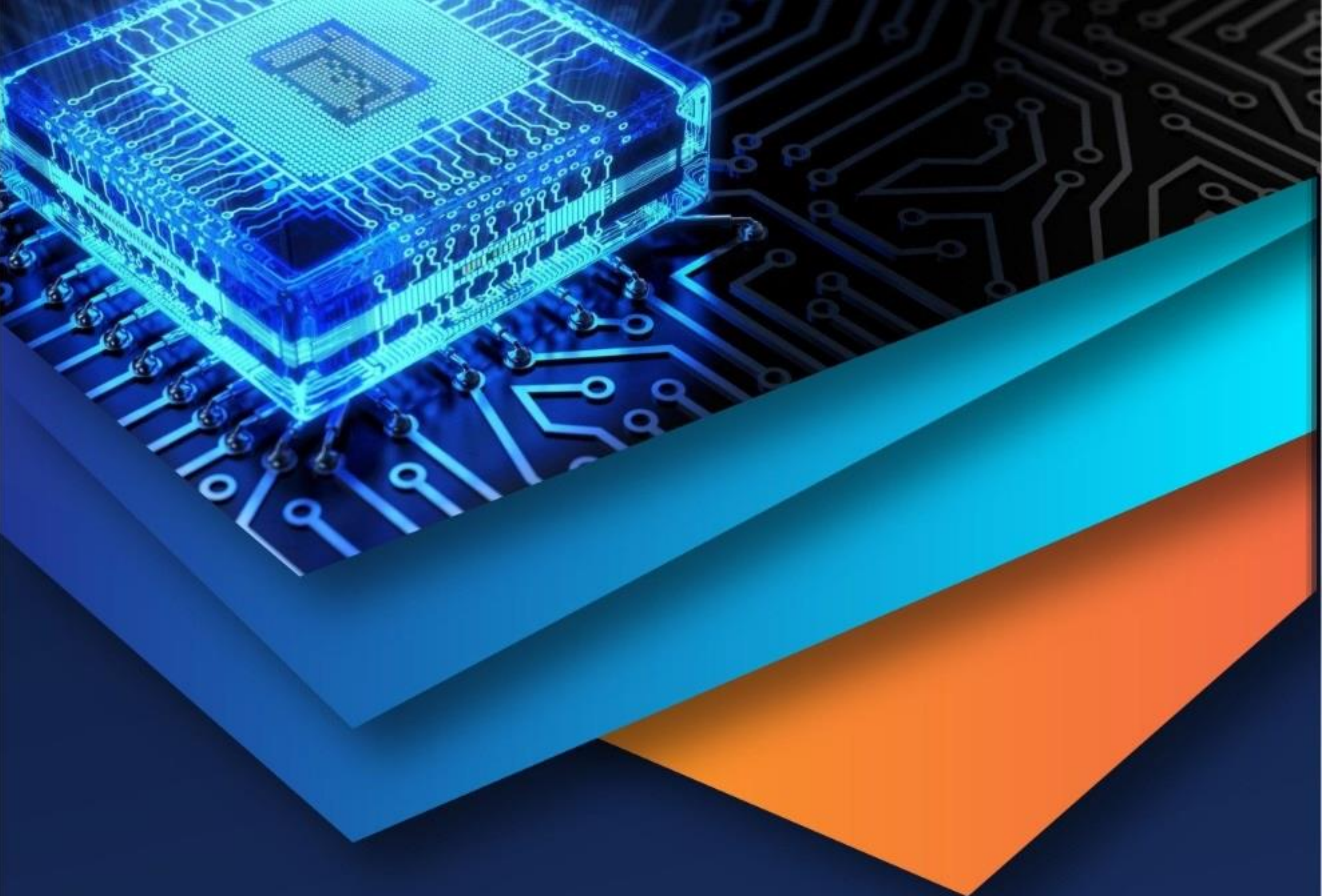
A. It deals with temperature distinction so contrarily it very well may be utilized to create temperature contrast by giving mechanical energy. In this manner it tends to be utilized both as warmth siphon and cry coolers.
B. The capacity of the Stirling motor to change geothermal energy over to power and afterward convert to hydrogen may will hold the way to substitution of petroleum derivatives later on hydrogen economy.
C. NASA were planned worker for hire and planned MOD I and MODE II.MODE II supplanted the typical flash start framework in 1985.
D. The greater part of the modern uses of Stirling Cycle concerns the refrigeration application sand in cryogenics.
E. Used in Marine engines in Swedish ship builders.
F. It works on temperature difference so reversely it can be used to generate temperature difference by providing mechanical energy. In this way it can be used both as heat pump and cry coolers.

XI. CONCLUSION

Despite the fact that yield of motor isn't so high yet it tends to be utilized as auxiliary motor in cars, and for all mechanical light obligation tasks. Henceforth the goal of planning and assembling of motor was fruitful and can be executed as a substitution to low power applications. The primary motivation behind the undertaking served to advance the utilization of Stirling motors in 'efficient power energy' applications. It's been demonstrated that running expense of the motor is likewise exceptionally less this will assist with limiting the utilization of fuel and diminish air contamination. By the by, the model is extraordinary for additional altering and upgrade, which should prompt kill lacks. To diminish the heaviness of the flywheel it is feasible to pick the material with the lower thickness (for example the ABS plastic). In spite of the way that the normal activity was not accomplished, the model would serve for scholastic capacities to show the instrument of the Stirling motor and to acclimate the intended interest group with the standard of its activity.

REFERENCES

[1] Can Cinar, Hamet Solmaz, Ahmet Uyumaz (2018). Manufacturing and testing of and alpha-type striling engine, Applied Thermal Engineering 130 (2018) 1373 to 1379.
[2] Dinesh K. Rakesh N. (2016).Design and fabrication of low cost Stirling engine for low duty industrial application, Procedia Engineering 157 (2016) 349 to 356.
[3] Vishal Ghelot, Abhinay Nigam (2017). Development and Fabrication of Alpha Stirling Engine, IOSR-JMCE, Volume 11, Issue 6 VER.4, Nov-Dec 2017 PP 69 to 71.
[4] Jir Podesve, Zacknek Poruba (2015). The striling engine mechanism and optimization, PISC. 2015.11.052, PP 1 to 6.
[5] N Ajey (2017). Experimental and Computational Studies on an Alpha Type Striling Engine for Combined Heat and Power Application, Science Direct
[6] Jose Egas and Don M. Clucas (2018). Stirling Engine Configuration Selection.
[7] Metin Giive, Hasan Bedir, Giinay Anla (2017). Optimization and application of Stirling engine for waste heat recovery from a heavy-duty truck engine, Energy Conversion and Management 180 (2018), 411 to 424.
[8] Fethi Aloui, Sassi Ben Nasarlla, Houda Hachem (2015). Methodology of Stirling engines.
[9] Khaled M. Bataineh (2018). Numerical thermodynamic model of alpha -type Stirling engine csite.2018.03.010
[10] Houda Hachema, Ramla Gheitha, Fethi Alouib Technological challenges and optimization eorts of the Stirling machine, Energy Conversion and Management 117(2018), 1365 to 1387.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY