ISSN 2229-5518

Seeking New Horizon.

Joshi Kuldeep R, Mr. Gunjan H. Desai, Kaila Bhavesh R

Mechanical Department
Takshashila College Of Engineering And Technology, Rajkot- Gujarat-INDIA

Abstract- This is an industrial defined project of UltraTech Cement – Narmada Cement Company Ltd., Babarkot (Ta: Jafrabad), Gujarat-India. The project mainly describes the ways to utilize the hot air which is being thrown away to the atmosphere which can be of great use.The project deals with the heat of the Bag House with the temperature range of $190^0 - 200^0$ C. This amount of heat can be directly converted to any other form of the energy using suitable transducers and the resultant can be utilized for various other minor or major activities of the factory. Further in this report various technical as well as economic aspects of the same are dealt which might seem to be helpful to the readers

Index Terms- Waste Heat Recovery, Stirling Engine, Schmidt Theory of Stirling Engine, Proposed model for the firm.

I. Introduction

Narmada Cement plant has got a huge number of departments and large number of assets. One of its assets is Bag House whose main purpose is to remove the fine lime stone particles from the air and releases the processed air to the atmosphere. Major components preset in the hot air are Nitrogen Oxides, Suspended Particles and traces of Sulphur Oxide. Out of all these Sulphur and Nitrogen can be considered as harmful but the amount obtained is too less. Thus the air in the bag house is almost free from the pollutants and only contains the fine lime stone particles in it. Fig 1, Fig 2

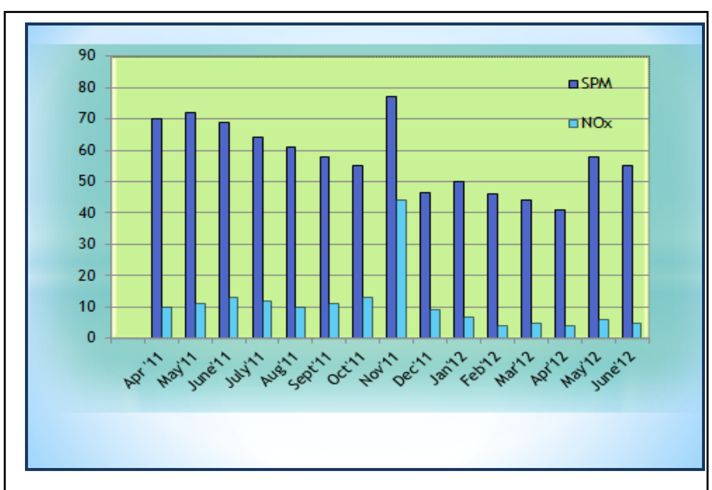


Fig. 1 Major Pollutants released by the plant

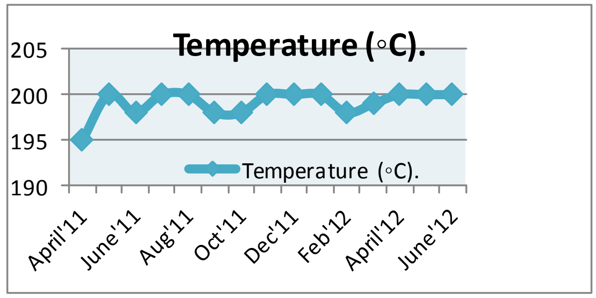


Fig 2 Average temperature of the Bag House

It is clear from the presented data (refer figures) that the heat obtained can be used for electricity generation purpose. Now we shall see the best way of generating the electricity using the hot air of the Bag House.

One of the best ways is to use Striling Engine at the heat source. The basics of the Striling Engine and all the technical details are provided in the succeeding section. Fig 3

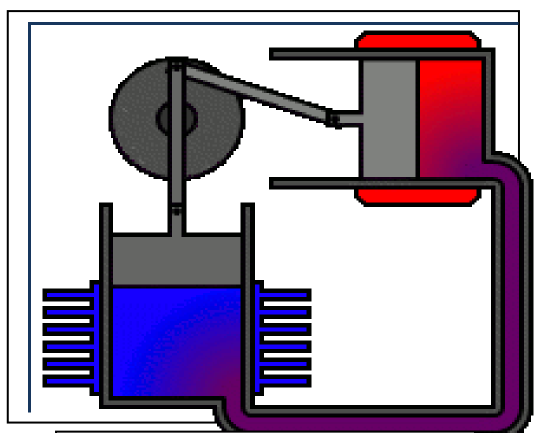
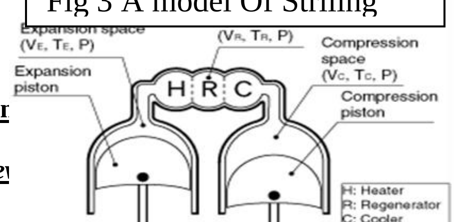


Fig 3 A model Of Striling



I. Ur … ne:

1.1 Revie

The Striling engine is a heat engine that is vastly different from the internal-combustion engine in your car. Invented by

ISSN 2229-5518

Robert Striling in 1816, the Striling engine has the potential to be much more efficient than a gasoline or diesel engine. But today, Striling engines are used only in some very specialized applications, like in submarines or auxiliary power generators for yachts, where quiet operation is important. Although there hasn't been a successful mass-market application for the Striling engine, some very high-power inventors are working on it.

A Striling engine uses the Striling cycle, which is unlike the cycles used in internal-combustion engines.

- The gasses used inside a Striling engine never leave the engine. There are no exhaust valves that vent high-pressure gasses, as in a gasoline or diesel engine, and there are no explosions taking place. Because of this, Striling engines are very quiet.
- The Striling cycle uses an external heat source, which could be anything from gasoline to solar energy to the heat produced by decaying plants. No combustion takes place inside the cylinders of the engine.

More specifically; a closed-cycle regenerative heat engine with a permanently gaseous working fluid, where closed-cycle is defined as a thermodynamic system in which the working fluid is permanently contained within the system and regenerative describes the use of a specific type of internal heat exchanger and thermal store, known as the regenerator. It is the inclusion of a regenerator that differentiates the Striling engine from other closed cycle hot air engines.

Getting into detail:

The Striling engine is noted for its high efficiency compared to steam engines, quiet operation, and the ease with which it can use almost any heat source. This compatibility with alternative and renewable energy sources has become increasingly significant as the price of conventional fuels rises, and also in light of concerns such as peak oil and climate change. This engine is currently exciting interest as the core component of micro **combined heat and power (CHP) units,** in which it is more efficient and safer than a comparable steam engine.

The Striling engine is traditionally classified as an **external combustion engine**, as all heat transfers to and from the working fluid take place through a solid boundary (heat exchanger) thus isolating the combustion process and any contaminants it may produce from the working parts of the engine. This contrasts with an internal combustion engine where heat input is by combustion of a fuel within the body of the working fluid.

The engine is designed so that the working gas is generally compressed in the colder portion of the engine and expanded in the hotter portion **resulting in a net conversion of heat into work**. An internal Regenerative heat exchanger increases the Striling engine's thermal efficiency compared to simpler hot air engines lacking this feature.

Due to the closed cycle operation, the heat driving a Striling engine must be transmitted from a heat source to the working fluid by heat exchangers and finally to a heat sink.

Requirements of a Striling Engine:

A Striling engine system requires **at least one heat source, one heat sink and heat exchangers.** The heat source may be provided by the combustion of a fuel and, since the combustion products do not mix with the working fluid and hence do not come into contact with the internal parts of the engine, a Striling engine can run on fuels that would damage other types of engines' internals, such as landfill gas which contains siloxane.

Other suitable heat sources include concentrated (**1) solar energy, (2) geothermal energy, (3) nuclear energy, (4) waste heat and bioenergy.**

If solar power is used as a heat source, regular solar mirrors and solar dishes may be utilized. The use of Fresnel lenses and mirrors has also been advocated. Solar powered Striling engines are increasingly popular as they offer an environmentally sound option for producing power while some designs are economically attractive in development projects.

On getting real:

In small, low power engines this may simply consist of the walls of the hot space(s) but where larger powers are required a greater surface area is needed in order to transfer sufficient heat. Typical implementations are internal and external fins or multiple small bore tubes.

Designing Striling engine heat exchangers is a balance between high heat transfer with low viscous pumping losses and low dead space (unswept internal volume).

ISSN 2229-5518

With engines operating at high powers and pressures, the heat exchangers on the hot side must be made of alloys that retain considerable strength at temperature and that will also not corrode or creep.

In a Striling engine, the regenerator is an internal heat exchanger and temporary heat store placed between the hot and cold spaces such that the working fluid passes through it first in one direction then the other. Its function is to retain within the system that heat which would otherwise be exchanged with the environment at temperatures intermediate to the maximum and minimum cycle temperatures, thus enabling the thermal efficiency of the cycle to approach the limiting Carnot efficiency defined by those maxima and minima.

The primary effect of regeneration in a Striling engine is to:

(1) Increase the thermal efficiency by **'recycling'** internal heat which would otherwise pass through the engine irreversibly.

(2) Increased thermal efficiency yields a higher power output from a given set of hot and cold end heat exchangers. It is these which usually limit the engine's heat throughput.

In practice this additional power may not be fully realized as the additional "dead space" (unswept volume) and pumping loss inherent in practical regenerators reduces the potential efficiency gains from regeneration.

2.2 Final Stage

Design Challenges:

The design challenge for a Striling engine regenerator is to provide sufficient heat transfer capacity without introducing too much additional flow resistance. These inherent design conflicts are one of many factors which limit the efficiency of practical Striling engines.

A typical design is a stack of fine metal wire meshes, with low porosity to reduce dead space, and with the wire axes perpendicular to the gas flow to reduce conduction in that direction and to maximize convective heat transfer.

Cooler Side And The Heat Sink:

In small, low power engines this may simply consist of the walls of the cold space(s), but where larger powers are required a cooler using a liquid like water is needed in order to transfer sufficient heat.

Heat Sink:

The heat sink is typically the environment at ambient temperature. In the case of medium to high power engines, a radiator is required to transfer the heat from the engine to the ambient air.

It's the foremost preliminary step for proceeding with any research work writing. While doing this go through a complete thought process of your Journal subject and research for its viability by following means:

1) Read already published work in the same field.
2) Goggling on the topic of your research work.
3) Attend conferences, workshops and symposiums on the same fields or on related counterparts.
4) Understand the scientific terms and jargon related to your research work.

Main Components of the Striling Engine: Fig 4

Displacer (Movable component)

A Hot Cylinder (Heat source)

A Cold Cylinder (Heat sink)

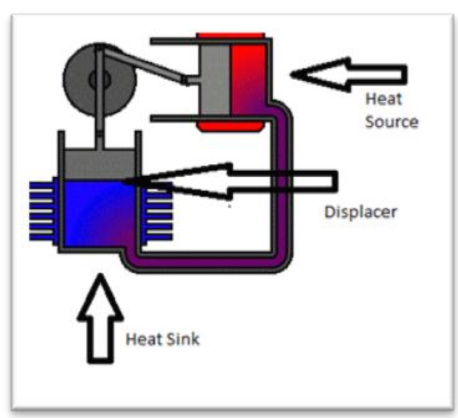


Fig 4 Detailed Parts of Striling Engine

The displacer is a special-purpose piston; used in almost all types of Striling engines, to move the working gas back and forth between the hot and cold heat exchangers. Depending on the type of engine design, the displacer may or may not be sealed to the cylinder, i.e. it is a loose fit within the cylinder and allows the working gas to pass around it as it moves to occupy the part of the cylinder beyond.

<u>What if this system is introduced in the plant?</u>

<u>Advantages:</u>

1. Total amount of hot air being released to the atmosphere reduces to a large extent.

2. There exists a new source of energy generation unit which would help reducing the overall production cost.

3. Overall efficiency of the plant increases.

4. Since the heat of the air is utilized before it is moved to the Bag House, the life of the bags increases considerably.

5. Avoidance of Kiln stoppage during high temperature of the Bag House as the bag house would never achieve such a high temperature.

6. Self-dependent plant if established on major scale.

7. An Eco-friendly operation included and also helps reducing the high temperature air to be released to the atmosphere.

8. High efficiency than other conventional power plants.

There are other countless advantages of this power plant which are discussed later in the section.

<u>Types of the Striling Engine:</u>

There are two major types of Striling engines that are distinguished by the way they move the air between the hot and cold sides of the cylinder:

1.The two piston **<u>Alpha</u>** type design has pistons in independent cylinders, and gas is driven between the hot and cold spaces. Fig 5

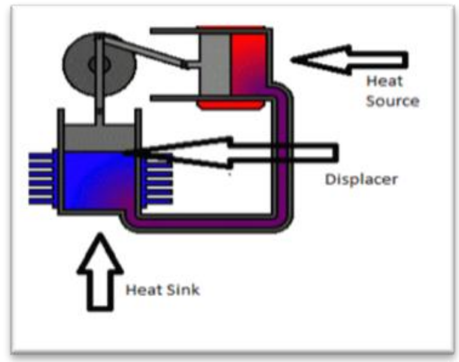


Fig 5 Alpha Type Striling Engine

2.The displacement type Striling engines, known as **<u>Beta</u>** and gamma types, use an insulated mechanical displacer to push the working gas between the hot and cold sides of the cylinder. The displacer is large enough to insulate the hot and cold sides of the cylinder thermally and to displace a large quantity of gas. It must have enough of a gap between the displacer and the cylinder wall to allow gas to flow around the displacer easily.

- **<u>Alpha Type Striling Engine:</u>**

An Alpha Striling contains two power pistons in separate cylinders, one hot and one cold. The hot cylinder is situated inside the high temperature heat exchanger and the cold cylinder is situated inside the low temperature heat exchanger. This type of engine has a high power-to-volume ratio but has technical problems due to the usually high temperature of the hot piston and the durability of its seals.

In practice, this piston usually carries a large insulating head to move the seals away from the hot zone at the expense of some additional dead space.

- **<u>Beta Type Striling Engine: Fig 6</u>**

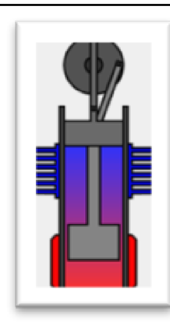


Fig 6 Beta Type Striling Engine

A beta Striling has a single power piston arranged within the same cylinder on the same shaft as a displacer piston. The displacer piston is a loose fit and does not extract any power from the expanding gas but only serves to shuttle the working gas from the hot heat exchanger to the cold heat exchanger. When the working gas is pushed to the hot end of the cylinder it expands and pushes the power piston. When it is pushed to the cold end of the cylinder it contracts and the momentum of the machine, usually enhanced by a flywheel, pushes the power piston the other way to compress the gas. Unlike the alpha type, the beta type avoids the technical problems of hot moving seals.

- **Gamma Type Striling Engine:**

A gamma Striling is simply a Beta Striling in which the power piston is mounted in a separate cylinder alongside the displacer piston cylinder, but is still connected to the same flywheel. The gas in the two cylinders can flow freely between them and remains a single body. This configuration produces a lower compression ratio but is mechanically simpler and often used in multi-cylinder Striling engines.

Processes involved in the Striling Engine: Fig 7

The idealized Striling cycle consists of **four** thermodynamic processes acting on the working fluid:

(1) Isothermal Expansion:

The expansion-space and associated heat exchanger are maintained at a constant high temperature, and the gas undergoes near-isothermal expansion absorbing heat from the hot source.

(2) Constant-Volume (known as isovolumetric or isochoric) heat-removal :

The gas is passed through the regenerator, where it cools transferring heat to the regenerator for use in the next cycle.

(3) Isothermal Compression:

The compression space and associated heat exchanger are maintained at a constant low temperature so the gas undergoes near-isothermal compression rejecting heat to the cold sink

(4) Constant-Volume (known as isovolumetric or isochoric) heat-addition:

The gas passes back through the regenerator where it recovers much of the heat transferred in 2, heating up on its way to the expansion space.

Theoretical thermal efficiency equals that of the hypothetical Carnot cycle - i.e. the highest efficiency attainable by any heat engine.

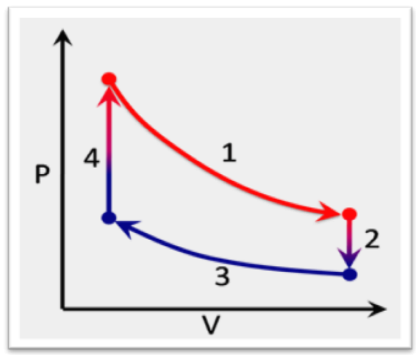


Fig 7 P-V diagram

Advantages:

- Striling engines can run directly on any available heat source, not just one produced by combustion, so they can run on heat from solar, geothermal, biological, nuclear sources or waste heat from industrial processes.
- A continuous combustion process can be used to supply heat, so those emissions associated with the intermittent combustion processes of a reciprocating internal combustion engine can be reduced.
- Most types of Striling engines have the bearing and seals on the cool side of the engine, and they require less lubricant and last longer than other reciprocating engine types.
- A Striling engine uses a single-phase working fluid which maintains an internal pressure close to the design pressure, and thus for a properly designed system the risk of explosion is low. In comparison, a

steam engine uses a two-phase gas/liquid working fluid, so a faulty release valve can cause an explosion. In some cases, low operating pressure allows the use of lightweight cylinders.

- They can be built to run quietly and without an air supply, for air-independent operations.
- They start easily (albeit slowly, after warm-up) and run more efficiently in cold weather, in contrast to the internal combustion which starts quickly in warm weather, but not in cold weather.
- A Striling engine used for pumping water can be configured so that the water cools the compression space. This is most effective when pumping cold water.
- They are extremely flexible. They can be used as CHP (combined heat and power) in the winter and as coolers in summer.
- Waste heat is easily harvested (compared to waste heat from an internal combustion engine) making Striling engines useful for dual-output heat and power systems.

Disadvantages:

- Striling engine designs require heat exchangers for heat input and for heat output, and these must contain the pressure of the working fluid, where the pressure is proportional to the engine power output. In addition, the expansion-side heat exchanger is often at very high temperature, so the materials must resist the corrosive effects of the heat source, and have low creep.

Typically these material requirements substantially increase the cost of the engine. The materials and assembly costs for a high temperature heat exchanger typically accounts for 40% of the total engine cost.

- All thermodynamic cycles require large temperature differentials for efficient operation. In an external combustion engine, the heater temperature always equals or exceeds the expansion temperature. This means that the metallurgical requirements for the heater material are very demanding. This is similar to a Gas turbine, but is in contrast to an Otto engine or Diesel engine, where the expansion temperature can far exceed the metallurgical limit of the engine materials, because the input heat source is not conducted through the engine, so engine materials operate closer to the average temperature of the working gas. The Striling cycle is not actually achievable, the real cycle in Striling machines is less efficient than the theoretical Striling cycle, also the efficiency of the Striling cycle is lower where the ambient temperatures are mild, while it would give its best results in a cool environment, such as northern countries' winters.

- Dissipation of waste heat is especially complicated because the coolant temperature is kept as low as possible to maximize thermal efficiency .This increases the size of the radiators, which can make packaging difficult. Along with materials cost, this has been one of the factors limiting the adoption of Striling engines as automotive prime movers. For other applications such as ship propulsion and stationary micro generation systems using combined heat and power (CHP) high power density are not required.

Calculation Sheet:

(all the data collected are from suitable reliable sources of the firm)

Assumptions:

1.Let the total mass of the hot air being taken by us from the Bag House= 500kg

2 .Specific Heat (C_p) = 0.2

3. Let the inlet temperature = 200^0C

4. Let the outlet temperature = 100^0C

Few Important Conversions:

1 kcal = 1.163 kwh
1 kcal = 4.14 * 10^{-3} joule

We know that,

$$Q = mC_p\Delta T$$

Where,

Q= Total energy in Joule
m= mass of air in kg
C_p= Specific Heat
ΔT= Change in the Temperature

Calculations:

∴ Q= (500)*(0.2)*(200°-100°)

= 10000 joule

= 2392.344 cal

= 2.392344 kcal

∴ Q = 2.7822 kWh

Total Monetary Benefits:

If a design is made for production of 13MW of power then; (13MW is selected because the complete unit at Narmada Cement runs on 13MW power.)

Total Units Produced	Cost/ Unit (approx.)	Total
216.66	Rs. 5/-	Rs. 1083.3/-
	Total	Rs. 1083.3/-

(per day)

Knowing a bitter truth…

1. Commencement Of the Plant : Year 1982
2. Today: 2012
3. Number of years: Approx. 30 years
4. Total Number of Days: 10950

Per day loss of **Rs. 1083.3/-**

Total Loss Incurred Till Now: Rs. 1,18,62,135.0/-

SCHMIDT THEORY FOR STIRLING ENGINES:

The Schmidt theory is one of the isothermal calculation methods for Stirling engines. It is the most simple method and very useful during Stirling engine development. This theory is based on the isothermal expansion and compression of an ideal gas.

The performance of the engine can be calculated a P-V diagram. The volume in the engine is easily calculated by using the internal geometry. When the volume, mass of the working gas and the temperature is decided, the pressure is calculated using an ideal gas method as shown in equation (1).

$$PV = mRT \quad (1)$$

The engine pressure can be calculated under following assumptions: Fig 8

a) There is no pressure loss in the heat-exchangers and there are no internal pressure differences.
b) The expansion process and the compression process changes isothermal.
c) Conditions of the working gas are changed as an ideal gas.
d) There is a perfect regeneration.

ISSN 2229-5518

e) The expansion dead space maintains the expansion gas temperature - T_E, the compression dead space maintains the compression gas temperature - T_C during the cycle.

f) The regenerator gas temperature is an average of the expansion gas temperature - T_E and the compression gas temperature - T_C.

g) The expansion space - V_E and the compression space - V_C changes according to sine curves.

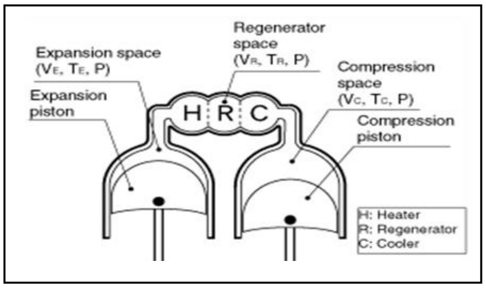


Fig 8 Construction of Striling Engine for Mathematical Equations

The volumes of the expansion- and compression cylinder at a given crank angle are determined at first. The momental volumes is described with a crank angle - x. This crank angle is defined as x=0 when the expansion piston is located the most top position (top dead point).
The momental expansion volume - V_E is described in below equation with a swept volume of the expansion piston - V_{SE}, an expansion dead volume - V_{DE} under the condition of assumption

$$V_E = \frac{V_{SE}}{2}(1-\cos x)+V_{DE} \quad \textbf{(2)}$$

The momental compression volume - V_C is found in following equation with a swept volume of the compression piston - V_{SC}, a compression dead volume - V_{DC} and a phase angle – dx

$$V_C = \frac{V_{SC}}{2}\{1-\cos(x-dx)\}+V_{DC} \quad \textbf{(3)}$$

The total momental volume is calculated as:

TABLE 1 Specifications of terminologies

Name	Symbol	Unit
Engine pressure	P	Pa
Swept volume of expansion piston or displacer piston	V_{SE}	m^3
Swept volume of compression piston or power piston	V_{SC}	m^3
Dead volume of expansion space	V_{DE}	m^3
Regenerator volume	V_R	m^3
Dead volume of compression space	V_{DC}	m^3
Expansion space momental volume	V_E	m^3
Compression space momental volume	V_C	m^3
Total momental volume	V	m^3
Total mass of working gas	m	kg
Gas constant	R	J/kgK
Expansion space gas temperature	T_H	K
Compression space gas temprature	T_C	K
Regenerator space gas temperature	T_R	K
Phase angle	dx	deg
Temperatuer ratio	t	
Swept volume ratio	v	
Dead volume ratio	X	
Engine speed	n	Hz
Indicated expansion energy	W_E	J
Indicated compression energy	W_C	J
Indicated energy	W_i	J
Indicated expansion power	L_E	W
Indicated compression power	L_C	W
Indicated power	L_i	W
Indicated efficiency	e	

$$V = V_E + V_R + V_C \quad \textbf{(4)}$$

By the assumptions (a), (b) and (c), the total mass in the engine - m is calculated using the engine pressure - P, each temperature - T , each volume - V and the gas constant – R

$$m = \frac{PV_E}{RT_E}+\frac{PV_R}{RT_R}+\frac{PV_C}{RT_C} \quad (5)$$

The temperature ratio - t, a swept volume ratio - v and other dead volume ratios are found using the following equations

$$t = \frac{T_C}{T_E} \quad (6)$$

$$v = \frac{V_{SC}}{V_{SE}} \quad (7)$$

$$X_{DE} = \frac{V_{DE}}{V_{SE}} \quad \textbf{(8)}$$

$$X_{DC} = \frac{V_{DC}}{V_{SE}} \quad \textbf{(9)}$$

$$X_R = \frac{V_R}{V_{SE}} \quad \textbf{(10)}$$

The regenerator temperature - T_R is calculated in equation (11), by using the assumption (f)

$$T_R = \frac{T_E + T_C}{2} \quad \textbf{(11)}$$

When equation (5) is changed using equation (6)-(10) along with (2) and (3), the total gas mass – m

$$m = \frac{PV_{SE}}{2RT_C}\{S - B\cos(x - a)\} \quad \textbf{(12)}$$

Where;

$$a = \tan^{-1}\frac{v \cdot \sin dx}{t + \cos dx}$$

$$S = t + 2tX_{DE} + \frac{4tX_R}{1+t} + v + 2X_{DC}$$

$$B = \sqrt{t^2 + 2tv\cos dx + v^2}$$

The engine pressure - P is defined as a next equation using equation (12)

$$P = \frac{2mRT_C}{V_{SE}\{S - B\cos(\theta - a)\}} \quad \textbf{(13)}$$

The mean pressure - P_{mean} can be calculated as follows

$$P_{mean} = \frac{1}{2\pi}\oint P\,dx = \frac{2mRT_C}{V_{SE}\sqrt{S^2 - B^2}} \quad \textbf{(14)}$$

c is defined in the next equation:

$$c = \frac{B}{S} \quad \textbf{(15)}$$

As a result, the engine pressure - P, based the mean engine pressure - P_{mean} is calculated in equation (16):

$$P = \frac{P_{mean}\sqrt{S^2 - B^2}}{S - B\cos(x - a)} = \frac{P_{mean}\sqrt{1 - c^2}}{1 - c \cdot \cos(x - a)} \quad \textbf{(16)}$$

On the other hand, in the case of equation (17), when cos(x-a)=-1, the engine pressure - P becomes the minimum pressure - P_{min}, the next equation is introduced:

$$P_{min} = \frac{2mRT_C}{V_{SE}(S + B)} \quad \textbf{(17)}$$

ISSN 2229-5518

Therefore, the engine pressure - P, based the minimum pressure - P_{min} is described in equation (18).

$$P = \frac{P_{min}(S+B)}{S - B\cos(x-a)} = \frac{P_{min}(1+c)}{1 - c\cdot\cos(x-a)} \quad \textbf{(18)}$$

Similarly, when cos(x-a)=1, the engine pressure - P becomes the maximum pressure - P_{max}. The following equation is introduced.

$$P = \frac{P_{max}(S-B)}{S - B\cos(x-a)} = \frac{P_{max}(1-c)}{1 - c\cdot\cos(x-a)} \quad \textbf{(19)}$$

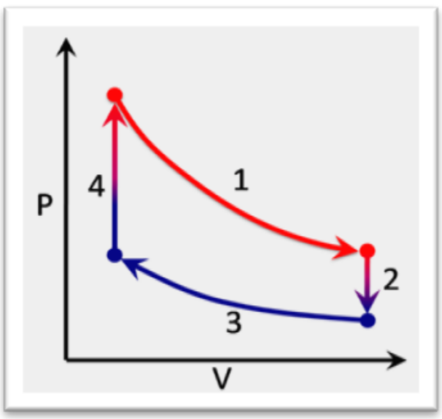


Fig 9 Processes in Striling

INDICATED ENERGY, POWER AND EFFICIENCY

The indicated energy (area of the P-V diagram) in the expansion and compression space can be calculated as an analytical solution with use of the above coefficients. The indicated energy in the expansion space (indicated expansion energy) - W_E(J), based on the mean pressure - P_{mean}, the minimum pressure - P_{min} and the maximum pressure - P_{max} are described in the following equations.

$$W_E = \oint P dV_E = \frac{P_{mean} V_{SE} \pi c \cdot \sin a}{1+\sqrt{1-c^2}}$$

$$= \frac{P_{max} V_{SE} \pi c \cdot \sin a}{1+\sqrt{1-c^2}} \cdot \frac{\sqrt{1-c}}{\sqrt{1+c}} \quad \textbf{(1)}$$

The indicated energy in the compression space (indicated compression energy- W_C is described in the next equations:

$$W_c = \oint P dV_c = -\frac{P_{mean} V_{SE} \pi ct \cdot \sin a}{1+\sqrt{1-c^2}}$$

$$= -\frac{P_{min} V_{SE} \pi ct \cdot \sin a}{1+\sqrt{1-c^2}} \cdot \frac{\sqrt{1+c}}{\sqrt{1-c}}$$

$$= -\frac{P_{max} V_{SE} \pi ct \cdot \sin a}{1+\sqrt{1-c^2}} \cdot \frac{\sqrt{1-c}}{\sqrt{1+c}} \quad \textbf{(2)}$$

The indicated energy per one cycle of this engine - W_i is demanded in the next equations.

$$W_i = W_e + W_c \quad (3)$$

$$= \frac{P_{mean} V_{SE} \pi c(1-t)\sin a}{1+\sqrt{1-c^2}}$$

$$= \frac{P_{min} V_{SE} \pi c(1-t)\sin a}{1+\sqrt{1-c^2}} \cdot \frac{\sqrt{1+c}}{\sqrt{1-c}}$$

$$= \frac{P_{max} V_{SE} \pi c(1-t)\sin a}{1+\sqrt{1-c^2}} \cdot \frac{\sqrt{1-c}}{\sqrt{1+c}}$$

Relations between P_{mean}, P_{min} and P_{max} are determined in the following equations:

$$\frac{P_{min}}{P_{mean}} = \sqrt{\frac{1-c}{1+c}}$$

$$\frac{P_{max}}{P_{mean}} = \sqrt{\frac{1+c}{1-c}}$$

The indicated expansion power - L_E(W), the indicated compression power - L_C(W) and the indicated power of this engine - L_i(W) are defined in the following equations, using the engine speed per one second , n(rps, Hz).

$$L_E = W_E n$$

$$L_C = W_C n$$

$$L_i = W_i n$$

The indicated expansion energy - W_E found equation (1) means an input heat from a heat source to the engine. The indicated compression energy - W_c calculated by equation (2) means a reject heat from the engine to cooling water or air. Then the thermal efficiency of the engine - e is calculated in the next equation

$$e = \frac{W_i}{W_E} = 1 - t$$

This efficiency equals that of a Carnot cycle which is the highest efficiency in every thermal engine.

(A Proposed Modified Version of the Striling Engine Which Can
Be Installed At the **UltraTech Cement (Narmada Cement Jafrabad Works)**). Fig 10

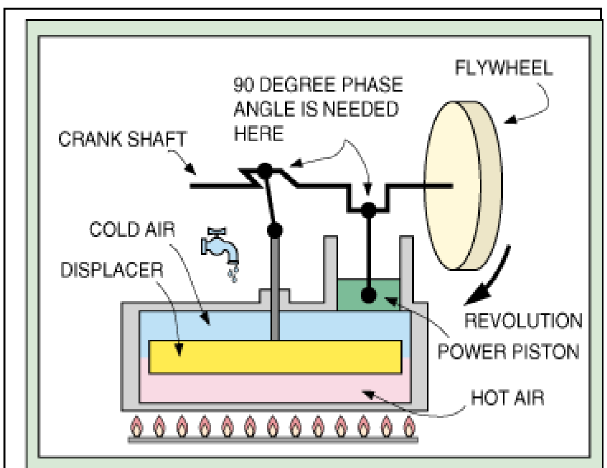


Fig 10

Copyright Agreement:

International Journal of Scientific and Engineering Research

COPYRIGHT AGREEMENT

Please complete and sign the form and send it with the final version of your manuscript. It is required to obtain written confirmation from authors in order to acquire copyrights for papers published in the journal so as to index them to various repositories.

Title of paper: Seeking New Horizon

Author(s); Master JOSHI KULDEEP R., Master KAILA BHAVESH R., Mr. GUNJAN H.DESAI

The undersigned hereby transfer any and all rights in and to the paper including without limitation all copyrights to the IJSER. The undersigned hereby represents and warrants that the paper is original and that he/she is the author of the paper, except for material that is clearly identified as to its original source, with permission notices from the copyright owners where required. The undersigned represents that he/she has the power and authority to make and execute this assignment.

This agreement is to be signed by at least one of the authors who have obtained the assent of the co-author(s) where applicable.

14/September/2012
Author's Signature & Date

Joshi Kuldeep R.
Typed or Printed Name

Takshashila College of Engineering And Technology, Rajkot, Gujarat-India.
Institution or Company

Send to: mailto:ijser.editor@ijser.org

Conclusion:

The project conducted has proved to be very helpful in today's energy depleating world. This works on the waste heat which is released to the atmosphere without making any kind of utilization. But if done so this can ofcourse not only save our mother Earth but would also be helpful in monetory terms.

Acknowledgement

A work of this nature while entailing a log of personal effort cannot be completed without the help of some external sources. I will be failing in my duty if I do not acknowledge with gratitude the invaluable contribution of these sources.

I am thankful to Mr. K.Darban (H.O.D-Mechanical), Mr. Praveen Rathod (Engineer Mechanical Department), Mr. D.M Shah (Pollution Department), Mr. B.D.Gandhi (Engineer Electrical Department), Mr.S.Khorana (Process Department), Mr. P.L Dave (H.R Department) and Mr. R.N Joshi (Mechanical Department).

It would have been very difficult to prepare this project without the enthusiastic support, advice and inspirations given to me by all the above mentioned people. I also wish to thank my family and friends for valuable assistance during planning and preparation of this project and bringing this out in such a short time.

Finally, I sincerely acknowledge the support given to me by all the departments and employees.

Any suggestions for further improvement of this topic are most welcome.

References:

1. The UltraTech Cement , Jafrabad Works Gujarat-India.
2. Power Plant Engineering- Arora & Domkundwar (Dhanpat Rai & Sons Publications)

Authors

- Joshi Kuldeep R – persuing Bechlor of Engineering in Mechanical Engineering Department from Takshashila College of Engineering & Technology , Rajkot-Gujarat, India
  Ph:-+919408489266
  E-mail: joshikuldeep77@rocketmail.com

.

- Mr. Gunjan H. Desai – Desai received Master's Degree in Manufacturing Engineering from Illinois Institute of Technology- Chicago, USA . Presently he is working as Assistant Professor in Mechanical Department, Takshashila College of Engineering & Technology- Rajkot, India
  Ph: +917600026528
  E-mail: ergunjaner@gmail.com

.

- Kaila Bhavesh R – persuing Bechlor of Engineering in Mechanical Engineering Department from Takshashila College of Engineering & Technology , Rajkot-Gujarat, India
  Ph:-+919510766323
  E-mail: bhaveshpatel.mech6016@gmail.com