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Design of Hybrid Striling Engine

1. N.AVINASH, 2.Mr.K.SIVA KOTESHWARAO

1.Pg Scholar, Department Of Mechanical Engineering,Sree Dattha Institute Of Engineering &Sciences (Approved By Aicte, Affiliated To J.N.T.U.H),Sheriguda Ranga Reddy Dist Telengana -501510

2.Assoc Professor,HOD, Department Of Mechanical Engineering,Sree Dattha Institute Of Engineering &Sciences (Approved By Aicte, Affiliated To J.N.T.U.H),Sheriguda Ranga Reddy Dist Telengana -501510

ABSTARCT:

This project was set out to with an objective to explore the practicality of power production from a Hybrid Stirling engine. This would include research, design and fabrication. Hybrid here meant that the engine model would run on different sources of sufficient external heat to generate the desired motion. This was done to supplement the government‟s efforts to provide affordable electricity to rural and marginalized parts of Kenya. With this end in sight, a thorough and comprehensive research was carried out on the working and configurations of Stirling engines. Research sources included the internet, engineering books on thermodynamics and engine machines as well consulting the project supervisor. In total, knowledge gathering took about six weeks. After it was decided that the Gamma configuration would best achieve the intended objective, sketches were made. This was then followed by the first design that was drawn up using the Rhinoceros Software, that led to the second and later third (final) designs using the Autodesk Inventor Software. After all the designs were approved by the project supervisor, an acquisition was made for funds and materials. This was then followed by fabrication, assembly and testing that span a period of 8 weeks. Test results revealed that the assembled engine had air leaks that mostly emanated from the piston cylinder. The piston cylinder was the highest precision part and also most expensive. The setback meant that the project needed more investment. Constrained by monetary resources, the project was concluded and further recommendations were drawn. From the theoretical analysis, the Stirling engine designed had and efficiency of about 7.7%. This was pointed out that there were energy losses, which were attributed to friction and the engine having some out-of-balance masses. To rectify this, it was proposed that a kinematic assessment of the engine be carried out to eliminate any out of balance masses. Upon completion of the project, it was recommended that more investment in the Stirling engine project needs to be made. Emerging economies such as India have turned to use of Stirling engines to provide electricity to the rural poor. In addition, developed economies such as the United States are taking advantage of this technology to generate electricity in „solar farms‟ using large solar powered stirling engines

1.INTRODUCTION:

A Stirling engine is a heat engine operating by cyclic compression and expansion of air at different temperature levels such that there is a net conversion of heat energy to mechanical work. Like the steam engine, the Stirling engine is traditionally classified as an external combustion engine, as all heat transfers to and from the working fluid take place through the engine wall. This contrasts with an internal combustion engine where heat input is by combustion of a fuel within the body of the working fluid. Unlike a steam engine"s (or more generally a Rankine cycle engine"s) usage of a working fluid in both of its liquid and gaseous phases, the Stirling engine encloses a fixed quantity of air.1 As is the case with other heat engines, the general cycle consists of compressing cool gas, heating the gas, expanding the hot gas, and finally cooling the gas before repeating the cycle. The efficiency of the process is narrowly restricted by the efficiency of the Carnot cycle, which depends on the temperature between the hot and cold reservoir. The Stirling engine is exceptional for of its high efficiency compared to steam engines, quiet in operation and the ease with which it can use almost any heat source. This is especially significant as the prices of conventional fuel prices rise in a more "green cautious" world. Competition from Internal combustion The invention of the internal combustion engine in the 1900"s put the nail on the coffin for the Stirling type of engine because it generated more power and proved to be more practical in the automobile industry. Due to the rigorous solar energy exploration taking place in the developed economies, this old technology is being given a newer and fresher approach. In the Kenyan scenario, the Stirling engine hopes to offer energy to rural and marginalized areas where the most common sources of energy include: • Biomass fuel –from burning of charcoal, firewood, rice husks, coal, maize cobs among others • Biogas- which has become of great use in the rural areas for both cooking and lighting • Solar heating- which has made its debut in the rural areas as an alternative means of cooking energy through use of solar concentrators. On September 27, 1816, Church of Scotland minister Robert Stirling applied for a patent for his economizer in Edinburgh, Scotland. The device was in the form of an inverted heat engine, and incorporated the characteristic phase shift between the displacer and piston that we see in all Stirling Engines today. 2 The engine also featured the cyclic heating and cooling of the internal gas by means of an external heat source, but the device was not yet known as a Stirling Engine. That name was coined nearly one hundred years later by Dutch engineer Rolf Meijer to describe all types of closed cycle regenerative gas engines. Stirling originally regarded his engine as a perpetual motion machine of the second kind (i.e. all heat supplied would be converted into work even though his original hot air engine did not include a cooling system. Due to the invention of the more powerful internal combustion engine at the middle of the 19th century, the Stirling technology was abandoned. But even so, the Stirling engine had an extra advantage over the steam engine due to its low operating cost. Also, the steam engine was prone to major failures like explosions. The only major problem with the Stirling engine was its tendency to fail when the cylinder being heated became too hot. Although improvements were made to curb up the problem, stiff competition from the internal combustion engine forced the hot air engine out of the commercial scene. Over the years, researchers have continued on Stirling engines, working out many of the design solutions that are used today in low temperature differential Stirling engines.

2.LITERATURE REVIEW:

The Stirling engine has over the years evolved. The most common configurations include the Alpha, Beta and Gamma. These vary in the arrangement of the different parts including the displacer, piston and flywheel. The Stirling engine operates on the Stirling cycle that has a theoretical efficiency close to the

Carnot efficiency. In the theory developed later, it is noted that addition of a regenerator in the configuration improves the overall performance and increases the output power of the system.

2.1.1 Basic Components A Stirling engine consists of a number of basic components, which may vary in design depending on the type and configuration. The most basic are outlined as follows: • Power Piston and Cylinder This consists of a piston head and connecting rod that slides in an air tight cylinder. The power piston is responsible for transmission of power from the working gas to the flywheel. In addition, the power piston compresses the working fluid on its return stroke, before the heating cycle. Due to the perfect air tight requirement, it is the most critical part in design and fabrication. • Displacer Piston and Cylinder The displacer is a special purpose piston, used 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. • Source of Heat The source of heat may be provided by the combustion of fuel, and since combustion products do not mix with the working fluid, the Stirling engine can run on an assortment of fuels. In addition, other sources such as solar dishes, geothermal energy, and waste heat may be used. Solar powered Stirling engines are becoming increasingly popular as they are a very environmentally friendly option for power production. • Flywheel The flywheel is connected to the output power of the power piston, and is used to store energy, and provide momentum for smooth running of the engine. It is made of heavy material such as steel, for optimum energy storage. Regenerator It 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 in the other. Its function within the system is to retain heat which would otherwise be exchanged with the environment. It thus enables the thermal efficiency of the cycle to approach the limiting Carnot efficiency. On the flip side, the presence of regenerator (usually a matrix of fine steel wool), increases the “dead space” (unswept volume). This leads to power loss and reduces efficiency gains from the regeneration. • Heat Sink The heat sink is typically the environment at ambient temperature. For small heat engines, finned heat exchangers in the ambient air suffice as a heat sink. In the case of medium to high power engines, a radiator may be required to transfer heat from the engine.

2.2 Operation and Configuration Since the Stirling engine is a closed cycle, it contains a fixed mass of gas called the "working fluid", most commonly air, hydrogen or helium. In normal operation, the engine is sealed and no gas enters or leaves the engine. No valves are required, unlike other types of piston engines. The Stirling engine, like most heat engines, cycles through four main processes: cooling, compression, heating and expansion. This is accomplished by moving the gas back and forth between hot and cold heat exchangers, often with a regenerator between the heater and cooler. The hot heat exchanger is in thermal contact with an external heat source, such as a fuel burner, and the cold heat exchanger being in thermal contact with an external heat sink, such as air fins. A change in gas temperature will cause a corresponding change in gas pressure, while the motion of the piston causes the gas to be alternately expanded and compressed. When the gas 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 cooled the pressure drops and this means that less work needs to be done by the piston to compress the gas on the return stroke, thus yielding a net power output. In summary, the Stirling engine uses the temperature difference between its hot end and cold end to establish a cycle of a fixed mass of gas, heated and expanded, and cooled and compressed, thus converting thermal energy into mechanical energy. The greater the temperature differences between the hot and cold sources, the greater the thermal efficiency. The maximum theoretical efficiency is equivalent to the Carnot cycle; however the efficiency of real engines is less than this value due to friction and other losses.

This project was set out to explore the practicality of power production from a Hybrid Stirling engine. This would include research, design and fabrication. “Hybrid” in this sense implies that, not at all like traditional Stirling motors that are composed in view of one method of warming, our motor model would keep running on various wellsprings of adequate outside warmth to create the coveted movement. In doing this extend, we were centered around making a motor model that could use warm from biomass, and in addition take a "green turn" and exploit sun oriented warmth by utilization of sunlight based concentrators. Our objective recipients would be Kenyans living in the minimized territories with little any expectation of accessing power. Seeing as these individuals utilize biomass for their customary vitality needs, the accomplishment of this undertaking would bear the cost of these individuals an opportunity to have manageable subsistent control in their homes. Further, as the Government submits its assets to accomplish the vision 2030, we took the test upon ourselves as the scholarly community to investigate potential outcomes of supporting in country jolt, in the more extensive objective of redesigning Kenyans' expectations for everyday comforts. More or less, the points of this undertaking incorporate the accompanying:

- Research on working guideline of Stirling motors
- Design of a Stirling motor that could be effectively manufactured for little scale subsistence utilize
- Fabrication of a model Stirling motor and evaluate its execution
- Give a suggestion from the discoveries and a path forward

CONCLUSION

The project was undertaken to explore the practicality of power production from a Hybrid Stirling engine. This included research, design and fabrication. The fabricated model was then tested and it was noted that some air leaks existed in the power cylinder. The power cylinder was an expensive part, and constrained by monetary resources, discussions and recommendations were made and the project was wrapped up. On the overall, the project was successful on several accounts. First, a successful research led to a design that was simulated on Autodesk Inventor, and showed kinematic synchronization. In addition, the prototype

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was fabricated and pointed the project exploration in the right direction. The setbacks encountered were used to give recommendations and pointed out some ways of project improvement. A theoretical energy assessment showed that with an open flame of sufficient temperature, (about 600oC) the designed Stirling engine would generate 45watts of power. In conclusion therefore, the project successfully explored the practicality of generating power from a Hybrid Stirling engine.

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