

“MICRO WIND TURBINE POWER PLANT ON A CHIP -A TECHNOLOGY TO GENERATE GREEN POWER USING MEMS”

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Today the buzzword in any industry is “**Miniaturization**”. The enabling impact of science and technology in shaping the design, development and realization of products what we see today as “revolutionary electronic products” needs no over emphasis especially for the new initiatives. Mems, as a topic, fits into this category. In terms of the material used for construction of conventional electronic engineering products that supported the information technology till recently, one cannot observe the usage of materials with special properties. After usage of Silicon in 1970s, application of newer methods and materials are emerging for replacing existing applications and for new products that would entail a ‘paradigm shift’ in the way we perceive the usage of such products in future. This paper presents the system-level and component design of a micro wind turbine power plant on a chip using MEMS. Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication. Using silicon micro fabrication processes, it has been suggested that common power generation systems could be miniaturized efficiently. These micro engines convert the kinetic energy of the hot air into mechanical energy and which is then converted into electrical energy. The fabrication approach is based on lithography, deep reactive ion etching, and aligned bonding of silicon and glass wafers. Expected power levels range from 1-12 W per chip with energy conversion efficiency in the range of 1-11%. Our paper focuses on converting the waste heat from the automobile engine and also to avoid pollution. The paper mainly explains about the underlying principles of MEMS and pollution control

Introduction:

The development in electro mechanical technology (MEMS) has opened the door for creation of power systems at unprecedented small scales. This paper also deals with one of the methods to produce power at small scale from waste energy. The micro engines convert the kinetic energy of the heat into mechanical, which is further converted into electrical energy. The waste heat itself can be used as an input to the devices, suppose if the kinetic energy of the heat is insufficient then Rankin’s cycle can be introduced in order to

produce additional kinetic energy. Also it uses a carbon filter before the exhausted air from the automobile is fed into the wind turbine.

All the components can be fabricated in a chip and covered. A heat supply and heat sink are also required in order to form a complete power generation system. Each power plant chip is expected to generate in the range of 1-10 Watts of electrical

power.

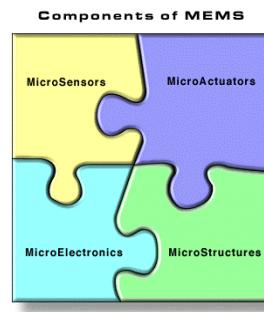
What is MEMS?

“The MEMS is the batch-fabricated integrated micro scale system (motion, electromagnetic, radiating energy and optical micro devices/microstructures controlling/ processing ICs) that:

- Converts physical stimuli, events, and parameters to electrical, mechanical, and optical signals and vice versa;
- Performs actuation, sensing and other functions;
- Comprise control (intelligence, decision-making, evolutionary learning, adaptation, self-organization, etc.), diagnostics, signal processing, and data acquisition features”

Basically, MEMS is a system that consists of microstructures, micro sensors, microelectronics, and micro actuators.

Microstructure builds the framework of the system; micro sensor detects signals; microelectronics processes the signals and gives commands to the micro actuator to react to these signals.



Principle used:

The main principle used in this method is ELEMROMAGNETIC INDUCTION.

The principle is that whenever there is a change in electric or magnetic field there will be a current induced in the circuit. Here we use a wind turbine coupled with a generator which uses the same principle. The input to the wind turbine is the hot combusted air from the automobile engines. Suppose if the kinetic energy of the air is insufficient to make up the speed, then Rankin's cycle is introduced.

As we know about Reheat Rankin's cycle, the input air is initially expanded, reheated and then used as the input of the wind turbine.

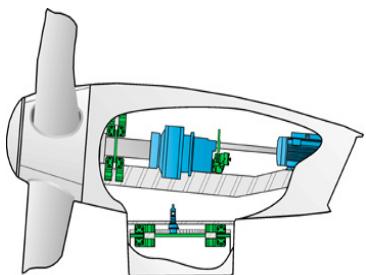
Components used:

The components required are as follows:

- Micro wind turbine
- Micro generator
- Battery
- Heat exchangers
- Carbon filter

Micro wind turbine:

Micro wind turbine is used as a prime mover to rotate the micro generator. Micro wind turbine is just a miniaturized wind turbine. Normally a wind turbine will require a wind velocity of 4m/s. The micro wind turbine is coupled with the micro generator using a shaft.

**Micro generator:**

Micro generator is used to generate electricity. The operations of the micro generator are similar to normal generator. Only difference is that the equipment is miniaturized. The micro generators will be able to produce an output of around 12w.

Battery:

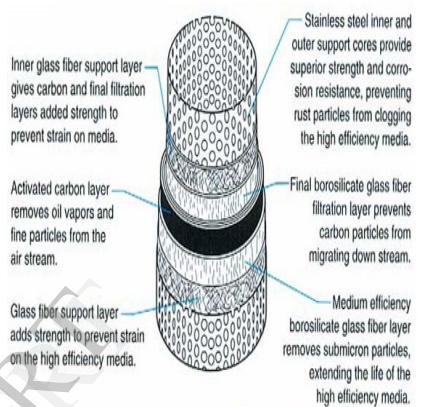
Battery is used to store the generated power. The capacity of the battery will be the maximum output of the generator. The generated power is stored as DC and can be converted in to AC by an inverter if required.

Heat exchangers:

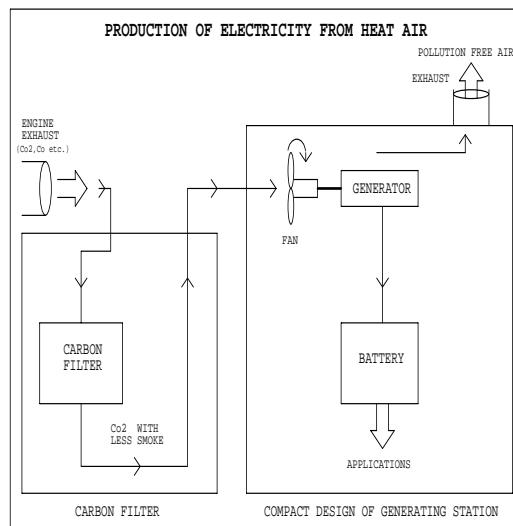
Heat exchangers are used to liberate any extra heat or over heat which would cause damage to the equipment. Suppose any extra heat is produced, it may damage the equipments. So it is necessary that heat exchangers should be installed surrounding the whole setup.

Carbon filters:

Carbon filters are used to filter out the carbon content in the input hot air. One of the main threats from automobile engines is that it produces carbon emission during combustion. The carbon emission cannot be completely eliminated, but the carbon particles which are the pollutants can be deposited and recycled.



These are the main components required and these all can be integrated in small scale.

Block diagram:

Working:

The working can be divided into two parts. They are

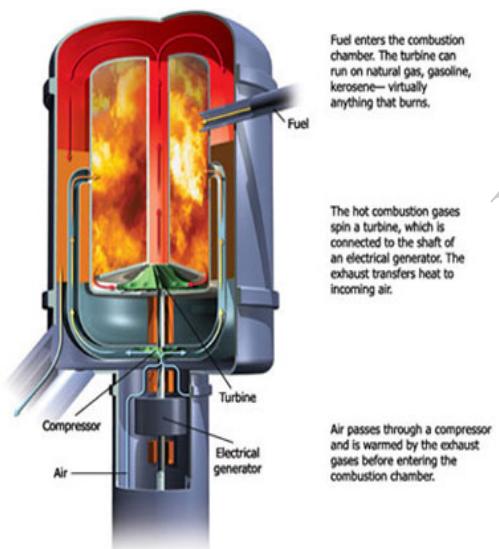
- Filtering unit
- Generating unit

Filtering unit:

In this unit there is a carbon filter located just after the engine outlet. This removes the minute carbon particle which causes pollution as smoke. This is to check the carbon emission of the vehicle.

Generating unit:

In this unit the filtered hot air is passed through a nozzle and is made to rotate the blades of the wind turbine. This kinetic velocity of the hot air is made to run the fanes of the wind turbine. This turbine is coupled with the generator, which produces electricity. The produced electricity is stored in a battery and can be used when needed.

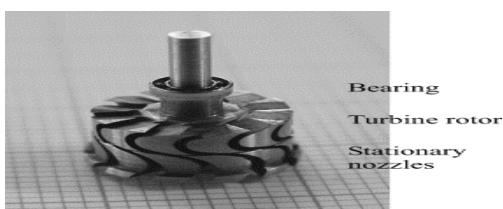
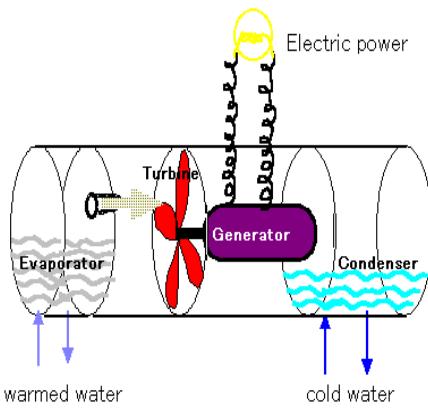


Thus the waste heat air from the engine exhaust is filtered and used to generate useful power.

High power applications:

From the above method a power range of approximately 1-12w can be generated. Also power for high power applications can be produced by introducing Rankin cycle. The reason for introducing Rankin cycle is that it can produce a very high velocity steam.

So in such a case the wind turbine is to be replaced by gas turbine which completely differs from the constructional features of wind turbine.

**Principle for high power generation:****Fabrication:**

The fabrication approach is based on silicon micro fabrication technology. First, the electrical components are fabricated on silicon wafers using thin and thick film processing and lithography. Shallow features, such as tip clearance, seal gaps, and grooves for the viscous pumps, are then lithographically defined and etched. Deep structures, such as turbine blades and flow channels, are then formed into the bulk of the silicon wafers by deep reactive ion etching (DRIE) of lithographically-defined features on both sides of the wafers. The final device is formed by bonding the silicon wafers, creating a laminated, monolithic static structure with integrated quasi-three dimensional flow paths. Reactive ion etching (DRIE) of lithographically-defined features on both sides of the wafers. The final device is formed by bonding the silicon wafers, creating a laminated, monolithic static structure with integrated quasi-three dimensional flow paths.

Performance:

The net output power will be equal to the cycle power minus viscous losses, such as bearing friction, seal drag, and disk windage (viscous drag other than in the bearings and seals), as well as ohmic losses in the generator and power electronics. While using wind turbine we have an efficiency of about 12% which is the efficiency of micro turbine. But when we introduce Rankin cycle the output power increases drastically but the size of the equipment increases slightly. As we are using waste heat as input, we are practically investing no raw materials.

Advantages:

- Waste heat is converted into useful energy (electrical energy).
- Compact in size
- Affordable and easily installable in any vehicle
- Temperature and corrosion resistant
- Less maintenance
- Good efficiency

Conclusion:

System-level and component design studies have been carried out for a miniature heat engine using MEMS-based, high performance micro machinery. These suggest that high power density Microsystems for power generation appear possible, with efficiency levels on the order of 1-11%. The design space for micro machined multistage turbines and viscous pumps were explored to confirm that viable designs are possible for this application. Also the application will make use of the waste heat generated. This can also be installed in large machinery which liberates heat during working. Thus it provides eco friendly power generation.

References

1. Edited by Gad-ed-Hak, Mohamed. 'The MEMS Handbook'. CRC Press, Boca Raton, Florida, 2002.
2. Lyshevski, Sergey Edward. 'MEMS and NEMS Systems, Devices, and Structures'. CRC Press, Boca Raton, Florida, 2002.