MHD POWER GENERATION FROM ENGINE EXHAUST

2016

B Tech
Main Project report

Done by

NOBIL VINCENT ELAVATHINGAL	**ETAMEME072**
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Department of Mechanical Engineering
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CERTIFICATE

Certified that this is a bonafide record of the Main Project Work titled

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of the Eighth Semester Mechanical Engineering in partial fulfillment of the requirement for the award of Degree Bachelor of Technology in Mechanical Engineering under the University of Calicut during the year 2015-16.

Project Guide:

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ABSTRACT

The main objective of the project is to design and fabricate a mechanism to generate electricity from the exhaust of a motorcycle engine using the principles of MHD power generation. It is really mortifying to hear the fact that only 30% of the energy from the fuel used reaches the wheels of a typical automobile implying most of the remaining energy is lost as heat. Since most of the energy consumed by an internal combustion engine is wasted, capturing much of that wasted energy can provide a large increase in energy efficiency. So the possibilities of where and how to capture this lost energy are matters of great significance. So there persists before us a challenge to come up with a new technique that would help in efficient utilization of fuel in automobile. The plan opted for was to incorporate an Magneto Hydro Dynamic (MHD) power generation unit in the exhaust pipe line which actually is a device that converts the energy loss through exhaust into useful electric power by making use of the Faraday's effect. This device works on the basis of magneto hydro dynamic power generation and it is a new unique method of power generation. Working of this device is by converting thermal energy and kinetic energy of high temperature exhaust gases into electrical energy. Externally added ions to the fast moving exhaust gases are allowed to pass through an externally applied magnetic field. This will give rise to generation of electric power on the plates kept at the sides. The project has also focused on the effect on generated emf had we used a Jet Engine instead of the motorcycle engine. The advantages and disadvantages of this method are also discussed along with an ANSYS FLUENT CFD simulation of the technique.

ACKNOWLEDGEMENT

We take this opportunity to express our boundless thanks and gratitude to each and every one who helped us in the successful completion of our project. We are so happy to acknowledge the help of all the individuals to fulfill our attempt.

It is with great pleasure that we place on record our indebtedness and deepest sense of gratitude to **Prof. C.P. Sunil Kumar**, The Head of Department, Department of Mechanical Engineering, GEC, Trissur, for providing the required facilities.

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LIST OF SYMBOLS

Volumetric efficiency	VE
Area of part of the duct where magnet is to be placed	A
Volume exhausted per second	Q
Induced emf	E
Velocity of flow entering into the magnetic field	u
RPM of the engine	N
Magnetic field strength	B
Distance between the electrodes	d
Electrical conductivity of Aluminium	σ
Power produced	W
Velocity of exhaust gas	v
Conversion efficiency of MHD	μ
Kinetic energy	KE
Electrical energy	EI
Area of electrode	A*
Internal resistance	Rg
Load resistance	R_L
Flowing current	I

CHAPTER ONE

INTRODUCTION

In the last years the rapid rise in the use of electric power has raised the problem how to provide the power increases. From sector studies the total electrical power consumption has almost doubled in the last twenty years. The problem of finding appropriate technologies to produce cheap energy and ensure the right standard of environmental compatibility has in recent years led to an increase in technological progress. Nowadays electrical energy is the form of energy to which all other forms of energy may be converted. It is easy to transport, easy to control and easy to transform. Most of the times, however, energy can be converted into electricity only through many intermediate transformations, which leads to limitations in efficiency, reliability, and compactness. The critical point in general in the energy conversion is the combination of heat and mechanical energy of the conversion system, which limits the maximum temperature involved. To avoid the mechanical limitations it seems promising to convert directly heat into electricity. We all know that it is a matter of global concern regarding the depletion of fossil fuels like petrol, diesel, natural gas etc. because of their extreme need in many of the practical applications such as in automobiles, aircrafts, power plants, locomotives etc. Especially when dealing with automobiles, the use of fuels like diesel and petrol for its running is just inevitable. These fuels have their applications in internal combustion engines of automobiles to derive power required for motion. But the problem that protrudes out from the studies conducted is that about 70% of the energy derived from the fuel is lost as heat which implies that only 30% proves beneficial for a vehicle's running. Since most of the energy consumed by an internal combustion engine is wasted, seizure of much of this wasted energy can provide a large increase in energy efficiency. For example, a typical engine producing 100 kilowatts of driveshaft power expels 68 kilowatts of heat energy through the radiator and 136 kilowatts through the exhaust. So the prospects of where and how the capture of this lost energy is accomplishable are matters of great significance. Also the enduring situation in internal combustion engines of a part of the engine power generated being consumed by the alternator incorporated in automobile leads to an increase in fuel consumption of the engine. So there persists before us a challenge to come up with a new technique that would help in efficient utilization of fuel in automobile. The strategy adopted was to amalgamate a Magneto Hydro Dynamic (MHD) power generation unit to the exhaust pipe line, thereby generating electric power which would thus replace the use of a conventional alternator and hence provide an efficient means of fuel management. Magneto hydro dynamics is the physical-mathematical framework that concerns the dynamics of magnetic fields in electrically conducting fluids, e.g. in plasmas and liquid metals. The word magneto hydro dynamics is comprised of the words magneto- meaning magnetic, hydro- meaning water (or liquid) and dynamics referring to the movement of an object by forces Yet an another factor that is propitious to the proposed methodology is that there are no moving parts incorporated in this method, thereby energy losses due to friction are next to zero. Hence the MHD power generation technique considerably has a higher efficiency. The number of vehicles on the road has rised exponentially. The huge amounts of heat rejected to the atmosphere by exhaust of these millions of these vehicles can be converted into electrical power which can be efficiently used.

CHAPTER TWO

LITERATURE REVIEW

The concept of MHD power generation was introduced for the very first time by Michael Faraday in the year 1832 in his Bakerian lecture to the Royal Society. He in fact carried out an experiment at the Waterloo Bridge in Great Britain for measuring the current, from the flow of the river Thames in earth's magnetic field. This experiment in a way outlined the basic concept behind MHD generation over the years then, several research work had been conducted on this topic, and later in August 13, 1940 this concept of magneto hydro dynamic power generation, was imbibed as the most widely accepted process for the conversion of heat energy directly into electrical energy without a mechanical sub-link.

The conversion process in MHD was initially described by Michael Faraday in 1893. However the actual utilization of this concept remained unthinkable. The first known attempt to develop an MHD generator was made at Westing house research laboratory (USA) around 1938. The first MHD-steam power plant U-25 was put into operation was of 75MW unit in USSR of which 25MW is generated by MHD means in early 1970’s & this work has been progressing fruitfully. The first pilot plant was set up in Tiruchirapalli (by BARC). A five year plan was signed in February 1975 which included 22 spheres of applied science and technology connected with the MHD energy generation. The Japanese program in the late 1980s concentrated on closed-cycle MHD. In 1986, Professor Hugo Karl Messerle at The University of Sydney researched coal-fueled MHD. The Italian program began in 1989 with a budget of about 20 million $US, and had three main development areas:

- MHD Modeling.
- Superconducting magnet development.

Over more than a ten-year span, Bosnian engineers in Bosnia, in the Institute of Thermal and Nuclear Technology (ITEN), Energoinvest Co., Sarajevo, had built the first experimental Magneto-Hydrodynamic facility power generator in 1989. It was here it was first patented.

In the 1980s, the U.S. Department of Energy began a vigorous multiyear program, culminating in a 1992 50MW demonstration coal combustor at the Component Development and Integration Facility (CDIF) in Butte, Montana. This program also had significant work at the Coal-Fired-In-Flow-Facility (CFIFF) at University of Tennessee Space Institute.

This program combined four parts:

1. An integrated MHD topping cycle, with channel, electrodes and current control units developed by AVCO, later known as Textron Defence of Boston. This system was a Hall Effect duct generator heated by pulverized coal, with a potassium ionisation seed. AVCO had developed the famous Mk. V generator, and had significant experience.

2. An integrated bottoming cycle, developed at the CDIF.

3. A facility to regenerate the ionization seed was developed by TRW. Potassium carbonate is separated from the sulphate in the fly ash from the scrubbers. The carbonate is removed, to regain the potassium.

4. A method to integrate MHD into preexisting coal plants. The Department of Energy commissioned two studies. Westinghouse Electric performed a study based on the Scholtz Plant of Gulf Power in Sneads, Florida. The MHD Development Corporation also produced a study based on the J.E. Corrette Plant of the Montana Power Company of Billings, Montana.

Initial prototypes at the CDIF were operated for short durations, with various coals: Montana Rosebud, and a high-sulphur corrosive coal, Illinois No. 6. A great deal of engineering, chemistry and material science was completed. After final components were developed, operational testing completed with 4,000 hours of continuous operation, 2,000 on Montana Rosebud, 2,000 on Illinois No. 6. The testing ended in 1993.

The Japanese program in the late 1980s concentrated on closed-cycle MHD. The belief was that it would have higher efficiencies, and smaller equipment, especially in the clean, small, economical plant capacities near 100 megawatts (electrical) which are suited to Japanese conditions. Open-cycle coal-powered plants are generally thought to become economical above 200 megawatts.

The first major series of experiments was FUJI-1, a blow-down system powered from a shock tube at the Tokyo Institute of Technology. These experiments extracted up to 30.2% of enthalpy, and achieved power densities near 100 megawatts per cubic meter. This facility was funded by Tokyo Electric Power, other Japanese utilities, and the Department of Education. Some authorities believe this system was a disc generator with a helium and argon carrier gas and potassium ionization seed.

In 1994, there were detailed plans for FUJI-2, a 5MW (electrical) continuous closed-cycle facility, powered by natural gas, to be built using the experience of FUJI-1. The basic MHD design was to be a system with inert gases using a disk generator. The aim was an enthalpy extraction of 30% and an MHD thermal efficiency of 60%. FUJI-2 was to be followed by a retrofit to a 300 MWe natural gas plant.

CHAPTER THREE

WORKING PRINCIPLE

FARADAY’S LAW OF ELECTROMAGNETIC INDUCTION.

Electromagnetic induction is the production of a potential difference (voltage) across a conductor when it is exposed to a varying magnetic field. Faraday's law of induction is a basic law of electromagnetism predicting how a magnetic field will interact with an electric circuit to produce an electromotive force (EMF). It is the fundamental operating principle of transformers, inductors, and many types of electrical motors, generators and solenoids.

FLEMING’S RIGHT HAND RULE

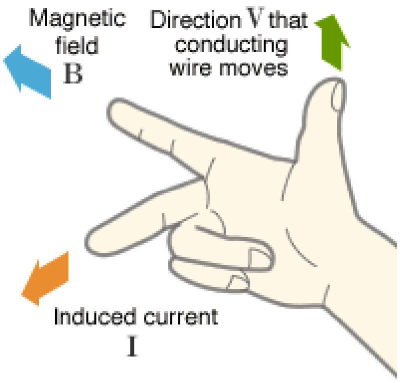

Figure 1: Fleming's Right Hand Rule

Fleming's right hand rule (for generators) shows the direction of induced current when a conductor moves in a magnetic field. The right hand is held with the thumb, first finger and second finger mutually perpendicular to each other (at right angles), as shown in the diagram.The thumb represents the direction of motion of the conductor. The first finger represents the direction of the field (North to South). The second finger represents the direction of the induced or generated current (the direction of the induced current will be the direction of conventional current; from positive to negative).

MAGNETO HYDRO DYNAMIC (MHD) POWER GENERATION

MHD portraits the study of the interaction of magnetic fields and electrically conducting liquids or gases, such as molten metal or plasma. According to Faraday's law of electromagnetic induction, when an electric conductor moves across a magnetic field, a voltage is induced in it which produces an electric current. In MHD generator, the solid conductors are replaced by a gaseous conductor, to be specific, an ionized gas. A suitable seed is used to ionize the gas. When this ionized gaseous conductor is moved so as to cut the lines of magnetic induction, the charged particles in the conductor experience a force in a direction mutually perpendicular to the magnetic field (B) and to the velocity of the conductor (V). The negative charges tend to move in one direction, and the positive charges in the opposite direction. This induced electric field, or motional EMF, provides the basis for converting mechanical energy into electrical energy. The EMF is perpendicular to both V and B according to the Fleming's Right hand rule. From the relation above it is evident that large EMF is induced, if the applied magnetic flux density, charge density and gas velocity are high.

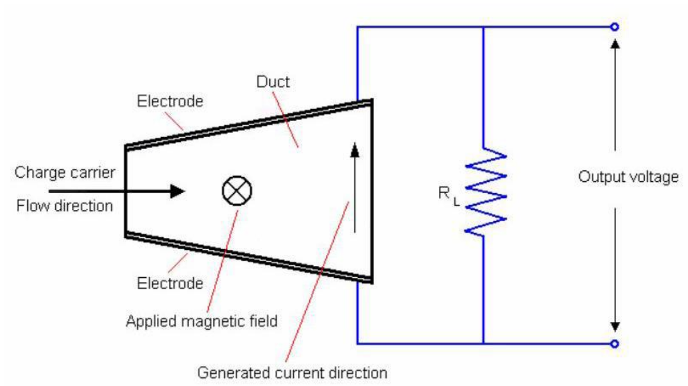

Figure 2: Method of Power Generation

The underlying principle of MHD power generation is elegantly simple. Typically, an electrically conducting gas is produced at high pressure by combustion of a fossil fuel. The gas is then directed through a magnetic field, resulting due to the Hall Effect. The MHD system constitutes a heat engine, involving an expansion of the gas from high to low pressure in a manner similar to that employed in a conventional gas turbo generator. In the turbo generator, the gas interacts with blade surfaces to drive the turbine and the attached electric generator. In the MHD system, the kinetic energy of the gas is converted directly to electric energy as it is allowed to expand. It is known, that if we have a current flowing in a conductor immersed in a magnetic field, in the same conductor will be generated a Lorentz force that is perpendicular to the direction of the magnetic field and to the current. The induced emf(E) is given by

$E_i = u \cdot B \cdot d$

Where u is the velocity of ionized gas and B is the strength of magnetic field intensity. The induced current density is given by

$I_i = \sigma \cdot E$ where σ is the electrical conductivity of gas.

The retarding force on the conductor is the Lorentz force given by

$F_i = I \cdot B$

In an MHD converter the electrical conductor is replaced by a plasma current at high speed and with high temperature to be partially ionized. So, the current flow is not only made of electrically neutral molecules but also with a mix of positive ions and electrons. When a high velocity gas flows into convergent-divergent duct and passes through the magnetic field an e.m.f is induced, mutual perpendicular to the magnetic field direction and to the direction of the gas flow. Electrodes in opposite side walls of the MHD flow channel provide an interface to an external circuit. Electrons pass from the fluid at one wall to an electrode, to an external load, to the electrode on the opposite wall, and then back to the fluid, completing a circuit. Thus the MHD channel flow is a direct current source that can be applied directly to an external load or can be linked with a power conditioning converter to produce alternating current. The electric energy produced is proportional to the reduction of kinetic energy and enthalpy of the fluid current. MHD effects can be produced with electrons in metallic liquids such as mercury and sodium or in hot gases containing ions and free electrons. In both cases, the electrons are highly mobile and move readily among the atoms and ions while local net charge neutrality is maintained. Any small volume of the fluid contains the same total positive charges in the ions and negative charges, because any charge imbalance would produce large electrostatic forces to restore the balance. Most theoretical and experimental work and power plant development and application studies have focused on high-temperature ionized gas as the working fluid. Unfortunately, most common gases do not ionize significantly at temperatures obtainable with fossil fuel chemical reactions. This makes it necessary to seed the hot gasses with small amounts of ionizable materials such as alkali metals. Materials such as cesium and potassium have ionization potentials low enough that they ionize at temperatures obtainable with combustion reaction in air. Recovery and reuse of seed materials from the MHD channel exhaust are usually considered necessary from both economic and pollution standpoints. Interest in MHD power generation was originally stimulated by the observation that the interaction of a plasma with a magnetic field could occur at much higher temperatures than were possible in a rotating mechanical turbine. The limiting performance from the point of view of efficiency of a heat engine is limited by the Carnot cycle. A system employing an MHD generator offers the potential of an ultimate efficiency in the range of 60 to 65%. This is much better than the 35 to 40% efficiency that can be achieved in a modern conventional thermal power station. The power output of an MHD generator for each cubic metre of its channel volume is proportional to the product of the gas conductivity, the square of the gas velocity, and the square of the strength of the magnetic field through which the gas passes. For MHD generators to operate competitively with good performance and reasonable physical dimensions, the electrical conductivity of the plasma must be in a temperature range above about 1800K.Apart of the MHD power generator, other apparatus are necessary to form the overall MHD system. It is necessary to burn the fuel and the oxidizer, to add the seed, and to make arrangements for exporting the generated electrical power. The fuel is usually fossil and the oxidizer is air, for obvious economic reasons. For large systems, some precautions should be taken to limit the amount of losses. The air may be enriched with more oxygen, and preheating of the incoming oxidizer becomes necessary to allow thermal ionization. In practice a number of issues must be considered in the implementation of a MHD generator: Generator efficiency, Economics, and Toxic products.

FARADAY GENERATOR

A simple Faraday generator would consist of a wedge-shaped pipe or tube of some non-conductive material. When an electrically conductive fluid flows through the tube, in the presence of a significant perpendicular magnetic field, a charge is induced in the field, which can be drawn off as electrical power by placing the electrodes on the sides at 90 degree angles to the magnetic field. The main practical problem of a Faraday generator is that differential voltages and currents in the fluid short through the electrodes on the sides of the duct.

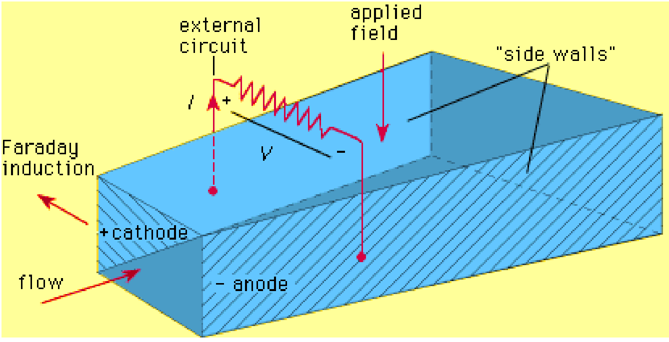

Figure 3: Faraday Generator

SIMPLIFIED ANALYSIS OF MHD GENERATOR

The following assumptions are made in the analysis of the MHD generator.

1. Working gas is an ideal gas

2. Gas flowing at constant velocity and pressure

3. Magnetic flux generated remains constant

4. No heat transfer to the surroundings

5. Gas flow is uniform

When the high velocity ionized gas flows through the magnetic field, the induced EMF tries to slow down the motion of the gas as it acts in the opposite direction. The duct is made diverging as the gas velocity decreases along the flow direction. The electrical energy is extracted from the thermal energy of the gases keeping axial velocity constant. The electrical energy is produced when the conductive gas cuts the magnetic lines of force. The gas is accelerated to restore its velocity with decrease of temperature and axial velocity held constant, large power is developed if the applied magnetic flux density and gas velocity are high. The Lorentz force induced on electrons acts in the direction of retarding the gas flow. The direction of Lorentz force is opposite to the velocity of conducting gas.

For open circuit,

$E=v.B.d$

If Rg is internal resistance and R_L is the load resistance and I is the flowing current, then

$I= E/ (Rg+R_L)$

W (power output from MHD generator)

$E\times I=I^2\times Rg = (E/Rg+R_L)^2\times Rg$

The condition for maximum power,

$Rg=R_L$, $W_{max}= E^2/4Rg= (v.B.d)^2/4Rg$

But $Rg= d/ (\sigma\times A)$ where σ is gas conductivity (mho/m) and A is electrode surface area (m^2)

$Wmax= [v^2.B^2.d^2/4\sigma]*(\sigma\times A)$

$= [v^2.B^2.\sigma/4] \times (A.\delta)$

Where (A.δ) becomes the volume of MHD generator.

This shows that W_{max} is proportional to the square of magnetic flux; therefore it needs strong magnetic field to make the generator compact.

Conversion efficiency of MHD (μ),

$\mu= E_{max}/u.B.d$

$Vmax=u.B.\delta-I\delta\sigma.A$

$I= Vo/(Rg+RL)= UB\delta/2Rg= u.B.A.\sigma/2$

$\mu=d(1-(d/2\sigma))$

CHAPTER FOUR

DESIGN CALCULATION

First we needed to get the main parameters of the apparatus to measure the emf generated from the bike exhaust. For that we needed the three critical parameters, the strength of magnet required and the area of the electrodes and the distance between the electrodes.

A diverging duct of inlet area 3*3 cm and outlet 10.5*10.5 was fabricated.

We are using a Hero Honda CD 100 4 cylinder engine in this project. The specifications are

Bore=5cm

Stroke=4.95cm

N (rpm) =8000(at max power)

VE (Volumetric efficiency) was taken to be 0.95

We needed to theoretically calculate the velocity of the exhaust gas at outlet

We used the following equations:

The total volume of the cylinders was 100*4=400cc

Then volume exhausted per second Q=400*N*VE

$$= (400\times8000\times0.95)/60=50667cc/s$$

We have Q=Av

The area of part of the duct where magnet is to be placed=8.2×8.2 sq cm

v=Q/A=50667/ (8.2×8.2) =7.46 m/s

Let v be the velocity of flow after entering into the magnetic field

Now we assume that we get a power of 1 W and induce a volt 0f 0.2 V

W=EI

Therefore $I=1/0.2=5$ A

Assume that is magnet is located at 8.2 cm from the inlet

Now consider section where magnet is to be located, on side towards the inlet with no magnetic flux and other side exposed to magnetic flux

Applying the conservation of energy, change in kinetic energy=electrical energy

$\frac{1}{2} m (v^2-u^2) = EI$

$\frac{1}{2}\times0.05\times1.3(7.46^2- u^2)=0.2\times5$

$u=5$ m/s, in the magnetic field

Now we have the formula for induced emf

E=vBd, where

v=velocity of exhaust gas

B=magnetic field strength

d=distance between the electrodes

Now we have $E=0.2$ V, $v=5$m/s substituting we have,

$0.2=5\times B\times d$

$B*d=0.04$

Now we have the constraint that $d<0.105$m

$0.04/B<0.105$

$B>0.38$

Now based on the available magnets in the market and their strengths, the most suitable was the pair of magnet having B=0.4 as the best option.

$d=0.04/0.4=10$cm

So we got both the magnetic field strength and the distance between the magnets,

Since we are using aluminium oxide, its electrical conductivity=4000 S/m

Power $W= [v^2.B^2.\sigma/4] \times (A^*.d)$

$1= [5^2\times0.4\times0.4\times4000]/4\times(A^*\times0.1)$

$A^*=0.0024\ m^2=0.06m\times0.04m$

So an electrode of 6 cm×4 cm should be used to get the required power.

Fom the above design calculation we get the following parameters,

Magnetic field B=0.4 T, so two neodymium magnets each of 0.2 T is selected

Distance between the electrodes d=10 cm

Area of electrode A*=6 cm×4 cm

Efficiency= $\mu=d(1-(d/2\sigma)=0.1(1-(0.1/8000)=11\%$

CHAPTER FIVE

ANSYS SIMULATION AND ANALYSIS

Simulation in a circular MHD duct was conducted using ANSYS FLUENT and MHD module was loaded to the software and the diameter of the duct was given to be 8.2 cm. Then the input parameters including inlet velocity, magnetic field, electrical conductivity obtained from the design calculation were given. The magnetic induction method was used ignoring Joule dissipation .The energy equation was enabled. Scale factor was given 1.The calculation was done for the entire duct.The data was analyzed in the cross sectional plane where the magnet is located which is at x=0.43m then the calculation was done in two conditions

- Magnetic field B=0 T
- Magnetic field B=0.4 T

From the contour graphic below, we can conclude that velocity decreases in the magnetic field region. This is because of the conversion of kinetic energy to electrical energy. From the design earlier we obtained the values of velocity with and without the application of magnetic field. The values obtained earlier were in the range of the below result. This is a validation of the design earlier used. The errors may be attributed to energy losses.

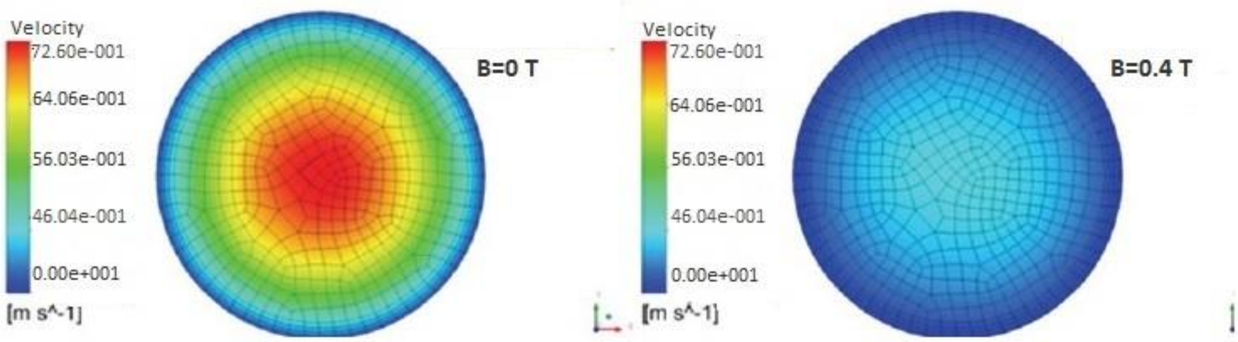

Figure 4: Velocity Contour

CHAPTER SIX

JET ENGINE MHD DESIGN

In aircrafts like boing need a large amount of electricity to run their navigation equipments, electrical equipments, air conditioning systems and other control equipments. As per the statistical data provided by the Aviation industry in an average about 1-3 MW of electrical energy is needed for each passenger aircrafts. To produce this much power alternators are directly coupled with the turbines of jet engine. The disadvantage of this method is that large frictional force reduces turbine efficiency, and also the weight of the alternator is too high which reduces the payload capacity of the aircraft. Since the size of the alternator is large it reduces the utilization space of the aircraft.

Under this circumstances we can use MHD generator to produce this much power. In this chapter we are trying to find out the magnetic field, electrical conductivity of the seeding material and other technical parameter required to create the desired MHD generator. We are designing MHD generator for Boeing 787 an aircraft commonly used by Air India.

JET ENGINE WORKING PRINCIPLE

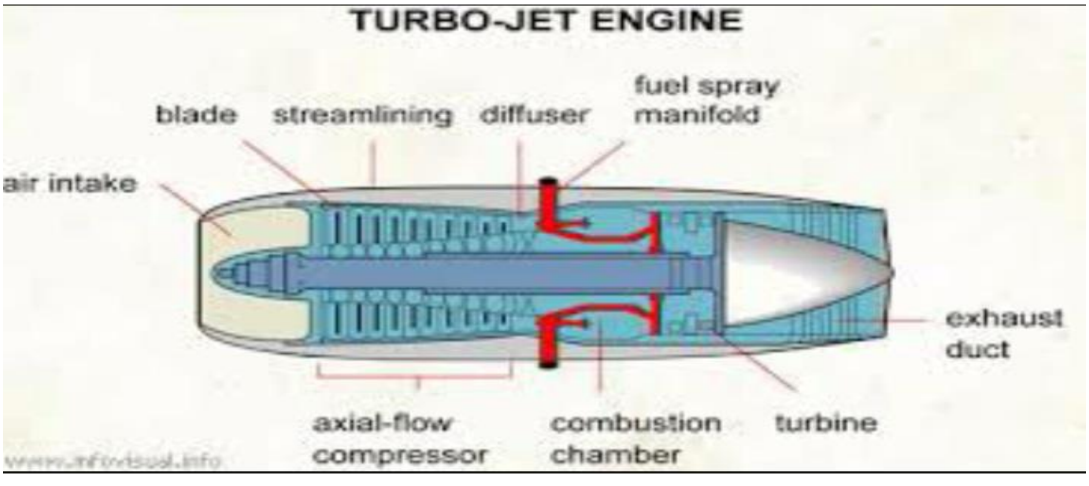

Figure 5: Jet Engine Principle

SPECIFICATIONS OF BOEING 787

Electrical energy needed: 1.45 MW

Voltage: 2 kV direct current

Current: 725A

Usually operating altitude: 43100ft

Engine specifications

Used two ROLLS ROYCE TRENT 1000 jet engine

Thrust: 2059kN

Air mass flow rate (m): 1290 kg/s

Exhaust gas pressure (pe): 720 kPa

Exhaust temperature: 860oC

Exhaust diameter (d): 63 inches

Now we need to find out the exhaust gas velocity (v), for that we can use engine thrust equation

Thrust = mass flow rate * velocity + (exit pressure – atmospheric pressure)*exhaust area

Exhaust area = 3.14*d2/4

= 3.14*1.62/4 = 2.011 m2

We need to consider the altitude of the aircraft to find the atmospheric pressure

Ie; the pressure at 43100ft which is about 16157.86 Pa

Therefore thrust,

2059000 = 1290*v + (720000-16157.86)*2.011

From this, velocity at the exhaust, v = 498.89 m/s

So in MHD actually change in kinetic energy (KE) is converted to electricity

Therefore change in KE = ½ m (v2-u2) = ½*1290* (498.892 – u2) = 1.45*106 W

From this, velocity of the exhaust in the magnetic field area (u) is equal to 496 m/s

Now we have the formula for induced emf

$E=vBd$, where

v=velocity of exhaust gas

B=magnetic field strength

d=distance between the electrodes

Now we have E=2kV, v=496m/s substituting we have,

$2000 = 496 \times B \times d$

$B*d=4.03$

Now we have the constraint that $d<1m$

$4.03/B<1$

$B>4.03$

Now based on the available magnets in the market and their strengths, the most suitable was the pair of magnet having B=5 T as the best option.

$d=4.03/5=80cm$

So we got both the magnetic field strength and the distance between the magnets,

Since we are using potassium carbonate because of its high electrical conductivity=16000 S/m

From earlier analysis, it has been determined efficiency of MHD SYSTEM

$\mu=d(1-(d/2\sigma)=0.8(1-(0.8/32000))=80\%$

So a jet engine has a high efficiency while used for MHD generation.

CHAPTER SEVEN

FABRICATION

The major components involved in the design and the fabrication of the MHD generator for two wheelers are as follows.

- Exhaust Duct
- Magnets
- Copper Electrodes
- Engine
- Silencer
- Frame
- Aluminum Oxide Powder
- Circuit Board
- Ball Valve

EXHAUST DUCT

Exhaust duct contains the hot exhaust gas from the silencer. It is made up of mild steel sheet. The duct has a diverging shape where area goes on increasing. Exhaust duct has an area of 3*3 cm^2 in inlet and 10.5*10.5 cm^2 in exit.

NEODYMIUM MAGNET (0.2T)

A neodymium magnet (also known as NdFeB, NIB or Neo magnet), the most widely used type of rare-earth magnet, is a permanent magnet made from an alloy of neodymium, iron and boron to form the Nd2Fe14B tetragonal crystalline structure. Here we use two Neodymium magnets, each of .2 Tesla.

COPPER ELECTRODES

The copper–copper(II) sulfate electrode is a reference electrode of the first kind, based on the redox reaction with participation of the metal (copper) and its salt, copper(II) sulfate. It is used for measuring electrode potential and is the most commonly used reference electrode for testing cathodic protection corrosion control systems.

ENGINE

In our project we use a sample engine from Hero Honda CD 100 4 cylinder Engine. A four-stroke cycle engine is an internal combustion engine that utilizes four distinct piston strokes (intake, compression, power, and exhaust) to complete one operating cycle. The piston makes two complete passes in the cylinder to complete one operating cycle. An operating cycle requires two revolutions (720°) of the crankshaft. The four-stroke cycle engine is the most common type of small engine. A silencer is connected between the exhaust of the engine and the exhaust duct.

FRAME

This is made of mild steel material. The whole parts are mounted on this frame structure with suitable arrangement. Boring of bearing sizes and open bores done in one setting so as to align the bearings properly while assembling. Provisions are made to cover the bearings with grease.

CIRCUIT BOARD

Circuit board is used to take the current produced in the electrode to a voltmeter. The reading in voltmeter is amplified using an amplifier. The current is used to charge a battery.

BALL VALVE

One-way valve that is opened and closed by pressure on a ball which fits into a cup-shaped opening. Used to regulate the amount of aluminum oxide into the duct.

FABRICATION PROCESS OF MHD POWER GENERATOR

The model was designed for Hero Honda Passion Plus having exhaust pipe diameter of 27 mm. Structural steel was used for the construction of the generator body. The engine was fixed on the frame by using screws and nuts. Fuel was supplied with help of a small fuel reservoir. An accelerating mechanism was also attached to the engine. The duct forms an integral part of the MHD generator. The duct was made by mild steel sheets. It has a tapered cross section area. The sheets were joined together by welding. The duct was welded to the silencer of the bike engine. 3 holes of 1 cm diameter were made by drilling. One for attaching the ball valve and the other two for placing nylon bush over the electrodes so that they are not in touch with the body of the duct. Magnets where placed on the duct at suitable places obtained from the design calculation. The electrodes were placed in perpendicular direction to the magnets. Metallic plates are placed in such a way that the EMF induced on the plates would be mutually perpendicular to the ionized gas velocity. The magnetic field Magnets used is neodymium magnets each of 0.2 T and the metallic plates are made of copper. Magnets are placed parallel to each other such that the magnetic flux gets doubled. The duct was then coated with metal paste on the welded portions to avoid the leakage of hot gases. The length of the MHD channel is 0.5m. The generator has a tapered cross-section. The height and width of the outside tapered portion through which the exhaust gas comes out are 105 mm and 110 mm respectively. The ball valve through which ionized seed is added has an inlet diameter of 10 mm. Through the ball valve we add the aluminium oxide for ionizing the hot gas. From the figure, it is pretty much clear that the magnetic field acts in a perpendicular direction towards the direction of ionized gas velocity. The electricity produced in the electrodes is taken by a circuit to charge a battery. The voltage produced was measured by a digital displayed voltmeter.

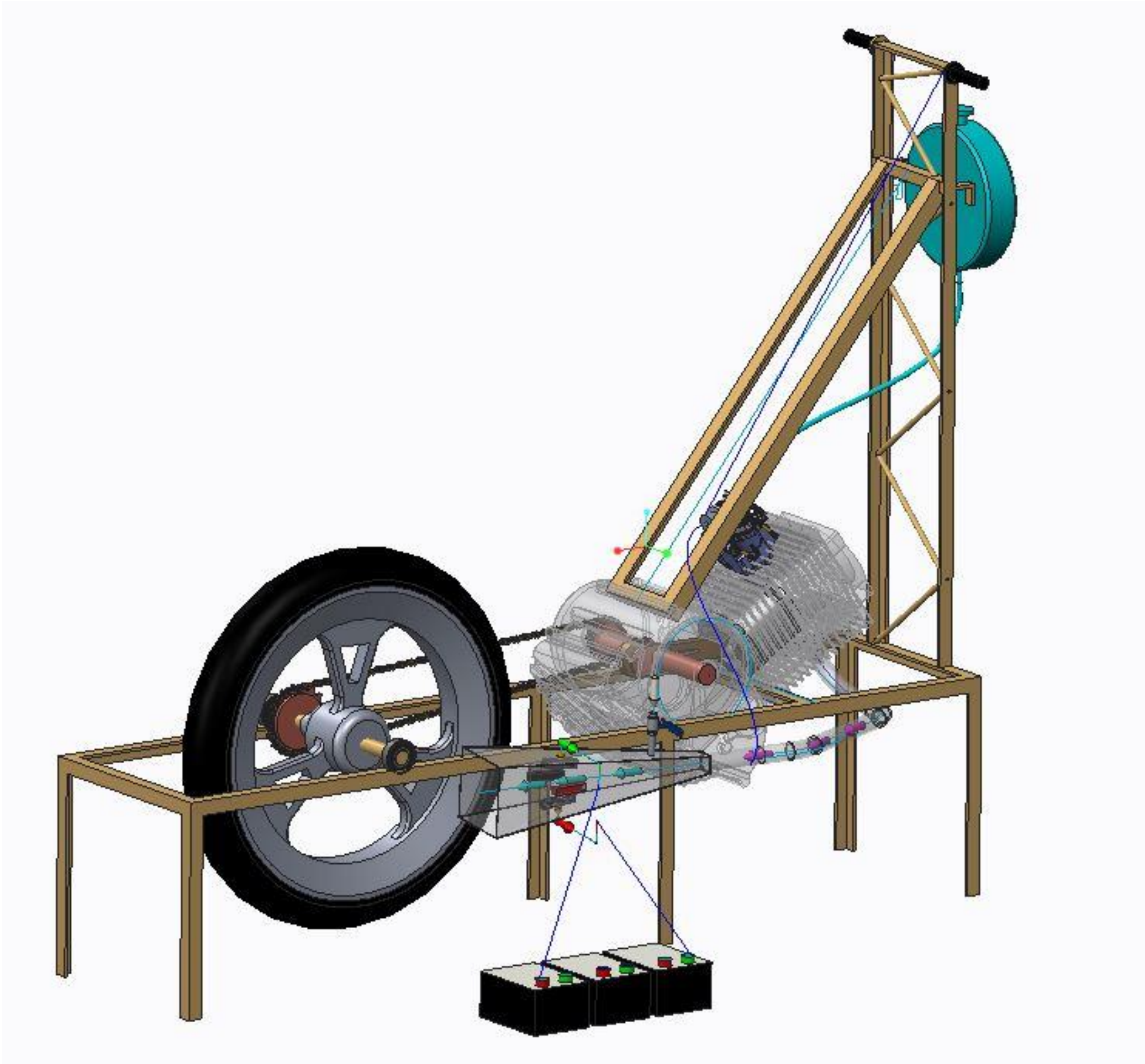

Figure 6: MHD Power Generation in the Exhaust of Engine

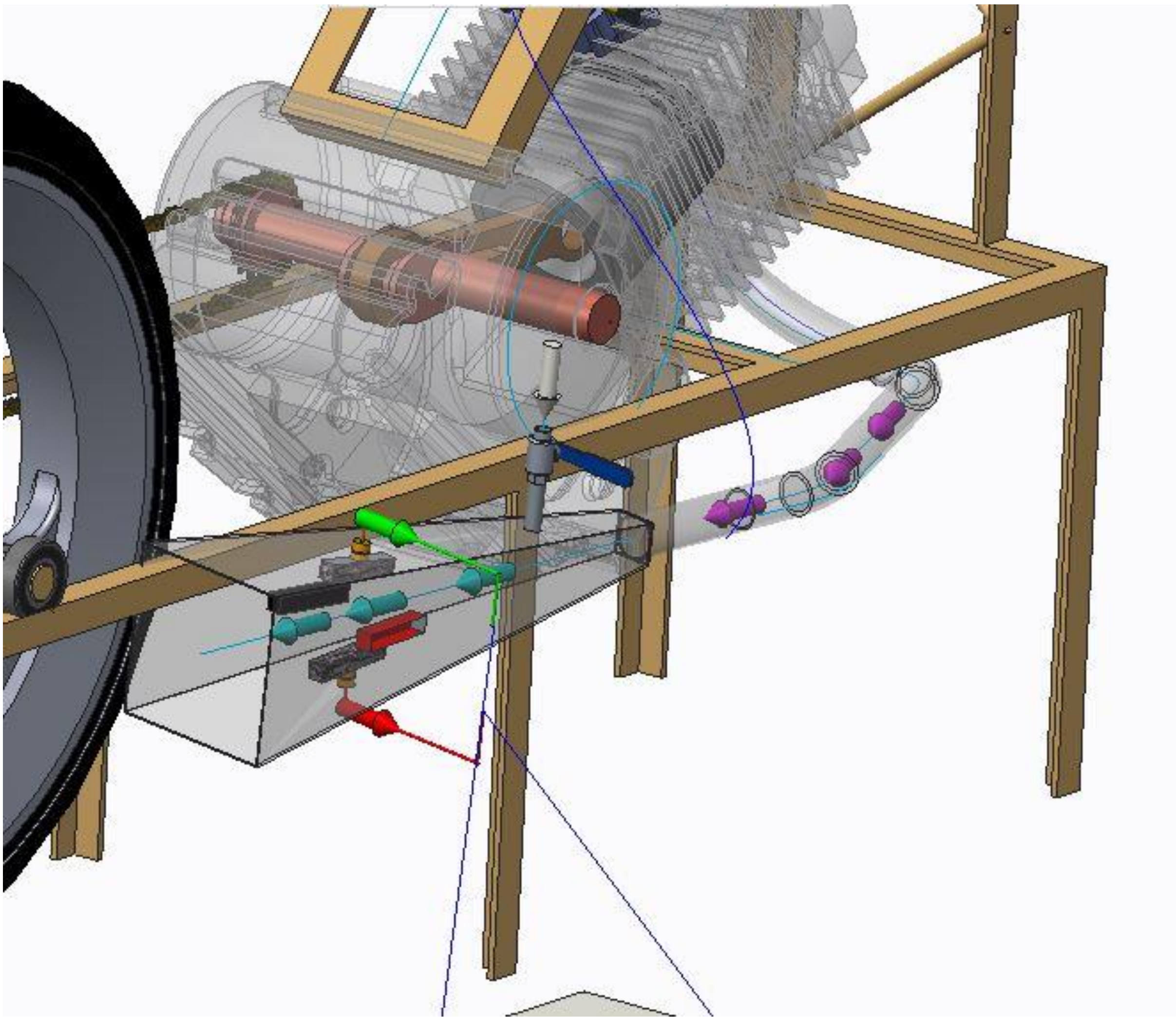

Figure 7: Movement of Exhaust Gas

Figure 8: Fabricated model

CHAPTER EIGHT

ADVANTAGES AND DISADVANTAGES

ADVANTAGES

- Conventional coal-fired generators achieve a maximum efficiency of about 35%. MHD generators have the potential to reach 50% - 60% efficiency.
- The higher efficiency is due to recycling the energy from the hot plasma gas to standard steam turbines. After the plasma gas passes through the MHD generator, it is still hot enough to boil water to drive steam turbines that produce additional power.MHD generators are also ecologically sound.
- Coal with high sulphur content can be used in the MHD without polluting the atmosphere. Although the cost cannot be predicted very accurately, yet it has been reported that capital costs of MHD plants will be competitive to conventional steam plants.
- It has been estimated that the overall operational costs in a plant would be about 20% less than conventional steam plants.
- Direct conversion of heat into electricity permits to eliminate the turbine (compared with a gas turbine power plant) or both the boiler and the turbine (compared with a steam power plant) elimination reduce losses of energy.
- These systems permit better fuel utilization. The reduced fuel consumption would offer additional economic and special benefits and would also lead to conservation of energy resources.
- It is possible to use MHD for peak power generations and emergency service. It has been estimated that MHD equipment for such duties is simpler, has capability of generating in large units and has the ability to make rapid start to full load

DISADVANTAGES

- Initial cost is high
- Intensity of electric power is proportional to high velocity ionized gas, strength of magnetic field, amount of seed ionized
- Only partial ionization takes place at lower temperatures (in case of a two wheeler). Greater voltage output can be obtained when the exhaust gas temperature for ionizing the seed is high (in case of a four wheeler where temperature ranges about 600-1200℃).
- It makes the noise while ionizing

CHAPTER NINE

FUTURE RECOMMENDATIONS

Increasing the power of magnetic field by using strong magnets such as neodymium magnets, can increase the output voltage to a large extent.

Velocity of ionized gas can be increased by using highly efficient nozzles, since induced voltage has a linear dependence towards the ionized gas velocity. Suitable arrangements can be made for trapping seed ions such as cooling ion traps, scrubbers etc. and techniques could be adopted for re-using the seed.

Electromagnets instead of permanent magnets would be a better method of choice, as strength of magnetic field can be retained permanently using electromagnets.

Selection of materials for construction of generator walls must be such that it must be corrosion free.

CHAPTER TEN

CONCLUSION

Generation of electric power from automobile exhaust with ionization method has been realized. Maximum induced voltage of 0.2V was obtained and amplified and shown as 7 V in in the display board. Only partial ionization takes place at lower temperatures (in case of a two wheeler). Greater voltage output can be obtained when the exhaust gas temperature for ionizing the seed is high (in case of a four wheeler where temperature ranges about 600-1200^{o}C).The use of a jet engine increases the conversion of otherwise waste exhaust heat into useful electrical energy.ANSYS FLUENT validated our design analysis.

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