

# Radial Magnetic Prime-Mover

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**Abstract:** *The Radial Magnetic prime-mover is the mechanism which is designed to use for the power and speed magnification using property of permanent magnet and the suitable arrangement of magnets over the radial piston cylinder arrangement. This mechanism uses the magnetic flux density for its operation. The phenomenon of repulsion between two magnets creates the motion of piston in the mechanism. There is the outer repulsive ring, having permanent magnets attached to it in specific manner, rotates over the radial five piston cylinder mechanism powering all the piston in specific manner so as to magnify the speed six times. One revolution of outer repulsive ring makes the six revolution of output shaft. Due to use of strong permanent magnets over piston and ring, there is also torque magnification. The project includes the CAD design of this mechanism, unique design of outer ring for particular odd number of cylinder, stimulation of mechanism and prototyping. The outer repulsive ring can be operated manually or can be powered by dc motor, water energy or by any other means like belt. It can be used as electricity generator, for power magnification in water turbine and transmission system.*

**Keywords:** Permanent magnet, repulsive ring, piston, cylinder, radial magnetic mechanism, water turbine, power transmission, speed magnification, high speed ratio, rotating magnets, magnetic engine.

## 1. Introduction

Shortage of fossil fuels, the associated costs, noise, low efficiency and pollution effects are some major demerits of IC engine operated electricity generator. So, it is inevitable to use the other alternative energy resources such as Renewable energy, Green energy, stored energy that can reduce the pollution drastically. Solar panels have low efficiency and small home generator have noise and pollution problems.

With diminishing fossil fuel resources and unabated increase in energy costs and environmental concerns, engine using alternate energy sources such as bio fuel, solar power, wind power, electric power etc. are being developed around the world. However such engine has limitations. Production of bio-fuel takes enormous resources and they still pollute environment. They do not meet increasing energy demand as well. Similarly the solar power is not efficient. Here the new concept, "Radial Magnetic Prime-mover", is introduced which is having more efficiency for transmitting power and can replace IC engine generator. It's an mechanism works on principle of magnetic flux density. This provides an ecofriendly, very high efficiency mechanism.

Magnetism is the basic principle of working like radial engine with five piston cylinders. The pistons are having permanent magnet. The general property of the magnet i.e. attraction forces is converted into mechanical work. A magnet has two poles, a north pole and a south pole. When like poles are brought near each other they repel and attract when like poles brought together.

In this mechanism, all the five pistons are repelled by the outer repulsive ring. The mechanism should ideally perform exactly same as the radial IC ENGINE. The power of the engine is controlled by the rotating speed of outer repulsive ring. If the speed increases the power generated by the engine also increases accordingly. The repulsive ring can be attached to the motor that takes power from DC source like lead acid battery. It may attach to the solar panel for charging

battery when it is used for generator. In case of water turbine the pelton wheels can attached to the outer repulsive ring. And in case of power transmission belt can be attached to the repulsive ring.

The main advantage of this mechanism is pollution free, easy to design and economical. Further, due to the principle of its operation, it uses low power or small force to generate very high power or large force.

## 2. Working Principle

The working principle of magnetic radial engine is based on the principle of magnetism of permanent magnet. A magnet has two poles a north pole and a south pole. Magnetism is a class of physical phenomenon that includes forces exerted by magnets. By principle of magnetism, when like poles of magnet are brought together they repel and when unlike poles are brought near to each other they attract. The repulsive power of permanent magnet is used to power the pistons in radial engine. So the idea is to modify the piston head and cylinder head with some suitable attachment of magnets so that forces can be generated to power the piston and hence the engine. The permanent magnets are arranged in such a way that they repel the magnets attached to five pistons in specific order to give the uniform output power.

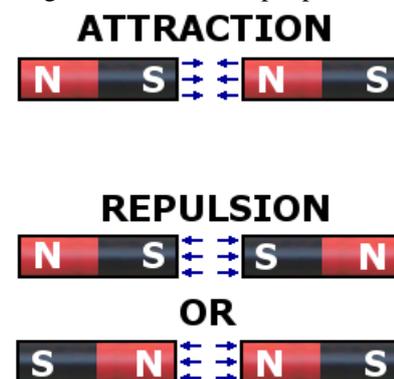
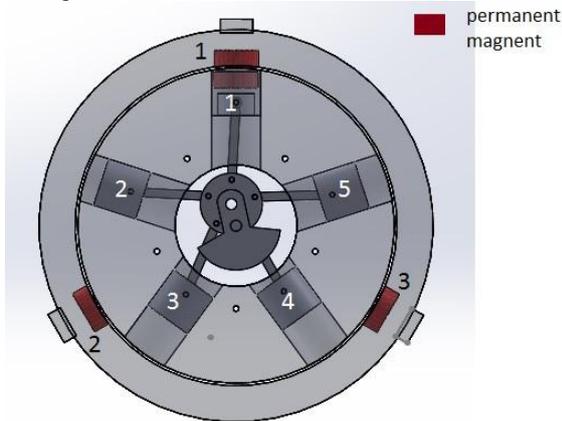


Figure 1: Property associated with magnets

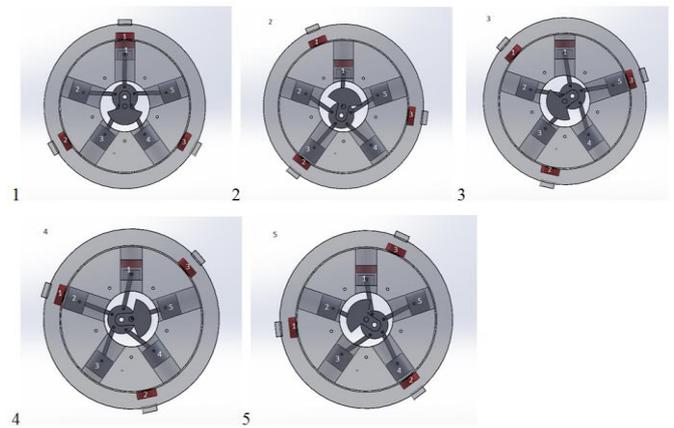
The engine greatly resembles the four stroke five cylinder radial IC engine as shown in fig 2. The Outer repulsive ring (ORR) is attached to the DC motor that is connected to battery. Battery may attach to a solar panel for recharging purpose. To start, let us begin from situation when piston 1 is at upper position i.e. top dead center (TDC). When piston 1 is at TDC the outer ring is in such a position that magnet1 is aligned with the magnet on piston1. As both magnets in piston and ring are of same polarity, a repulsive force is exerted by ring on piston causing the piston to move downwards. This movement of piston1 causes a crank rotation of 144 degrees. At same instant piston3 reaches TDC and magnet2 attached to ring faces the piston3. Piston3 gets repelled by magnet2. After 144 degree revolution of crankshaft piston5 reaches TDC and magnet3 attached to ring faces piston5. Piston5 get repel by magnet3 and go down to bottom dead center (BDC). Then piston2 and piston4 also get repelled by magnet1 and magnet2 respectively. This one cycle rotates the repulsive ring in 120 degree and crankshaft gets rotated through 720 degree (i.e. two revolutions) as shown in fig 3.



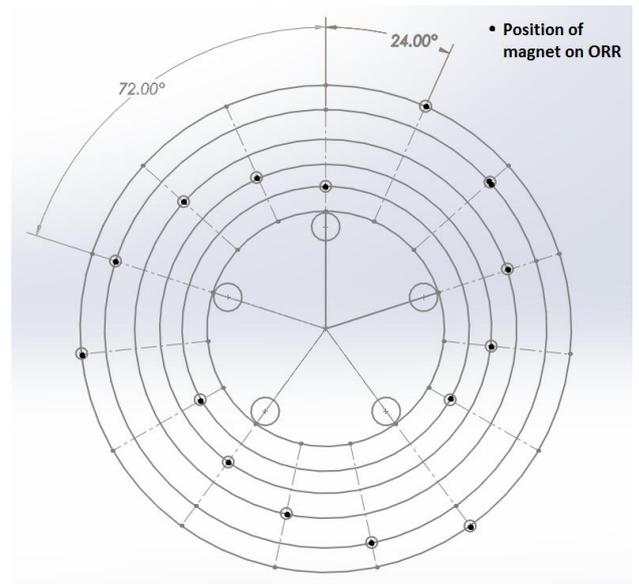
**Figure 2:** View of RMP. 3 magnets on outer repulsive ring and 5 magnets on 5 piston head

When repulsive ring completes its 1/3<sup>rd</sup> revolution all five pistons make their four strokes. At this time, crank-shaft completed its two revolutions. Now next situation comes when (ORR have completed 120 degree revolutions) magnet3 is on the surface of piston1 same cycle repeats (again two revolution of crankshaft) until magnet2 reaches piston1. When piston2 starts moving same cycle makes two revolutions of crank shaft. At the end magnet1 comes to its original position and at this instant crank shaft have been completed the six revolutions. **one revolution of repulsive plate produces six revolution of crankshaft**

The permanent magnets are attached to repulsive ring in such a way that it repels the magnet attached to five pistons in the **order 13524** same as that in the Radial IC engine. The speed and force exerted on piston by outer ring magnets is directly proportional to speed at which ring revolves. The output torque also depends on size of magnet used. Speed of outer ring is controlled by CRO for testing the maximum efficiency. We come to know that the magnetic field produced is inversely proportional to the time required to complete revolution by outer ring.



**Figure 3:** Five position at the time of repulsion in one revolution

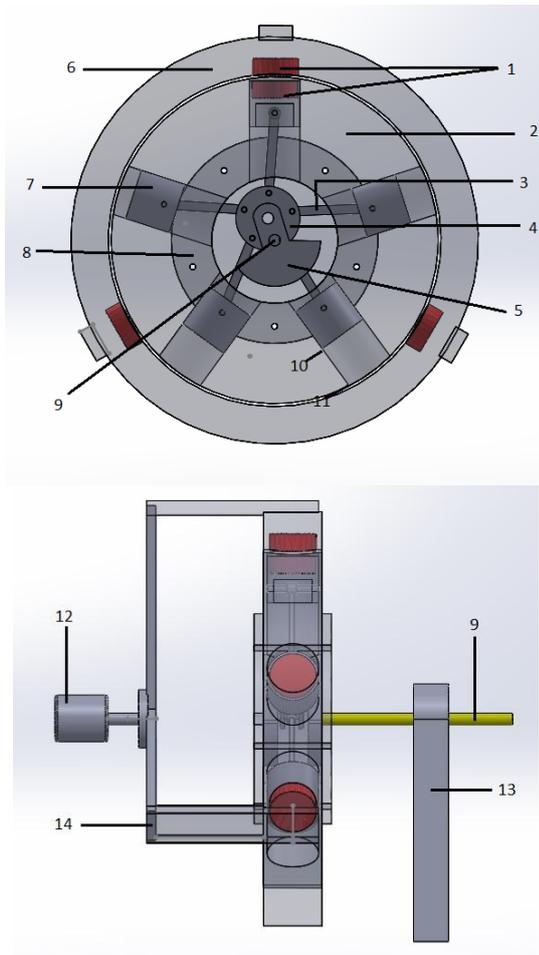


**Figure 4:** Schematic diagram of position of magnet on ORR

In fig 4 every circle denotes the position of magnet on ORR after every successive 24 degree rotation of ORR. This mechanism behaves like a four stroke radial IC engine. After 120 degree revolution of ORR all five piston have reciprocated from TDC to BDC hence making the two revolution of crankshaft (o/p shaft). So here 360 revolution of ORR makes the 6 revolution of output shaft.

### 3. Component Design

All the components of radial magnetic prime-mover is designed and assembled in the Solidworks 2014 software. Motion study of the whole mechanism is also done in the same software. The results of it are same as per theoretical assumptions.



**Figure 5:** front and side view of RMP

**Table 1:** Components in RMP

No.	Description
1	Neodymium Permanent Magnet
2	Five Cylinder Casing
3	Connecting Rod
4	Connecting Rod Hub
5	Crankshaft
6	Repulsive Ring
7	Piston
8	Shaft Bearing Plate
9	Output Shaft To Alternator
10	TDC
11	BDC
12	Motor
13	Bearing Support
14	Motor Linkage To Outer Ring

### 3.1 Cylinder

This mechanism uses five cylinders for operation arranged in same manner as like in radial engine. The cylinder must resist unwanted magnetic field and other losses. Further, cylinder material should not get attracted to the magnet. To take care this issues, the cylinder only made up of none magnetic material such as stainless steel, aluminum, titanium having high resistivity and low electrical conductivity. The temperature generated during the process is very low because of that no fins required for heat transfer. Because of that engine can easily manufacturable. Aluminum and non-magnetic material limits the magnetic field within the

boundaries of cylinder periphery. Usage of aluminum or plastic makes engine lighter.

### 3.2 Piston

The hollow piston casing is made up of aluminum of high resistivity and low electrical conductivity. One end of the hollow case is fitted with a powerful neodymium-iron-boron magnet having high field strength. The permanent magnet acts as core of the piston. The flat surface of the piston head completely exposed. The other end of the piston connected to connecting rod which connects to the crankshaft. The crankshaft and piston converts linear reciprocating motion of the piston to circular motion.

### 3.3 Connecting rod

In a reciprocating engine, the connecting rod is used to connect the piston to the crankshaft. It converts the linear motion or reciprocating motion of the piston to the circular motion of the crankshaft. The material of the connecting rod is cast iron. As the magnetic fields are contained inside the cylinder, the connecting rod will not be affected much. The connecting rod is same as that of an Internal Combustion engine.

### 3.4 Connecting rod hub

This is a circular part which is connected to the all five pistons through the five connecting rods. Hub is attached to the dead weight of crankshaft at point 20mm apart from shaft.

### 3.5 Permanent magnet

In this system, a permanent neodymium iron-boron magnet was adhered to the top surface of each piston. Hence the magnet travelled along with the piston with reciprocating motion. Three magnets are attached to the outer repulsive ring 120 degree apart. It is cylindrical in shape having 40mm diameter and 20mm thickness.

Magnetism is a phenomenon where a force arises between magnets and objects, creating a magnetic field around, which in turn may create a repulsive or attractive force. The fields indicate values of strength as well as in the directions they are acting. Magnets are dipoles in nature, i.e., one face possess a north pole, and the other south. Permanent magnet is an object made from material that is magnetized and creates its own persistent magnetic field. Main way the permanent magnet created is by heating ferromagnetic material to a key high temperature. The temperature is specific to each kind of metal, but has the effect of fixing and aligning the domains of the magnet in the permanent position. It is conjectured that this same process inside the earth is what creates natural permanent magnets. Ceramic, Alnico, Samarium, Cobalt, Neodymium Iron Boron, Injection molded and Flexible are the types of magnets.

### 3.6 Repulsive ring

The repulsive ring is one of the most important element in the magnetic radial engine, since this assists in repelling the like poles of the magnets. This ring rotates over the five cylinder casing. The permanent magnets are attached to repulsive ring in such a way that it repels the magnet attached to five pistons in specific order (13524). The material used for the construction of this ring is very critical. It must be made up of nonmagnetic material which should not be affected by the magnetic field produced by the magnets attached to pistons and the ring itself. Any material like stainless steel, aluminum etc. can be used. High density plastic is also a good option which reduced weight of assembly. In addition to proper selection of the materials, proper construction is also important. This repulsive ring is designed in such a way that it can slide on the five cylinder casing. (Repulsive ring is also designed for any odd number magnetic radial engine.)

## 4. Calculation

### Case 1

As shown in fig.5, a dc motor powered by solar panel is rotating the outer repulsive ring.

Input conditions for motor -

Voltage - 12V DC

Current - 6.5 A

RPM - 30

Torque - 2 Nm.

Input power = Voltage X Current

$$= 12 \times 6.5$$

$$= 78 \text{ W.}$$

Repulsive ring consist of three magnets

Specifications:

Magnet - neodymium magnet

Diameter (D) - 40mm

Radius (R) - 20mm

Thickness (T) - 20mm

Grade - N5014

Remance field (Br) - 1.42T

Z - distance between the magnet in ring and in the piston - 3mm

$$B = Br / 2 \times [ (T+Z) / ((R^2 + (T+Z)^2)^{0.5} - Z / (R^2 + Z^2)^{0.5}) ] \quad [7]$$

Substituting all the values

$$B = 0.4304 \text{ T.}$$

Force calculations

Pole strength (M)wb = B X area

$$= B \times \pi / 4 (R^2)$$

$$= 5.41 \times 10^{-4} \text{ wb}$$

Force of repulsion between two magnets

$$F = M_1 M_2 / \mu_0 Z^2$$

M1, M2 - pole strength of two magnets

$\mu_0$  = Permeability of medium =  $4\pi \times 10^{-7} \text{ Wb/A.m}$

Substituting values we get,

$$F = 258.57 \text{ N}$$

Crank length = 20mm

Torque = force X crank length

$$= 5.17 \text{ Nm.}$$

This is no load maximum torque.

There is no torque loss in the mechanism, though by considering minimum torque of 4Nm

Speed of motor is 30 rpm. Radial magnetic Prime-mover gives the speed ratio of 1:6. Therefore the speed of crankshaft (output shaft) of mechanism is 180rpm.

At 180 rpm,

Power =  $2 \pi NT / 60$

$$= 97.47 \text{ watt.}$$

Selection of motor for given specification of mechanism

Material of outer ring- ABS (Acrylonitrile Butadiene styrene)

Density -  $913 \text{ Kg/m}^3$ .

Volume used for ring -  $\pi (D^2 - d^2) l$

D = outer diameter of ring = 0.355m

d = inner diameter of ring = 0.29m

Substituting values,

$$\text{Volume} = 2.09 \times 10^{-3} \text{ m}^3.$$

Mass of ring = volume X density

$$= 1.91 \text{ Kg.}$$

Mass of one magnet = 150gm.

Mass of three magnets = 450gm.

Total mass (M) = 2.36Kg.

$$\text{Moment of inertia (I)} = 0.5 \times M \times (R^2 + r^2) = 0.248 \text{ Kg m}^2.$$

Angular velocity,

$$w_1 = 0$$

$$w_2 = (2 \pi N) / 60$$

$$= 20.9 \text{ rad/sec}$$

Angular velocity,

$$\alpha = (w_2 - w_1) / t$$

t- time require to accelerate the ring = 4 sec.

$$\alpha = 20.9 / 4 \text{ rad/sec}^2.$$

Torque = I.  $\alpha$

$$= 1.3 \text{ Nm}$$

This is the torque require to accelerate the total mass of outer ring. Thus the dc motor is of 2Nm torque. This torque is not sufficient to rotate the ORR. Due to load on output shaft more torque require to rotate it.

### Case 2

Considering the RMP is used in the pelton wheeled water turbine.

The pelton wheel is attached to the ORR as shown in fig.8. pelton wheel configuration



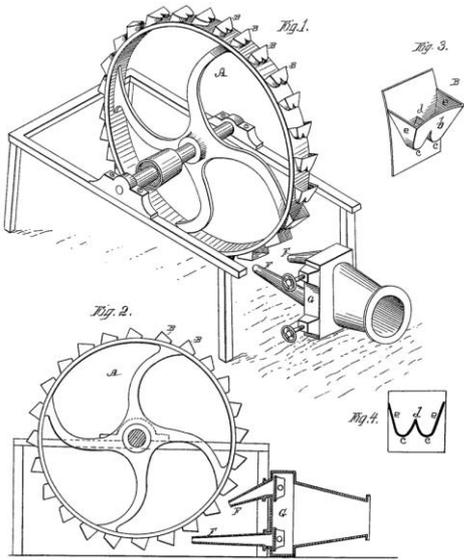


Figure 7: water turbine with pelton wheel

These mechanism of Radial Magnetic Prime-mover can also be used in the water turbine for power magnification. It can more easily attach to the pelton wheel turbine as shown in fig. 7. The Pelton wheel extracts energy from the impulse of moving water. Conventional water turbine is having the less efficiency. Instead of connecting the pelton wheel directly to generator through shaft, it can be connected through Radial Magnetic Prime-mover. The pelton wheels are attached to the the outer repulsive ring. When water rotates the wheel, it thereby rotates the ORR. As the function of Radial Magnetic Prime-over, it magnifies the power.

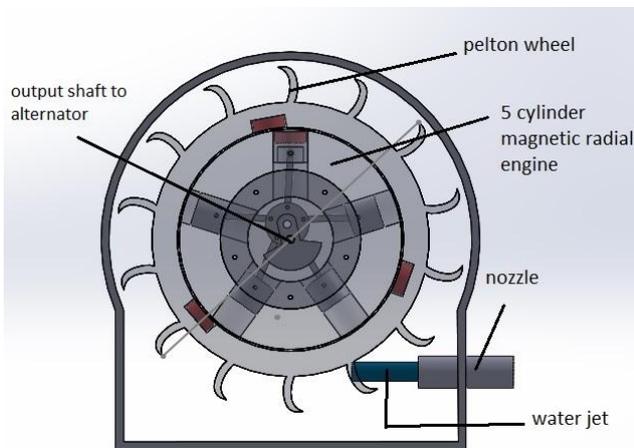


Figure 8: Water turbine with pelton wheel attached to the ORR of RMP.

### 5.3 Power transmission

Many systems used for the power transmission like gear train, belt drive, chain drive etc. In most mechanical system belt drive is used for the power transmission. In CVT (Continuously Variable Transmission) belt drive is used along with the movable pulleys for various speed ratios.



Figure 9: Power transmission by belt.

RMP can also use in the belt drive transmission system as shown in fig. 9. In transmission many times we need the torque magnification which is done by the speed reduction, like we use reduction box for more torque. We need to reduce the speed for more torque. We can achieve the more torque even at high speed by introducing the RMP in the system. This five piston cylinder RMP give the speed ratio of 1:6 with minimal loss of torque

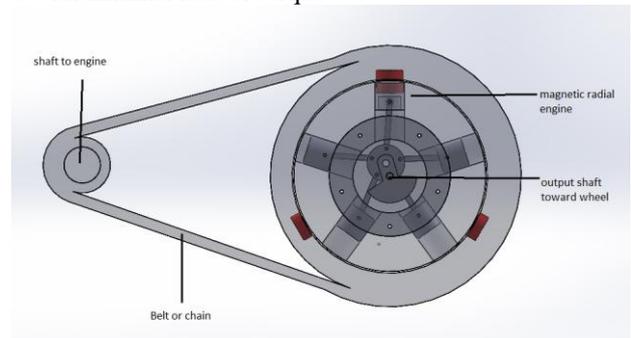


Figure 10: RMP used in the belt power transmission system.

## 6. Further study

The study of Radial Magnetic Prime-over is not limited to the radial five cylinder mechanism. The speed and power magnification can also be achieved in three and seven cylinder mechanism using the unique arrangement of magnets on ORR for respective mechanisms.

Speed magnification of 1:4 is achieved in radial 3 cylinder mechanism by placing 4 permanent magnets on ORR at exactly 90 degree to each other.

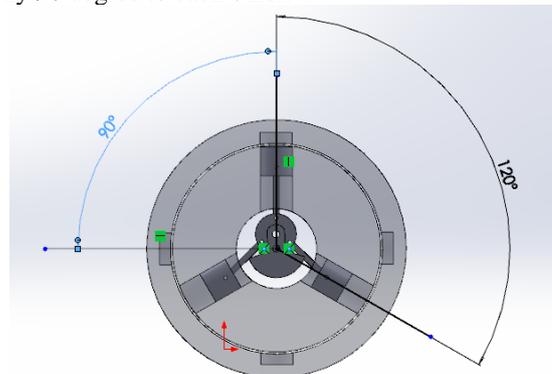
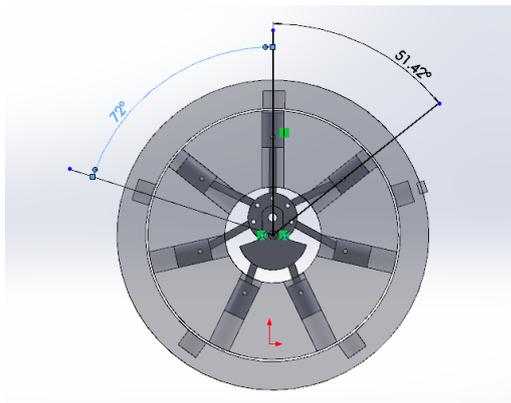


Figure 11: Radial Magnetic three cylinder mechanism

Speed magnification of 1:10 is achieved in radial 7 cylinder mechanism by placing 5 permanent magnets on ORR at exactly 72 degree to each other.



**Figure 12:** Radial Magnetic seven cylinder mechanism

## 7. Prototype

The prototype of radial five cylinder mechanism magnetic prime-mover is for testing purpose. Prototype is fabricated on the scale of 1:2. The ORR is made up of aluminum sheet. Piston, connecting rod and hub are made from plastic material.



**Figure 13:** Prototype of Radial Magnetic Prime-mover

## 8. Conclusion

This mechanism gives the 1:6 speed ratio with less loss of torque. It can be used as generator, water turbine and in the transmission of vehicle. . As there is no combustion taking place inside the cylinder there is only very little heat generation. By the use of materials like Aluminum, plastic etc. we can reduce the weight of the mechanism. Less noise is produced during its working which is one of disadvantage of

IC engine operated generator. This is the only arrangement of magnet in outer repulsive ring in odd number of cylinder magnetic radial mechanism. Innovation is applied to any odd number of cylinder magnetic radial engine. By using the large size permanent magnet, the more torque magnification can achieve. The efficiency of mechanism increases with the increase in speed of ORR.

With the keen manufacturing of all parts of system and some testing on it, this mechanism will give the good results. Some detailed study about the behavior of permanent magnets is being required, which is the future scope of this paper. Further improvements of the current technology can help its progress and implementation in current systems.

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## Author Profile

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## Definition/Abbreviations

- RMP** – Radial Magnetic Prime-mover
- ORR** – Outer Repulsive Ring
- IC ENGINE** - INTERNAL COMBUSTION ENGINE
- TDC** - Top dead center
- BDC** - Bottom dead center.