THE BASIS OF DESIGN AND MODELING APPROACH OF MAGNETIC ENGINE GOPI GEN

Manoj Kumar Gattani
Assistant Professor
University of Petroleum and Energy Studies, Dehradun. India

ABSTRACT

This paper describes the design and modeling approach of GOPI gen, applicable to generate electrical and mechanical power simultaneously in large-scale system. The operating characteristics of the GEN were found to differ significantly from those conventional engines, giving potential advantages in terms of fuel efficiency and emission. By removing complex fuel burning process to propel the piston completely, design of the GEN become very simple and leads to very cost effectiveness in both manufacturing and running of it.

KEY WORDS: *GOPI GEN, power, complex fuel burning process, piston propulsion.*

I. INTRODUCTION

As the GOPI GEN is a blend and advancement of GOPI Engine and GOPI Generator [1]-[3], the operational problems of the GOPI engine and generator were illuminated in the GOPI GEN. In GOPI engine, when the movable magnet in form of magnetic piston brings near to gate of the magnetic shielded material near the TDC, it virtually attached to the gate and hence, it requires more input power to operate the gate. The opening and closing mechanism of the gate not only reduces engine efficiency but also increase its manufacturing and running cost.

In GOPI generator, the movable magnet has to change its direction of movement by 180^0 after getting power stroke from the fixed magnets. This change in direction brings the movable magnet to zero velocity for a moment. It decrease the generator efficiency and increase running cost of it as Acceleration zone (Az) has to work more to attain the same speed with which the movable magnet should passes through the electrical coil.

In GOPI GEN, the magnetic shielded gate with its opening and closing mechanism is removed permanently. By doing this, not only the manufacturing and running cost of the GEN is reduced but its design became simpler. The efficiency of the GEN is increased by a large extend as very less input power is required to operate the gate but also the speed of the movable magnets in form of magnetic pistons does not decreased at any step of the operation. As the name, the GOPI **GEN** can work as **G**enerator and **En**gine at a same time and hence can produce electrical and mechanical power simultaneously.

II. GOPI GEN- DESIGN

GOPI GEN can be assembled in various designs. The common parts of all designs are acceleration zone (Az), single sided magnetic piston (SSP) or double sided magnetic piston (DSP) clamped with acceleration zone, crank and flywheel mechanism, magnetic piston attached with crank, micro - processor based control units, electric coils etc.

The DSP or SSP is clamped with Az so that the piston can be moved to and fro motion along their axial line. The magnetic pistons with proper cranks are placed end to end of the Az. The individual

cranks are coupled with common shaft for better synchronization with Az. The movement of Az is controlled with help of micro-processor based control units. Electrical coils are wrapped round the magnetic pistons.
The various models of GOPI GEN can be named as alpha, beta, gamma and poly. All models have their own advantages and limitations. The working principle is same for all the models of the GOPI GEN. In all models, mechanical output can be gained at the common shaft of the GEN and electrical power can be collected at the electrical coil terminals.
For the design of GOPI GEN, magnetic piston is clamped with crank and flywheel assembly and placed at one end of the embodiment. The crank may be individual type for single piston or a common crank for multi pistons. A magnetic piston attached with crank and with proper electrical coil construct part a (P_a) of the GEN. and the acceleration zone with proper SSP or DSP form part b (P_b) of the GEN. These P_a and P_b are placed on GEN track which is made up of non-metallic and non-magnetic materials. The pistons of P_a and P_b are used to move on this track. The P_a and P_b are arranged on the track in such a way that the opposite poles of P_a and P_b are facing to each other. Some of the models of GOPI GEN are described in the next section.

A. GOPI GEN –Alpha

This model of GOPI GEN contains one P_a and one P_b with SSP. There is only one power stroke in one complete rotation of the crank. The left part shown in the figure (Fig 1) is acceleration zone with SSP i.e. part b. The right part of the figure is the part a having magnetic piston with crank assembly (electrical coil is not shown here).

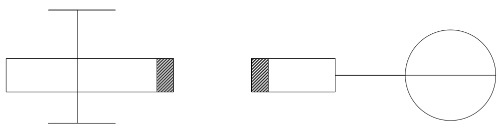

Figure 1: Alpha model of the GOPI GEN

B. GOPI GEN-Beta

A common crank with two magnetic pistons form part a and SSP with Az form part b of the GOPI GEN beta model. Total two P_b and one P_a are required to construct the model as shown in the figure 2. In this design, acceleration zone can be arranged in such a way that power stroke can be produced simultaneously on both the magnetic pistons or can be produced at an interval of 180^0. One power stroke is produced on individual magnetic piston in one complete cycle. Therefore total two strokes can be maintained in one complete cycle.

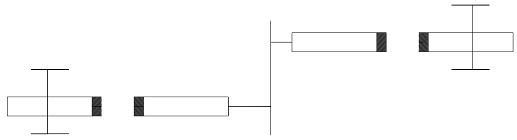

Figure 2: Beta model of GOPI GEN

C. GOPI GEN- Gamma

A DSP with Az is used for P_b and two SSP with individual cranks are used to construct two P_a.
The P_b is placed in between these two P_a as shown in the figure 3.The double sided piston is used to produce stroke in both the magnetic pistons. Total two Power stroke can be produced at an interval of 180^0.

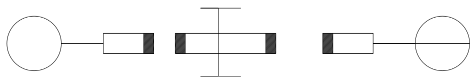

Figure 3: Gamma model of GOPI GEN

D. GOPI GEN –Poly

This design is combined expansion of GOPI GEN –beta model and GOPI GEN- gamma model. In this, double sided piston is used with acceleration zone to produce stroke in the GEN.
In this design part a contains both individual crank and common crank with proper arrangement of the magnetic pistons.
In it, two individual cranks are required which are placed end to end of the embodiment. The number of common cranks is one less than the Az used. In this design, any number of P_a and P_b in proper arrangement can be used. The power stroke in one complete cycle depends upon total number of Az used.

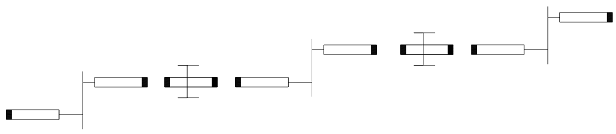

Figure 4: Poly model of GOPI GEN

In the table 1, a comparison between Az, magnetic pistons, types of cranks and power strokes is done for alpha, beta, gamma and poly models

Table 1: Details of GOPI GEN-alpha, beta, gamma and poly models

Model	Az	Az piston		Crank		mp	Power stroke
	q	q	t	q	t	q	one cycle
Alpha	1	1	SSP	1	I	1	1
Beta	2	2	SSP	1	C	2	2
Gamma	1	1	DSP	2	I	2	2
Poly	n	n	DSP	n-1	C	2*n	2*n
				2	I		

Az=acceleration zone, mp=magnetic piston, q= quantity, t= type, SSP= single sided piston, DSP= double sided piston, I=individual crank, C= common crank, n= any integer number
For n=1, the poly model of the GOPI GEN will become the gamma version of the GOPI GEN.

E. Gopi Gen- Working

The GOPI GEN works on repulsive properties of magnets. When two magnets of same pole come near to each other they will face repulsive force between them and will try to move in direction of stronger force. In GOPI GEN the magnets in form of magnetic pistons faces repulsive force and make a continuous motion. To understand properly the working principle of the GEN, working of gamma model is described here. In this the acceleration zone is placed between the magnetic pistons. A double sided piston will be used in it to produce power stroke with both of the magnetic pistons.

Let say the magnetic piston are mp_1 and mp_2 and are placed at both side of DSP. The arrangement of pistons is made in such a way that mp_1 and mp_2 faces repulsive force from DSP at constant interval. The repulsive force between mp_1 and DSP or mp_2 and DSP will be known as power stroke. The individual cranks of mp_1 and mp_2 are coupled with common shaft and placed at 180^0 crank angle so that stroke can be produced at an interval of every 180^0 of crank rotation.

Initially, when the GEN is at rest position, the mp_1,mp_2 and DSP will positioned in such a way that there will be no repulsive force between any of the pistons. Let say this position as neutral position of the GEN. At this time the mp_1 and mp_2 are equidistance from DSP. Let suppose at this time, the mp_1 is moving towards its Top Dead Center (TDC) (minimum distance from neutral position) and the mp_2 is moving towards Bottom Dead Center (BDC) (maximum distance from neutral position).

As the mp_1 is moving TDC, the DSP will start moving towards mp_1 with help of acceleration zone. When the mp_1 approaches to its TDC, the DSP will move very near to the mp_1 and will produce power stroke (power stroke happens only when mp_1 or mp_2 is at TDC). At this time the mp_2 will approaches to its BDC. Because of the power stroke between the mp_1 and DSP, the mp_1 will start moving towards its BDC (similarly the mp_2 will start moving towards its TDC) while the DSP will be kept in stationary position after stroke for few moments and after that the DSP will be brought back to neutral position to repeat the stroke process with mp_2

In the same manner another power stroke will be produced when the mp_2 will reach to its TDC. In this way, the strokes which are produced at a constant interval will keep the piston- crank assembly in continuous motion.

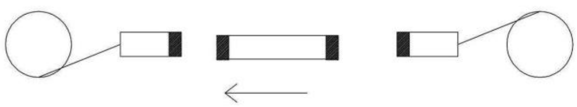

Figure 5: The DSP is moving towards P_a as mp is moving towards TDC to generate power stroke

F. Gopi Gen- Modeling

Magnetic engines are under investigation by a number of research groups worldwide due to their potential advantages in terms of efficiency and engine emissions. Some proto type have emerged, mainly aimed for vehicle propulsion and stand alone power source [4]-[15]. But very little work on modeling and simulation is done. The GOPI GEN can be used to produce both mechanical and electrical power at same time but for this document only mechanical power as output is calculated.

As in other magnetic engines, the GOPI GEN also has a number of unique features, some give it potential advantages and some represents challenges that must be overcome for the GOPI GEN as a magnetic engine or generator to be a realistic alternative to conventional technology.

Piston dynamics and control

In conventional engines, the crank mechanism and flywheel serve as both piston motion control and energy storage. In the GOPI GEN the motion of the mover at any point in the cycle is determined by the sum of the forces acting upon it. Hence, the interaction of these forces must be arranged in a way that ensures the mover motion is within acceptable limits for all type of models.

In conventional engine, the power stroke happens because fuel burn in combustion chamber and the chemical energy of the fuel produce high thrust on the piston head which rotate the attached crank and flywheel. In GEN, the power stroke produces with help of repulsive force between the Az piston and the magnetic piston. Magnetic force remains there for all the time but the intensity of the field is changed with help of Az piston movement. The piston motion can be derived from Newtons 2 nd law, avoiding complex mechanism of the crank rotation, given by

$$\sum F = Mp\frac{d^2x}{dt^2}$$

Where ∑F is the net force acting on the piston head and it can be given as

∑F=Fm-Fb-Fr-Fn-Fc

Here,

Fm= Magnetic force between the m_1 & m_2.

Fb= Bouncing forcing with which DSP or mp may bounce back.

Fr=Frictional force between the track and piston cylinder
Fn= Reduced magnetic strength of the magnet in due course of time, and
Fc=Counter force on magnetic piston when passes through coil
Mp= moving mass (piston crank assembly)
x= position of the piston with respect to DSP in the time frame.
Here, the Fm is the magnetic force which occurs at piston head and is responsible for power stroke. In actual, this force is repulsive force between the two identical cylindrical bar magnets placed end to end in form of magnetic piston and Az piston is approximately given by the following equation [16].

$$F = \left[\frac{B_0^2 A^2 \left(L^2+R^2\right)}{\pi \mu_0 L^2}\right]\left[\frac{1}{x^2}+\frac{1}{(x+2L)^2}-\frac{2}{(x+L)^2}\right]$$

Where,
B_0 is the magnetic flux density very close to each pole
A is the area of each pole
L is the length of each magnet
R is the radius of each magnet
x is the separation between the two magnets. Here x will be the distance between the magnetic piston and Az piston.
If the common shaft of GEN rotates with angular velocity ω and the torque by τ, then the output power at the shaft of the GEN will be given by P=τ*ω/5252.
The torque τ is equal to magnetic force F occurring at the piston head multiplied by the connecting length l. therefore, the torque in terms of magnetic force available at piston head will be given by
τ=F*l and the output power in terms of magnetic force will be given by
P=F*l*ω/5252
The value of ω is decided by Az motion.
Operating principle
Let suppose initially that the mp is x_1 distance away from TDC and DSP at neutral (position N) position shown in the figure 6. The total distance of DSP from TDC is x_{min} + x_0.

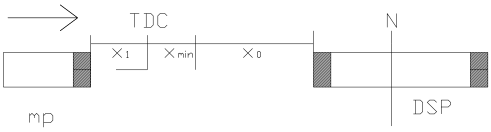

Figure 6: Position of mp and DSP before power stroke.

This time there will no repulsive force between the mp and DSP. The mp is continuously moving towards TDC as the crank rotates continuously while the DSP is at rest. TDC is the location where power stroke has to happen. Here only one mp is shown. The arrow on mp represents its direction of motion.
For stroke, when mp reaches x_1, the DSP will have to reach at x_{min} point by covering x_0 distance as shown in the figure 7. The x_0 is more than x_1 and to cover more distance in same time, the DSP will have to move with higher speed than that of the mp.

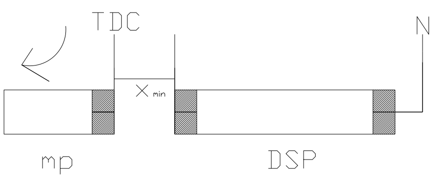

Figure 7: Power stroke happens at TDC.

After the stroke, the mp will start moving towards BDC while the DSP will remain at this position till the repulsive force does not became zero between the mp and DSP(figure 8). After this, the DSP will bring back to neutral position. In this way, power stroke with constant interval will be produced by moving the DSP towards mp_1 and mp_2 in the same manner.

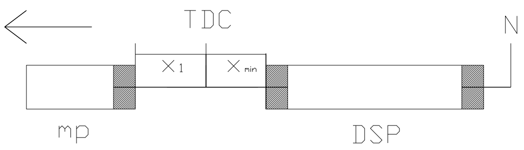

Figure 8: After stroke, the mp returns back to its path while the DSP is retain at the position.

G. GOPI GEN-advantages and limitations

The elimination of complete mechanism of fuel burning process of the traditional engine reduces the number of parts and the complexity of the GOPI GEN significantly and this potentially gives a number of advantages as low frictional losses, reduced manufacturing cost, compactness, low maintenance cost and increased lifetime.

Above all, the GOPI GEN is designed in such a way that it can be used to produce mechanical and electrical power at same time. But at the same time, if the synchronization of magnetic piston is not done with Az, the GEN will not work properly or may stop after few cycles.

III. CONCLUSION

The basic design and unique features with advantages and limitations of the GOPI GEN have been discussed. Although several reports have confirmed that the magnetic engine is a viable concept, more research is required to investigate potential advantages over conventional technology. The area with most uncertainty is clearly that of piston motion control. In GOPI GEN the motion of the piston is controlled with help of acceleration zone which must be synchronized with DSP and mp. A detailed study is required to investigate experimental relation between these parameters.

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BIOGRAPHY

Manoj Gattani had completed his engineering and masters degree from Jodhpur University. Mr. Gattani is working for magnetic engines for power generation from last 4 years. Beside this he has a keen interest in waste to energy and solar and biomass form of energy for power generation. He has five Indian patents(pending) and won several awards like young scientist award 2011, best technology of the year, 2011 etc. He is performing Ph. D. in Green Energy & Power Generation System from University of Petroleum and Energy Studies, Dehradun, India.