EXECUTIVE SUMMARY

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The endeavor of this study is to model and simulate the Gate Operated magnetic Piston engine (GOPI Engine) and to develop working mechanism of it. The assortment of the magnetic engine is based on a widespread review of literature which indicates that this is relatively unexplored technique. Both the simulation and experimental investigation are followed by the theoretical and mathematical modeling of the engine to establish a relation for engine working mechanism. As there is a non-availability of permanent magnetic engine for commercial or experimental purpose and insufficient literature on it, only manual operated engine is developed. The purpose of this type of development is to investigate and forecast the working conditions of the engine along with establishment of the theoretical and mathematical relations.

The primary components of the GOPI engine are magnetic component as fixed magnet (m_1), magnetic piston (m_2) and the gate, and mechanical component are piston cylinder, connecting rod, crank-shaft assembly. In GOPI engine, only repulsive force of the permanent magnets has been used to produce thrust or power stroke. The gate of the magnetic shield material is introduced between the fixed magnet and the magnetic piston for this purpose. A fixed magnet and the magnetic piston are arranged in such a way that m_2 is brought again and again near to m_1 (after a fixed interval). The gate remains in closed position except when the piston is at TDC.

The permanent magnets have magnetic free energy associated with them but there is no device available to make a direct use of it. In the development of the GOPI engine, this magnetic free energy is converted into magnetic potential energy and then into magnetic kinetic energy. This magnetic kinetic energy is then used to operate the engine.

The mathematical equations for the working of engine indicate that the gate should block the magnetic field between the fixed magnet and the magnetic piston properly. The magnetic field of a magnet can be diverted, transmitted, or blocked, when a shield material is placed near it to complete the magnetic circuit. When the magnetic field lines are transmitted through the gate completely, the engine will not complete its cycle as the magnetic piston will be stuck in its upward motion as there are repulsive forces that exist

between the magnets. When the gate blocks or diverts these magnetic fields, the engine will run and that power can be availed at the attached shaft.

The engine is modeled with rare earth permanent magnets having magnetic intensity of 1.2 T, radius of 60mm and thickness of 10mm. The magnetic shield material selected for the gate development is having a permeability of 30,000. The gate is two panel and operates between the fixed magnet and the magnetic piston. The magnetic piston is having stroke length of 139.7mm and a bore of 60 mm. Acrylic materials is chosen with a bore of 60mm for piston cylinder and a cover of 15mm for piston magnet. Pro-E software package is used to design and develop the engine parts and engine unit.

The operating mechanism of the engine is that the gate should block magnetic field of the fixed magnet except the piston is at TDC. The power stroke will be produced when the magnetic piston just starts moving towards BDC and at the same time, the gate opens. With this unique approach, complete elimination of fuel burning mechanism of the traditional IC engines is made possible with GOPI engine. Magnetic force remains there for all the time but the intensity of the field is changed with the help of the gate. As GOPI engine works on some specific operating characteristics as compared to the conventional engines, both software and experimental approach of modeling is adopted. The engine unit is studied for simulation with the Ansys software package to investigate the magnetic behavior of the GOPI engine that includes the magnetic circuit contour lines, magnetic field intensity, magnetic forces at the gate center, magnetic field patterns of the permanent magnet sat the static position, distribution of the magnetic flux across the gate when the gate is in neutral mode, magnetic flux distribution across the gate when the gate is in active mode, maximum approach distance of the magnetic piston, total available force at piston head, attachment of the gate with m_1& m_2, and force required to pull the gate from neutral position.

For these various studies, gate thickness of 1mm and 2mm is selected for 30,000 (30k), 1,00,000 (100k) and 3,00,000 (300k) permeability of the gate material and distance of 60mm, 30mm, 20mm, 10mm between the fixed magnet and the piston head. The simulation investigates that high permeability of the gate material with more thickness is most efficient to block the magnetic field between the magnets.

When the permeability of the gate is equal to air medium, the counter magnetic force (f) will be maximum as the magnetic field lines passes through the gate completely. It is the condition when the engine may not work. As the permeability of the gate material increases, the blocking of the magnetic field between the magnet and the gate improves and the counter magnetic force is reduced. The maximum approach distance of the magnetic piston increases. The engine tends to run with maximum efficiency when the field is completely diverted by the gate. If the gate does not work efficiently, the piston will get stuck somewhere during the upward movement towards TDC and will not complete the cycle.

A manual operated GOPI engine prototype is developed to investigate the relation between the fixed magnet, magnetic piston, and gate operating mechanism. The parts of the engine are designed with 3D printing technique. The engine is set to run at a constant speed of 10 revolutions per minute. The gate is having width and length of 80mm to cover the magnets fully to develop a complete magnetic circuit between the magnets and the gate. The shielding increases by inserting the gate inside the magnetic piston as it moves towards TDC. The shielding becomes maximum when the piston reaches to TDC. In reverse stroke, as gate is moved out thereby reducing the shielding, the piston starts moving from TDC to BDC and when it reaches to BDC, the gate is fully withdrawn. In the manual operation of the engine, the synchronization of the piston movement is found a bit difficult as the gate tends to attach with the magnets and divert from its path of motion.

It is obvious that the self-driven operating mechanism for the piston and gate operations, will not only improve the engine working but also a strong power stroke can be availed as the maximum approach distance of the magnetic piston will be increased because of the proper shielding effect.

Yet the magnetic engine is a viable concept, more research is required to investigate potential advantages over conventional technology. The area with most uncertainty is piston motion control. In GOPI engine the motion of the piston is controlled with help of gate which further depends upon many parameters like, thickness and type of shield material, distance of gate from magnets and mechanism used to operate the gate. A detailed study is required to investigate experimental relation between these parameters.