DESIGNING AND PROTOTYPING OF AN ALTERNATIVE ELLIPTIC INTERNAL COMBUSTION ENGINE

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ABSTRACT

In the conventional internal combustion engines, the elements of linear movement cause the friction power to increase the manufacturing economy to deteriorate and also cause vibration. The diameter of intake valves, which is smaller than the diameter of the cylinder, causes the volumetric efficiency to decrease. In the two stroke engines, in which the number of works per cycle is increased, power output per unit volume (kW/liter) is higher; however, specific fuel consumption decreases considerably.

In this study, an alternative elliptic internal combustion engine, in which crankshaft, camshaft and valve mechanism are not used, has been designed and its prototype has been manufactured. The three-dimensional solid modeling and animation of the engine has been performed in 3D Studio Max 5.1.

The elliptic engine works on 4 stroke Otto cycle principle. However, the cycle is completed in 360 degrees. The first prototype has been manufactured and proved workable. And the problems related to the first prototype have been determined. It has been anticipated that by eliminating the problems that affect the running of the first prototype, some advantages for the second prototype could be obtained such as improved manufacturing economy, increase in the mechanical efficiency and decrease in the specific fuel consumption. Furthermore, the patent application of this new engine has already been made.

Key Words : Alternative engines, elliptic engine, internal combustion engine

1. INTRODUCTION

The elements of linear movement in the conventional internal combustion engines such as connection rod, crankshaft, camshaft and valve mechanism cause a part of the power to be wasted for the friction losses in the conventional internal combustion engines and cause the manufacturing economy to deteriorate and also noise and vibration. (1, 2). Besides, since the plate diameter of intake valve is smaller than the diameter of the cylinder, volumetric efficiency decreases (3, 4). And in two stroke engines, the increase rate of specific fuel consumption is higher than the increase rate of the power output per unit volume due to the fact that intake, compression, power and exhaust stroke are all interconnected (5, 6).

In this study an alternative elliptic internal combustion engine with air cooling system, in which connection rod, crankshaft, camshaft, valve mechanism and other gears in connection with these are not used, has been designed and its prototype has been manufactured[1]. In the elliptic engine which operates according to the 4 stroke Otto cycle principle, while one power stroke is performed for each cylinder per cycle of 360 degrees, the four strokes are independent of each other. The three-dimensional solid modeling and the animation of the engine has been performed in 3D Studio MAX 5.1. Moreover, the patent application of this new engine has already been made.

[1] The manufacture of this prototype has been funded by Gazi University, Scientific Research Projects.

The first manufactured prototype of the elliptic engine has proved workable. The problems related to manufacturing and working parameters of this prototype have been determined. One of these problems is compression leakage that occurs between the cylinder case and timing shaft. It has been anticipated that by eliminating this problem which affects the running of this first prototype, some advantages for the second prototype could be obtained such as improved manufacturing economy, increase in mechanical efficiency and decrease in the specific fuel consumption[2].

2. SOURCE RESEARCH

The thought of creating variable volumes in a closed cell, which is the working principle of the internal combustion engines, could be put into practice with various designs. In the new engine designs, there is a tendency towards the conversion of the pressure occurred by ignition of the compressed fuel-air mixture to direct circular movement. The common property of most of these new engines is that camshaft, valves and the other parts with linear movement that operate in connection with these are not used. It is observed that while crankshaft, cylinder and piston are used in some systems, these engine elements are not used in some others. (7, 8). In some of the designs of new engines, the pistons tend to perform the linear movement in order to form four cycle movement when they are turning around an axis rather than performing it in a constant position. And this facilitates the engine to get over the dead points and accordingly to overcome the inertia power more easily with comparison to the conventional piston engines which move only in one axis (up and down). Apart from that, efforts related to using big ports instead of small intake valve and exhaust valve and accordingly decreasing the number of the parts used and on

[2] Visit http://web.ttnet.net.tr/nadiraksoy and http://www.geocities.com/eliptikmotor01.

the other hand improving the volumetric efficiency draw attention in recent days. Exhaust stroke occurs when pistons, which are passing through the exhaust ports, push the burnt exhaust gases. Increasing the power stroke per cycle, decreasing the friction power by reducing the number of the parts used and increasing the volumetric efficiency by using wide ports instead of valves are all the advantages of these alternative engines. Some of the designs that resemble the structure of the elliptic engine are illustrated below.

2.1. The Tritec Power Unit

It is shown in Figure 2.1, pistons at constant position form four cycle movement by making regular linear movement as the conventional internal combustion engines.

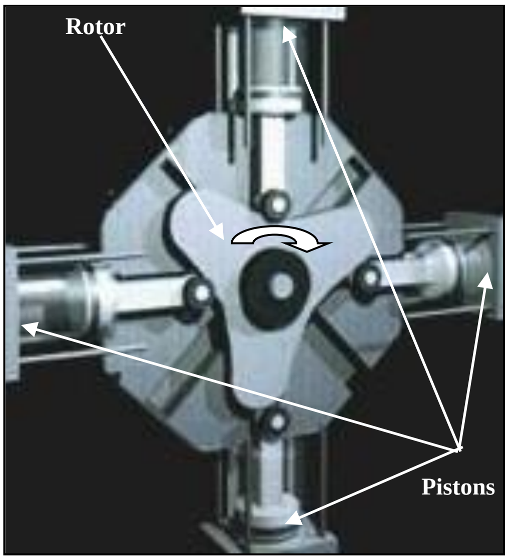


Figure 2.1. The General View and Operation of the Tritec Engine

Here, the difference is the use of a rotor instead of crankshaft. The pistons are free and have no connection with rotor. The triangle rotor turns in arrow direction as shown in Figure 2.1, so course movement of the pistons occurs. The pressure that occurs by ignition of compressed fuel-air mixture pushes the piston through the rotor and by this way the rotor is turned in arrow direction by the piston.

The engine, which is USA patented with the number of 5229529, is a Canadian design and have some advantages such as reduced number of the parts, low cost of maintenance and lower volume. Its manufacturing and installation are easier as well (9). Its engine speed is higher in comparison with the conventional engines. Other advantages of this engine include easy modular design, high tork output at low speeds, reduced number of the moving parts and high thermal efficiency. According to the measurements on the prototype, a rate of 25% increase in general efficiency has been observed.

2.2. Turbine Engine

The engine with number 6164263 is USA patented and that with number 2192714 is Canada patented. As shown in Figure 2.2, the rotor, which is composed of four parts, rolls in an oval guide roller and performs four cycle movement by making use of the gaps of different volumes as in Wankel engine (10).

a) b) c) d)

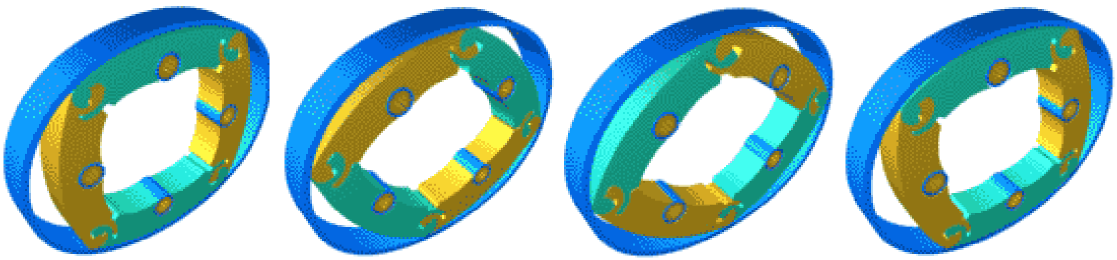


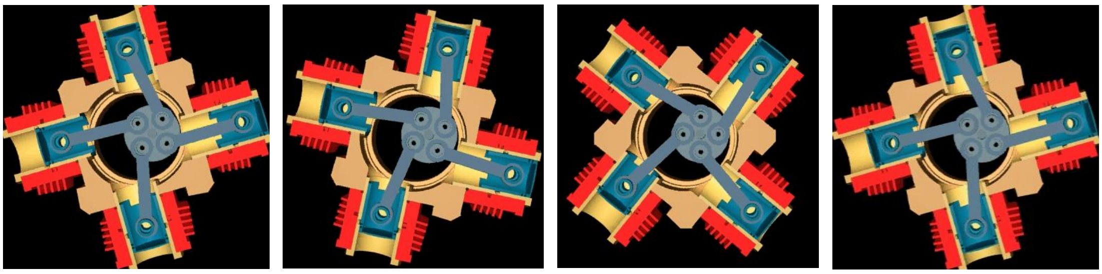
Figure 2.2. Operation of Turbine Engine

Figure 2.3. Manufacturing of a small Turbine Engine

Four power strokes are formed per each cycle. It can easily be structured as in low-volume manner (Figure 2.3). It is successfully applied in wood choppers and at least a rate of 20% energy is saved. Moreover, value of vibration and noise is reduced. A small prototype with a QT400 series of air-cooling system shows that these engines can also be used in aviation industry (11) and have a wide range of applications like pneumatic type.

2.3. Markel Engine (Or Rotary Body Markel Engine)

Markel Engine, whose operation is shown in Figure 2.4, is USA patented. Pistons in the cylinder block rotate the outlet shaft, which is offset from the center, together with the cylinder block, by the help of combustion pressure. There is a shaft which is placed in center instead of crankshaft and turns at a speed rate of 1/1 together with the cylinder block. Power stroke for each piston occurs at 720 degrees of outlet shaft type (12).



a) b) c) d)

Figure 2.4. Operation of Rotary Body Markel Engine

The moment produced does not differ much in angular variety with outlet shaft. The cycle efficiency is increased by 30 % (13). Both vibration and number of the parts are reduced, and cost of manufacturing is lower in comparison with conventional internal combustion engine. It is air-cooled and does not need cooling water. Moreover, it is simple in mechanical design.

3. OPERATIONAL PRINCIPLES OF DESIGNED ELLIPTIC ENGINE

3.1. Principle of Operation

As shown in Figure 3.1, the pistons in the cylinders create combustion chamber with their movements inside the elliptic guide. The pistons rotate the cylinder block while leaving the cylinder by the help of the pressure occurred by the combustion of fuel-air mixture compressed in this combustion chamber. Since the pressure which occurs in combustion chamber affects the guide at different angles, connecting rods rotate and move inside of the guide and accordingly the cylinder block turns around itself. The cylinder block rings prevent the fuel-air mixture that is compressed between the pistons and timing shaft to leak from the combustion chamber (14).

Intake port which induces fuel and air into the cylinders, exhaust port which directs exhaust gases out from the cylinders, fuel-air entrance placed at both side of the timing shaft and exhaust outlet are shown in Figure 3.1. Carburetor is connected to fuel-air entrance.

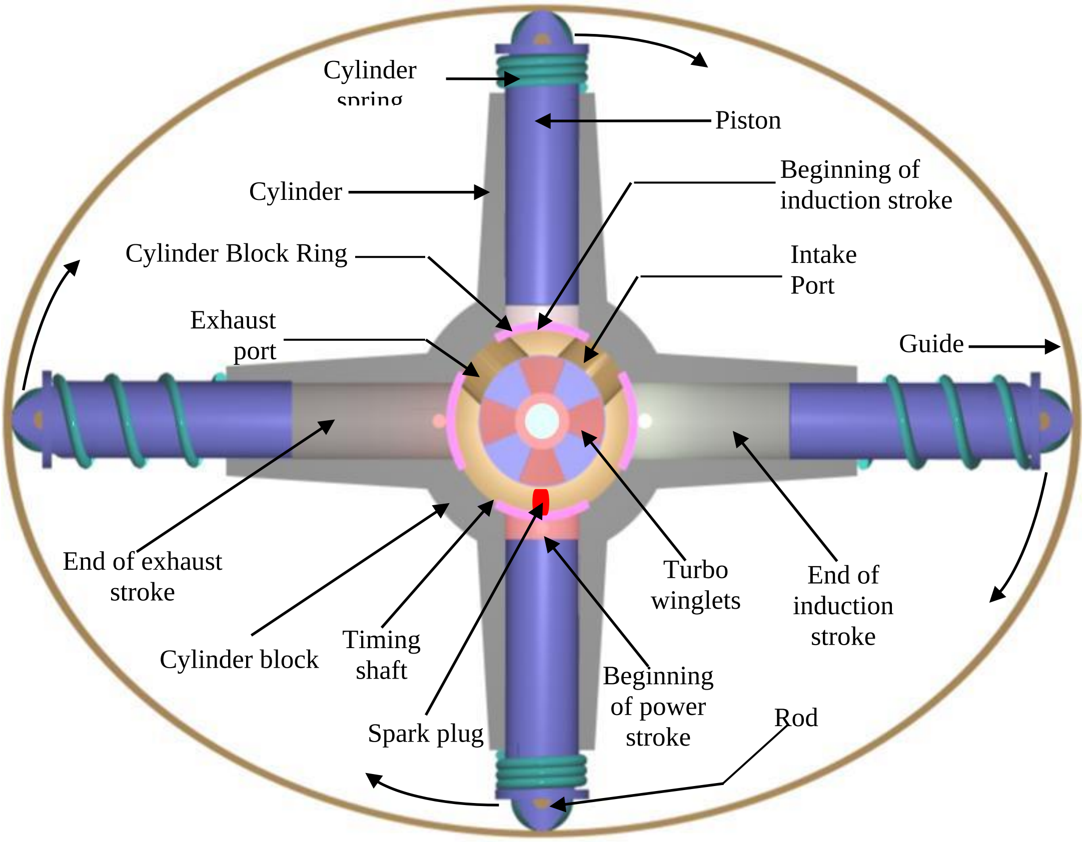


Figure 3.1. Cutaway view of elliptic engine

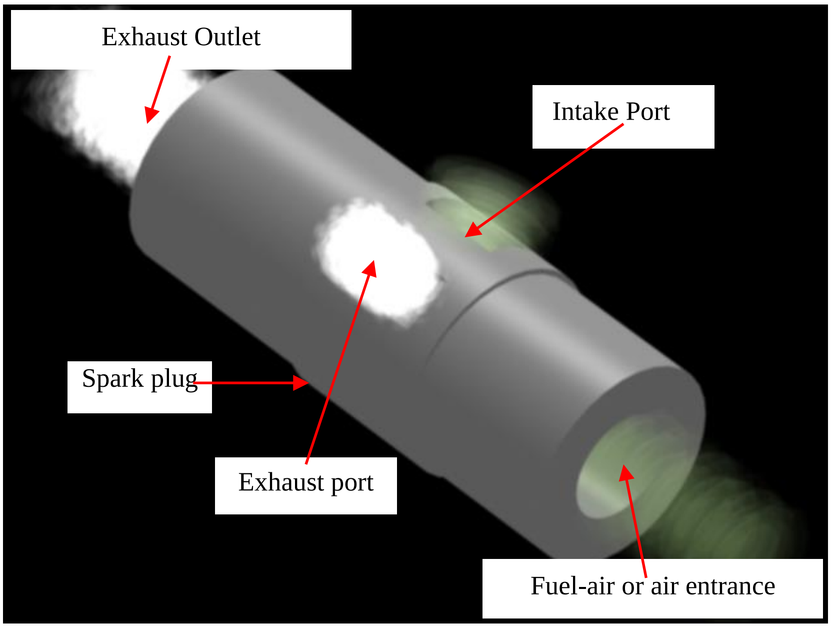
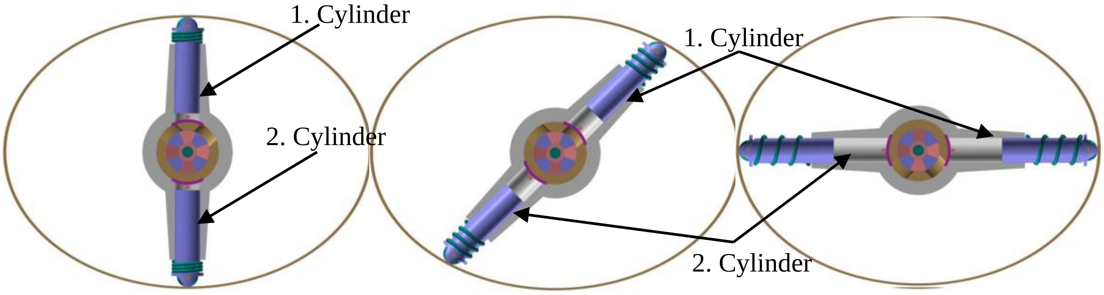


Figure 3.2. Timing shaft and parts of the Elliptic Engine

3.2. Theoretical Cycle of the Elliptic Engine

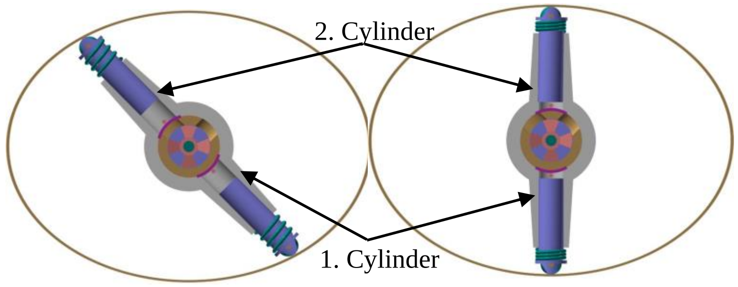
First period (0-90 degrees): As shown in Figure 3.3.a, the cylinder body is rotated with the first movement. Pistons are pushed outside with the effect of cylinder springs and centrifugal force. When the first cylinder reaches the induction port, induction stroke begins for this cylinder in Figure 3.3.a, continues in Figure Figure 3.3.b and ends in Figure Figure 3.3.c. During this period, the first cylinder rotates at 90 degrees and fuel-air mixture fills through the induction port into the cylinder. The second cylinder completes the compression period in Figure 3.3.a. At this point, the power stroke begins by ignition of spark plug, continues in Figure Figure 3.3.b and ends in Figure Figure 3.3.c. During this period, the second cylinder also rotates at 90 degrees.



a) Start of the movement b) 45 degrees c) 90degrees

Figure 3.3. Operational Principle of the Elliptic Engine, First Period (0-90 degrees)

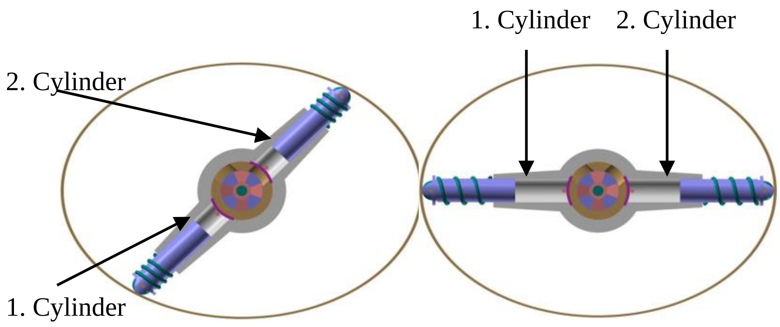
Second Period (90 – 180 degrees) : As it is shown in Figure 3.4.a, for the first cylinder which passes the induction port, induction stroke ends and compression stroke begins and it ends in Figure 3.4.b. In Figure 3.4.a, the second cylinder forms the exhaust stroke by directing the exhaust gases out from the exhaust port. The exhaust stroke ends in Figure 3.4.b.



a) 135 degrees b) 180 degrees

Figure 3.4. Operational Principle of the Elliptic Engine, Second Period (135-180 degrees)

Third period (180 – 270 degrees) : As it is shown in Figure 3.5.a, the first cylinder performs the power stroke. The power stroke continues until Figure 3.5.b. While the second cylinder continues its movement on the induction port as shown in Figure 3.5.a, induction stroke begins and ends in Figure 3.5.b.



a) 225 degrees b) 270 degrees

Figure 3.5. Operational Principle of Elliptic Engine Third Period (225-270 degrees)

Fourth Period (270 – 360 degrees) : As it is shown in Figure 3.6.a, when the first cylinder continues its movement on the exhaust port, it directs the exhaust gases inside itself out from this port. The exhaust stroke continues until Figure 3.6.b. The second cylinder forms the compression stroke in Figure 3.6.a. the compression stroke continues until (Figure 3.6.b).

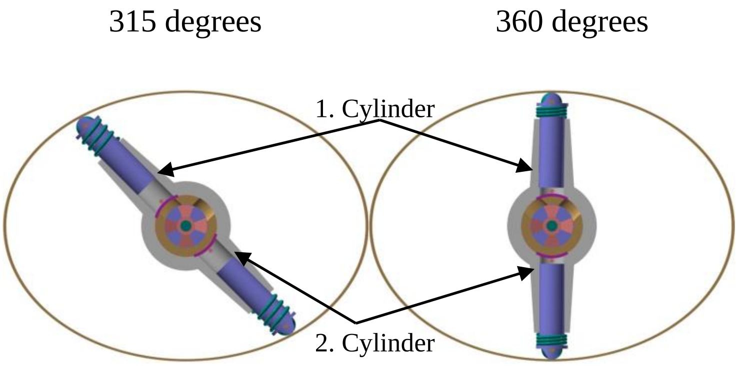


Figure 3.6. Operational Principle of Elliptic Engine Fourth Period (315-360 degrees)

3.3. The Valve Timing Diagram Of The Elliptic Engine

The valve timing diagram of the elliptic engine is shown in Figure 3.7. and the total values of the diagram are also given in Table 3.1. below. As it is understood from the values, one power stroke occurs for each cylinder per each cycle of 360 degrees in the elliptic engine.

Table 3.1. Values of valve timing diagram of the elliptic engine

Induction		**Exhaust**		**Ignition advance**	**Valve overlap**
The intake valve opening before the top dead center	**The intake valve closing after the top dead center**	**The exhaust valve opening before the top dead center**	**The exhaust closing after the top dead center**		
6^{o}	29^{o}	29^{o}	6^{o}	5^{o}	12^{o}

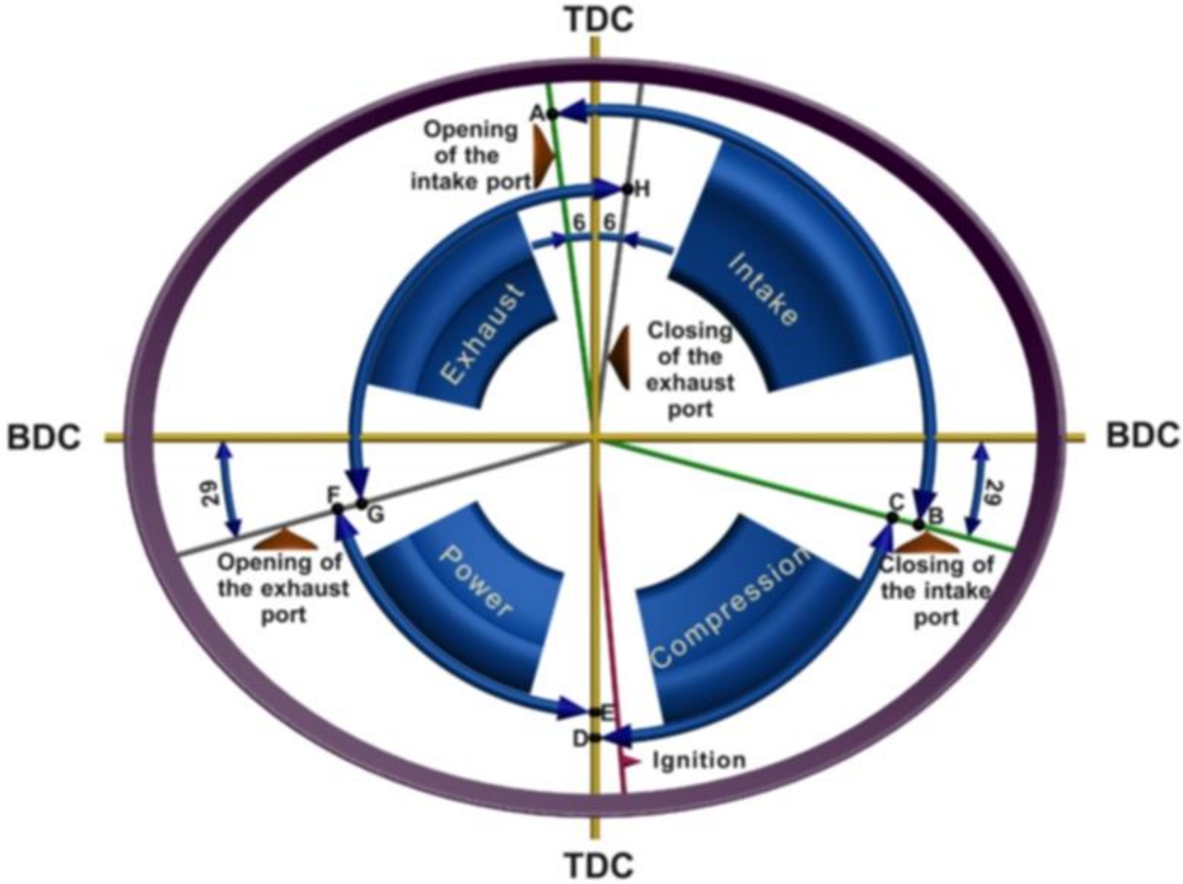


Figure 3.7. The valve timing diagram of the elliptic engine

4. MANUFACTURING AND TESTING OF THE PROTOTYPE

In order to manufacture the parts such as the body, cylinder block and timing shaft, whose three-dimensional solid modeling has been made, first their models have been designed by using wooden material. The parts, whose models have been prepared, have been construction. The body has been manufactured with aluminum and sfero casting materials (GGG 70 series) have been used for the cylinder block and timing shaft.

Casting engine parts (body, cylinder block and timing shaft) and other metal parts have been worked for the market within the scope of the project. Aluminum has been used for the piston. Piston balls have been supplied from the market.

It is shown in Figure 4.1 all of the manufactured parts have been installed.

After the installation, prototype engine has been run with gasoline.

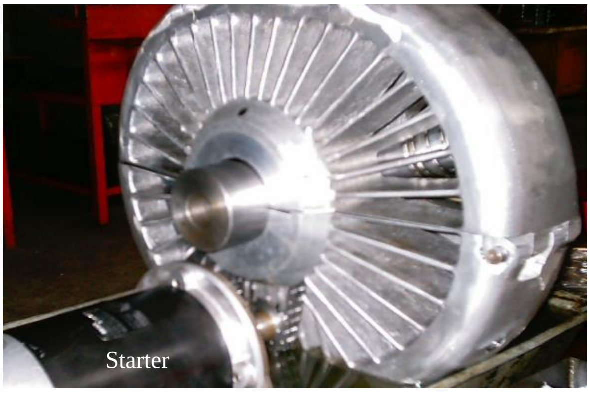


Figure 4.1. First installation of the elliptic engine (closed body)

5. CONCLUSION AND EVALUATION

In this study, parametric calculations, designing, modeling and simulation operations of the elliptic engine have been carried out. According to the parametric calculations, it is concluded that the four cylinder elliptic engine, having a total volume of 132 cc and whose prototype has been manufactured, has a capacity of generating 10.2 KW power at 3000 cycle per minute theoretically.

After the engine proved workable by the help of simulations in virtual environment, the first prototype has been manufactured, installed and operated. Due to some problems related to processing tolerances during manufacture, a precise manufacture couldn't be materialized. The main problem is the manufacture of an elliptic guide. The second prototype will be manufactured on vertical processing bench.

After the engine has been operated, at the point where the piston is closest to the timing shaft, compressed fuel-ail mixture has leaked out from the working gap and caused compression leakage. In this situation, since the pressure after compression has not occurred properly, the combustion has not been efficient. A part of the exhaust gases occurred after combustion has leaked through the same gaps to the other cylinders and induction port of the timing shaft. This has resulted from the inappropriate processing tolerances during manufacture. Consequently, it is understood that the manufacture of the second prototype of this engine, which is being designed, requires more precise tolerances.

The elliptic engine, whose first design and prototype has been manufactured, can be an alternative to the conventional internal combustion engines once the problems related to the technological manufacture has been solved. Furthermore, this study will serve as a source for everyone who wants to conduct a study about alternative engines.

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