An Overview Study of Camless Combustion Engines

Thanh Hai Truong, and Van Huong Dong

Abstract—The internal combustion engine (ICE) finds its place in the market with latest design modifications in various components to improve efficiency, economy and overall performance. However, one component has remained unchanged in the internal combustion engine development i.e., the camshaft, has been the primary means of controlling the valve actuation and timing, and therefore, influencing the overall performance of the vehicle. Camless technology is capturing the future of internal combustion engines. It has been known to man that if valves could be controlled independently in an Internal Combustion Engine then there would be benefits like increased power, reduced emissions and increased fuel economy. In the camless technology valve motion is operated by valve actuators of electro-mechanical and electro-hydraulic type. In this paper we compare camless valve operation with conventional valve operation and we deal with the valve actuating mechanisms of camless engine by considering the electromechanical and electrohydraulic actuators as the important types of actuating valves in camless engines.

Index Terms—Valve Actuation, Electromechanical Actuators, Electro-Hydraulic Actuators.

I. INTRODUCTION

Rudolf Diesel - an outstanding engineer at the Technical University of Munich in Germany invented a type of internal combustion engine and a patent granted to him in 1892 protects the copyright of an engine called diesel[1]. Along with the development of the car industry, diesel engines have been constantly improved. Although there are still doubts related to performance, reliability, fuel consumption, etc., some companies have tried to apply diesel engines to cars[2].

Mercedes has become the first automobile manufacturer in the world to equip a diesel engine for a 260D since 1936. The testing of the 260D taxi lot in Germany has shown the efficiency and real life of a diesel engine[3]. Diesel engines attracted the attention of consumers at that time. Mercedes' success has encouraged many companies to participate in the manufacture and installation of diesel engines for cars, including Audi, Cadillac, Ford, Buick, Chevrolet, Volvo and BMW[4]. The role of diesel engines became more evident when two oil crises occurred in the 1970s and 1980s[5].

Despite many outstanding advantages, especially fuel economy than gasoline engines of about 30%, diesel engines are still less popular than gasoline engines due to inherent limitations in noise and emissions[6].

Cams, thrusters, armors, etc. All these details have now been incorporated into the internal combustion engines, but these parts will soon be replaced, and camless engine technology will soon be adopted. series on internal combustion engines[7]. In a camshaftless engine, the movement of the panes is controlled directly by the actuator without using a camshaft or mechanical connections. Numerous studies have shown that a camless pan system can remove many components compared to a traditional gas distribution system. The automatic engine is equipped with a camless gas distribution system with electro-hydraulic and electro-mechanical control mechanisms that have been studied for more than 20 years, but it has not yet been highly applicable[8].

Noise has been identified as a major problem with electro-mechanical actuator technology, arising due to the high-speed contact of components[9]. To reduce this noise, the soft contact of the pan valve is required.

The normal suspension system in internal combustion engines consists of a number of moving components, a number of rotary movements and some translational movements. Includes the mushroom valve body acted by the trigger, with the springs used to push the valve out of the closed position[10]. In this system, the engine's energy is used to hybrid the components of the gas distribution system, and is consumed by the friction of the camshaft, springs, camshaft transmission belts ... the power output part. This costs 5% -10% of the total power output of the engine[11].

Another factor against the traditional suspension powertrain is the shape of the cam. Usually, the delivery time and impact of cams are predetermined. The cam lugs are pre-shaped and therefore it is difficult to change the timing and order of their actions[12]. The impact of the valve on the base causes noise and reduces the life[13].

Differences in the profile of the cam result in a difference in the characteristics of the engine. When the engine rotation is high, torque is low, so it is necessary to calculate to achieve the optimal on the same engine. With variable timekeeping technology, this problem can be better achieved[14]. But the problem that exists is that the camber slip still exists, which is why the electromechanical traction system is considered in subsequent studies. With the ability to change the time acting on the pancakes, the opening and closing time of the pancakes will be calculated optimally necessary for each load mode of the engine as well as for each cylinder[15].

The camshaftless pontoon system can be divided into two groups: electro-hydraulic and electro-mechanical. With the mechanical powertrain, there are several designs being tested[16]. Most of the developers are using the regular disk valve system (as we see now) but it can also be a spherical pan valve. Both use electromagnets one way or another to close and open the valve. As for the hydraulic pontoon boat system, the pistons are opened and closed by a mechanism using high pressure hydraulic fluid.

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II. DISC VALVE WITH ELECTRO-MECHANICAL DRIVE.

This type of system uses an armature to act on the body of the valve. The outer shell consists of an electromagnet coil that can attract or push the steel core, from which the valve opens and closes.

Most of these systems use electromagnetism or magnets to create the attraction or push of the main actuators made of iron or ferromagnetic core. These types of armature are limited by the actuators because they depend on the travel range. If this gap becomes larger (such as when the distance between the moving part and the permanent magnet or the electromagnet increases), the impact force will decrease. In order to maintain the forces exerting heavily on the armature as the size of the displacement increases, a high voltage current in the coil must be used[18]. Increasing the current leads to an increase in the system's energy loss, in addition to non-linear operation, which makes it difficult to achieve the desired effect. As a result, most designs have a high speed of opening and closing of the valve (sudden and difficult to close) and the system cannot change the movement amount of the valve[19].

The latest electromechanical valve actuator mechanism of the type of dish pan type plate does not use an iron or ferromagnetic armature instead of a armature that is a live coil[9]. An electromagnetic field is created by an electromagnetic field generator and directly passes through a fixed gap. An armature with a live armature coil is placed in the electromagnetic field in the void. When current flows through the armature coil and the current is perpendicular to the electromagnetic field, an impact force will affect the armature. When current flows across the armature coil horizontally or vertically in the electromagnetic field, an electromagnetic induction force (Lorentz force) will apply to the armature coil. The force generated on the armature causes the armature to move forward in the space parallel to the body of the pan. Depending on the direction of the current supplied to the armature coil, the pan will be moved to the pile or open position. The latest electromechanical potters have a higher development and better control of the force. compared to previous designs. These forces are constant throughout the armature's displacement because the size of the gap does not change.

Refer to Figures 1 to 4, an electromechanical valve set of a dish pan valve illustrates the construction of the suction or exhaust pan valve in the engine. The valve valve (22) includes a guide tube (28), the body of the valve (30), and the valve base (32). The Pupil Operator System (20) of the disc pan system generally consists of an outer box (34) with 2 upper and lower halves (36) and a lower half (42), an electromagnetic field generator consisting of a magnetic coil high (48) and high (52), a core (56) consisting of a high core (58) and a low core (68), and an armature (78) connected to the body of the valve. The best inductance coil is made of aluminum wire or other lightweight conductive materials. The reduction of the weight of the armature is intended to reduce the effect of inertial forces in both directions[21].

The ability of the actuator to act on the force generated in both directions and to the change in the magnitude of the force acting on the armature in both directions is an important advantage of this design. For example, changing the current flowing through the armature coil and or changing the intensity of the electromagnetic field can control the opening and closing speed of the pan. This method can also be used to slow down the movement of the valve, reducing the opening and closing speed of the valve as well as reducing the noise[22].

Fig. 1. Principle of disc valve actuator by electromechanical[17]

Fig. 2. New type electromechanical actuator driver[20]
This system can work without springs, as shown in Fig. 2 or may have springs as shown in Fig. 3

III. SPHERICAL VALVE WITH ELECTRO-MECHANICAL IMPACT

Unlike the regular dish, this type of valve has a spherical shape. The impact system of this type of valve consists of a marble that can move along a corridor. If the marble rotates along the path up to the opening of the marble, air may pass through it. The opening and closing of the valve pan is done by electromagnets arranged around its outside.

Refer to Figure 4, the valve cover (7) consists of 2 halves. Pancake balls (8) have two hardened pivots connected to balls (12). Disc (10) is fixed and driven to the valve ball and has electromagnets surrounding the circumference. Electromagnets (11) are located on both sides of the valve pan (8) and they are fixed with a valve pan.

The electromagnets are controlled via ECU electronic controller. A crankshaft sensor mounted on the engine crankshaft provides information about the relative position of the piston relative to the upper dead point. At the upper dead point of the cycle, the ECM unit can be used to polarize both electromagnets so that they are polarized opposite to the electromagnet of the pan balls, which rotate the pan balls into closed position.

By such a simple replacement, the efficiency of the spherical pan valve and the arrangement of the valve pan in the four-stroke engine eliminates all moving parts in the pan-type driver. This can even be an improvement beyond the camless pan-plate pan system - the bridge pan simply rotates on its axis to achieve the desired flow, further accelerating up and down in compliance. linearity. Incomplete mode can also be created to increase the turbulence of air flow into the engine, increasing the mixing effect of the fuel.

The total wind power potential of Vietnam is estimated at 513,360 MW, which is equal to more than 200 times the capacity of Son La hydropower and more than 10 times the total capacity forecasted by the electricity industry by 2020. Of course, to switch from theoretical potential potentials can be exploited, so that the technical potential and ultimately the economic potential is a long story [12]. Considering the standard for building small wind power stations for economic development in difficult areas, Vietnam has 41% of rural areas that can develop small wind power. If comparing this figure with neighboring countries, Cambodia has 6%, Laos has 13% and Thailand 9% of the rural area can develop wind volume. This is indeed a privilege for Vietnam but we are still indifferent to how to make use of it.

The electromechanical actuator won’t work well with the standard 12V electrical system; the auto industry chose the 42V system as the standard for automation [24].

IV. DISC VALVE WITH ELECTRO-HYDRAULIC IMPACT

In this section, the introduction of electro-hydraulic pan valve designs includes panes that can be moved between the first and second position. Energy use is a turbocharged hydraulic line and a hydraulic actuator mounted on the disc pan. The movement between the first and second position depends on the flow of the high-pressure hydraulic line. An electrically controlled hydraulic valve controls the flow of high-pressure fluid to the hydraulic actuator.
In one design, electricity is supplied to an electrically controlled 3-way valve to control the flow of the high-pressure fluid flow to the actuator. This valve is supplied with pressure oil when the electrical pulse is open, and discharges oil into the engine oil tank when the valve is reversed with the electrode to the closed position. The use of engine oil as a hydraulic oil supply simplifies the system and lowers the cost of the design by removing some of the details compared to a specific hydraulic system.

The basic hardware design of the electro-hydraulic valve set as shown in Figure 5. The disc-type pan-plate of the engine (22) and the springs of the valve valve (24) are used to restore the status of the valve. Disc-type panes are driven by actuators (26), which are driven by hydraulic electro-valves (28) to supply hydraulic oil to pipelines (29). The preferred hydraulic fluid is oil, which is supplied to the electro-hydraulic valves from the common pipe (30). A hydraulic pump hybrid engine (32) feeds pressure oil, receiving oil from the engine's oil tank (34). The pump outlet pressure is also limited by a no-load valve (36), and is also controlled by a reservoir (38) connected to a shared pressure oil pipe. With this design the hydraulic pump can be disconnected periodically, such as under braking mode, when the traction unit will work by the source of pressure oil in the tank[26].

Following the trend of all modern engine systems, camshaft engines are more reliable based on sensors. The special puffer and control system needs a common pressure sensor, a common temperature sensor, a flow sensor, a cooling temperature sensor, a piston speed sensor, an exhaust sensor, an engine position encoder with high analytical capability, a decoder for burning fuel time, electronic injection controller, coil of electronic control valve, Built-in electronic control of electronic combustion, electronic air speed controller and electronic power reducer[27]. A pan type of valve developed by industrial firm Sturman says its speed could be about six times faster than conventional hydraulic pan. To achieve such speed, it uses a small tube sandwiched between the two coils, a microprocessor-based controller that can quickly move the small tube forward and backward, thereby acting on the valve. engine appropriately.

V. BENEFITS OF CAMLESS ENGINES

The benefits of a cam freezer actuation are many. One of its greatest benefits is the ability to change time indefinitely.

Increasing torque can be created by trying to change a series of time values to obtain the optimum usable volume. This increases engine efficiency and reduces fuel consumption, also reduces toxic emissions, increases engine durability and longevity, and allows adjustment to suit different types of fuel, as well as the conditions of each region of activity.

The cessation of cylinder operation (eg from 8 cylinders to 6 cylinders) is also possible, with the combined reduction of exhaust. In addition, the reduction in fuel consumption can be achieved by combining the technology of the camshaft pan-less technology with a high-pressure direct fuel injection system. The amount of lubricant required for the engine is also reduced because there is no need to lubricate the previous complicated camshaft system. The engine start-up process is also optimized for the gas distribution system. The electromechanical actuator acts to increase the overall efficiency of the engine by eliminating friction losses of the camshaft components, reducing the engine weight and reducing the output power of the crankshaft, to hybridize gas distribution devices.

VI. COMPARE THE XUPAP SPEED BETWEEN THE MECHANICAL CAMSHAFT AND THE CAMLESS DRIVE

The enhancement of the speed of the valve driver and control system is illustrated in Figure 6.

The figure depicts a comparison of the speed of the valve effect between the engine using mechanical cam and camless engine. Journey length of the pan (inch) according to the rotation of a mechanical camshaft described on the chart[28].

On the graph, the open and close cycle of a pan valve is driven by a mechanical camshaft shaped like a sinusoidal curve. The open phase (measured according to the rotation of the crankshaft) remains a constant for any mode of load or rotation of the engine. However, the opening and closing of the pan valve is driven faster by the electromechanical actuator[29]. Designed in accordance with the opening rate of the valve at the minimum rotation of the engine, the electric actuator opening of the opening and opening of the opening at the same time is the same as the unexpected mode of exploitation of the engine. Due to this improvement in speed, it leads to greater flexibility in the situation with muffins, allowing for higher moomen levels, reduced exhaust emissions, and improved fuel economy. The large
opening stages for electromechanical valve actuators are also shown on the graph.

The control of the intake pan allows to control the air intake, minimizing unnecessary excess air, thereby improving the quality of combustion, reducing air loss and compressor capacity.

The use of a camshaft-free torque control allows pre-programming of engine reversals. This can be done simply by reversing a pair of input wires. The reversing process is a big advantage for ships equipped with two-axis propulsion or two single-propeller hybrid engines. This also allows the removal of the necessary mechanisms for reversing such as gears[30].

However, there are still big problems with electric control valve. The problem is not only in the software requirements but also the mechanical system of the actuator. The number of times the impact of the wire and steel core is not long, and the effect of poor impact at high revolutions is a matter of discussion.

VII. CONCLUSION

The main difference between a camshaft engine and a traditional engine is when we mention the traction method in both types of engines. In the traditional valve engine, the engine is driven by the use of camshafts, cam lugs and gears. But in camshaftless internal combustion engines all these parts are removed with electric or electro-hydraulic actuators which we have difficulty with conventional engines. Benefits such as reduced emissions, increased power output, and increased fuel efficiency can be achieved by using camless technology for internal combustion engines. From all of the above we can conclude that by applying camless technology to the internal combustion engine the performance of the machine will be enhanced.

REFERENCES