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Cam-Gears Forces, Velocities, Powers and Efficiency

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Abstract: The paper presents a method of the original type in order to determine the effectiveness of a mechanism camshaft and adept. The originality of this method consists of eliminating the friction. In this research analyzes the four types of side camshaft: 1. Camshaft rotary switch and the motherboard translated adept; 2. The mechanism with the camshaft rotary switch and openness to be translated with roll; The 3. The camshaft rotary switch and the rocking chair adept with roll; The 4. The camshaft rotary switch and the rocking chair adept. For any mechanism with the camshaft and the follower is uses a different method to determine the most efficient design. We take into account the mechanism (the timing end) cam, which is the second of the mechanism in internal combustion engines. Optimization of this mechanism (timing end), can improve the functionality of the engine and may increase the comfort of the vehicle too.

Keywords: Kinematics, Forces, Velocities, Powers, Cam, Cams, Efficiency, Translated Follower, Rocking-Follower, Follower with Roll

Introduction

In mechanics, the distribution groups together the mechanisms that ensure the intake and exhaust of gases in the cylinders of an internal combustion engine. The camshaft, valves or timing belt are a non-exhaustive list of components of the distribution (Fig. 1).

During its operation, an internal combustion engine performs various phases carried out in a precise order called "time". In order for these to proceed in an orderly manner, it is necessary to synchronize the different phases. A two-stroke engine uses few mechanical parts insofar as it is necessary to discover, during the stroke of the piston, different inlet and outlet ports of the fuel mixture at the intake and of the burnt exhaust gases and Sometimes of actuating, by depression, of the valves on the admission circuit. The four-stroke engine is a more complex system because it uses many moving parts simultaneously and synchronously moving closer to a timepiece movement1. In this case, the circular movement described by the crankshaft is transmitted to the opening mechanism of the valves (the camshaft (s)) either by belt or by chain of transmission, or else by a cascade of pinions. Engines of rather old design are equipped with a chain, or a cascade of pinions, to transmit the movement of the crankshaft to the camshaft. Their lifetime is theoretically equal to that of the entire engine, if properly lubricated, however these drive techniques are power consuming, at acceleration, because of their inertia, because they are quite heavy. They hinder the overall mechanical efficiency of the engine. In modern engines, very often, timing belts are used. They have the advantage of requiring no lubrication and being silent; On the other hand, their periodic replacement is imperative (every 50 000 to 240 000 kilometers, but also after a few years, between five and ten years, when the mileage is not reached, due to the progressive degradation of the components of this belt, Essentially rubber coating a braid (core) made of aramid or fiberglass). Breaking this belt is definitely destructive for the entire high engine, except for non-interference engines (the pistons in the high position can't touch the valves even if they are lowered to the maximum).

First we See the Role of Valves

Already the valves are part of the 4 stroke engines the 2 stroke engines have no valves but lights. The purpose of the valves is to allow the admission of the air/fuel mixture and the evacuation of the flue gases, but also to seal the combustion chamber at the time of the explosion - seeing the engine running - and you generally have 2 valves (Usually why, some engines may have more, but in moto culture it is rare).

There are 2 types of motors, with overhead valves and side valves, the principle of operation for the engine is the same, the position of the valves differs, that the position of the valves at the head allows a better mixing of the intake and a more direct evacuation.

Currently the majority of engines are equipped with overhead valves.

We have seen in the operation of the engine the way in which the valves are actuated and the function of the springs, we have also seen the necessity of a play in contact with the push-pieces/valves, in fact the moving organs dilate not in the same way and thus without this margin the risk is that the pushers remain in contact with the valve and thus prevents the complete closure of the latter, with time and wear, this clearance can be modified in one direction and thus alter the operation of the combustion chamber (combustion chamber: Part between the piston head in the high position and the top of the cylinder head).

Either the clearance has become too large is in this case the opening of the valve is too weak (either the reverse and closing the valve, are not complete). It is therefore one of the first possible failures. In order to control this clearance, it is generally not necessary to carry out an important disassembly, for the overhead valves it is sufficient to dismantle the rocker arm cover to gain access to the valves and for side valve motors it can generally be accessed by a cover on the motor side.

To control the clearance you need a clearance and the instructions of the manufacturer, then simply put one of the valves in maximum opening and check the clearance of the other valve. Now on some engine, mainly with side valves the setting is non-existent except to grind the valve stem.

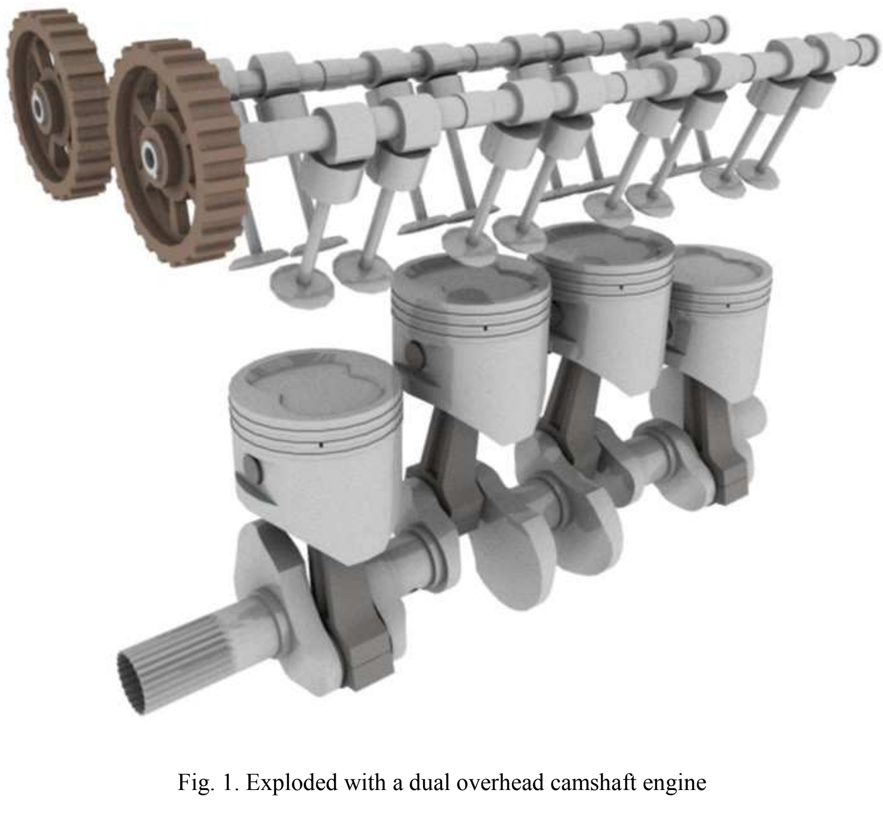

Fig. 1. Exploded with a dual overhead camshaft engine

Other Valve Failures

A valve operates in extreme conditions, the temperature first of the order of 500°C the exhaust valve is the most exposed, the temperature can exceed 700°C, the rate, for a motor running at 4000 Turns the valve opens and closes 33 times per second, you will easily understand that under these conditions any deviation of play can cause problem, even a bad cooling of the engine and Go! The valve takes 100°C more. In addition the combustion of the air/petrol mixture is not perfect (in addition, if the engine is improperly adjusted), residues of combustion result, which can accumulate in the combustion chamber and valve.

Temperature Problem

Seat-Valve

Mainly for the exhaust valve an abnormal rise in the internal temperature can burn the valve and as a result deteriorate the bearing part on the valve seat.

If the marking of the valve is not too great, a valve break-in may be sufficient, in other cases it will be necessary to replace the valve and according to the state of the seat either to realize it or for certain engine, which can be replaced.

Valve Breaking

The aim of the valve break-in is to improve the contact of the valve with the seat, the parts are in contact with a width of 1 to 1.5 mm with an angle of 45 to 30°, needless to say, imperfection to consequences. For lapping you need lapping paste and a suction cup, the principle is to coat the bearing part of the dough valve to rotate it on its seat with the suction cup, you have several grains of dough including a fine grain for finishing. The operation is fairly simple, but nevertheless requires removal of the cylinder head and valve springs.

Small flat even when the running-in of valves is done cold and the range of the valve with its seat is not exactly identical engine warm, cold engine. This is why mechanics workshops prefer to start on new or on a reaming.

Problem with Calamine

When combustion is never perfect, deposits are created, the majority is ejected by the exhaust, but over time a tiny part is deposited on the head of the piston, the cylinder head and the valves. Residues which in the long run can cause problems (especially as with age the engine tends to consume oil) and therefore pollute more. It is this scale that when deposited on the valve can hinder its closing and therefore causes loss of compression, this loss of compression you will feel quickly by difficulties in starting hot engine.

The remedy will be to prowl the valves.

Sealed Valve

It happens on engines that have not been turned for some time or on engines that sleep outside, that a valve influences, the valve to perform its reciprocating slides in a particularly calibrated guide and adjusted to the diameter of the tail Of valve, it is therefore possible that over time an oxidation occurs and influences the valve, in principle a little of the unlock will solve the problem, if not it must be disassembled.

Oil Rise

Yes, but! This seizure will have a high chance of subsequently causing rising oil, indeed the valve just slides in its guide but also needs to be lubricated and, to avoid the rising of oil there is a seal. It is the deterioration of this joint which can cause the oil to rise and there dismantling and change of the joint, especially since this rise of oil goes directly into the cylinder and thus contributes to the deposit of scale.

The cycle of Beau de Rochas, four-cycle cycle or even Otto cycle is a theoretical thermodynamic cycle. Its main practical interest lies in the fact that internal combustion engines with spark-ignition, generally gasoline engines such as those used in automobiles, have a practical thermodynamic cycle which can be represented in an approximate manner by the cycle of Beau de Rochas.

Its principle was patented for the first time on 26 October 1860 by Christian Reithmann (de), who was inspired by the two-stroke engine of Étienne Lenoir.

It was patented again by Beau de Rochas in 1862 (the patent of Reithmann expiring in 1861) and then successfully implemented by Étienne Lenoir (1863).

Nikolaus Otto initially described in 1876 the stroke of the piston in a movement from top to bottom in a cylinder. Otto's patent was reversed in 1886 after it was discovered that Beau de Rochas had already described the principle of the four-cycle cycle in a private broadcasting brochure in 1862, but he had, however, filed the patent.

This cycle is characterized by four times or linear movements of the piston.

Admission: The cycle begins at top dead center, when the piston is at its highest point. During the first stage the piston descends (intake), a mixture of air and fuel from the carburetor or injection is sucked into the cylinder via the intake valve.

Compression: The intake valve closes, the piston ascends compressing the admixture.

Combustion-Relaxation: The air-fuel mixture is then ignited, usually by a spark plug, just before the second top dead center (full rise of the piston). The pressure of the flaming gases carried at high temperature produces the complete combustion of the air-fuel mixture and the expansion of the gases, which forces the piston to descend for the third time (combustion-expansion).

Exhaust: During the fourth and last stage the exhaust valve opens to evacuate the burned gases pushed by the rise of the piston.

The theoretical cycle as described above very well presents the principle. In practice, there are subtleties that add up. Indeed, between each theoretical time, there are transitions, or even half-times. At the compression cycle, for example, the valves close again after the piston begins to rise. So we're talking about a delay. As the exhaust cycle proceeds and even before the piston is at its upper level, the intake valve is already open. The exhaust valve closes as the piston begins its descent and fresh air is already present in the cylinder. The four-stroke engine is actually very flexible and by playing with the valve opening times, each engine is fit to have its own character and features in terms of pollution. Modern motors play a lot with these parameters by varying them continuously in operation. It is the result of electronics.

Intake and Exhaust

The intake and exhaust of the gases are generally controlled by valves although there are other systems with oscillating liner or distribution discs.

For an atmospheric engine, the air intake is at the ambient pressure (defined as approximately one bar) which attempts to fill the vacuum left by the exhaust phase. There are, of course, head losses which limit the full filling of the cylinder, but with the dynamics of the fluids, it is possible to see fillings that exceed atmospheric pressure without external help. For a petrol engine, the volume of air entering the cylinder is controlled and a quantity of gas is injected into it to obtain a good air/fuel mixture. Thus, when the engine works little, an important restriction is exerted so as to have a motor behaving somewhat like a vacuum pump. Thus, the greater the cylinder capacity of an engine, the greater the energy required to operate this vacuum pump for the same engine speed.

The diesel engine is distinguished by the fact that the cylinder always fills to the maximum when there is no control of the volume of incoming air. The control is done only by injecting the quantity of fuel in order to obtain the desired power. The engine working less like a vacuum pump automatically leads to better efficiency when the engine is not at full load.

Given that a four-stroke engine runs its cycle on two crankshaft turns, it follows that a 1-liter engine for example aspires at best a half-liter per revolution. A two-stroke engine of 1 liter displacement aspires for it 1 liter of air per revolution, leading to a potential of more power for the same displacement.

A supercharged engine does not operate at atmospheric pressure an over-power system (turbocharger, volumetric compressor, etc.) charges the engine with an equivalent volume of air greater than the engine displacement. It's a bit like making the engine look bigger than it actually is. Thus, if a motor is supplied with a supercharging pressure of one bar (i.e., a bar above atmospheric pressure), the cylinder is filled with a volume twice as large as at atmospheric pressure. Twice as much air allows a potential power twice as high. There are many other factors that come into play, but the principle is there.

On the first combustion engines, the intake side was often neglected with small valves, or even (very rare) activated by the vacuum inside the cylinder. The exhaust valves were larger with the idea of compensating for the expansion of the air created by the combustion. These perceptions have long changed and intake valves are still larger than exhaust valves.

Advantages and Disadvantages

In the case of a fuel intake with air (carburettor or indirect injection) the four-stroke cycle has a better efficiency than the two-stroke cycle but with equal displacement it is less efficient. In addition, a 4-stroke engine requires a complex distribution (valves, camshafts, etc.). As on the 4 strokes a single stroke is motor (the 3rd, which directly follows the combustion) the piston delivers mechanical energy once every 2 turns, then irregularities occur in the torque of the engine. A disadvantage may be cited, 4-stroke engines are long and expensive to repair due to the number of parts required for their operation. For direct fuel intake engines in the cylinder, the mechanical gains of the two-stroke cycle provide better efficiency (no loss of fuel in the exhaust), but the emissions of the two-stroke pollutants remain higher.

Combustion and Explosion Engine

The term "combustion and explosion engine" refers to any type of internal combustion engine with reciprocating or rotary, diesel or spark-ignition internal combustion engines in which gases burn with a flame front whose speed is normally lower than that of sound. This engine is mainly used for the propulsion of transport vehicles (such as airplanes, cars, motorcycles, trucks, boats) but also for many mobile tools such as chainsaws, lawn mowers and many fixed installations, (Pumps, etc.).

An explosion or detonation is a particular form of combustion in which the velocity of the flame front is at least partly supersonic. In spark-ignition engines, detonation is a malfunction (rattling), normally it is a deflagration that occurs within these engines.

Four-Stroke Spark-Ignition Engine

These are all engines that use gasoline, alcohol, or even a gas (LPG, etc.) as fuel and whose combustion must be triggered by an external source of energy (candle, Shaker, breaker, Delco, etc.).

These motors convert the potential energy, chemical, stored in a fuel in work (mechanical energy) thanks to very rapid combustion, hence the term, unjustly used, of "explosion". They consist of one or more cylinders to confine the combustion and use energy. In each cylinder, a piston slides in an alternating rectilinear motion. This movement is transformed into rotation by means of a connecting rod connecting the piston to the crankshaft, an assembly of cranks on an axis.

A camshaft is a mechanical device for synchronizing several displacements. As its name indicates, it is a tree with several cams. It transforms the continuous rotation movement of the shaft into an alternating translation movement (for example of a valve), or alternatively of rotation (for example of a rocker arm).

The first trace of a camshaft is found in the construction, by the Greeks, in the Hellenistic period, in the 2nd century BC. J.-C. (in hydraulic automatic). It is also found in some automata of Heron of Alexandria.

The camshaft is used by the Romans to crush the gold ore and to make the tannin used to treat the leathers. It is attested in the Roman gold mines of Wales and the northeast of the Iberian peninsula, as well as in a tannery of the second half of the second century (or early fourteenth century) in Saepinum, Italy.

Bertrand Gilles locates the use of the camshaft in the eleventh century.

The camshaft was also described at the end of the twelfth by the scholar Al-Djazari who mainly used it in water mills specialized in the threshing of iron or leather tanning (transformation of rotary movement, resulting from the driving of the paddlewheel by the water, in longitudinal movement). According to Jean Guimpel, in "The Industrial Revolution of the Middle Ages", the camshaft appeared around the twelfth century and was used in mills (especially water mills) which carried out operations such as tanning hides and other.

Today, the camshaft is an essential part of the internal combustion engine. The camshaft, also known as the "timing shaft", controls the opening of the valves, by transforming the rotary motion from the motor into longitudinal movement actuating the valves. It is a shaft driven by sprockets, chain or toothed belt.

Industrial Use

The camshaft was used in different industries:

For the manufacture of pulp a camshaft was used to produce a reciprocating motion at one, or several, masses. This tree is generally made of wood, with attached cams, either wooden or metallic.

To raise the hammers of the fullers in mills which treat the "crushing" of wool or animal skins (to rid them of fats and other impurities). In the industry, a hammer is a set of hammer driven by a camshaft.

Camshaft in the Engine

The camshaft is a mechanical part used mainly in 4-stroke internal combustion engines for the synchronized control of the valves. It consists of a cylindrical stem with as many cams as there are valves to be controlled independently or in groups, sliding on the valve stem, or on a mechanical gear (e.g., the shoe of a rocker arm). It is placed at the crankshaft (in the case of a tumbled engine, described below, or a lateral valve engine), or on the cylinder head (in the case of a so-called camshaft engine in the head").

The synchronization of the camshaft with the drive shaft takes place via sprockets, chain or toothed belt. The design and physiognomy of the engine determine the angular position of the camshaft. The possible arrangements also depend on the engine architecture and its performance. Thus, in four-stroke internal combustion engines, the complete combustion cycle requires two crankshaft turns for one revolution of the camshaft. The latter must therefore rotate half the speed of the engine crankshaft. The follower element of the cams (the part in contact with one of the cams of the shaft) takes, depending on the case, different names: When this element is subjected to a rectilinear translation movement, it is called pusher, centered or eccentric depending on whether its axis meets that of the camshaft. If it performs an oscillating movement of rotation about an axis, it bears the name of rocker; It can also be directly the valves themselves. As mentioned above, the shaft controls the opening of the valves. The valve stem (underneath) is subjected to a spring, which keeps it closed when the cam does not attack (directly or indirectly, by means of the pusher or rocker arm). When the cam engages, the valve is mechanically pushed on its axis perpendicular to the axis of rotation of the camshaft. The openings and closures of the valves are thus totally mechanically, at a certain rate depending on the engine speed. The materials used for the manufacture of camshafts must be able to withstand wear, taking into account the considerable friction with the tappets or rocker arms, especially during cold starts when lubrication is not yet ensured under pressure. In general, in particular for large-scale engines, hardened castings are used on the cams and bearing surfaces 4. The design of the cams is very important because their profiles determine: The moment of opening of the valves; The duration of the opening; The physiognomy of lifting the valves (distribution diagram). The profile of the cams is different for the intake or exhaust valves, due to the laws governing their operation (Fig. 2).

At the beginning of the automobile era, the camshaft was arranged laterally in the crankcase and controlled only the exhaust valves arranged laterally to the cylinder. The inlet valves automatically opened by vacuum at the inlet. later, an additional set of cams was added to the shaft for the control of the intake valves. The valves were always arranged laterally and actuated by pushers. This configuration simplified the drive of the shaft by the crankshaft, implementing a simple gear train. However, the lateral valves did not make it possible to achieve high compression ratios due to the mechanical play induced by the action of the multiple parts; therefore, the yield remained low. This arrangement also imposes a large dead space in the cylinder head, unnecessarily increasing the volume of the combustion chamber. After 1910, moving the valves in the cylinder head, while keeping the side camshaft, imposed the rocker arms. This distribution system has been adopted on a very large scale for about seven decades. However, the mass of the tappets, rods and rocker arms became important, requiring careful adjustments and greatly limiting the speed of rotation of the engine.

The overhead camshaft, which had appeared in 1903 on a motor car engine of the English Mandslay, was adopted in series by Isotta Fraschini in 1905 on the model D 100 HP and only much later Production in large industrial series.

A system with two overhead camshafts is often preferred to us, for its many advantages in the V-shaped arrangement of valves on high-efficiency motors.

The Peugeot Grand Prix 7.6 liters was the first to inaugurate this technique in motorsport.

In a tumbling engine, the camshaft is located laterally and near the crankshaft (called the lateral motor) and transmits its movement to the valves via rods and rockers.

The problem with this type of engine is that the kinematic chain includes many reciprocating movements (rods, rocker arms and valves).

The weight of all these moving parts gives a certain inertia to the kinematic chain, which limits the rise in engine speed but also the maximum speed of the engine and therefore the maximum engine power (Fig. 3).

Overhead Camshaft

The overhead camshaft (SOHC) is a particular arrangement of the camshaft (s) above the cylinder head in order to improve the control of the valves by a drastic reduction of the moving parts, their weight and therefore the inertia. In order to avoid valve leakage at high speeds (about 4000 rpm or more), it is necessary to minimize reciprocating parts such as tappets, rocker arms and rocker arms themselves. The elimination of these parts eliminates the inertia and parasitic mechanical play and the control accuracy of the valves is improved. To do this, the camshaft (s) is placed directly above the valves.

Fig. 2. An engine Camshaft

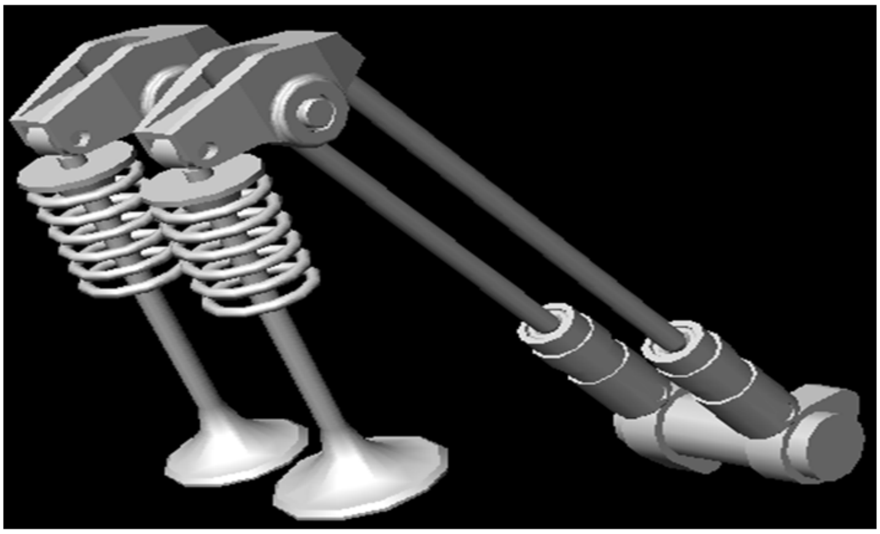

Fig. 3. Diagram of a tumbled engine with rods and tippers

In a overhead valve engine, it is customary to transmit the valve opening control by a rotary movement taken from the crankshaft, which in this case is transmitted directly to a camshaft. By arranging this camshaft at the top, i.e., at the top of the engine, immediately above the valves and no longer at the crankshaft but away from the valves, the shaft-to-valve return rods are no longer necessary. On the other hand, the synchronization of the shaft and the crankshaft, which are remote from one another, must be done by transmission, that is to say with a shift of their axes of rotation (which also permits possible angular offsets). Initially adopted in competition on innovative engine architectures, this solution has gradually been generalized to all passenger car engines, due to its reliability and its low cost.

The transmission of the rotation of the crankshaft to the camshaft is done by a chain, a toothed belt, a cascade of pinions, a shaft with conical couples, or even exceptionally a connecting rod (NSU). It is necessary simply to maintain a strict synchronization with a ratio of two turns of crankshaft for one turn of camshaft, in the typical case of a four-stroke engine. When all valves are on the same line, a single camshaft is enough to actuate all the valves without the need for rocker arms or a second shaft. More complex engine architectures sometimes require dual overhead camshafts. For a long time, manufacturers have shunned the overhead camshaft for mass production cars, because of maintenance costs (access to parts), lubrication problems and changes in engine production lines. In fact, since the overhead camshafts were of interest only to reach high speeds, it was customary to reserve them for sports engines. Nowadays, the majority of automotive engines are equipped with overhead camshafts, often double, to operate the current 16 valves on modern inline 4-cylinder engines. V-shaped engines using this technology take up more space in the engine compartment of cars than lateral or overhead valve engines with rocker arms. Overhead camshaft engines achieve maximum torque and maximum horsepower at higher engine speeds than overhead valve actuators with rocker arms. To maximize performance, vehicle manufacturers must therefore match them with high-ratio transmissions (six-speed gearboxes, etc.; Fig. 4).

Double Overhead Camshaft

The notion of double shaft is conceivable only for each row of cylinders. For example, a V engine with only one camshaft per row of cylinders is considered a single shaft, although it has two camshafts in total. Sometimes, several motors with several rows of cylinders are called "QOHC" or quadruple overhead camshaft. This in fact refers to a motor where each row of cylinders has a double overhead camshaft. Thus, the terms "V6 DOHC" or "V6 QOHC" refer strictly to the same thing. The double camshaft is often associated with distributions using four valves per cylinder, but this is not an obligation.

Double camshaft engines began in 1912 at Peugeot thanks to Ernest Henry and Fiat. The dual overhead camshaft (2 ACT) was regularly used in competition in the 1920s. Salmson, as early as 1922, produced consumer automobiles with this technique, enabling it to compete with motors much larger in the 1940s. The technique of the double camshaft at the top became widespread in the 1960s to the whole of automobile production. The Fiat 124 in its sedan, coupe and spyder was the beneficiary from 1966.

Fig. 4. Overhead camshaft

In the early 1970s, in order to allow a good centering of the spark plug in the cylinder head, as well as an easier adjustment of the distribution laws, one camshaft was placed for the intake valves and another for the valve 'exhaust. The space between the shafts makes it possible to place the spark plug in the center of the combustion chamber.

By motorcycle, the generalization on the passenger cars was the fact of the Japanese manufacturers.

The Double Overhead Camshaft (DOHC) is a variant of the overhead camshaft, where the rows of intake and exhaust valves are operated by a different camshaft. This technique allows almost all intermediate parts to be removed between the camshaft and the valve, without the necessity of aligning all the valves. Due to the reduction in weight of each weapon, the motor can thus turn faster while producing less friction and mechanical noises due to play. Several developments concerning the distribution and the camshafts are to be noted.

Variable distribution motors make it possible to modify the distribution laws according to the engine speed and the action of the driver on the accelerator, with the aim of improving the efficiency of the engine at high and low speed. For example, camshaft (Toyota VVTI) shift systems, Honda VTEC, or 2-4 valves per cylinder (Honda 800 VFR) have been developed.

Camless technology is also linked to the variable valve timing, in which case the valves are controlled not by a camshaft but by electromagnetic actuators.

This technology makes it possible, via a computer, to independently control each valve according to all known parameters of the engine at a given instant, which makes it possible to better manage torque, efficiency, gas temperatures or pollution (Fig. 5), (Angelas and Lopez-Cajun, 1988; Antonescu *et al*., 2000; Ge, 2011a; 2011b; Ghazimirsaied, 2010; Giordana *et al*., 1979; Hain, 1971; Hamid, 2011; Liu and Qian, 2011; Petrescu and Petrescu, 1995; 2005; Petrescu, 2008; Samim, 2008; Shriram, 2012; Taraza, 2002; Wang, 2011; Xianying, 2012; Zhao *et al*., 2012; Zhou *et al*., 2012).

The paper presents a method of the original type in order to determine the effectiveness of a mechanism camshaft and adept.

The originality of this method consists of eliminating the friction. In this research analyzes the four types of side camshaft: 1. camshaft rotary switch and the motherboard translated adept; 2. The mechanism with the camshaft rotary switch and openness to be translated with roll; The 3. The camshaft rotary switch and the rocking chair adept with roll; The 4. The camshaft rotary switch and the rocking chair adept.

For any mechanism with camshaft and follower one uses a different method to determine the most efficient design. One takes into account the mechanism (the timing end) cam, which is the second of the mechanism in internal combustion engines.

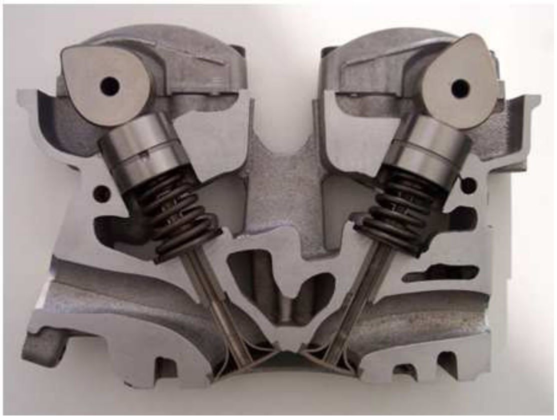

Fig. 5. Double overhead camshaft

Optimization of this mechanism (timing end), can improve the functionality of the engine and may increase the comfort of the vehicle too.

Determining of Momentary Mechanical Efficiency of the Rotary Cam and Plate Translated Follower

The consumed motor force F_c, perpendicular in A to the vector r_A, is divided into two components: (a) F_m, which represents the useful force, or the motor force reduced to the follower; (b) F_ψ, which is the sliding force between the two profiles of cam and follower (Fig. 6). See the written relations (2.1-2.10):

$$F_m = F_c \cdot \sin\tau \tag{2.1}$$

$$v_2 = v_1 \cdot \sin\tau \tag{2.2}$$

$$P_u = F_m \cdot v_2 = F_c \cdot v_1 \cdot \sin^2\tau \tag{2.3}$$

$$P_c = F_c \cdot v_1 \tag{2.4}$$

$$\eta_i = \frac{P_u}{P_c} = \frac{F_c \cdot v_1 \cdot \sin^2\tau}{F_c \cdot v_1} = \sin^2\tau = \cos^2\delta \tag{2.5}$$

$$\sin^2\tau = \frac{s'^2}{r_A^2} = \frac{s'^2}{(r_0+s)^2 + s'^2} \tag{2.6}$$

$$F_\psi = F_c \cdot \cos\tau \tag{2.7}$$

$$v_{12} = v_1 \cdot \cos\tau \tag{2.8}$$

$$P_\psi = F_\psi \cdot v_{12} = F_c \cdot v_1 \cdot \cos^2\tau \tag{2.9}$$

$$\psi_i = \frac{P_\psi}{P_c} = \frac{F_c \cdot v_1 \cdot \cos^2\tau}{F_c \cdot v_1} = \cos^2\tau = \sin^2\delta \tag{2.10}$$

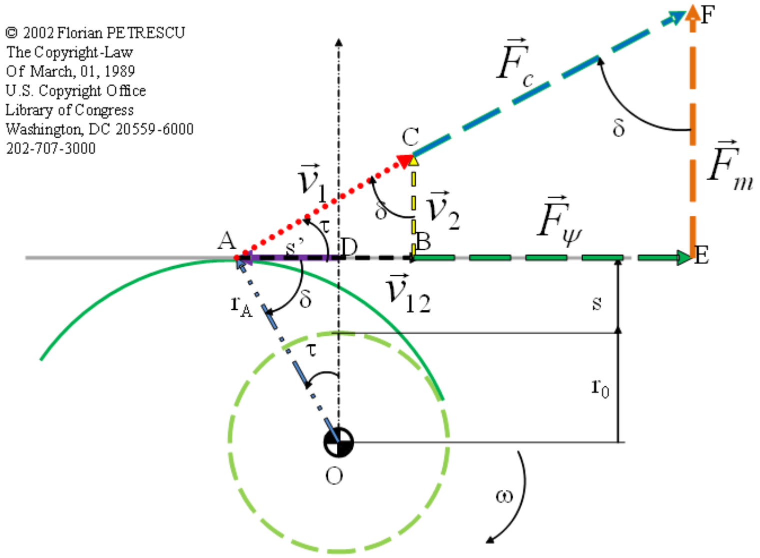

Fig. 6. Forces and speeds to the cam with plate translated follower

Determining of Momentary Dynamic Efficiency of the Rotary Cam and Translated Follower with Roll

The pressure angle δ (Fig. 7), is determined by relations (3.5-3.6). We can write the next forces, speeds and powers (3.13-3.18). F_m, v_m, are perpendicular to the vector r_A at A. F_m is divided into F_a (the sliding force) and F_n (the normal force). F_n is divided too, into F_i (the bending force) and F_u (the useful force). The momentary dynamic efficiency can be obtained from relation (3.18).

The written relations are the following:

$$r_B^2 = e^2 + \left(s_0 + s\right)^2 \tag{3.1}$$

$$r_B = \sqrt{r_B^2} \tag{3.2}$$

$$\cos\alpha_B \equiv \sin\tau = \frac{e}{r_B} \tag{3.3}$$

$$\sin\alpha_B \equiv \cos\tau = \frac{s_0 + s}{r_B} \tag{3.4}$$

$$\cos\delta = \frac{s_0 + s}{\sqrt{(s_0+s)^2 + (s'-e)^2}} \tag{3.5}$$

$$\sin\delta = \frac{s'-e}{\sqrt{(s_0+s)^2 + (s'-e)^2}} \tag{3.6}$$

$$\cos(\delta+\tau) = \cos\delta\cdot\cos\tau - \sin\delta\cdot\sin\tau \tag{3.7}$$

$$r_A^2 = r_B^2 + r_b^2 - 2\cdot r_b\cdot r_B\cdot\cos(\delta+\tau) \tag{3.8}$$

$$\cos\alpha_A = \frac{e\cdot\sqrt{(s_0+s)^2+(s'-e)^2} + r_b\cdot(s'-e)}{r_A\cdot\sqrt{(s_0+s)^2+(s'-e)^2}} \tag{3.9}$$

$$\sin\alpha_A = \frac{(s_0+s)\cdot[\sqrt{(s_0+s)^2+(s'-e)^2} - r_b]}{r_A\cdot\sqrt{(s_0+s)^2+(s'-e)^2}} \tag{3.10}$$

$$\cos(\alpha_A-\delta) = \frac{(s_0+s)\cdot s'}{r_A\cdot\sqrt{(s_0+s)^2+(s'-e)^2}} = \frac{s'}{r_A}\cos\delta \tag{3.11}$$

$$\cos(\alpha_A-\delta)\cdot\cos\delta = \frac{s'}{r_A}\cdot\cos^2\delta \tag{3.12}$$

$$\begin{cases} v_a = v_m\cdot\sin(\alpha_A-\delta) \\ F_a = F_m\cdot\sin(\alpha_A-\delta) \end{cases} \tag{3.13}$$

$$\begin{cases} v_n = v_m\cdot\cos(\alpha_A-\delta) \\ F_n = F_m\cdot\cos(\alpha_A-\delta) \end{cases} \tag{3.14}$$

$$\begin{cases} v_i = v_n\cdot\sin\delta \\ F_i = F_n\cdot\sin\delta \end{cases} \tag{3.15}$$

$$\begin{cases} v_2 = v_n\cdot\cos\delta = v_m\cdot\cos(\alpha_A-\delta)\cdot\cos\delta \\ F_u = F_n\cdot\cos\delta = F_m\cdot\cos(\alpha_A-\delta)\cdot\cos\delta \end{cases} \tag{3.16}$$

$$\begin{cases} P_u = F_u\cdot v_2 = F_m\cdot v_m\cdot\cos^2(\alpha_A-\delta)\cdot\cos^2\delta \\ P_c = F_m\cdot v_m \end{cases} \tag{3.17}$$

$$\eta_i = \frac{P_u}{P_c} = \frac{F_m\cdot v_m\cdot\cos^2(\alpha_A-\delta)\cdot\cos^2\delta}{F_m\cdot v_m} = [\cos(\alpha_A-\delta)\cdot\cos\delta]^2 = [\frac{s'}{r_A}\cdot\cos^2\delta]^2 = \frac{s'^2}{r_A^2}\cdot\cos^4\delta \tag{3.18}$$

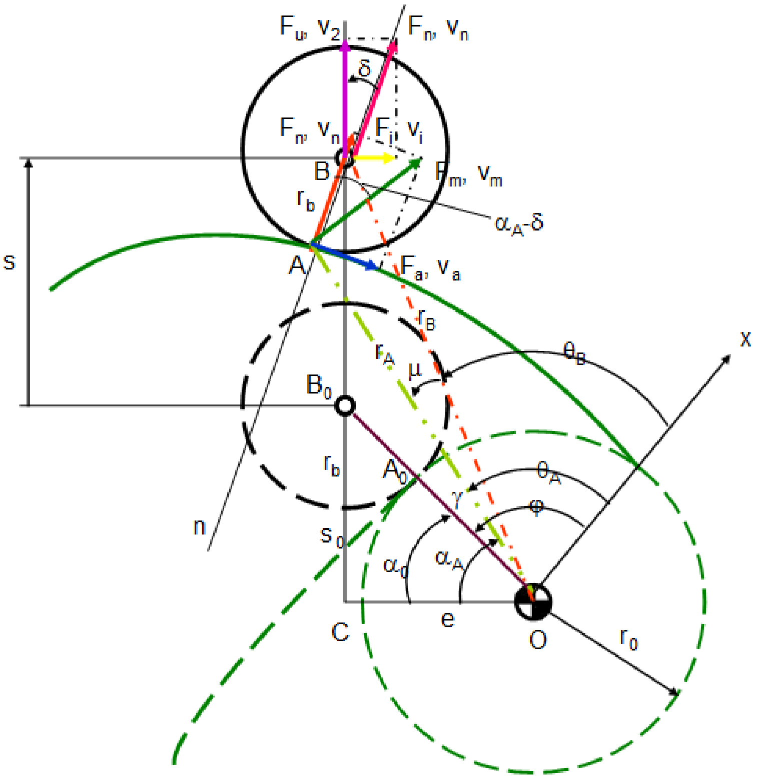

Fig. 7. Forces and speeds to the cam with translated follower with roll

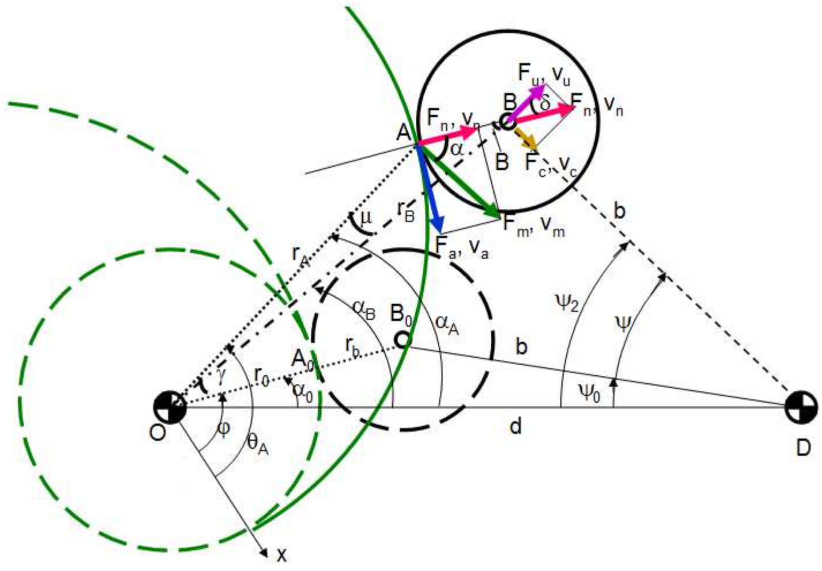

Fig. 8. Forces and speeds for the rotary cam and rocking follower with roll

Determining of Momentary Dynamic Efficiency of the Rotary Cam and Rocking Follower with Roll

F_m, v_m, are perpendicular to the vector r_A at A. F_m is divided into F_a (the sliding force) and F_n (the normal force). F_n is divided too into F_c (the compressed force) and F_u (the useful force); Fig. 8. The written relations are the following (4.1-4.31):

$$\cos\psi_0 = \frac{b^2 + d^2 - (r_0 + r_b)^2}{2 \cdot b \cdot d} \tag{4.1}$$

$$\psi_2 = \psi + \psi_0 \tag{4.2}$$

$$RAD = \sqrt{d^2 + b^2(1-\psi')^2 - 2bd(1-\psi')\cos\psi_2} \tag{4.3}$$

$$\sin\delta = \frac{d\cdot\cos\psi_2 + b\cdot\psi' - b}{RAD} \tag{4.4}$$

$$\cos\delta = \frac{d\cdot\sin\psi_2}{RAD} \tag{4.5}$$

$$r_B^2 = b^2 + d^2 - 2\cdot b\cdot d\cdot\cos\psi_2 \tag{4.6}$$

$$\cos\alpha_B = \frac{d^2 + r_B^2 - b^2}{2\cdot d\cdot r_B} \tag{4.7}$$

$$\sin\alpha_B = \frac{b\cdot\sin\psi_2}{r_B} \tag{4.8}$$

$$\sin(\delta+\psi_2) = \sin\delta\cos\psi_2 + \sin\psi_2\cos\delta \tag{4.9}$$

$$\cos(\delta+\psi_2) = \cos\delta\cos\psi_2 - \sin\psi_2\sin\delta \tag{4.10}$$

$$B = \delta + \psi_2 + \alpha_B - \frac{\pi}{2} \tag{4.11}$$

$$\cos B = \sin(\delta + \psi_2 + \alpha_B) \tag{4.12}$$

$$\sin B = -\cos(\delta + \psi_2 + \alpha_B) \tag{4.13}$$

$$\cos B = \sin(\delta+\psi_2)\cdot\cos\alpha_B + \sin\alpha_B\cdot\cos(\delta+\psi_2) \tag{4.14}$$

$$\sin B = \sin(\delta+\psi_2)\cdot\sin\alpha_B - \cos\alpha_B\cdot\cos(\delta+\psi_2) \tag{4.15}$$

$$r_A^2 = r_B^2 + r_b^2 - 2\cdot r_b\cdot r_B\cdot\cos B \tag{4.16}$$

$$\cos\mu = \frac{r_A^2 + r_B^2 - r_b^2}{2\cdot r_A\cdot r_B} \tag{4.17}$$

$$\sin\mu = \frac{r_b}{r_A}\cdot\sin B \tag{4.18}$$

$$\alpha_A = \alpha_B + \mu \tag{4.19}$$

$$\cos\alpha_A = \cos\alpha_B\cos\mu - \sin\alpha_B\sin\mu \tag{4.20}$$

$$\sin\alpha_A = \sin\alpha_B\cos\mu + \cos\alpha_B\sin\mu \tag{4.21}$$

$$\alpha = \pi - \alpha_A - \psi_2 - \delta \tag{4.22}$$

$$\cos\alpha = -\cos(\psi_2+\delta+\alpha_A) = \sin(\psi_2+\delta)\cdot\sin\alpha_A - \cos(\psi_2+\delta)\cdot\cos\alpha_A \tag{4.23}$$

$$\cos\alpha = \frac{\psi'\cdot b}{r_A}\cdot\cos\delta \tag{4.24}$$

$$\cos\alpha\cdot\cos\delta = \frac{\psi'\cdot b}{r_A}\cdot\cos^2\delta \tag{4.25}$$

$$\begin{cases} F_a = F_m\cdot\sin\alpha \\ v_a = v_m\cdot\sin\alpha \end{cases} \tag{4.26}$$

$$\begin{cases} F_n = F_m\cdot\cos\alpha \\ v_n = v_m\cdot\cos\alpha \end{cases} \tag{4.27}$$

$$\begin{cases} F_c = F_n\cdot\sin\delta \\ v_c = v_n\cdot\sin\delta \end{cases} \tag{4.28}$$

$$\begin{cases} F_u = F_n\cdot\cos\delta = F_m\cdot\cos\alpha\cdot\cos\delta \\ v_2 = v_n\cdot\cos\delta = v_m\cdot\cos\alpha\cdot\cos\delta \end{cases} \tag{4.29}$$

$$\begin{cases} P_u = F_u\cdot v_2 = F_m\cdot v_m\cdot\cos^2\alpha\cdot\cos^2\delta \\ P_c = F_m\cdot v_m \end{cases} \tag{4.30}$$

$$\eta_i = \frac{P_u}{P_c} = \cos^2\alpha\cdot\cos^2\delta = (\cos\alpha\cdot\cos\delta)^2 = \left(\frac{\psi'\cdot b}{r_A}\cdot\cos^2\delta\right)^2 = \frac{\psi'^2\cdot b^2}{r_A^2}\cdot\cos^4\delta \tag{4.31}$$

Determining of Momentary Mechanical Efficiency of the Rotary Cam and General Plate Rocking Follower

The written relations are following, (5.1-5.6) (Fig. 9):

$$AH = \left[\sqrt{d^2-(r_0-b)^2}\cdot\cos\psi - (r_0-b)\cdot\sin\psi\right]\cdot\frac{\psi'}{1-\psi'} \tag{5.1}$$

$$OH = b + (r_0-b)\cdot\cos\psi + \sqrt{d^2-(r_0-b)^2}\cdot\sin\psi \tag{5.2}$$

$$r^2 = AH^2 + OH^2 \tag{5.3}$$

$$\sin\tau = \frac{AH}{r}; \sin^2\tau = \frac{AH^2}{r^2} = \frac{AH^2}{AH^2+OH^2} \tag{5.4}$$

$$\begin{cases} F_n = F_m\cdot\cos\alpha = F_m\cdot\sin\tau; \\ v_n = v_m\cdot\cos\alpha = v_m\cdot\sin\tau \end{cases} \tag{5.5}$$

$$\eta_i = \frac{P_n}{P_c} = \frac{F_n\cdot v_n}{F_m\cdot v_m} = \frac{F_m\cdot v_m\cdot\sin^2\tau}{F_m\cdot v_m} = \sin^2\tau = \frac{AH^2}{AH^2+OH^2} \tag{5.6}$$

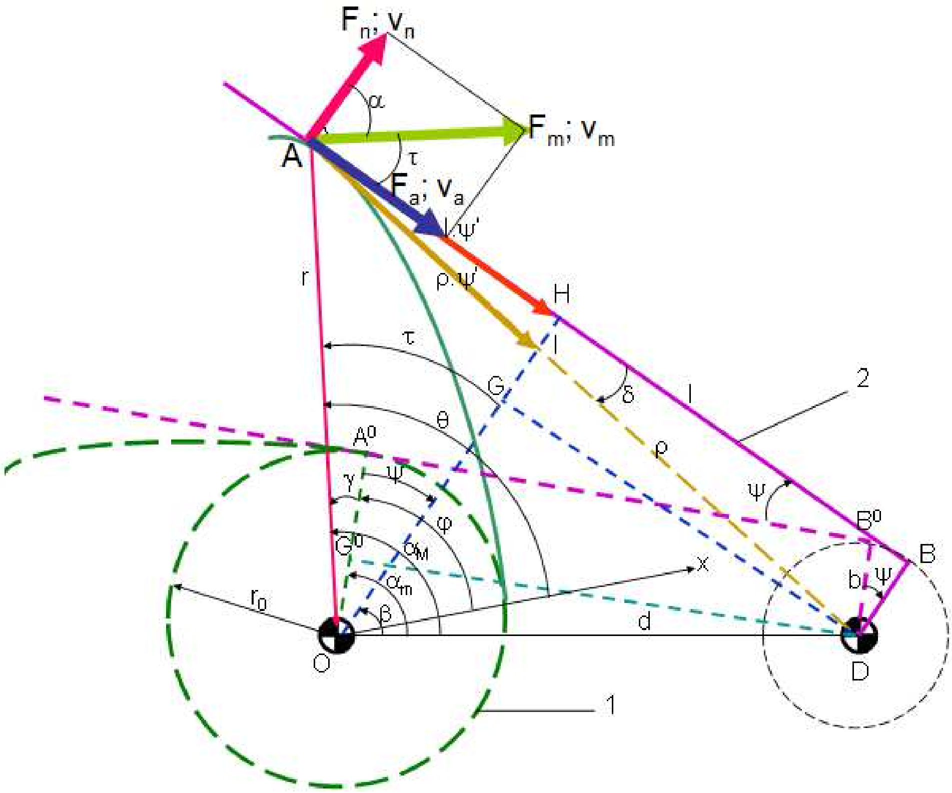

Fig. 9. Forces and speeds for the rotary cam and general plate rocking follower

Discussion

Development and diversification of machinery and mechanisms with applications in all areas advertise new scientific research for the systematization and the improvement of the mechanical systems existing, through the creation of new mechanisms adapted to the requirements of the modern, which implies the topological structures more complex.

The modern industry, the practice of design and the completion of the construction of machines shall be based more and more on the findings of scientific research and application software.

Each industry in the research activity theoretical and experimental work computer-assisted by which it solve problems more complex with programs high performance computing using software more specialist.

Robotics technological processes determine and influences more and more the emergence of new industries, applications under the special conditions of the environment, the general approach of new types of technological operations, handling of objects in the space the alien, teleworkers in the subjects top as well as medicine, robots covering an area of increasing the benefits of services in our society, modern and computerized.

In this context the work of front is trying to make a contribution in the field of scientific and technical in automate analysis and dynamic synthesis of mechanisms camshaft and gears on flat surfaces.

In the preparation of the thesis have been taken into account the following requirements:

- The establishment of a uniform work as regards the documentation and scientific contributions personal
- The way of the schedule of the presentation of the various aspects analyzed
- To highlight the achievements of the researchers and specialists in the field of the mechanisms
- The composition of the high-level scientific, but with the possibility to be easily monitored by professionals
- The formulation of conclusions aimed to fix what is essential and at the same time to be generators of new ideas

Mechanisms with the cam and the tappet have multiple applications from the most ancient times.

They have been used in particular when they had transmitted large forces, moments large, high powers, at high speeds in the repeated cycling multiple.

Short History of the appearance and development of internal combustion, which have occurred and have developed and the mechanisms of distribution; of this history are linked to the names of some scientists and engineers, Dutch, 685, French, the Swiss, the British and especially the German: Is the merit of the german engineers Eugen Langen and Nikolaus August Otto to be built the first internal combustion engine in four-stroke, in 1866, having regard the illumination of the diagram, carburation and distribution in a form advanced. In the year 1892, the german engineer Rudolf Christian Karl Diesel Injection, invents the engine with the compression ignition, in short diesel engine. The first side with valves appear in 1844, being used in the engines of the steamer; they have been designed and built by the mechanic engineer Egide Belgian Walschaerts. The first mechanisms are used in England and the Netherlands the wars of tissue. An overview of the mechanisms of distribution used in internal combustion engines: It is to be noticed the current models with four valves per cylinder with variable distribution and in particular the Swedish model of the company "Scania", the French companies met "Peugeot-Citroen" and the models of the German concern "Volkswagen".

In the year 1680 the Dutch physicist, Christian Huygens projects first internal combustion engine.

In 1807 the Swiss Francois Isaac of Rivaz invents an internal combustion engine which used as fuel a mixture of hydrogen and oxygen gases. The car designed by Rivaz for new or engine was a great mind, so that and the engine or put on a dead, having an application immediately.

In 1824 The English engineer Samuel Brown adapted to an engine with the steamer causing it to run on petrol.

In 1858), the engineer of Belgian origin Jean Joseph Etienne Lenoir, invents and patents the two years later, practically first motor with internal combustion electric ignition engines with liquid gas (extract from coal), this being an engine that operate in two-stroke engines. In 1863 all the Belgian guy Lenoir is the one that adapts to the engine or a carburettor making it to work with petroleum gas (or).

In the year 1862 the French engineer Alphonse drink of Rochas, patents for the first time internal combustion engine in four-stroke engines (but without it build).

Is the merit of the german engineers Eugen Langen and Nikolaus August Otto to build (physically achieve virtually theoretical model of the French Rochas), first internal combustion engine in four-stroke, in 1866, having regard the illumination of the diagram, carburation and distribution in a form advanced.

Ten years later, (in 1876), Nikolaus August Otto he licensed his engine or.

In the same year (1876), Sir Dougald Clerk, put the engine in two stages of belgianului Lenoir, (bringing to the form of the known and today).

In 1746 Daimler Gottlieb arranges an internal combustion engine four-stroke engines with a single cylinder upright and with a carburettor improved.

A year later and defeating Spanish Karl Benz bring some improvements to the engine in four stroke on petrol. Both Daimler and Benz worked new engines for their new low (so famous).

In 1889 Daimler improves the internal combustion engine four stroke, building a "two cylinders in V" and bring the timing to the classical shape of today, "with valves in the form of mushrooms".

In 1890, Wilhelm Maybach, build the first "four-cylinder", with internal combustion four-stroke engines.

In the year 1892, the german engineer Rudolf Christian Karl Diesel Injection, invents the engine with the compression ignition, in short diesel engine.

The first side with valves appear in 1844, being used in the engines of the steamer; they have been designed and built by the mechanic engineer Egide Belgian Walschaerts.

The first mechanisms are used in England and the Netherlands the wars of tissue.

In 1719 in England, some John Kay open in a building with five stories high a second time former. With a staff of over 300 women and children, but this would have to be the first factory in the world. He becomes the famous fabricating the shuttle flying saucers, thanks to whom the tissue becomes much more quickly. But cars were still operated manually. Only on at 1750 textile industry would be changed by applying on a large scale of this inventions. Initially it was meet opposed, destroying the flying dusted and abuse it on the inventor. On 1760 appear wars of the tissue and the first factories in the modern meaning of the word. There was need for the first engines. By more than a century, the Italian Giovanni Branca proposed the use of steam for the operation of turbines. Subsequent experiments have not given satisfaction. In France and England, inventors of the trade mark, that Denis Papin or marchizul of Worcester, came with us and new ideas. At the end of the twentieth century XVII, Thomas Savery had already "miner's friend", an engine with the steamer what was she in the pump for the removed water from the galleries. Thomas Newcomen has carried out a commercial variant of the pump with steam and the engineer James Watt performed and adapts a speed governor that enhances the net engine. Together with the manufacturer Mathiew Boulton builds the first naval engines with steam and in less than half a century, the wind that knew more than 3000 years propelling force on the sea grows even bigger now only the sails of vessels for leisure. In 1785 comes into operation, the first second time former operated by the force of steam, followed by another few dozens.

Fig. 10. The Scania distribution mechanism

In Fig. 10 one can see a mechanism for a balanced distribution of the latest generation, with four valves per cylinder, two for the inlet and the two for the exhaust; it has returned to the classic mechanism with the push rod and rocker arm, because the dynamics of this model to the mechanism is much better (only at the model without rocker).

The manufacturer of the Swedish considered as they can improve the dynamic classic mechanism used by replacing the classic clevis with the base plate by one with the roll (already presented module B).

The combustion chamber modular has a unique construction of the driving system of the valves. The valve springs exert large forces to ensure their closure. Forces to open are ensured by the push rods with roller set by the camshaft.

Economics: The push rods and the cams are large, ensuring a smooth action and precise on the valves. This is reflected in the low fuel consumption.

Pollutant emissions: Reduced accuracy of the functioning mechanism of the timing cover is a vital factor in the efficiency of the engine and in obtaining a clean combustion.

Cost of operation: A benefit to the dimensions of the tappet is the low rate to wear them. This reduces the need for adjustments. Operation of Valves remains constant for a long period of time. If adjustments are required, they can be made quickly and easily.

Conclusion

The follower with roll makes the input-force be divided into several components.

This is the reason why, the dynamics and the precise-kinematics (the dynamic-kinematics) of mechanism with rotary cam and follower with roll, are more different and difficult.

The presented dynamic efficiency of followers with roll is not the same like the classical mechanical efficiency.

For plate followers the dynamic and the mechanical efficiency are the same. This is the great advantage of plate followers.

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Author's Contributions

All the authors contributed equally to prepare, develop and carry out this manuscript.

Ethics

This article is original and contains unpublished material. Authors declare that are not ethical issues and no conflict of interest that may arise after the publication of this manuscript.

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