Original Research Paper

Machine Motion Equations at the Internal Combustion Heat Engines

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Abstract: This paper presents an algorithm for setting the dynamic parameters of the classic main mechanism of the internal combustion engines. One presents the dynamic, original, machine motion equations. The equation of motion of the machine that generates angular speed of the shaft (which varies with position and rotation speed) is deduced by conservation kinetic energy of the machine. An additional variation of angular speed is added by multiplying by the coefficient dynamic (generated by the forces out of mechanism). Kinetic energy conservation shows angular speed variation (from the main shaft) with inertial masses, while the dynamic coefficient introduces the variation of ω with forces acting in the mechanism. Deriving the first equation of motion of the machine it obtains the second equation of motion dynamics. From the second equation of motion of the machine one determines the angular acceleration of the motor shaft. It shows the distribution of the forces (on the main mechanism of the engine) to the internal combustion heat engines. Dynamic, the velocities can be distributed in the same way as forces. Practically, in the dynamic regimes, the velocities have the same timing as the forces. The method is applied separately for two distinct situations: When the engine is working on a compressor and into the motor system. For the two separate cases, two independent formulas are obtained for the engine dynamic cinematic (forces speeds). Calculations should be made for an engine with a single cylinder.

Keywords: Machine Motion Equations, First Equation of Motion, Second Equation of Motion, Internal Combustion Engines, Heat Engines, Dynamic Parameters, Engine Main Mechanism, Dynamic Synthesis

Introduction

In conditions which started to magnetic motors, oil fuel is decreasing, energy which was obtained by burning oil is replaced with nuclear energy, hydropower, solar energy, wind and other types of unconventional energy, in the conditions in which electric motors have been instead of internal combustion in public transport, but more recently they have entered in the cars world (Honda has produced a vehicle that uses a compact electric motor and electricity consumed by the battery is restored by a system that uses an electric generator with hydrogen combustion in cells, so we have a car that burns hydrogen, but has an electric motor), which is the role and prospects which have internal combustion engines type Otto, Diesel or Wankel (Amoresano *et al*., 2013;

Dawson, 2005; De Falco *et al*., 2013a; 2013b; Dieter, 2000; Eneşca, 2007; Ferguson and Kirkpatrick, 2001; Ganapathi and Robinson, 2013; Gunston, 1999; Gupta, 2006; Guzzella, 2004; Heywood, 1988; Karikalan *et al*., 2013; Lee, 2005; Liu, 1995; Mahalingam and Ramesh Bapu, 2013; Naima and Liazid, 2013; Narasiman *et al*., 2013; Petrescu and Petrescu, 2005; 2009a; 2009b; 2013a; 2013b; Petrescu *et al*., 2005; Petrescu and Petrescu, 2014; 2013c; 2013d; 2011; Petrescu, 2012a; 2012b; Piltan *et al*., 2012; Rahmani *et al*., 2013; Ravi and Subramanian, 2013; Ronney *et al*., 1994; Sapate and Tikekar, 2013; Sethusundaram *et al*., 2013; Zahari *et al*., 2013; Zhu *et al*., 2007)?

Internal combustion engines in four-stroke (Otto, Diesel, Wankel) are robust, dynamic, compact, powerful, reliable, economic, autonomous, independent and will be increasingly clean (Amoresano *et al*., 2013; Dawson,

2005; De Falco *et al*., 2013a; 2013b; Dieter, 2000; Eneşca, 2007; Ferguson and Kirkpatrick, 2001; Ganapathi and Robinson, 2013; Gunston, 1999; Gupta, 2006; Guzzella, 2004; Heywood, 1988; Karikalan *et al*., 2013; Lee, 2005; Liu, 1995; Mahalingam and Ramesh Bapu, 2013; Naima and Liazid, 2013; Narasiman *et al*., 2013; Piltan *et al*., 2012; Rahmani *et al*., 2013; Ravi and Subramanian, 2013; Ronney *et al*., 1994; Sapate and Tikekar, 2013; Sethusundaram *et al*., 2013; Zahari *et al*., 2013; Zhu *et al*., 2007).

Magnetic motors (combined with the electromagnetic) are just in the beginning, but they offer us a good perspective, especially in the aeronautics industry (Gunston, 1999). Probably at the beginning they will not be used to act as a direct transmission, but will generate electricity that will fill the battery that will actually feed the engine (probably an electric motor).

The Otto engines or those with internal combustion in general, will have to adapt to hydrogen fuel (Eneşca, 2007). Hydrogen can be extracted industrially, practically from any item (or combination) through *nuclear*, chemical, by radiation, by burning, etc... (Most easily hydrogen can be extracted from water by breaking up into constituent elements, hydrogen and oxygen; by burning hydrogen one obtains water again that restores a circuit in nature, with no losses and no pollution) (Eneşca, 2007). Hydrogen must be stored in reservoirs cell (a honeycomb) for there is no danger of explosion; the best would be if we could breaking up water directly on the vehicle, in which case the reservoir would feed water (and there were announced a few successes) (Eneşca, 2007).

Now and the life of the jet engine begin to end (only in these forms). Even in these conditions internal combustion engines will be maintained in land vehicles (at least), for power, reliability and especially their dynamics.

Otto engines design (Amoresano *et al*., 2013; Dawson, 2005; De Falco *et al*., 2013a; 2013b; Dieter, 2000; Eneşca, 2007; Ferguson and Kirkpatrick, 2001; Ganapathi and Robinson, 2013; Gunston, 1999; Gupta, 2006; Guzzella, 2004; Heywood, 1988; Karikalan *et al*., 2013; Lee, 2005; Liu, 1995; Mahalingam and Ramesh Bapu, 2013; Naima and Liazid, 2013; Narasiman *et al*., 2013), includes and the dynamic design.

Old gasoline engines carry us every day for nearly 150 years. "Old Otto engine" (and his brother, Diesel) is today: Younger, more robust, more dynamic, more powerful, more economical, more independent, more reliable, quieter, cleaner, more compact, more sophisticated, more stylish, more secure and more especially necessary and wanted. At the global level we can manage to remove annually about 60,000 cars. But annually appear other million cars (Table 1).

Table 1. World cars produced

Year	Cars produced in the world
2011	59,929,016
2010	58,264,852
2009	47,772,598
2008	52,726,117
2007	53,201,346
2006	49,918,578
2005	46,862,978
2004	44,554,268
2003	41,968,666
2002	41,358,394
2001	39,825,888
2000	41,215,653
1999	39,759,847

In full energy crisis since 1970 until today, production and sale of cars equipped with internal combustion heat engines has skyrocketed, from some millions yearly to over sixty millions yearly now and the world fleet started from tens of millions reached today the billion. As long as we produce electricity and heat by burning fossil fuels is pointless to try to replace all thermal engines with electric motors, as loss of energy and pollution will be even larger. However, it is well to continuously improve the thermal engines, to reduce thus fuel consumption. Planet supports now about one billion motor vehicles in circulation. Even if we stop totally production of heat engines, would still need 10,000 years to eliminate total the existing car park in the current rate. Electric current is still produced in majority by combustion of hydrocarbons, making the hydrocarbon losses to be higher when we use electric motors. When we will have electric current obtained only from green energy or nuclear, sustainable and renewable energy sources, it is only then that we'll be able to enter gradually and electric motors (Piltan *et al*., 2012; Rahmani *et al*., 2013; Ravi and Subramanian, 2013; Ronney *et al*., 1994; Sapate and Tikekar, 2013; Sethusundaram *et al*., 2013; Zahari *et al*., 2013; Zhu *et al*., 2007).

Otto and diesel engines are today the best solution for the transport of our day-to-day work, together and with electric motors and those with reaction.

For these reasons it is imperative as we can calculate exactly the engine efficiency, in order to can increase it permanently.

Nomenclature

J^*:
Is the moment of inertia (mass or mechanical) reduced to the motor shaft

J^*_{Max}:
Is the maximum moment of inertia (mass or mechanical) reduced to the motor shaft

J^*_{min}:
Is the minimum moment of inertia (mass or mechanical) reduced to the motor shaft

J_m^* : Is the average moment of inertia (mass or mechanical) reduced to the motor shaft

v_C : Is the normal (cinematic) velocity of the point C

$v_C^{Din.c}$: Is the dynamic velocity of the point C (in compressor system)

$v_C^{Din.m}$: Is the dynamic velocity of the point C (in motor system)

a_C : Is the normal (cinematic) acceleration of the point C

$a_C^{Din.c}$: Is the dynamic acceleration of the point C (in compressor system)

$a_C^{Din.m}$: Is the dynamic acceleration of the point C (in motor system)

$\varphi_1 = \varphi$: Is the position angle of the crank

$\omega_m = \omega_n$: Is the constant (nominal) angular rotation speed of the crank (the motor shaft)

ω: Is the variable (dynamic) angular rotation speed of the crank (the motor shaft)

ε: Is the angular rotation acceleration of the motor shaft; Appears only in dynamic schemes

$\varphi_{2'} = \psi$: Is the position angle of the rod (element 2), if the rod is considered from the point C

$\dot{\psi}$: Is the angular rotation speed of the rod (element 2)

$\varphi_2 = \theta$: Is the position angle of the rod, if the rod is considered from the point B

l_1: Is the length of the crank

l_2: Is the length of the rod (the connecting rod)

λ: Is the raport between l_1 and l_2

D^c : Is the dynamic coefficient (in compressor system)

$\dot{D}^c$: Is the derivative of D^c in function of the time

$D^c{}'$: Is the derivative of D^c in function of the position angle of the motor shaft, φ

D^m : Is the dynamic coefficient (in motor system)

$\dot{D}^m$: Is the derivative of D^m in function of the time

$D^m{}'$: Is the derivative of D^m in function of the position angle of the motor shaft, φ

Determining the First Machine Equation

One presents the dynamic, original, machine motion equations. The equation of motion of the machine that generates angular speed of the shaft (which varies with position and rotation speed) is deduced by conservation kinetic energy of the machine. An additional variation of angular speed is added by multiplying by the coefficient dynamic (generated by the forces out of mechanism).

Kinetic energy conservation shows angular speed variation (from the main shaft) with inertial masses, while the dynamic coefficient introduces the variation of ω with forces acting in the mechanism (Petrescu and Petrescu, 2005; 2009a; 2009b; 2013a; 2013b;

Petrescu *et al*., 2005; Petrescu and Petrescu, 2014; 2013c; 2013d; 2011; Petrescu, 2012a; 2012b).

In system (1) one determines the variable rotation velocity of the (motor) shaft, in function of the position φ of the shaft and of rotation nominal speed ω_m. One starts from the equation of kinetics energy (that is conserved):

$$
\begin{cases}
\dfrac{1}{2} \cdot J_m^* \cdot \omega_m^2 = \dfrac{1}{2} \cdot J_{max}^* \cdot \omega_{min}^2 = \\[2mm]
= \dfrac{1}{2} \cdot J_{min}^* \cdot \omega_{max}^2 = \dfrac{1}{2} \cdot J^* \cdot \omega^2 \Rightarrow \\[2mm]
\Rightarrow J_m^* \cdot \omega_m^2 = J_{max}^* \cdot \omega_{min}^2 = J_{min}^* \cdot \omega_{max}^2 = J^* \cdot \omega^2 \\[2mm]
\Rightarrow J_m^* \cdot \omega_m^2 = J^* \cdot \omega^2 \\[2mm]
\omega^2 = \dfrac{J_m^*}{J^*} \cdot \omega_m^2 ; \omega = \sqrt{\dfrac{J_m^*}{J^*}} \cdot \omega_m \\[3mm]
J_m^* = \dfrac{J_{max}^* + J_{min}^*}{2} \\[3mm]
\omega_m \equiv \omega_{med} \equiv \omega_n = 2 \cdot \pi \cdot \nu = 2\pi \cdot \dfrac{n}{60} = \dfrac{\pi}{30} \cdot n \\[3mm]
\omega^2 = \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \\[3mm]
\omega = \sqrt{\dfrac{J_m^*}{J^*}} \cdot \omega_m
\end{cases}
\tag{1}
$$

The first movement equation of the machine takes the initial forms (system 2) (were selected from system 1 just the two final relations):

$$
\begin{cases}
\omega^2 = \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \\[3mm]
\omega = \sqrt{\dfrac{J_m^*}{J^*}} \cdot \omega_m
\end{cases}
\tag{2}
$$

Since J^* is a function of the angle φ and ω_n is a function of n, it follows that ω is a function of angle φ and angular rotation speed $n \Rightarrow \omega = \omega(\varphi, n)$.

An additional variation of angular speed is added by multiplying by the coefficient dynamic (generated by the forces out of mechanism). The final forms of the first movement equation of the machine can be seen in the system (3).

$$
\begin{cases}
\omega^2 = \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D^2 \\[3mm]
\omega = \sqrt{\dfrac{J_m^*}{J^*}} \cdot \omega_m \cdot D
\end{cases}
\tag{3}
$$

where, the dynamic coefficient D takes the values of the system (4) or (5); (4) when the engine works in

compressor system and (5) when the mechanism works in motor system:

$$
\begin{cases}
D^c = \sin^2 \psi \\
\dot{D}^c = \sin 2\psi \cdot \dot{\psi} \\
D^c{}' = \sin 2\psi \cdot \psi' \\
\psi' = \dfrac{\dot{\psi}}{\omega}
\end{cases}
\qquad (4)
$$

$$
\begin{cases}
D^m = \sin^2 (\psi - \phi) \\
\dot{D}^m = \sin 2(\psi - \phi) \cdot (\dot{\psi} - \omega) \\
D^m{}' = \sin[2(\psi - \phi)] \cdot (\psi' - 1)
\end{cases}
\qquad (5)
$$

Method is applied separately for two distinct situations: When the engine is working on a compressor and into the motor system. Calculations should be made for an engine with a single cylinder (Petrescu and Petrescu, 2005; 2009a; 2009b; 2013a; 2013b; Petrescu *et al.*, 2005; Petrescu and Petrescu, 2014; 2013c; 2013d; 2011; Petrescu, 2012a; 2012b).

Determining the Second Machine Equation

The second machine equation is determined by the derivation of the first machine equation in function of the time (6):

$$
\begin{cases}
\omega^2 = \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D^2 \Rightarrow \\
\Rightarrow \omega^2 \cdot J^* = J_m^* \cdot \omega_m^2 \cdot D^2 \\
\dfrac{d}{dt}\left(\omega^2 \cdot J^* = J_m^* \cdot \omega_m^2 \cdot D^2 \right) \Rightarrow \\
2 \cdot \omega \cdot \dfrac{d\omega}{dt} \cdot J^* + \omega^2 \cdot \dfrac{dJ^*}{dt} = J_m^* \cdot \omega_m^2 \cdot 2 \cdot D \cdot \dfrac{dD}{dt} \Rightarrow \\
\Rightarrow 2 \cdot \omega \cdot \dfrac{d\omega}{dt} \cdot J^* + \omega^2 \cdot \dfrac{dJ^*}{d\phi} \cdot \dfrac{d\phi}{dt} = \\
= 2 \cdot J_m^* \cdot \omega_m^2 \cdot D \cdot \dfrac{dD}{d\phi} \cdot \dfrac{d\phi}{dt} \Rightarrow \\
\Rightarrow \omega \cdot \varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot \dfrac{dJ^*}{d\phi} \cdot \omega = J_m^* \cdot \omega_m^2 \cdot D \cdot \dfrac{dD}{d\phi} \cdot \omega \\
\Rightarrow \varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot \dfrac{dJ^*}{d\phi} = J_m^* \cdot \omega_m^2 \cdot D \cdot \dfrac{dD}{d\phi} \Rightarrow \\
\Rightarrow \varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot J^{*'} = J_m^* \cdot \omega_m^2 \cdot D \cdot D' \\
\varepsilon = -\dfrac{1}{2} \omega^2 \cdot \dfrac{J^{*'}}{J^*} + \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D \cdot D' \\
\varepsilon = -\dfrac{1}{2} \dfrac{J_m^* \cdot J^{*'}}{J^{*2}} \cdot \omega_m^2 \cdot D^2 + \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D \cdot D'
\end{cases}
\qquad (6)
$$

One keeps just the final relations (7):

$$
\begin{cases}
\varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot J^{*'} = J_m^* \cdot \omega_m^2 \cdot D \cdot D' \\
\varepsilon = -\dfrac{1}{2} \omega^2 \cdot \dfrac{J^{*'}}{J^*} + \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D \cdot D' \\
\varepsilon = -\dfrac{1}{2} \dfrac{J_m^* \cdot J^{*'}}{J^{*2}} \cdot \omega_m^2 \cdot D^2 + \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D \cdot D'
\end{cases}
\qquad (7)
$$

Observation

If one compares the presented equation of motion of the machine (6-7) with the fever (Lagrange), it can identify the reduced (rotation) force, (the reduced load: 8):

$$
\begin{cases}
\begin{cases}
\varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot J^{*'} = J_m^* \cdot \omega_m^2 \cdot D \cdot D' \\
\varepsilon \cdot J^* + \dfrac{1}{2} \omega^2 \cdot J^{*'} = M^*
\end{cases} \Rightarrow \\
\Rightarrow M^* = J_m^* \cdot \omega_m^2 \cdot D \cdot D'
\end{cases}
\qquad (8)
$$

Application to the Otto Engine

To determine dynamics at an Otto engine must (first at all) to set the formula of reduced moment of inertia (9); Fig. 1 (it takes $a_1 = 0$).

$$
\begin{cases}
J^* = J_{G_1} + J_{G_2} \cdot \left(\dfrac{\dot{\psi}}{\omega} \right)^2 + m_3 \cdot \left(\dfrac{v_{G_3}}{\omega} \right)^2 + m_2 \cdot \left(\dfrac{v_{G_2}}{\omega} \right)^2 \\
= J_{G_1} + J_{G_2} \cdot \lambda^2 \cdot \dfrac{\sin^2 \phi}{\sin^2 \psi} + m_3 \cdot r^2 \cdot \dfrac{\sin^2 (\psi - \phi)}{\sin^2 \psi} \\
+ m_2 \cdot \left(r^2 + a^2 \cdot \psi'^2 - 2ar \cdot \psi' \cdot \cos(\psi - \phi) \right) \\
= J_{G_1} + J_{G_2} \cdot \lambda^2 \cdot \dfrac{\sin^2 \phi}{\sin^2 \psi} + m_3 \cdot r^2 \cdot \dfrac{\sin^2 (\psi - \phi)}{\sin^2 \psi} \\
+ m_2 \cdot \left(r^2 + a^2 \cdot \lambda^2 \cdot \dfrac{\sin^2 \phi}{\sin^2 \psi} - 2a \cdot r \cdot \lambda \cdot \dfrac{\sin \phi}{\sin \psi} \cdot \cos(\psi - \phi) \right) \\
J^* = J_{G_1} + m_2 \cdot r^2 + \left(J_{G_2} + m_2 \cdot a^2 \right) \cdot \lambda^2 \cdot \dfrac{\sin^2 \phi}{\sin^2 \psi} \\
+ m_3 \cdot r^2 \cdot \dfrac{\sin^2 (\psi - \phi)}{\sin^2 \psi} - 2m_2 \cdot a \cdot r \cdot \lambda \cdot \dfrac{\sin \phi \cdot \cos(\psi - \phi)}{\sin \psi}
\end{cases}
\qquad (9)
$$

One determines:

$$
J_{Max}^*, J_{min}^*, J_{med}^* \equiv J_m^* = \frac{J_{Max}^* + J_{min}^*}{2}
$$

And $J^{*'}$, with relation (10):

$$
\begin{cases}
J^{*'} = \dfrac{1}{\sin^4 \psi} \cdot \Big\{ \big(J_{G_2} + m_2 \cdot a^2 \big) \cdot \lambda^2 \\
\cdot \big(\sin 2\phi \cdot \sin^2 \psi - 2\lambda \cdot \sin^3 \phi \cdot \cos \psi \big) \\
+ m_3 \cdot r^2 \cdot \big[\sin 2(\psi - \phi) \cdot \big(\lambda \sin \phi \cdot \sin \psi - \sin^2 \psi \big) \\
- 2\lambda \cdot \sin^2 (\psi - \phi) \cdot \cos \psi \cdot \sin \phi \big] \\
+ 2 m_2 a r \lambda \cdot \big[\sin \phi \cdot \sin \psi \cdot \sin(\psi - \phi) \\
\cdot \big(\lambda \sin \phi \cdot \sin \psi - \sin^2 \psi \big) \\
+ \lambda \cdot \sin^2 \phi \cdot \sin \psi \cdot \cos(\psi - \phi) \cdot \cos \psi \\
- \sin^3 \psi \cdot \cos \phi \cdot \cos(\psi - \phi) \big] \Big\}
\end{cases} \tag{10}
$$

How to work: With $J^*, J^{*'}$ and J_m^* it determines the variable ω and ε with relations (3, 7), or (11):

$$
\begin{cases}
\omega = \sqrt{\dfrac{J_m^*}{J^*}} \cdot \omega_m \cdot D \\[2mm]
\varepsilon = -\dfrac{1}{2} \dfrac{J_m^* \cdot J^{*'}}{J^{*2}} \cdot \omega_m^2 \cdot D^2 + \dfrac{J_m^*}{J^*} \cdot \omega_m^2 \cdot D \cdot D'
\end{cases} \tag{11}
$$

Then one calculates the dynamic cinematic with the relations from the system (12):

$$
\begin{cases}
y_C = r \cdot \sin \phi - l \cdot \sin \psi \\[1mm]
\dot{\psi} = \lambda \cdot \dfrac{\sin \phi}{\sin \psi} \cdot \omega \\[2mm]
v_C^{Din} \equiv \dot{y}_C = r \cdot \cos \phi \cdot \omega - l \cdot \cos \psi \cdot \dot{\psi} \\[2mm]
\ddot{\psi} = \dfrac{\lambda \cos \phi \cdot \sin^2 \psi - \lambda^2 \sin^2 \phi \cdot \cos \psi}{\sin^3 \psi} \cdot \omega^2 + \dfrac{\lambda \sin \phi}{\sin \psi} \cdot \varepsilon \\[2mm]
a_C^{Din} \equiv \ddot{y}_C = -r \cdot \sin \phi \cdot \omega^2 + r \cdot \cos \phi \cdot \varepsilon \\[1mm]
+ \dfrac{l \cdot \lambda^2 \cdot \sin^2 \phi}{\sin \psi} \cdot \omega^2 - l \cdot \cos \psi \cdot \ddot{\psi}
\end{cases} \tag{12}
$$

Dynamic Kinematics Analysis for the Otto Engine in Compressor System

Now, one can see the engine main mechanism in compressor system (when the motor mechanism is acting from the crank) (Petrescu and Petrescu, 2005; 2009a; 2009b; 2013a; 2013b; Petrescu et al., 2005; Petrescu and Petrescu, 2014; 2013c; 2013d; 2011; Petrescu, 2012a; 2012b). It is determining now, the velocities and the accelerations of the piston and motor shaft, normal and dynamic (Fig. 2-5).

Dynamic Kinematics Analysis for the Otto Engine in Motor System

Now, one can see the engine main mechanism in motor system (when the motor mechanism is acting from the piston) (Petrescu and Petrescu, 2005; 2009a; 2009b; 2013a; 2013b; Petrescu et al., 2005; Petrescu and Petrescu, 2014; 2013c; 2013d; 2011; Petrescu, 2012a; 2012b). It is determining now, the velocities and the accelerations of the piston and motor shaft, normal and dynamic (Fig. 6-9).
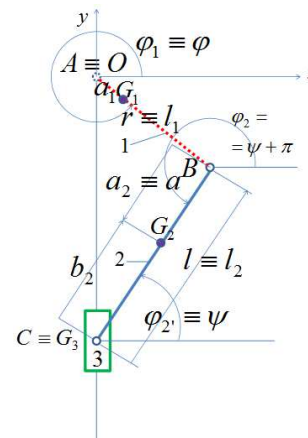

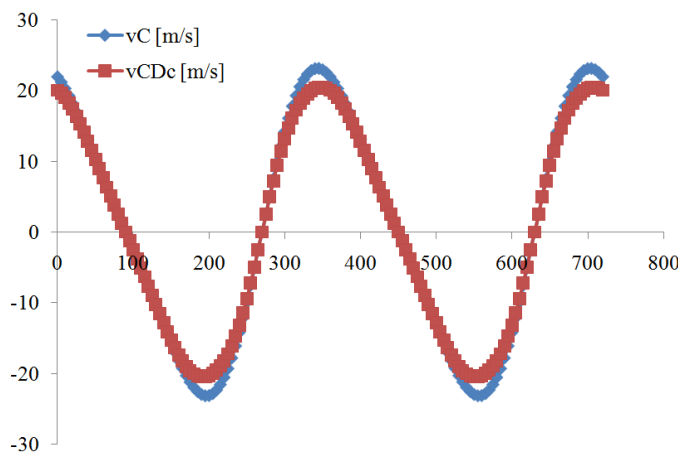Fig. 1. The geometry of an Otto engine mechanism

Fig. 2. The velocities of the piston, when the engine works in the compressor system
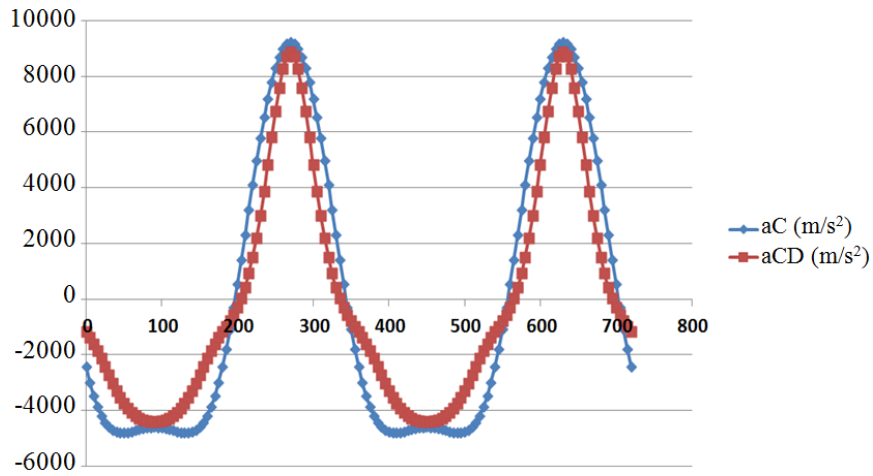
Fig. 3. The accelerations of the piston, when the engine works in the compressor system
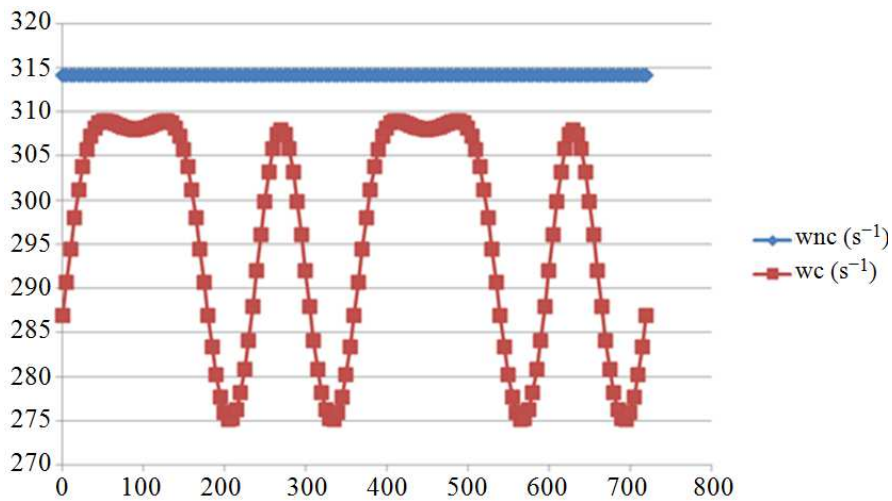

Fig. 4. The angular velocities of the motor shaft, when the engine works in the compressor system
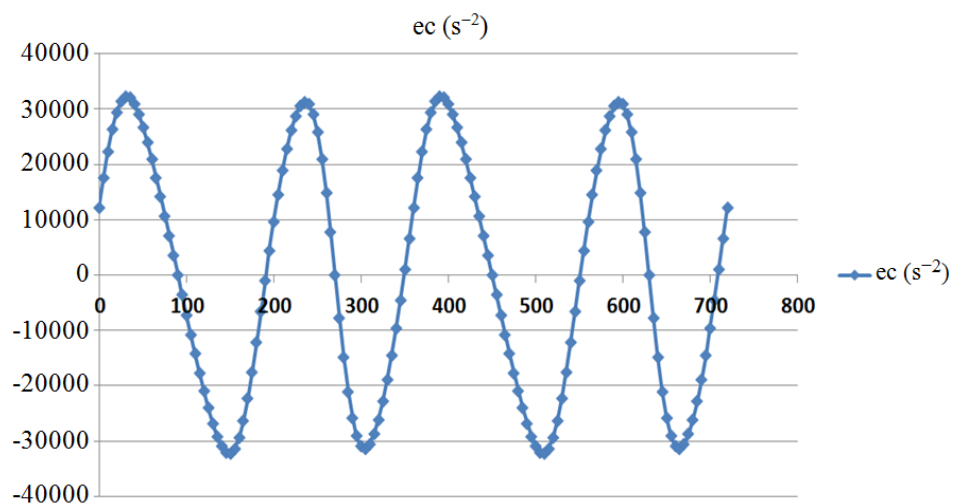

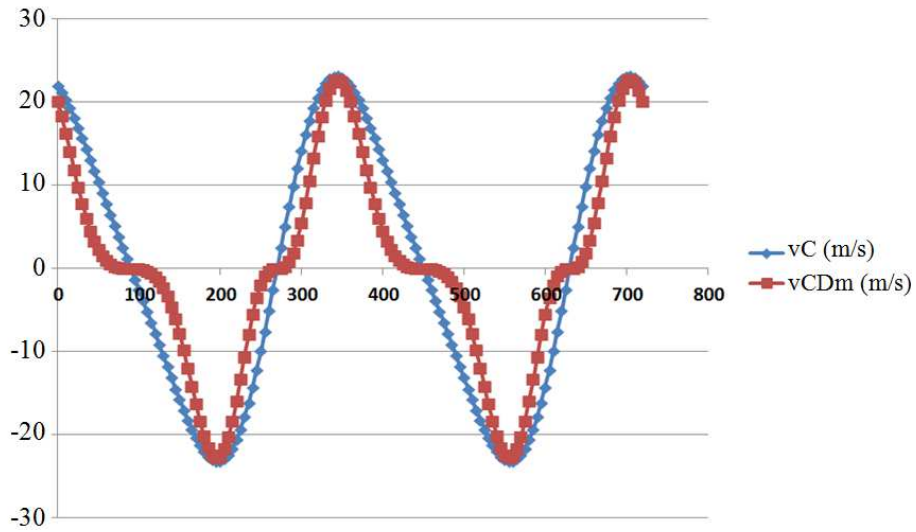Fig. 5. The angular accelerations of the motor shaft, when the engine works in the compressor system

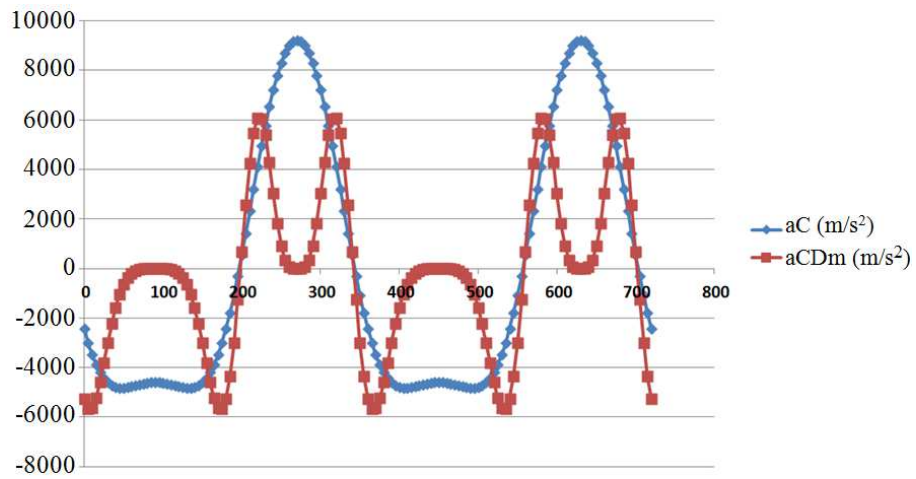Fig. 6. The velocities of the piston, when the engine works in the motor system

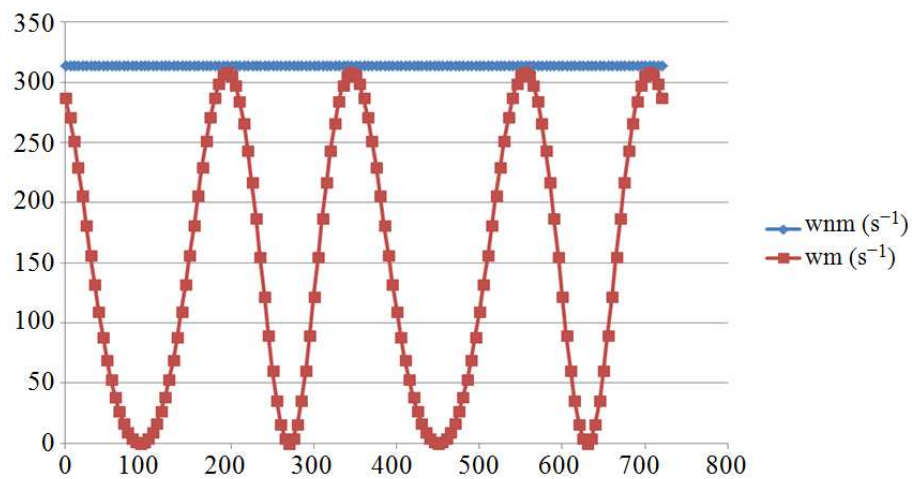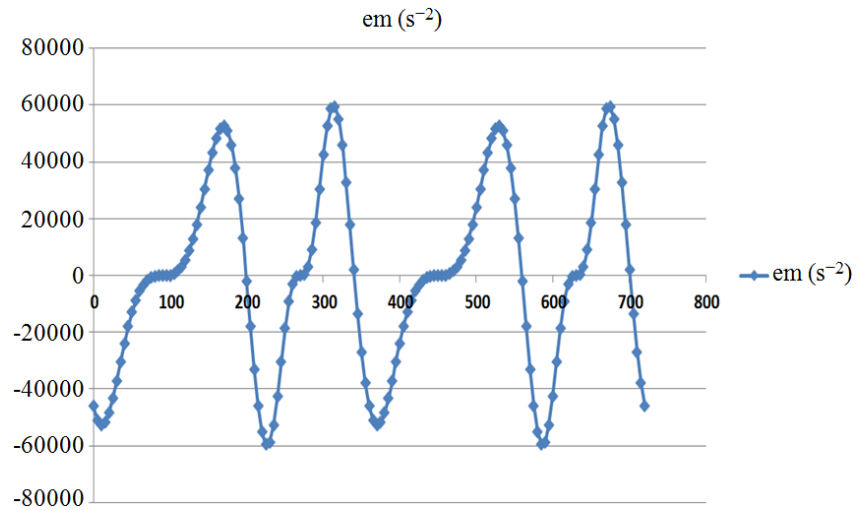Fig. 7. The accelerations of the piston, when the engine works in the motor system

Fig. 8. The angular velocities of the motor shaft, when the engine works in the motor system

Fig. 9. The angular accelerations of the motor shaft, when the engine works in the motor system
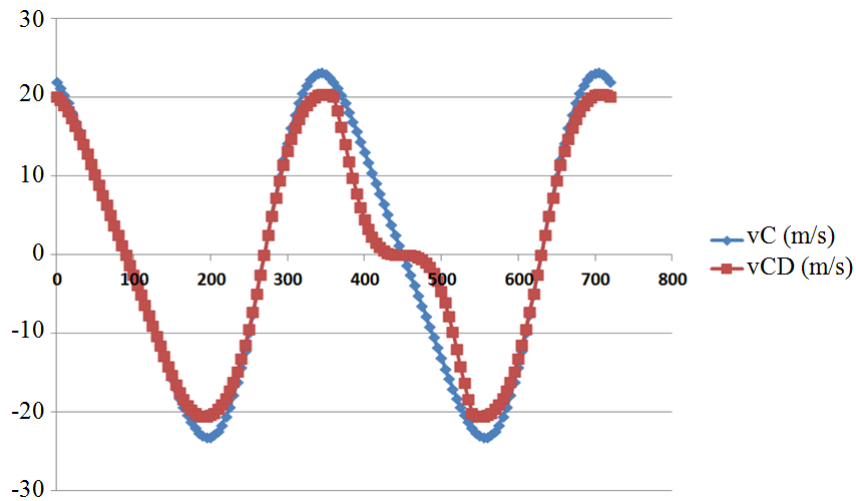

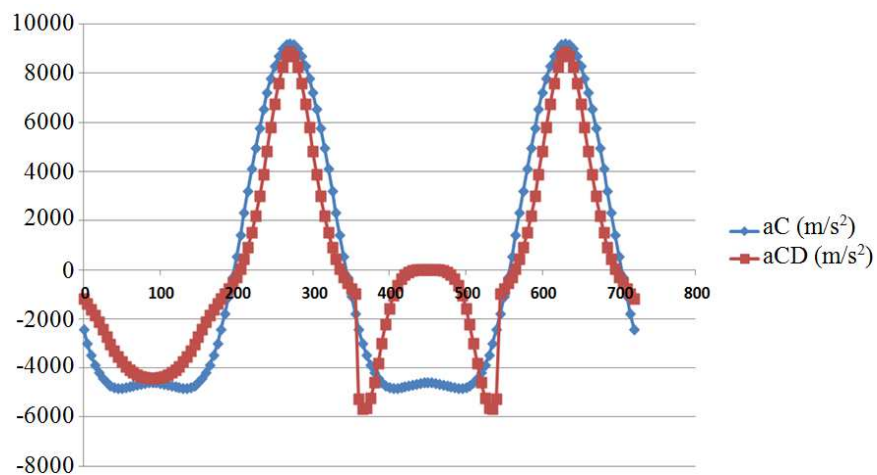Fig. 10. The velocities of the piston, for a mono cylinder engine

Fig. 11. The accelerations of the piston, for a mono cylinder engine, oriented upside down
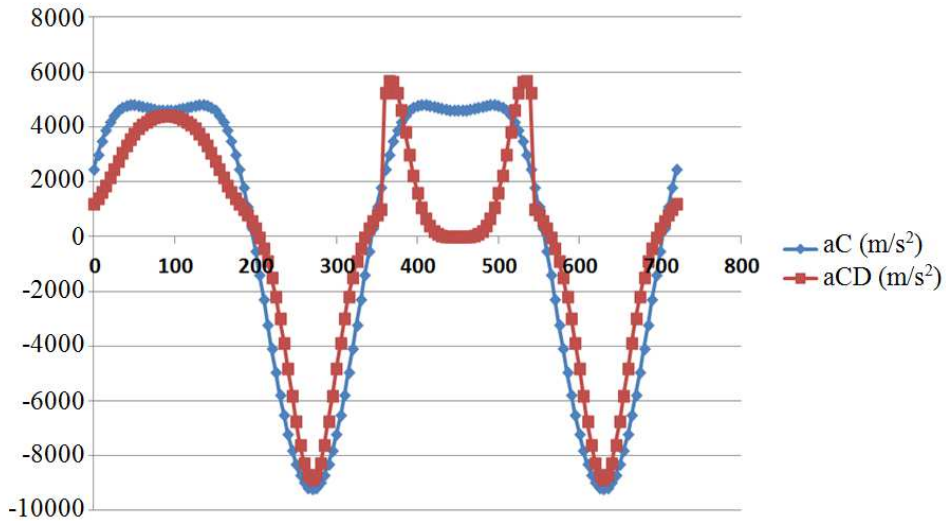
Fig. 12. The accelerations of the piston, for a mono cylinder engine, oriented head upward
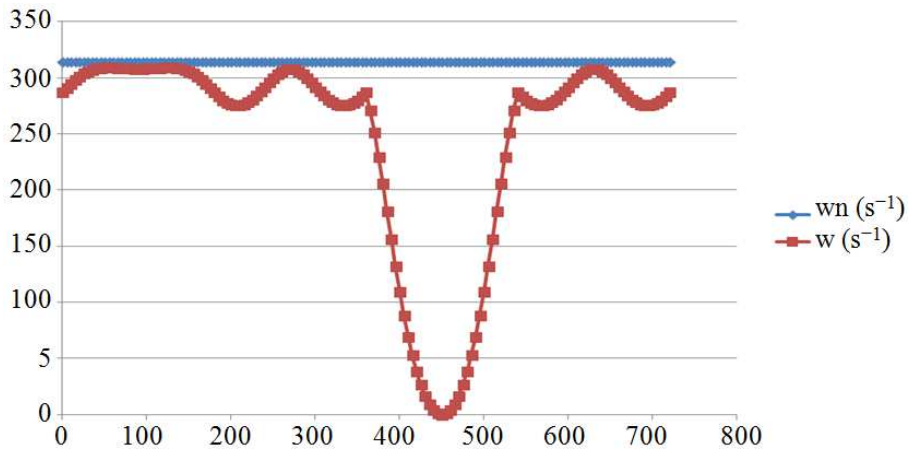

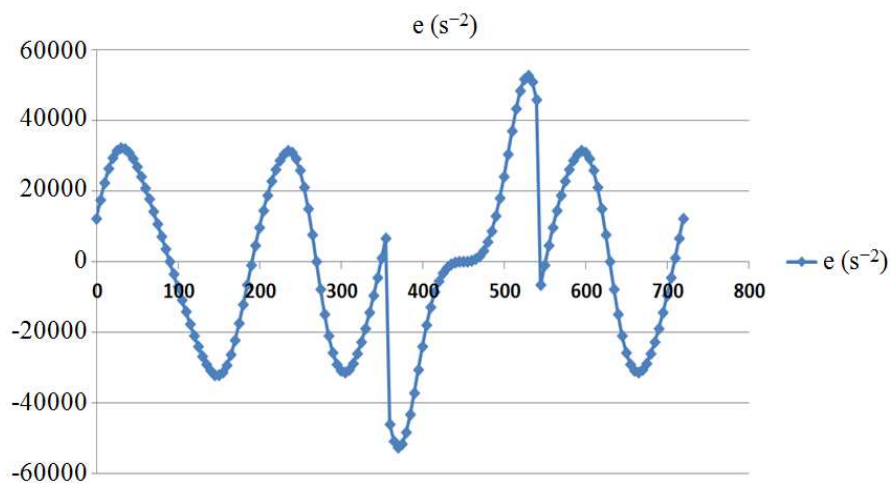Fig. 13. The angular velocities of the motor shaft, for a mono cylinder engine

Fig. 14. The angular accelerations of the motor shaft, for a mono cylinder engine

Dynamic Kinematics Analysis for an Otto Engine, Mono-cylinder

Now, one can see the engine main mechanism in motor and compressor system (when the motor mechanism is acting from the piston and from the crank). It is determining now, the velocities and the accelerations of the piston and motor shaft, normal and dynamic (Fig. 10-14).

Discussion

In full energy crisis since 1970 until today, production and sale of cars equipped with internal combustion heat engines has skyrocketed, from some millions yearly to over sixty millions yearly now and the world fleet started from tens of millions reached today the billion. As long as we produce electricity and heat by burning fossil fuels is pointless to try to replace all thermal engines with electric motors, as loss of energy and pollution will be even larger. However, it is well to continuously improve the thermal engines, to reduce thus fuel consumption. Planet supports now about one billion motor vehicles in circulation. Even if we stop totally production of heat engines, would still need 10,000 years to eliminate total the existing car park in the current rate. Otto and diesel engines are today the best solution for the transport of our day-to-day work, together and with electric motors and those with reaction. For these reasons it is imperative as we can calculate exactly the engine efficiency, in order to can increase it permanently. However, it is well to continuously improve the thermal engines, to reduce thus fuel consumption.

Conclusion

To the internal combustion heat engines the real velocities and accelerations (in dynamic regimes) are different that the cinematic (classic) velocities and accelerations. In this study one can see the engine main mechanism in motor and compressor system (when the motor mechanism is acting from the piston and from the crank). It is determining now, the velocities and the accelerations of the piston and motor shaft, normal and dynamic.

The first movement equation of the machine takes the initial forms (see the relations 2).

The second machine equation is determined by the derivation of the first machine equation in function of the time (see the relations from the system 6).

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Ethics

Author declares that are not ethical issues that may arise after the publication of this manuscript.

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