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Theoretical and experimental resources elements in electrostatic propulsion of the spherical rolling bodies in case of electrostatic motor

Titus Deliman
University of Oradea, Managerial Engineering and Technology Faculty

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Abstract: In the construction of the electrostatic motor, that we developed, the rolling spherical bodies caused the rotation at the level of the rotor. For this reason the mechanical complex movement of the rolling spherical body is so important in the function of this kind of electrostatic motor. In this case the rolling body is made from solid steel.

1. Theoretical and experimental elements

The function of the electrostatic engine, what have been developed at the University of Oradea, it's based on a very cure secondary electrostatic effect. About this effect and other ells connections that cause a continuously movement tray to develop a new kind of the electrostatic engine types. The starting of the rotor's rotation movement, the suggested variant, is ensured by the spherical rolling body / bodies (in other contractions kinds), which, through the electric field produced by the spatial condenser. [1.2]
In the conception of geometrical form of the mechanical movement collector, in this case the rotor of the electrostatic motor is very important to establish the complex rotation of the rolling spherical body.

In the first step [3.4] experimental studies and resources proves that the metal ball, (rolling body), have a "winding" (sinuous) trajectory of the rolling body on the inner perimeter of the superior fitting's ring of the spatial condenser. [4.5] The rolling of the metal ball is caused by the concurrence of many forces and interactions, among which there are the effect of the Coulomb force between the sphere and the metallic ring of the spatial condenser's fitting, the effect of the centrifugal force of the rolling body, the instantaneous distribution of duties on the surface of the rolling body reported to the condenser's fittings, and not in the last, the rolling of this body on the surface of the superior dielectric. [6]

All this are caused a "winding" (sinuous) trajectory of the rolling body on the inner perimeter of the superior fitting's ring of the spatial condenser. The rolling movement of the body involves the precession of the instantaneous axis of the body's rotation – implying a continuous variation of the sphere's rolling circle, a variation of both this circle's plane on the rolling area, and of the length of this circle. In this case result a conic surface for the precession movement.

In second step we tray to determine the relative position of this conic surface in relation with rolling body, also is very important to determine the direction of this rotation in rapport with the spinning of the rolling body.

In conclusion, this complex rotation of the rolling body we tray to modeling with the principle of Euler anglers in association with the rotation of the ball in the inner perimeter of the superior fitting's ring of the spatial condenser. [7]

The third step tray to compound the complex rotation with the trajectory of the rotation body and the rotation direction.

2. Mathematical model for the rotation of the ball

At the level of rotation body we have too reference systems placed in the geometrical center of the ball, one of them is fixed at the rotation body – (x, y, z), another

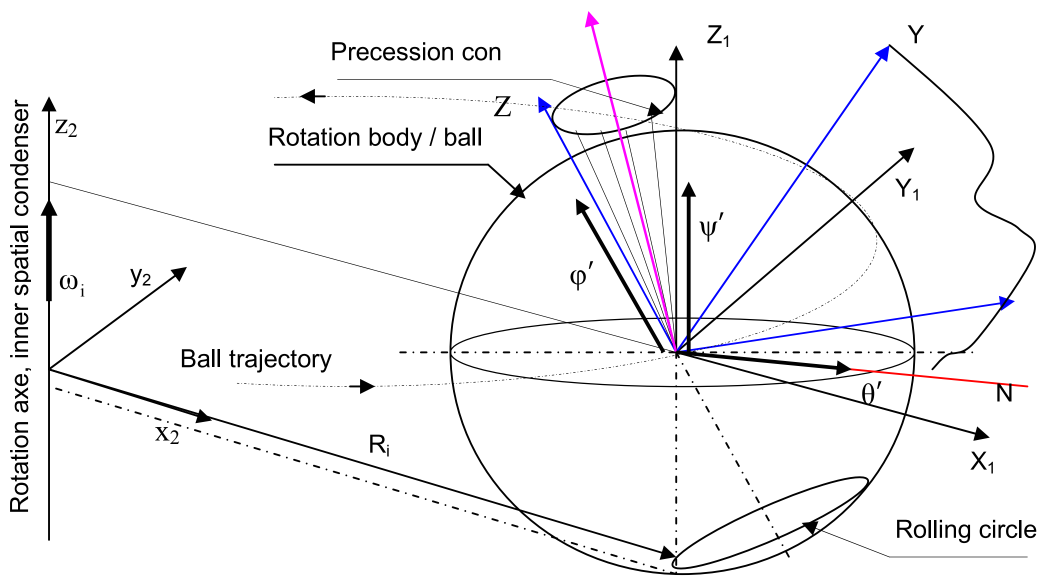

Fig.1 Modeling the complex rotation of the metal ball

remain with the "x" axe belong the radius direction (R_i). For the Euler anglers and their angular rotations we can write, see also figure 1 ;

$$\begin{Vmatrix} \omega_x \\ \omega_y \\ \omega_z \end{Vmatrix} = \begin{Vmatrix} \sin\theta\sin\varphi & 0 & \cos\varphi \\ \sin\theta\cos\varphi & 0 & \mp\sin\varphi \\ \cos\theta & 1 & 0 \end{Vmatrix} \bullet \begin{Vmatrix} \psi' \\ \varphi' \\ \theta' \end{Vmatrix} \tag{1}$$

Euler anglers depend at time, the angular rotations can bee determine by experimental resources most of them. For example, correlation between φ' and ω_i, we can write;

$$\omega_i R_i = \varphi' R \sin\theta \tag{2}$$

Where ω_i, is the rotation on the inner perimeter of the spatial condenser and "R" is radius of the rotation body. If consider ω_i, a constant angular movement can say that φ' is constant too, but experimentally can't prove this affirmation. If accept this conclusion the value of ψ', θ' rotations is possible to determine, even approximately. This entire are calculate for a fix value of the high voltage existing at the condenser level.

Between the too reference systems, figure 1, it possible to write the complex rotation at mathematical level with Euler rotation.

$$\|A_\varphi\| \bullet \|A_\theta\| \bullet \|A_\psi\| = \|A\| \tag{3}$$

Where $\|A\|$, is the compound rotation gives by the Euler angler. This matrix, have nine coefficients which depends for example;

$$\left\| A_\psi \right\| = \left\| \begin{matrix} \cos\psi & -\sin\psi & 0 \\ \sin\psi & \cos\psi & 0 \\ 0 & 0 & 1 \end{matrix} \right\| \tag{4}$$

So that the rotation vector reporting at the (x, y, z) reference system it can write;

$$\vec{\omega} = \omega_x \vec{i}_x + \omega_y \vec{j}_y + \omega_z \vec{k}_z \equiv \omega_{x_1} \vec{i}_{x_1} + \omega_{y_1} \vec{j}_{y_1} + \omega_{z_1} \vec{k}_{z_1} \tag{5}$$

If we write the transformation between the too reference systems at the level of rotation body and name the matrix of the rotation with $\|\alpha\|$, where this matrix has nine coefficients depends at Euler instant anglers, we can write;

$$\left\| \begin{matrix} \omega_{x_1} \\ \omega_{y_1} \\ \omega_{z_1} \end{matrix} \right\| = \|\alpha\| \bullet \left\| \begin{matrix} \omega_x \\ \omega_y \\ \omega_z \end{matrix} \right\| \tag{6}$$

Rotational vector components are reporting to the (x_1, y_1, z_1,) mobile referent system and finally this system are rotating round about the second fix system (x_2, y_2, z_2).

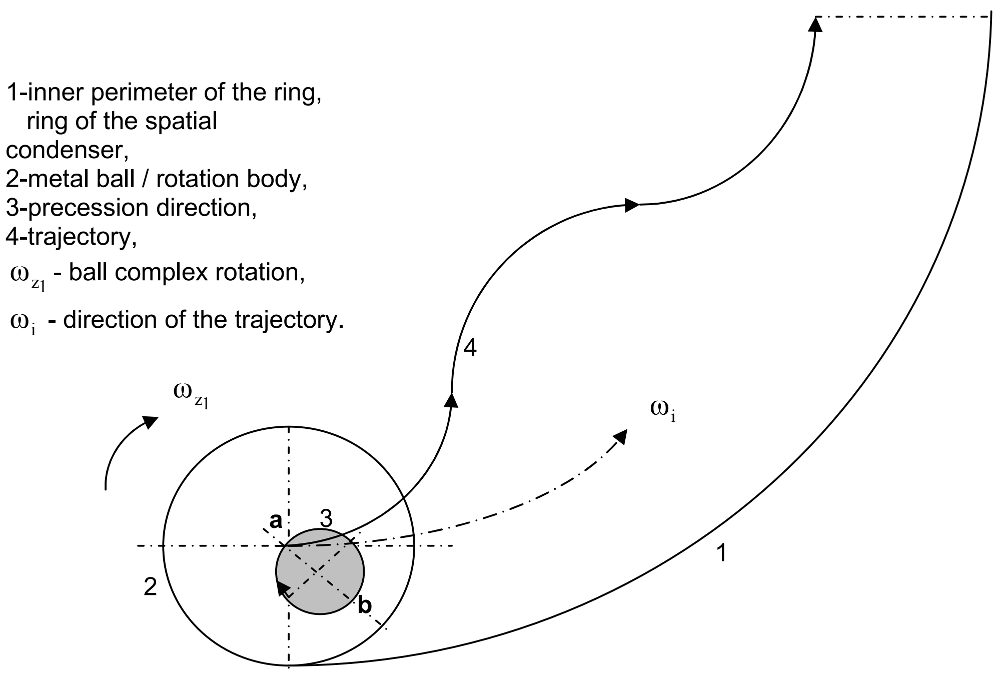

Fig.2 Illustration at complex rotation of the ball and translation

If in relation 1, we can estimate a medium value by experimental method at least it's possible to estimate the mechanical energy that seems to propulsion the spherical rotation body;

$$E_c = \frac{J_x\omega_x^2}{2} + \frac{J_y\omega_y^2}{2} + \frac{J_z\omega_z^2}{2} + \frac{M\omega_i^2R_i^2}{2} \equiv \frac{J_{x1}\omega_{x1}^2}{2} + \frac{J_{y_1}\omega_{y1}^2}{2} + \frac{J_{z1}\omega_{z1}^2}{2} + \frac{M\omega_i^2R_i^2}{2} \tag{7}$$

In above mentioned relation "M" represents the mass of the rotation body, the last term represents the cinematic energy reported at the at the mass center level. In figure 2, we represent the relative position of the precession con 3, and the direction of the rotation at the instantaneously rotation axe. The complex rotation cause the ball movement after the (approximately) sinuous trajectory, see also relation 2.

In correlation with the precession of the rotation axe the ball has a rolling circle with cause the” winding” (sinuous) trajectory of the rolling body on the inner perimeter of the superior fitting’s ring of the spatial condenser. The mechanical moment that determines the movement can it bee write;

$$M_z = sMg + \mu MgR\sin\theta \quad \text{and} \quad M_z = J_z\omega'_z \tag{8}$$

Where “s” represent the rolling friction arm for the spherical body in contact with the dielectrically plane and the friction coefficient between the ball and his rolling plain, is ”μ” (dielectrically plane). At the (x, y, z,) reference system we have more two moments,

$$M_x = J_x\omega'_x \quad \text{and} \quad M_y = J_y\omega'_y \quad \text{where} \quad J_x = J_y = J_z \tag{9}$$

3. Conclusions for the proposed model

Geometrical construction of the rotor at this motor is in correlation with the axe of the precession con, they mast bee perpendicularly to offer a smoothly rolling of the spherical rotation body. In this case, of course, the frictions between the ball and rotor are smaller for the entire electrostatic motor. The material of the rotor is very important for the distribution of the electrical charge. Experimental we determine that insulator material increase the effect, of propulsion generate by the metal ball.

That show in figure 2, geometrical plane of the rotor is not parallel with the insulator plane, (rolling plane for the ball), because the precession con has the particularly position in report with rotation body.

In the next step, an energetic appreciation of the movement can be done, which evidently can be compared to the consumed energetic parameters, method that gives the possibility to estimate the propulsion efficiency of the spherical body in the suggested experimental group. This approximation is equal with the electrical energy existing in the spatial condenser [6]

Mechanical moment estimate in relation 8 and 9 at the reference system (x, y, z) in vector interpretation is estimating the whole movement moment;

$$\vec{M}_x + \vec{M}_y + \vec{M}_z = \vec{M}_\Delta \tag{10}$$

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