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NAVAL PROPULSION SYSTEM BASED ON A ROTARY MOVEMENT

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Abstract

This work presents the theoretical and experimental study of a new propulsion system based on a rotary movement that applied to a specific case is rendering hopeful results.

We consider our research to be of some application in the naval industry. Our presentation is based on the experiments and tests carried out with a scale model boat in which have been installed three scale model prototypes of our propulsion system working synchronously. The obtained results show that the amount of gained impulse is considerable and to be kept in mind. Following tests and experiments showed also an improvement in the manoeuvrability of the ship. In this work we present the ship model and the theoretical and practical research carried out.

Keywords: Propulsion system; rotary movement; centrifugal forces.

INTRODUCTION

The centrifugal force term comes from two Latin words, from Latin "Centrum" centre and "Fugger" to flee, means get away from the centre, and that explains the being of a force that tends to get any body away from the circle's centre. Let see how this concept can be interpreted.

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Centrifugal force as reaction of the centripetal force:

When the circular movement of the bodies is observed, we only pay attention to the force which gets over the moving body. In our example, in one of the two cases examined, the force of a stretched (deformed) elastic body acts upon a small ball on circular movement.

By the Newton's Third Law, the elastic body action over the sphere will get an equal reaction and opposed to it.

As we know, while the sphere is rotating, a force acts upon it: the centripetal force. Over the elastic body acts an equal force but in opposed way to the first one mentioned, which is called centrifugal force. Then, the centrifugal and centripetal forces act upon different bodies, and, thus, can not balance each other. Figure one shows: (F) the centripetal force applied on the sphere; (Q) the centrifugal force applied to the elastic body and by it upon the small ball's rotation centre, for example, the hand.

Knowing that if a body gets a force over any other body, both will get deformed. So, in the case of the rotary small ball and the elastic body both will get deformed.

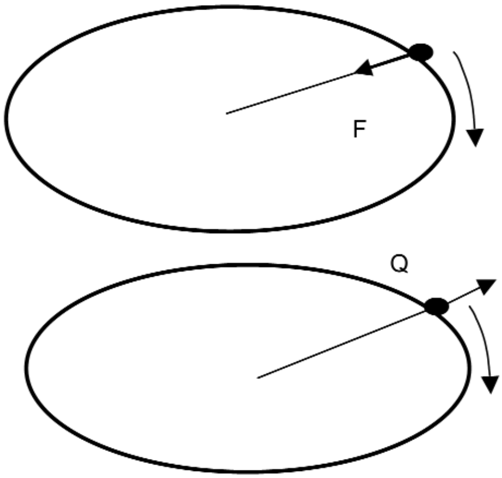

Figure 1. Centrifugal and centripetal forces.

This is referred to every case of the circular movement of the bodies. Thus, for example, when a trolley moves on a bend the rails are deformed and they exert a force over the wheels. These, at the same time, get deformed and press over the rails.

Not to confuse the centrifugal force concept with the one used on the forces of inertia, the real centrifugal force will be called unidirectional gravitational vector, and labelled F_d.

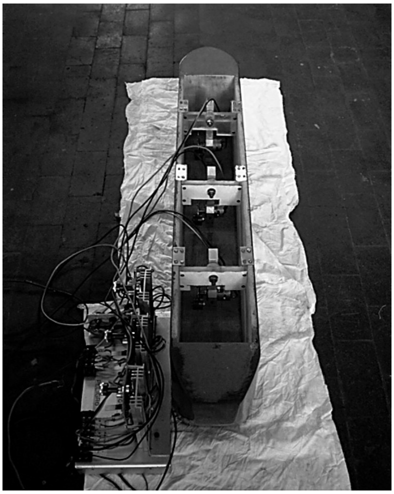

Figure 2. Ship model's photo.

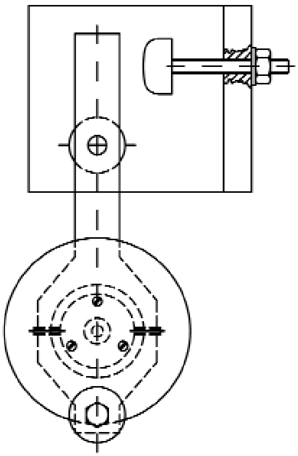

Figure 3. The pendulous system.

LABS MODEL

Figure 2 shows our lab model which consists in a rectangular wooden case and its dimensions are 930x180x240 mm, its total mass is 17.36 kg.

The propulsion for this ship is obtained through the pendulous system represented in figure 3. This system consists in a pendulum with a hole drilled in the centre. The device to be attached in the centre of the pendulum consists in an assembly of a rotating wheel a shaft crossing the pendulum from forward to aft through the drilled hole and a driving small electrical engine fast to the shaft and moving the wheel. This wheel has a mass placed in its outer border. Once the electrical engine is started consequently the rotary wheel will rotate and the whole assembly will star moving from side to side heating against the kinetic brake. Thus, getting some impulse.

Figure 4 shows several sides of the prototypes installed on board the model ship.

Inside each complete pendulum system we have a mass m=121.5 g, situated almost in the periphery of the rotary disk with a radius r=35.8 mm, which rotates with an angular velocity of rotation

$$\omega = \frac{30\ turns}{10\ seconds} = 18.85\ rad/s$$

The rotary wheel releases a useful force on the pendulum during a half turn, while on the other half accumulates the energy. The only energy need is the one for the driving electrical motor.

The test model ship does not possess a propeller no any other known system of propulsion. Our scale model has three complete pendulum and rotary wheel systems in it. These three assemblies work in sequence, in such a way that one of them is always delivering a useful propulsion force. It is clearly seen that the smoothness of the propulsion is in consonance with the number of pendulum systems fit on board the model.

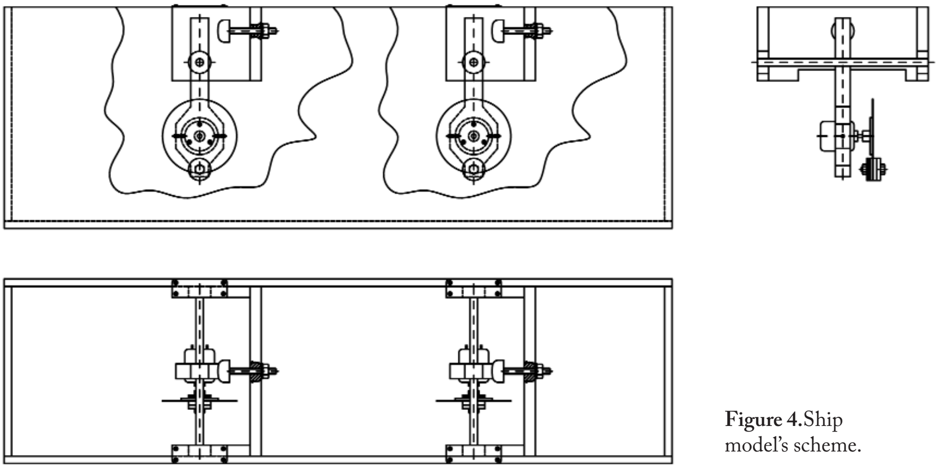

Figure 4. Ship model's scheme.

To calculate the advance of the ship we carried out a dynamic study of what happens inside the pendulous system. For it we take any position and we examine the forces involved.

$$\Sigma\tau_A = I_A.\alpha = I_A.\frac{d^2\theta}{dt^2} \tag{1}$$

Being:

$\Sigma\tau_A$: The sum of moments respect to A

θ : The angle that displaces itself the pendulum,

α : The angular acceleration of the pendulum.

The equation results:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g\,(r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - F_{Coriolis} =$$
$$= \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I^A_{bar} + m \cdot a^2\right]\frac{d^2\theta}{dt^2} \tag{2}$$

Being:

$b = \overline{AJ}$

$\varphi = \omega \cdot t\,\varphi$

$F_d = m \cdot \omega^2 \cdot r$

$d = \overline{OA} \cdot \sin\varphi$

$$d = \overline{OA} \cdot \sin\varphi$$

$$a = \left[\overline{OA}^2 + r^2 - 2\overline{OA} \cdot r \cdot \cos\varphi\right]^{1/2}$$

$$F_{Coriolis} = 2m \cdot v \cdot \frac{d\theta}{dt} = 2m \cdot \omega \cdot r \frac{d\theta}{dt}$$

Resolving this differential equation we can calculate $\theta = \theta_t$, deducing the highest value of θ (θ_{max}) and the angle β at which the accumulation of energy is maximum and is delivered to the kinetic brake. Once has been reached the θ_{max} elevation, the energy transmitted to the kinetic brake is due to the pounding movement of the pendulum system.

We see now what happens with the first collision and in others subsequent. For it, we will apply the principle of conservation of the quantity of movement according to the horizontal axis x, so the speed of the boat can be calculated through:

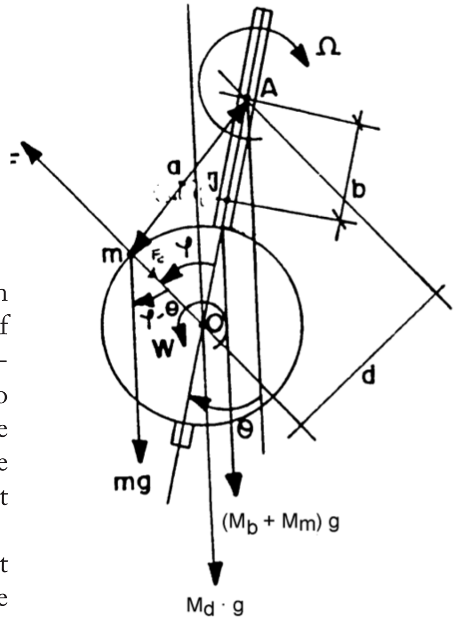

Figure 5. Pendulous system forces.

$$\dot{x} = \frac{(\dot{\theta}_0 + \dot{\theta}_1) \cdot \left[M_b + M_m \cdot \overline{AJ} + M_d \cdot \overline{AO} + m \cdot \overline{AO} - m \cdot r \cdot \sin\beta\right]}{M_T} \quad (3)$$

Being, $\dot{\theta}_0$ the angular velocity on arriving to the collision; and $\dot{\theta}_1$ to bounce; and considering a collision inelastic with a coefficient of restitution e that relates the relative velocities later and before the collision. This will be the velocity of the model after the collision. With that velocity $\dot{x} = v_0$ after the collision and with a friction force $F_r = \mu \cdot M_T \cdot g$ it will be produced a deceleration $a = \mu \cdot g$ and an advance by collision of $\Delta x = \frac{v_0^2}{2\mu \cdot g}$ during the interval of time $\Delta t = \frac{v_0}{2\mu \cdot g}$. So the new differential equation considering the friction will be the one below.

$$\begin{aligned} &F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g \cdot (r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - \\ &- F_{Coriolis} \cdot d - (M_b + M_m) \cdot \overline{AJ} \cdot \cos\theta \cdot \ddot{x} - M_d \cdot \overline{AO} \cdot \cos\theta \cdot \ddot{x} - \\ &- m \cdot \left[\overline{AO} \cdot \cos\theta - r \cdot \cos(\omega t - \theta)\right] \cdot \ddot{x} = \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \cdot \frac{d^2\theta}{dt^2} \end{aligned} \quad (4)$$

THEORETICAL VERSUS EXPERIMENTAL RESULTS

The data pertaining to the pendulous system and to the ship are the following:

$OA = 85\ mm$	$m = 121.5\ g$	$M_d = 139.13\ g$
$e = 0.7$	$r = 35.8\ mm$	$\omega = 18.85\ rad/s$
$M_b = 319.28\ g$	$\mu = 3.5 \cdot 10^{-3}$	$M_m = 178.9\ g$
$b = AJ = 47.1\ mm$	$M_T = 17.36\ kg$	

Substituting in the differential equations, we will have:

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) = \\ = \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right]\ddot{\theta} + 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta} \quad (5)$$

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) - 0.001596 \cdot \cos\theta + \\ +0.0001479 \cdot \cos(18.85t - \theta) = \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right] \cdot \ddot{\theta} + \\ +0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta} \quad (6)$$

Resolving these differential equations by finite differences, by means of a calculator program and substituting in the expressions of $\dot{x}$ and Δx we will obtain $\dot{x} = 7.1\ cm/s$ and $\Delta x = 0.21\ cm$

These results agree very well with them observed experimentally.

WATER VEHICLES

It is understood that the same principles used for a canoe can be used for a transatlantic ship; the only difference seems to be matter of proportional size. The principles of this propulsion system can also be applied to a road vehicle. And it is clearly seen that propellers are not needed for ship propulsion no even for manoeuvring and steering the ship (Fig. 6).

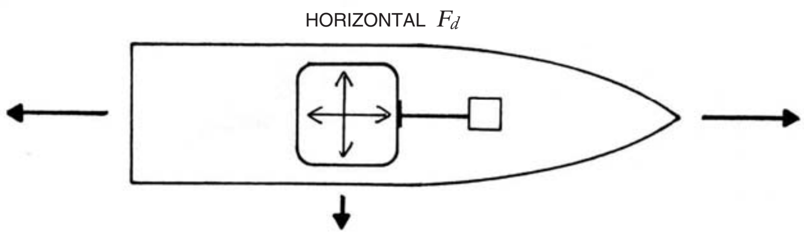

Figure 6. Ship.

This propulsion system could also have applications in underwater crafts, such as submarines, bathyscaphes, submarine investigation vehicles, submarine specialised system to get wires, pipes etc. The directional movement capability of he F_d vector make it very appropriate to be used in all kind of sceneries such as underwater, planets surface, and air (Fig. 7).

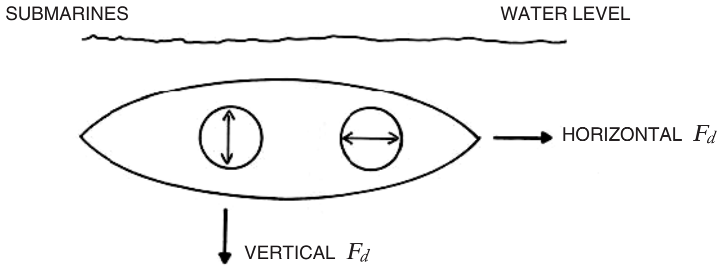

Figure 7. Underwater ships.

CONCLUSIONS

As our propulsion system is based on intermittent impulses, a continuous and smooth movement can be achieved by the synchronization of several autonomous pendulum propulsion systems.

No propellers no any other known propulsion device is required to move a ship through the water.

Vectors can push not only in the aft –fwd direction, but also in any other, so facilitating the steering and berthing of the vessel.

Propellers and wheels will not be needed for propulsion and steering purposes.

Further developments of this system will allow higher speeds on vessels and a better ratio engine power/weight.

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SISTEMA DE PROPULSIÓN NAVAL BASADO EN UN MOVIMIENTO ROTATORIO

INTRODUCCIÓN

Algunas veces, al explicar el movimiento circular, se utiliza el término fuerza centrífuga. Este término se deriva de dos palabras latinas, cuyo significado es *alejarse del centro*, lo que implica la existencia de una fuerza que tiende a alejar el cuerpo del centro del círculo.

Al examinar el movimiento circular de los cuerpos, prestamos atención solamente a la fuerza que actúa sobre un cuerpo en movimiento. Así, por ejemplo, si tenemos una bolita unida a un muelle (o un hilo) realizando un movimiento circular, sobre la bolita actúa una fuerza: la fuerza centrípeta. Sobre el muelle actúa otra fuerza igual pero de sentido opuesto a la primera, que es la llamada fuerza centrífuga. Luego vemos que las fuerzas centrífuga y centrípeta actúan sobre cuerpos diferentes y, por tanto, no pueden equilibrarse mutuamente. En la figura 1 se aclara esto: (F) es la fuerza centrípeta aplicada a la esfera; (Q) es la fuerza centrífuga aplicada al cordel y a través de éste sobre el centro de rotación de la bolita, por ejemplo en la mano. Para evitar confundir el concepto de fuerza centrífuga con el utilizado en las fuerzas de inercia, a la fuerza centrífuga real la llamaremos *Vector Unidireccional Gravitatorio*, también conocido como F_d.

MODELO DE LABORATORIO

Nuestro modelo de laboratorio, figura 3, consiste en un pequeño buque de forma rectangular de dimensiones 930x180x240 *mm*, y de masa total 17,36 *kg*. La propulsión de este buque se consigue a través de tres sistemas pendulares de la figura 4. Dentro de cada uno tenemos una masa m =121,5 *g* situada casi en la periferia de un disco de radio r =35,8 *mm*, el cual gira con una velocidad angular de rotación ω =18,85 rad/s. La energía que se utiliza es la energía eléctrica que necesita el motor para girar. Los tres sistemas están desfasados en cuanto al impulso para conseguir que cuando un péndulo esté chocando con el freno cinético, los otros estén preparados para hacerlo; consiguiendo así un impulso más continuo.

El buque no posee hélice ni ningún otro sistema conocido para su propulsión. Si lo colocamos flotando en el agua y ponemos nuestro sistema a funcionar, el buque es impulsado y se mueve por el agua.

Para calcular el avance del buque realizamos un estudio dinámico de lo que sucede dentro del sistema pendular, para ello tenemos una posición cualquiera y examinamos qué es lo que ocurre, figura 5. Resulta la ecuación:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g(r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) - F_{Coriolis} =$$
$$= \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \frac{d^2\theta}{dt^2}$$

Resolviendo esta ecuación diferencial podemos calcular $\theta = \theta_t$, deduciendo el valor máximo de θ (θ_{max}). Una vez llegado al θ_{max} de elevación, la energía transmitida al freno cinético es debida a la caída del conjunto. La velocidad con la que se moverá todo el sistema después del choque será:

$$\dot{x} = \frac{(\dot{\theta}_0 + \dot{\theta}_1) \cdot \left[M_b + M_m \cdot \overline{AJ} + M_d \cdot \overline{AO} + m \cdot \overline{AO} - m \cdot r \cdot \sin\beta\right]}{M_T}$$

Siendo $\dot{\theta}_0$ la velocidad angular al llegar al choque y $\dot{\theta}_1$ al rebotar, y considerando un choque inelástico de restitución que relaciona las velocidades relativas después y antes del choque. Con esta velocidad $\dot{x} = v_0$ tras el choque y con una fuerza de rozamiento $F_r = \mu \cdot M_T \cdot g$, se producirá una deceleración $a = \mu \cdot g$, y un avance por choque de $\Delta x = \frac{v_0^2}{2\mu \cdot g}$ durante el intervalo de tiempo de $\Delta t = \frac{v_0}{2\mu \cdot g}$, y entonces habrá que considerar la ecuación diferencial:

$$F_d \cdot d - M_d \cdot g \cdot \overline{OA} \cdot \sin\theta - (M_b + M_m) \cdot g \cdot b \cdot \sin\theta - m \cdot g \cdot (r \cdot \sin(\varphi - \theta) + \overline{OA} \cdot \sin\theta) -$$
$$- F_{Coriolis} \cdot d - (M_b + M_m) \cdot \overline{AJ} \cdot \cos\theta \cdot \ddot{x} - M_d \cdot \overline{AO} \cdot \cos\theta \cdot \ddot{x} -$$
$$- m \cdot \left[\overline{AO} \cdot \cos\theta - r \cdot \cos(\omega t - \theta)\right] \cdot \ddot{x} = \left[\frac{1}{2} M_d \cdot r^2 + M_d \cdot \overline{OA}^2 + M_m \cdot \overline{OA}^2 + I_{bar}^A + m \cdot a^2\right] \cdot \frac{d^2\theta}{dt^2}$$

RESULTADOS EXPERIMENTALES Y COMPARACIÓN CON LOS TEÓRICOS

Introduciendo los datos correspondientes al sistema pendular y al buque, tendremos:

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) =$$
$$= \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right] \ddot{\theta} + 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta}$$

$$0.13137 \cdot \sin(18.85t) - 0.4485 \cdot \sin\theta - 0.04227 \cdot \sin(18.85t - \theta) - 0.001596 \cdot \cos\theta +$$
$$+ 0.0001479 \cdot \cos(18.85t - \theta) = \left[0.00473945 - 0.00074639 \cdot \cos(18.85t)\right] \cdot \ddot{\theta} +$$
$$+ 0.0139386 \cdot \sin(18.85t) \cdot \dot{\theta}$$

Resolviendo estas ecuaciones diferenciales por diferencias finitas, mediante un programa por ordenador y sustituyendo en las expresiones $\dot{x}$ y Δx, obtendremos $\dot{x} = 7.1\ cm/s$ y $\Delta x = 0.21\ cm$. Estos resultados concuerdan muy bien con los observados experimentalmente.

VEHÍCULOS ACUÁTICOS

Se puede aplicar tanto a una canoa como a un trasatlántico, la única diferencia sería la sofisticación de la utilización del vector en un trasatlántico que no sería rentable en una canoa; el principio es el mismo. Además, el vector, para empuje de proa o popa, se puede variar para que empuje también de estribor a babor, lo que facilitaría las maniobras de atraque del buque. No se precisa hélice para la propulsión del buque.

En el caso de naves para funcionar bajo la superficie del agua: submarinos, batiscafos, vehículos de investigación submarina, sistemas especializados submarinos para tender cables, tuberías, etc., esta aplicación de los vectores F_d será más versátil. El vector F_d permite una extremada complejidad de traslaciones dentro de una esfera donde el vehículo estaría en punto central.

CONCLUSIONES

Dado que nuestro sistema funciona a impulsos, sincronizando varios motores se puede conseguir un impulso *cuasi-continuo*.

Las pruebas realizadas muestran que con nuestro sistema el modelo de laboratorio es impulsado sin necesitar hélices u otro propulsor conocido.

Los vectores empujan de proa a popa o viceversa pudiéndose variar para que actúen de babor a estribor, facilitando las maniobras del buque.

Basándonos en el mismo principio físico de este modelo podríamos conseguir obtener velocidades mayores que con los sistemas actuales y mejorar ostensiblemente la relación peso-potencia. Además se pudiera conseguirla desaparición de la hélice y del timón.