Propulsive Forces From Rotating Objects

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Thrust is generated when a particle with momentum interacts with a rotating medium and is released from the constraints of the rotation.

I. Introduction

THE search for innovative propulsion technologies has always been at the forefront of scientific exploration. While current propulsion systems have undergone numerous refinements over the years, there remains a promising yet underexplored method of generating thrust using rotating objects. This paper presents a novel approach to propulsion that has the potential to transform transportation across various mediums, including land, water, air, and space.

II. Objective

This paper aims to present a new technological concept and solicit funding for its further validation and development.

III. Target Audience

The primary audience for this paper includes propulsion research institutions, physicists, aerospace engineers, photonic engineers, and others with a foundational understanding of the Physics concepts discussed.

IV. Technical Background

Consider a stone tied to a string, spun overhead. If the string breaks, the stone will move in a straight line, tangential to its last path from the curvature [1], as depicted by v in Fig. 1. This linear motion of the stone effectuates a reaction force in the opposite direction as indicated by F in Fig. 1. Any argument refuting the existence of this reaction force goes against Newton's Third Law of Motion. For instance, within a space-based hypothetical scenario (Fig. 2), if one were to fling the stone inside a closed container continuously, said container would show signs of acceleration in the absence of reaction force, thereby negating the established laws of Physics. Therefore, to induce movement towards a designated orientation (Fig. 2, shown as E), the stone must either be expelled from the container or bounced off an interior wall before release to the direction represented by W in Fig. 2. Presuming no loss of energy, both these actions would eject the stone at almost identical velocities, subsequently generating a comparable reaction force, impelling the container in the opposing direction. The consecutive hurling of the stone would lead to an acceleration of the container.

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The expulsion of an object through rotational motion is the working principle of the Rielles Drive invention [2] which uses particles carrying momentum as propellant.

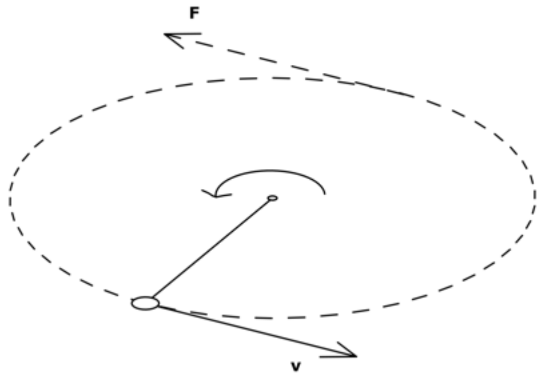

Fig. 1 Rotating stone

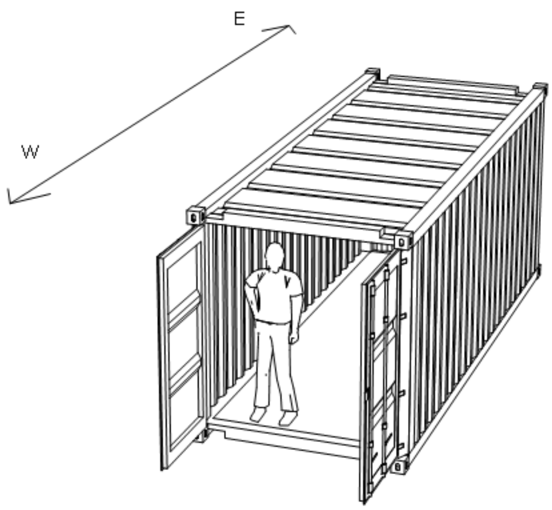

Fig. 2 Shipping container in space

V. Invention

The Rielles Drive is an advanced propulsion system designed to rotate propellants. It is categorized into seven distinct variants:

1) Rielles Drive 1.0

As shown in Fig. 3, the propellant (water) is fed through duct **10** and released via exit port **20**. The release of water is regulated by valve **15**, which is actuated only when the drive achieves the desired angular velocity and the spatial orientation of exit port **20** is at an optimal angle for thrust generation (perpendicular to the direction of motion).

The propellant may be pressurized to avoid cavitation, particularly when the drive operates in an environment with significant ambient pressure.

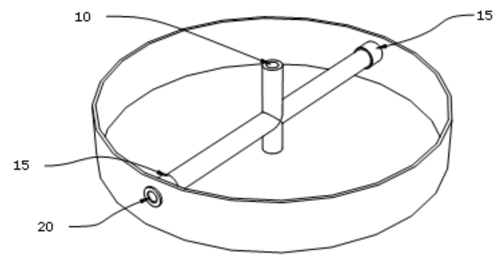

Fig. 3 Cutaway illustration of Rielles Drive 1.0

Suppose a Rielles Drive 1.0 has a diameter of one meter, rotates at 10,000 times per minute in a frictionless environment with no energy loss, and expels 2 milliliters (equivalent to 2 grams) of water via a singular exit port during each rotation, the thrust can be calculated as follows:

1) **Calculation of Linear (Tangential) Velocity**:

Given the angular velocity ω in terms of revolutions per minute (RPM), we will convert it to radians per second:

$$\omega = 10,000 \times \frac{2\pi}{60\text{ s}}$$

$$\omega \approx 1,047.20\text{ rad/s}$$

It is important to note that within the context of this discussion, the terms "revolution" and "rotation" are interchanged. This similarity arises due to the roles of the Rielles Drive and the propellant: the Rielles Drive executes a rotational motion, while the propellant undergoes a revolutionary motion.

The linear velocity v of a point (or the propellant, in this case) on the rim of the rotating member with a 1-meter diameter is:

$$v = r \times \omega$$

Where r is the radius, which is half of the 1-meter diameter, so $r = 0.5$ m.

$$v \approx 0.5\text{ m} \times 1,047.20\text{ rad/s}$$

$$v \approx 523.60\text{ m/s}$$

2) **Calculation of Thrust**:

Given that 2 ml of water is 2 grams or 0.002 kg is ejected per rotation, the mass flow rate $\dot{m}$ (mass ejected per unit time) is:

$$\dot{m} = 0.002 \text{ kg/rotation} \times \frac{10,000 \text{ rotation}}{60 \text{ s}}$$

$$\dot{m} \approx 0.33 \text{ kg/s}$$

The thrust T is then:

$$T = \dot{m} \times v$$

$$T \approx 0.33 \text{ kg/s} \times 523.60 \text{ m/s}$$

$$T \approx 172.79 \text{ N}$$

With a diameter of one meter, rotating at 10,000 times a minute, and ejecting 2 ml of water in each rotation, the Rielles Drive produces a thrust of 172.79 N. Suppose this is attached to a vehicle having a total mass of 50 kg including the drive, the acceleration would be:

$$a = \frac{F}{m}$$

$$a = \frac{172.79 \text{ N}}{50 \text{ kg}}$$

$$a \approx 3.46 \text{ m/s}^2$$

Three units of Rielles Drive 1.0 with the given parameters, when attached to a vehicle weighing a total of 50 kg inclusive of the drives, are sufficient for the vehicle to ascend at sea level if the said ideal environment were to exist on Earth.

Going back to the space-based shipping container analogy where the stone is directed to impact the wall opposite the open side: a similar setup can be implemented to a Rielles Drive 1.0 by attaching a parachute-like contraption near the water exit port in order for the water to collide to the contraption (analogous to a thrust reverser [3] in an aircraft). With this, we can then calculate the acceleration of the 50 kg vehicle using Collision Equation.

$$\text{Mass of propellant (Object A)}, \ m_A = 2 \, \text{grams} = 0.002 \, \text{kg}$$

$$\text{Initial velocity of Object A}, \ v_{A1} = 523.6 \, \text{m/s}$$

$$\text{Mass of vehicle (Object B)}, \ m_B = 50 \, \text{kg}$$

$$\text{Initial velocity of Object B}, \ v_{B1} = 0 \, \text{m/s}$$

Using the equations for a one-dimensional elastic collision:

$$v_{A2} = \frac{m_A - m_B}{m_A + m_B} v_{A1} + \frac{2m_B}{m_A + m_B} v_{B1}$$
$$v_{B2} = \frac{2m_A}{m_A + m_B} v_{A1} + \frac{m_B - m_A}{m_A + m_B} v_{B1}$$

Substituting the values:

$$v_{A2} = \frac{0.002\text{ kg} - 50\text{ kg}}{0.002\text{ kg} + 50\text{ kg}} \times 523.6\,\text{m/s} + \frac{2 \times 50\text{ kg}}{0.002\text{ kg} + 50\text{ kg}} \times 0\,\text{m/s}$$
$$v_{A2} \approx -523.6\,\text{m/s}$$

$$v_{B2} = \frac{2 \times 0.002\text{ kg}}{0.002\text{ kg} + 50\text{ kg}} \times 523.6\,\text{m/s} + \frac{50\text{ kg} - 0.002\text{ kg}}{0.002\text{ kg} + 50\text{ kg}} \times 0\,\text{m/s}$$
$$v_{B2} \approx 0.0209\,\text{m/s}$$

Now, we find the change in velocity for Object B:

$$\Delta v_B = v_{B2} - v_{B1} = 0.0209\,\text{m/s}$$

Since this collision happens 166.67 times in a second, the total change in velocity over one second for Object B is:

$$\Delta v_B \times 166.67 \approx 3.48\,\text{m/s}$$

The acceleration of Object B is the change in velocity over time:

$$a_B = \Delta v_B \times 166.67 \approx 3.48\,\text{m/s}^2$$

The observed consistency between the acceleration calculated from the mass-velocity relationship and the one obtained through collision equation analysis substantiates the previously presented concepts.

The energy usage of the Rielles Drive 1.0 is primarily determined by the amount of energy the propellant extracts from the system during each rotation. A rotating object retains its rotational energy, provided there is no substantial energy loss from drag or friction like in a flywheel energy storage system [4]. This intuitively demonstrates the efficiency of the Rielles Drive in translating rotational motion into thrust. The thrust can be quantified by the mass flow rate multiplied by the velocity of the propellant. The release of the propellant mirrors the dynamics of the flywheel energy storage system when energy is extracted out from it. So, the energy imparted to the propellant can be computed as follows in which its total could also be used in determining the power consumption of the Rielles Drive:

1) **Energy Carried Away by Propellant:**

$$KE = \frac{1}{2}mv^2$$

$$KE = \frac{1}{2} \times 0.002 \text{ kg} \times (523.6 \text{ m/s})^2$$

$$KE = 274.16 \text{ J}$$

2) **Power Consumption:**

$$P = KE \times 166.67 \text{ rotation/second}$$

$$P = 274.16 \text{ J} \times 166.67 \text{ rotation/second}$$

$$P = 45{,}694.24 \text{ W}$$

The specific impulse, I_{sp}, can be calculated as follows:

$$I_{sp} = \frac{T}{\dot{m} \times g_0}$$

$$T = 172.79 \text{ N}$$

$$\dot{m} = 0.002 \text{ kg} \times 166.67 \text{ rotation/s} = 0.33 \text{ kg/s}$$

$$I_{sp} \approx \frac{172.79 \text{ N}}{0.33 \text{ kg/s} \times 9.81 \text{ m/s}^2} \approx 53.37 \text{ s}$$

The specific impulse of the Rielles Drive 1.0 is not predominantly determined by the type of propellant used. Instead, it is influenced by the amount of energy applied to the propellant and the drive's capacity to withstand g-force loads. It is inferred that the Rielles Drive has the potential to surpass the specific impulse of today's best chemical rocket engines, as shown in Fig. 4.

Another way to calculate thrust is by examining the conservation of angular momentum. As the propellant is ejected, the drive experiences an increase in its angular velocity due to the change in its moment of inertia.

1) **Moment of Inertia with Propellant Intact**

   The moment of inertia I for a point mass is calculated using the formula:

$$I = m \times r^2$$

   where m is the mass of the propellant and r is the radius of the drive.

2) **Change in Moment of Inertia**

   Upon the ejection of the propellant, it is hypothesized that the moment of inertia is reduced by half. This reduction results in an increase in angular velocity to conserve angular momentum.

3) **Angular Velocity Post Ejection**

   Using the conservation principle, the angular velocity after the propellant's ejection is determined. The conservation of angular momentum is expressed as:

$$I_i \times \omega_i = I_f \times \omega_f$$

   where the subscripts i and f denote initial and final states, respectively.

4) **Acceleration Due to Change in Angular Velocity**

   The tangential acceleration a resulting from a change in angular velocity is given by:

$$a = r \times \Delta\omega$$

   where $\Delta\omega$ is the difference in angular velocities before and after the propellant ejection.

5) **Determination of Thrust**

   Finally, the thrust F is calculated using Newton's second law:

$$F = m \times a$$

By applying the aforementioned methodology, the thrust generated by the Rielles Drive can be determined, offering another alternative perspective to traditional thrust calculations.

2) Rielles Drive 0.5

This is the simplest variant (Fig. 5). It uses radially opposing tubes to rotate the water propellant. The water, once expelled, impacts the external circular boundary. However, there is a designated segment where the water is allowed to

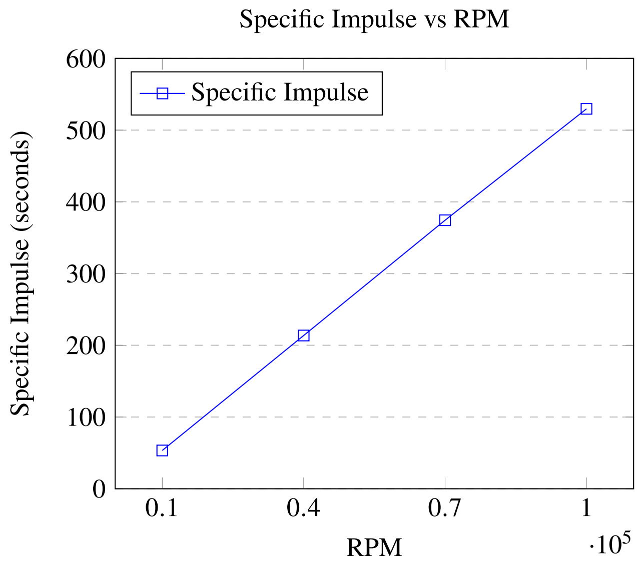

Fig. 4 Specific Impulse vs RPM

exit unimpeded. In areas where the water ricochets, the resulting thrust is counteracted. The deflected water is then captured, cooled, and reintroduced into the reservoir.

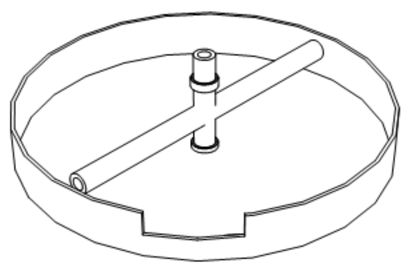

Fig. 5 Cutaway illustration of Rielles Drive 0.5

3) Rielles Drive 2.0

This conceptual variant uses photons instead of water as propellant, hypothesized to offer enhanced thrust, as compared to firing the photons at the rear end alone, due to the Doppler effect. The increase in photon's energy is analogous to the increase of kinetic energy of the expelled water in Rielles Drive 1.0.

4) Rielles Drive 3.0

In this variant, the traditional rotating tubing with a shaft is substituted by a compact capsule **35**. This capsule is constrained and set into motion by electromagnetic forces within an electromagnetic array setup **25**, as depicted in Fig. 6. This can be conceptualized as a Maglev train [5] operating in a circular trajectory or akin to a shaftless turbine. This design offers the advantage of reduced g-force stresses and more stabilized vibration management for the drive. The propellant is introduced to the capsule using a strategic non-contact approach, represented by **30**. As the propellant is released, the reactionary force is transmitted via the electromagnetic confinement back to the drive. By modulating the confinement power at the moment of propellant discharge, there is an option to augment the thrust by transferring additional kinetic energy to the propellant.

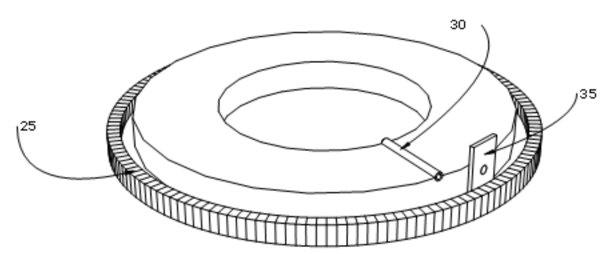

Fig. 6 Cutaway drawing of Rielles Drive 3.0

5) Rielles Drive 4.0

This is similar to Rielles Drive 3.0 but uses photons as propellant.

6) Rielles Drive 5.0

This is similar to Rielles Drive 3.0 but the tiny rotating capsule is replaced with an actual particle that generates photons when triggered.

7) Rielles Drive 6.0

This variant is similar to the Rielles Drive 3.0 in design. However, within the capsule, atomic fission and/or fusion processes take place. The slight reduction in mass, resulting from the conversion of matter to energy, leads to an alteration in the capsule's angular momentum which is similar to the operational principles of Rielles Drive 3.0.

For all Rielles Drive variants, when multiple drives are integrated into a vehicle, a counter-rotating configuration is necessary. This arrangement neutralizes the reactionary angular momentum, preventing the vehicle from becoming unstable or tumbling during motion.

VI. Expected Outcome

This technology once developed could be a viable alternative to traditional rocket engines and propulsion mechanisms in satellites and deep space probes. It could also augment propeller-driven systems in vertical take-off and landing (VTOL) aircraft.

VII. Conclusion

The Rielles Drive system introduces a groundbreaking approach to propulsion, leveraging its capacity to impart momentum to its propellant. When these propellants are freed from the rotational force, they exhibit a tangential motion due to inertia. This motion, in turn, produces a reactionary force in the opposite direction. The system's versatility is evident in its ability to utilize a wide range of propellants, as long as they possess momentum. Furthermore, the specific impulse of the drive is not solely dependent on the propellant type but is significantly influenced by the energy input to the system. To achieve stability and ensure efficiency, particularly in the case of multi-drive configurations, implementing a counter-rotating design is crucial, thereby effectively negating undesirable reaction forces. This pioneering propulsion technology shows potential in transforming transportation in diverse sectors, ranging from terrestrial applications to extraterrestrial explorations.

References

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