A SEMINAR REPORT ON

SUPERCAVITATION PRINCIPLE & APPLICATIONS

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NEED OF SUPERCAVITATION

Water limits even nature's strategies, and the fastest bird moves twice as quickly as the fastest fish. The phenomenon holding back the fish is the tremendous resistance that water offers to a moving object, called drag. The same drag acts on the bird as well, but the magnitude is considerably less owing to the lesser density of air. The human being has crossed the sound barrier in air and land, what about underwater? Water is the most challenging environment for an Engineer. Being 1000 times denser than air, it offers resistance roughly 1000 times as high as that in air. Supersonic under Water Travel is the dream of scientists working on a bizarre technology called SUPERCAVITATION. Supercavitation is the state of the art technology that may revolutionize underwater propulsion systems.

This fluid-mechanical effect occurs when bubbles of water vapor form in the lee of bodies submerged in fast-moving water flows. The trick is to surround an object or vessel with a renewable envelope of gas so that the liquid wets very little of the body's surface, thereby drastically reducing the viscous drag. Supercavitating systems could mean a quantum leap in naval warfare that is analogous in some ways to the move from prop planes to jets or even to rockets and missiles.
I. CAVITATION & SUPERCAVITATION

I.1. CAVITATION

- Formation of vapour bubbles of flowing fluid in a region where the pressure of the liquid falls below its vapour pressure and the sudden collapsing of these vapour bubbles in region of high pressure.
- Cavities implode violently and create shock waves that dig pits in exposed metal surfaces.
- Cavitation not only causes damage but also decreases efficiency.
- Marine engineers try to avoid cavitation.
I.2. SUPERCAVITATION

- Cavitation becomes a blessing under a condition called supercavitation, i.e., when a single cavity called supercavity is formed enveloping the moving object almost completely. In Supercavitation, the small gas bubbles produced by cavitation expand and combine to form one large, stable, and predictable bubble around the supercavitating object.

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Supercavitation is an extreme version of cavitation in which a single bubble is formed that envelops the moving object almost completely. At velocities over about 50 meters per second, (typically) blunt-nosed cavitators and prow-mounted gas-injection systems produce these low-density gas pockets (what specialists call supercavities). With slender, axisymmetric bodies, supercavities take the shape of elongated ellipsoids beginning at the forebody and trailing behind, with the length dependent on the speed of the body.
III. U.S. SUPERCavitATION EFFORTS

III.1. RAMICS (Rapid Airborne Mine Clearance System)
The 20-millimeter flat-nosed projectiles, which are designed to travel stably through both air and water, are shot from a modified rapid-fire gun with advanced targeting assistance.

III.2. AHSUM (Adaptable High-Speed Undersea Munitions)
supercavitating "kinetic-kill" bullets that are fired from guns in streamlined turrets fitted to the submerged hulls of submarines, surface ships or towed mine-countermeasure sleds.

III.3. TORPEDOS
Torpedo with a maximum velocity of about 200 knots.
Cavitators creates the gas cavity in which the craft moves. The cavitators disk will be tilted forward at the top, providing an "angle of attack" to generate the lift needed to support the forebody of the device.
V. ADVANCED PROPULSION SYSTEMS

- Supercavitation requires a lot of power.
- A typical solid-rocket motor can achieve a maximum range of several tens of kilometers and a top speed of perhaps 200 meters per second.
- High-efficiency gas turbines and jet propulsion systems burning metal fuels (aluminum, magnesium or lithium) and using outboard water as both the fuel oxidizer and coolant of the combustion products have real potential for propelling supercavitating vehicles to high velocities.
- Researchers are operating an aluminum-burning "water ramjet" system, which was developed as an auxiliary power source for a naval surface ship.
- In the novel American design, powdered aluminum feeds into a whirlpool of seawater occurring in what is called a vortex combustor.
- Tests have shown that prop screws offer the potential to boost thrust by 20 percent compared with that of rockets, although in theory it may be possible for screws to double available thrust.
VI. FUTURE OF SUPERCavitATION

NEUTRALIZING MINES

Rapid Airborne Mine Clearance System operating from helicopters, RAMICS will locate subsurface sea mines with an imaging blue-green LDAR (light detection and ranging) system, calculate their exact position despite the bending of light by water refraction, and then shoot them with supercavitating rounds that travel stably in both air and water. The special projectiles contain charges that cause the deflagration, or moderated burning, of the mine's explosive.
ANTIMINE PROJECTILE

Supercavitating projectiles shot from above the ocean surface must fly stably in both air and water - a difficult engineering task. The RAMICS round (partially visible) was developed by C Tech Defense Corporation.

Supercavitating Ships

Supercavitating ships are at the desk of researchers now-a-days. Use of supercavitation phenomenon to throttle the ships is carried by installing cavitators at the bottom of the ship. The part of the ship submerged is supercavitated and the speed of ship increases tremendously.
VII. CASE STUDY – VA-111 SHKVAL TORPEDO

VII.1. DESCRIPTION

- The torpedo has a nearly flat, conical disk at its nose that creates the gas cavity for supercavitation.
- The disk tilts to help guide the weapon and keep it stable.
- The solid-rocket propelled torpedo achieves a high velocity of 386 kmph by producing an envelope of supercavitating bubbles from its nose and skin, which coat the entire weapon surface in a thin layer of gas.
- The weapon reportedly has an 80 percent kill probability at a range of 7,000 m.
VII.2. VARIANTS

Shkval High-Speed Underwater Rocket

Original unguided production model. Uses a tactical nuclear warhead on a timer to destroy incoming torpedoes and/or the submarine that launched them. This model was deployed in 1977; it could only be fired in a straight line and had a range of about 10 miles (16.2 km).

Improved Shkval

Original model with guided targeting system and a conventional warhead.

Shkval-E

Export variant. This model requires the crew of a submarine or ship to define the target's parameters -- speed, distance and vector. The torpedo must also be fed data for the automatic pilot. This variant does not have a homing warhead and must follow a computer-generated program. Warhead weight is reported to be greater than 462.9 lb (210 kg).
VII.3. CHARACTERISTICS

**WEIGHT:**
- Total 2,700 kg
- Warhead
  - Shkval-E 210 kg

**DIMENSIONS:**
- Length 8,200 mm
- Diameter 533 mm

**PERFORMANCE:**
- Speed Maximum 360 kmph or 100 m/sec Some reports say in excess of 483 kmph
- Exit from tube 93 kmph

**Range:**
- launch 7.0 km
- cruise 10.0 km
- minimum 0.5 km
- Launch depth 30 m
- Cruise depth 6 m

**WARHEAD:**
- Explosive
- Weight 210 kg
- Type TNT
CONCLUSION

A supercavitating body has extremely low drag, because its skin friction almost disappears. Instead of being encased in water, it is surrounded by the water vapour in the supercavity, which has much lower viscosity and density. An important point regarding future supercavitating vehicles is the fact that transitions from normal underwater travel into the supercavitating regime and back out again can be accomplished by artificially ventilating a partial cavity to maintain and expand it through the velocity transitions. Thus, a small natural cavity formed at the nose (at lower speeds) can be "blown up" into a large one that fully encloses the entire body. Conversely, braking maneuvers can be eased by augmenting the bubble with injection gases to maintain and then slowly reduce its size so as to gradually scrub speed.
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THANK YOU.