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The Effectiveness of Depleted Uranium on Penetrating Ammunition and Its Impact on Environment: a Journal Review

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Abstract

Nuclear technology has significantly impacted the military, especially in weaponry. Depleted Uranium (DU), a byproduct of uranium purification rich in U-238 with low radiation levels, is notably used in ammunition due to its high density. This study investigates DU's effectiveness as ammunition material compared to tungsten-based alternatives. U.S. Army report on testing involved firing DU at a 150 mm steel plate, demonstrating DU's superior penetration capabilities, with an impulse pressure of 4.6 GPa, unlike tungsten, which tended to ricochet. Despite DU's effectiveness, its use is controversial due to its radioactive properties, though less potent than natural uranium. The International Atomic Energy Agency (IAEA) has found no harmful radioactive activity in DU usage areas, suggesting minimal environmental impact. However, the chemical toxicity of DU poses significant health risks, especially when fragments are inhaled or ingested.

Keywords: *Depleted Uranium, Military, Nuclear Radiation, Penetrating Ammunition*

Introduction

The technology of war has been evolving throughout the history of human beings. Human instinct for self-preservation and fulfill their needs has trained human skill and their knowledge towards a more advanced civilization. We cannot deny the fact that a war can force human to innovate and create revolutionary technologies such as jet engine, Radar, GPS, etc. One of the revolutionary technologies from war is Depleted Uranium (DU) armor piercing bullet and we will discuss this technology on this paper.

Depleted Uranium (DU) is a byproduct of the uranium enrichment process. This process separates the more reactive isotope, U-235, from natural uranium. The resulting material is "depleted" in U-235 and enriched in the less reactive U-238 isotope. While not significantly radioactive, DU's high density and exceptional physical properties make it an attractive choice for military ammunition components.

DU's usefulness extends beyond the battlefield. It finds application in various civilian sectors. For instance, DU can be found in aircraft counterweights, providing crucial stability. Additionally, its shielding properties make it ideal for hospital radiation therapy units, protecting medical personnel and patients from harmful radiation. Furthermore, DU is used as a constituent material in containers designed for the safe transportation of radioactive materials. Stockpiles of DU are maintained by many countries, including Russia, the United States, and the United Kingdom, primarily for its use in military ammunition.

Materials and Methods

Methods

This research including literature review and follow bibliographic methods.

Result and Discussion

Works Process of DU

Based on its properties, the DU used in ammunition for many defense equipment such as Armored Personnel Carrier, Main Battle Tank, Ground Attack Aircraft, etc. DU is immensely hard and dense, it can provide a huge performance for dealing with thick armor than a regular ammunition.

The DU ammunition contains a steel armored casing of the shell and headed by aluminum sabot. Mainly, the material of DU take part in the penetrator part of the shell to pierce through thick armor. When the shell is fired, the aluminum sabot will release in mid-air while the DU penetrator thrust forward and push through heavy armor. The dart-like projectile of DU giving high momentum and penetrative power causing the armor plate of target will be shattered and shard of armor disperse will kill human inside, making the tank or target cannot operate [1].

Figure 1. The works of DU shell

Penetration Performance of DU Projectile

At 1991, the US Army Ballistic Research Laboratory conducted trials on DU alloy to test its penetration ability on high velocity. This test used tungsten alloy penetrator as comparison material. To gain the optimum velocity for both materials, they use an enhanced performance 120-mm launch system in which each component was modified. The modified has done by in-bore mass projectile made lighter, using extended length gun tube, and heating process of granular propulsion charge.

The result of DU ammunition with tungsten alloy ammunition as comparing material is shown by the figure 2. As we can see, the DU ammunition has outclassed the Tungsten Heavy Alloys (WHA) ammunition especially at speed of 1 -1.8 km/s [2]. From this graph can also be seen that at the speed of more than 1.8 km/s, WHA ammunition is able to equalize the DU ammunition in case of penetration abilities. We should note that the velocity of bullet usually not higher than 1.8 km/s, as the example the projectile of M1A1 Abrams tank had a speed of 1.575 km/s or bullet from A-10 Thunderbolt aircraft is 1.01 km/s. Based on this data, DU ammunition was an excellent choice foe AP ammunition.

The US Army method for this test is firing a total of six KE projectiles against semi-infinite Rolled-Homogeneous Armor (RHA) target configuration. After firing test, the Army records several sets of post-impact target measurement. Penetration entrance, exit hole location and dimension of each RHA for each target package. Additional measurement recorded when the penetrator has go through the approximate centerline of target including maximum depth of penetration.

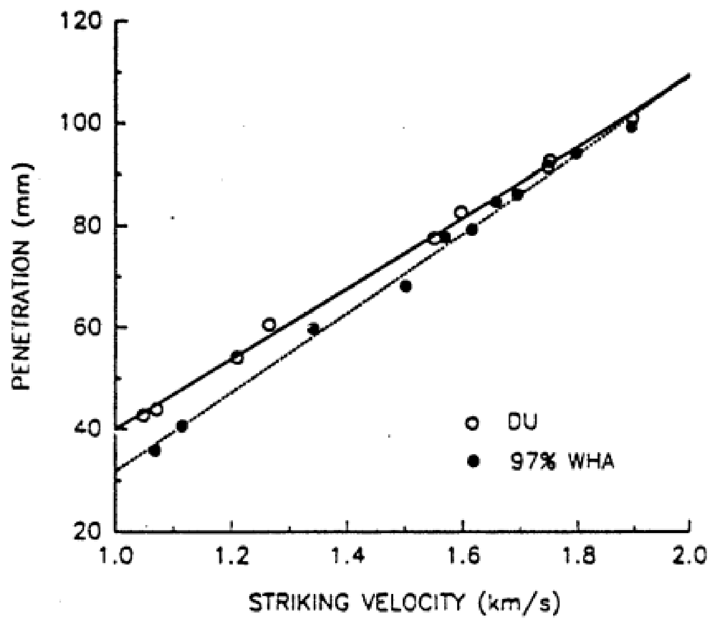

Figure 2. Penetration performance of DU shell and 97% WHA

DU Ammunition Performance in Gulf War

Depleted Uranium (DU) ammunition gained widespread use during the 1990s, coinciding with the Gulf War and the Yugoslav Wars. The first extensive use of DU for military was happen in Gulf War 1990-1991. It is estimated that between 315-350 tons of DU are used in Gulf War for armor addition, and ammunition of tank, aircraft, and anti-material sniper rifle [3]. M8249A4 is one of the AP ammunition used for the United States Abrams tank which using a depleted uranium penetrator [4].

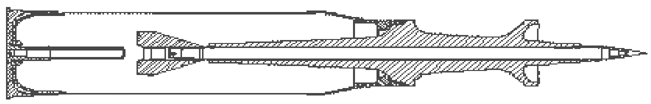

Figure 3. DU Rounds Cross Section

In the battlefield, DU ammunition are very effectives against enemy armour such as tank, light vehicle or armoured personnel carrier. One of US armour brigade even getting amazed for his soldier who never trained to shoot at 2400 meter but in the battle they routinely destroy enemy T-72 tank on 3000 meter [5]. There are many case that one M1A1 Abrams can destroy many Iraq T-72 tank even when they were outnumbered [6].

Not only the army, different 3 branch of US Armed Force were providing DU ammunition to their soldier. The air force using armor piercing incendiary (API) round with DU penetrator slug as the ammunition for A-10 attack aircraft Gatling gun [7]. The Navy uses DU such as 25-mm PGU-26 API (Armor Piercing Incendiary) attached to its aircraft and CIWS (Close In Weapon System) [8]. In other side, since the Marines mainly use the Abrams as their main tank, that was where depleted uranium used both as ammunition or armor plate [9].

Environment Impact of DU Ammunition

Naturally occurring uranium is primarily composed of three isotopes, there are 238U, 235U, and 234U. We should realize that all of the uranium are radioactive that including depleted uranium which is rich on less radioactive 238U. According to International Atomic Energy Agency (IAEA), DU is only slightly radioactive (60% as radioactive as natural uranium) [10]. While in accord with the document made from U.S. Navy Medicine, Depleted uranium produces modest amounts of radiation, including alpha and beta particles and gamma rays. Alpha particles are prevented from entering your body by the skin. Clothing blocks beta particles. Although gamma rays are powerful and penetrate deeply, depleted uranium emits very little of them [11].

The bigger concern with DU lies elsewhere. Inhaling DU dust can be harmful because alpha particles inside the body can cause significant damage. There are no adverse health effects have been observed from radiation exposure, but for the internal exposure of the Alpha Particles it can caused damage nearby cells and potentially leading to mutation and cancer [12]. internal radiation exposure to DU depends on several factors such as dose of radiation received, time length of exposure on high dose rate, and organ susceptibility [13].

Studies suggest that the potential health risks associated with Depleted Uranium (DU) stem more from its chemical properties as a heavy metal than its radioactivity [11] [14]. DU's high atomic weight and density, characteristic of heavy metals, pose a threat when inhaled as dust. These particles can accumulate in the body, particularly in organs like the kidneys, bones, and liver. The kidneys are especially vulnerable to the effects of DU, and high concentrations can cause damage. Similar to other types of dust, high exposure to DU dust through inhalation can lead to pulmonary function disorders.

Due to potential health and environmental concerns, the U.S. Armed Forces, one of the biggest users of DU weapons, still maintains regulations regarding the use of DU ammunition. An incident in 1999 highlights the importance of these regulations. US Navy AV-8 Harrier aircraft stationed at Vieques Naval Base, Puerto Rico, discharged 263 rounds of 25mm PGU-20 API (armor-piercing incendiary) ammunition containing

DU into the live impact area. The U.S. Navy Radiation Safety Committee deemed this a Severity Level IV violation, signifying a major incident with significant consequences [15]. Unfortunately, further information regarding the specific effects of the incident, its cause, and the Navy's response actions is unavailable due to a lack of publicly accessible documents.

Conclusion

DU is notably effective in penetrating armor due to its high density and hardness, outperforming tungsten-based ammunition, especially at velocities common in artillery and tank rounds. Comparative tests demonstrated that DU penetrators achieve higher penetration pressures, making them superior in battlefield conditions, as evidenced during the Gulf War where U.S. military units successfully employed DU ammunition against enemy tanks. Despite its proven effectiveness, DU's use remains controversial due to concerns about long-term environmental and health impacts. The chemical toxicity of DU poses significant risks, particularly when fragments are inhaled or ingested. These risks include potential kidney damage and other health issues related to heavy metal exposure. The International Atomic Energy Agency (IAEA) and U.S. Navy Medicine suggest that the environmental impact of DU is relatively minor, asserting minimal harmful radioactive activity in areas where DU has been used. However, the potential for chemical toxicity remains a critical concern. Nonetheless, the debate over DU's safety and long-term effects continues to be a critical aspect of its ongoing use in military applications.

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