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A6_1 Sea Titans

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Abstract

During WWII, two of the largest Naval powers in the world, the USA and Japan, raced to create the most powerful ships ever seen. This goal was represented by the two famous battleships USS Missouri and IJN Yamato for the USA and Japan respectively. In this paper, we estimate the penetration power of USS Missouri and IJN Yamato's Main Battery Guns. By comparing these values to the known belt armour schemes of both ships, at $\sim 20km$, we determine that USS Missouri has $\sim 0.335m$ of penetration; IJN Yamato has $\sim 0.392m$ of penetration. This means that at this distance, IJN Yamato has a distinct tactical advantage, under the assumptions of our system.

Introduction

Two of the most famous vessels in maritime history are the two World War II battleships USS Missouri and IJN Yamato. Both were the pinnacle of battleship design by the two powers, with the USS Missouri remaining in active service until 1992.

Although these two flagships never engaged in combat together during WWII, there has always been a question surrounding these ships as to whether they could counter each other in a straight fire fight. Here, we answer that question.

Method

The results found here were computed using Python. Firstly, we make the following assumptions about the system: The density of air, $\rho = 1kg/m^3$ and the drag coefficient, $c_d = 0.1$ (approximating the shell as a streamlined object)[2]. From [2] we see that the equation for drag, (1), is:

$$F_d = 0.5\rho v^2 S c_d, \tag{1}$$

where S is the base surface area of the shell, taken from caliber, (diameter of shell), (m^2) and v is the velocity (m/s). From [3], we find that the mass, initial (muzzle) velocity, caliber and firing elevation of USS Missouri's shells are: $m = 1230kg$, $v = 760m/s$, $c = 0.406m$, $\theta = 15°$ respectively. Using these values, Eq.1, and considering the physics of Projectile Motion, we find the relevant velocity-time (VT) curve shown in Fig.1. By integrating the horizontal VT curve, we find that the the shell has travelled $\sim 20km$ at $\sim 35s$, giving us an estimate of the impact velocity of $\sim 534m/s$. From the projectile motion, we also find the impact angle of the shell to be $\theta = \sim 37.8°$.

Similarly, from [4], we find that for IJN Yamato; $m = 1460kg$, $v = 780m/s$, $c = 0.460$, $\theta = 13°$. We find that the flight time is $\sim 34s$. Using Eq.1 and the relevant horizontal VT curve in Fig.1, we find the impact velocity and angle

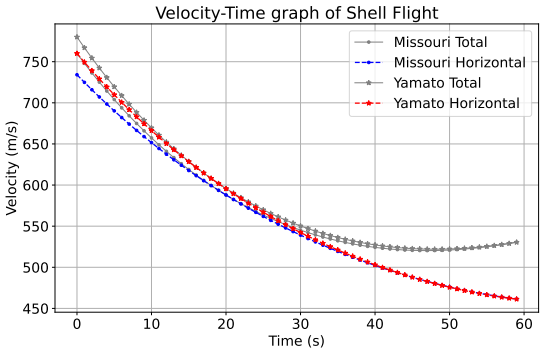

Figure 1: Velocity-Time graph, containing both net and horizontal velocities

is $u =\sim 541m/s$ and $\theta =\sim 38.2°$.

To find the penetration capacity of these shells, we use the "Thompson F-Formula" [5]:

$$t = 0.0623(mv^2/d^2F^2)\cos^2\theta \qquad (2)$$

where d is the diameter of the shell in metres, F is the F-Factor (equation in [5], omitted from paper due to size), θ is the impact angle in radians and t is the armour penetrated. To calculate the penetration and F-Factor, we need the armour thickness of the belt, given for USS Missouri and IJN Yamato as $0.344m$[6] and $0.410m$[7] respectively.

By substituting all of the calculated values so far, we find that USS Missouri is able to penetrate $\sim 0.335m$ of armour, with IJN Yamato able to penetrate $\sim 0.392m$ of armour. Therefore, if these two ships were to engage each other at $\sim 20km$, the USS Missouri would be unable to penetrate the belt of IJN Yamato - hence not able to severely damage her. The opposite can be said for IJN Yamato, her shells do have enough penetration to go through the belt of USS Missouri.

Conclusion

As we determined in the Method section, in our system, at $\sim 20km$, Yamato has the ability to penetrate the belt armour of Missouri, but this is not the case vica versa. This gives IJN Yamato a distinct tactical advantage, in our scenario.

As stated, our system here contains a number of assumptions. These being that we have approximated the drag coefficient of the shells to 0.1. In reality, as the shells slowed mid flight, the drag coefficient would decrease. Additionally, USS Missouri and IJN Yamato shells would intrinsically have different c_d values due to manufacturing differences.

Secondly, we assumed the same type of armour in both ships (for F-Factor calculation). This was to make the results easier to compare, but in reality the composition of the armour would be different, hence changing the amount of penetration each battleship would theoretically have.

References

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