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Fastest Man Alive … Underwater

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Abstract
If based purely on modern records, Jamaican Sprinter Usain Bolt is the fastest man to have ever lived. In Berlins 2009 World Championships, he recorded a time of 9.58 s over 100 m with a negligible tail wind of 0.9 ms^{-1}, giving him an average velocity of 10.44 ms^{-1}. However while this feat was performed on land, he would require more power to accomplish such a speed under water. This paper models the amount of extra power required to run at this same velocity, at a depth of 500 m in the Atlantic Ocean. The additional power required to overcome drag forces from the water was calculated as 728 horsepower.

Introduction

Usain Bolt, considered the fastest man in the world, is a 28-year-old Jamaican sprinter. Currently the holder of 18 major championship medals, 16 being gold medals, he is the Olympic and World record holder for the 100 m and 200 m sprint races. Along with his team, he is also the 4x100 m relay world record holder. Bolt's current world record for the 100 m is 9.58 s [1], with a tail wind of 0.9 ms^{-1} which would have had little to no effect on his time [2].

Whilst these impressive records are held on land, what would happen to Bolt's performance if he were fully submerged in water? This paper models the amount of extra power required for the athlete to run at the same velocity along the seabed and hence the power required for him to run at his record speed underwater.

Drag Force

The model presented in this paper first requires a calculation for the drag force working against Usain Bolt if he were underwater. In order to calculate this force the drag equation is used (1).

$$F_D = \frac{1}{2}\rho v^2 C_D A \qquad (1)$$

In this equation F_D is the drag force, ρ is the density of the fluid, v is the velocity, C_D is the drag coefficient (found from Reynold's number or by reference to the drag coefficient for some common shapes) and A is the surface area of the object.

For the calculation of Usain Bolt underwater the density is stated at 1027 kgm^{-3} [3]: this is the value at 500 m deep in the Atlantic Ocean as shown by the graph in figure 1. For the remainder of these calculations it is assumed that he is running on the seafloor which is at this depth of 500 m.

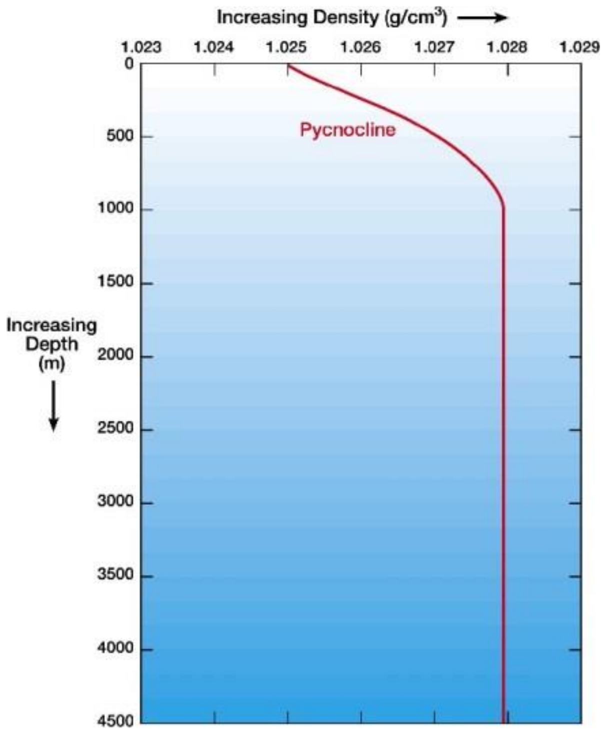

Figure 1 – Graph showing density of seawater at varying depths [4].

The next value is velocity: his world record for 100 m is 9.58 s, this equates to an average velocity of 10.44 ms^{-1}. The drag coefficient has been selected as that for a person standing and has a value of 1.0 [5]. This is taken from the lower end of a range of 1.0-1.3 as listed on [5].

Lastly, the value of area is calculated by the cross section of a rectangle with height 195.58 cm (using Bolt's height of 6'5" [6]), and a width of 47.6 cm (sourced from the NASA database for average width of back [7]). The area is therefore 0.93 m^2.

The drag force acting on Usain Bolt if he were running at the same average speed underwater as he can on land is now shown by (2).

$$F_D = \frac{1}{2} \times 1027 \times 10.44^2 \times 1.0 \times 0.93$$
$$F_D = 52050N \qquad (2)$$

Power

Now that the drag force has been found, the power required to overcome this force can be determined. For the purpose of this report the drag force is used as the only force acting upon him and the gravity is determined as negligible: in reality gravity would also have some effect.

The equation for power (*P*) is shown in equation 3, and takes into the account the force and the velocity that Bolt is travelling.

$$P = \vec{F}.\vec{v} \qquad (3)$$
$$P = 5.43 \times 10^5 W$$

This extremely large value is in comparison to the average power required for him on land when the only force is modelled as gravity:

$$P = 102.42\ W$$

Note that gravity alone is modelled here in order to simplify the model, however as with the underwater calculation, other forces would come into effect in a realistic situation.

It can therefore be seen that there is an extremely large change in the amount of power required to be exerted by Bolt if he were to maintain the same land speed at a depth of 500 m in seawater.

Converting this underwater value to horsepower shows that Bolt would need to be running at 728 hp (where 1 hp is equal to 746 W [8]).

Conclusion

Using the assumptions that it is possible to run underwater and that gravity would negligible in comparison to the drag force, the additional power required to run at the same average speed over 100 m as Usain Bolt's world record has been calculated.

This was done by working out the additional drag force of running at a depth 500 m in comparison to on land, 52,050 N. Thereafter, the power required to overcome this additional force was determined as 5.43×10^5 W, equivalent to 746 hp; this is more power than a Dodge Challenger SRT Hellcat [9]. Considering this vehicle can go from 0-60 mph in 3.9 s and has a top speed of 199 mph [9], it can be concluded that it is a substantial amount of additional power required by the world's fastest man to replicate his land-based feats underwater.

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