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Renewable Energy in the Nation of Panem

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Abstract
In the film *The Hunger Games: Mockingjay — Part 1*, the destruction of a single hydroelectric dam leaves the Capitol of the nation of Panem with no electrical power. In this paper, measurements of the hydroelectric dam are used to calculate its power output in order to estimate the power consumption in the Capitol, calculated to be 15.84MW.

Introduction

The 2014 film *The Hunger Games: Mockingjay — Part 1*, takes place in the future North American nation of Panem, led by the dictatorial President Snow in the country's wealthy Capitol. During a revolution, a single hydroelectric dam is destroyed, resulting in the entire Capitol being without electrical power [1]. This suggests that the entire Capitol is powered by this single dam. This paper will attempt to estimate the power output of this dam to determine the Capitol's power consumption.

Height of the Dam

The power generated by a hydroelectric turbine can be calculated using the formula:

$$P = \eta \rho g Q H, \tag{1}$$

where P is the power generated by the turbine in watts, η is the dimensionless turbine efficiency, ρ is the density of the fluid in kg/L, g is the acceleration due to gravity in m/s^2, Q is the fluid flow rate in L/s, and H is the effective pressure head at the turbine in m [2].

H, the effective pressure head at the turbine, is equal to the height the water falls before reaching the turbine. To determine this value, stills from the film were used. In the absence of any other familiar objects with which to measure the dam's dimensions, human body proportions were used to determine a scale with which to determine the size of the dam (figure 1). Using ratios of on-screen measurements, the ratio of real-size measurements can be calculated.

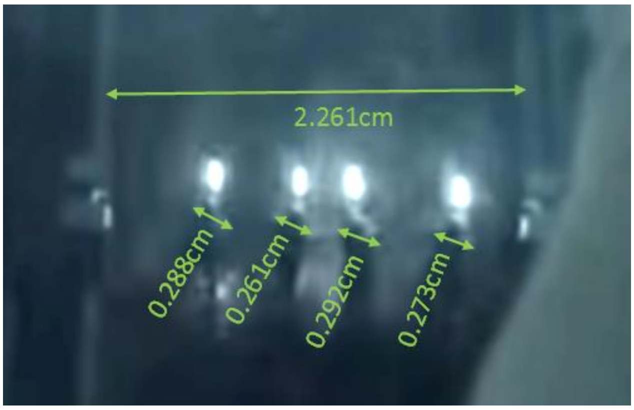

Figure 1 – Measurements of a screenshot of four human characters standing on a bridge leading into the hydroelectric dam. Adapted from [1].

Four characters' shoulder-to-shoulder breadths were measured and the mean was taken, resulting in a mean on-screen shoulder-to-shoulder breadth of 0.279cm. The median male forearm-forearm breadth, which is close to the shoulder-shoulder breadth, is 55.1cm [3]. Based on this, the width of the bridge is:

$$\frac{2.261cm}{0.279cm} \times 55.1cm = 446cm. \tag{2}$$

This value can now be used to determine the size of a larger portion of the dam. The distance from the outside edge of the water outflows on either side of the bridge were determined using the measurements in Figure 2.

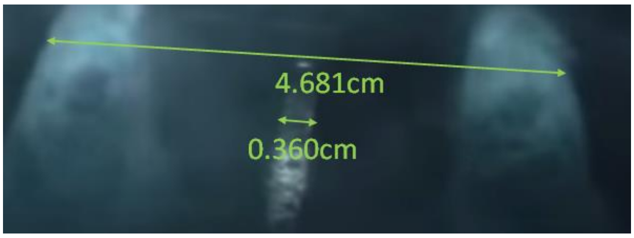

Figure 2 – Measurements of intermediate-scale features of the hydroelectric dam. Adapted from [1].

That distance was determined to be:

$$\frac{4.681cm}{0.360cm} \times 4.46m = 58.0m. \quad (3)$$

Finally, this value can be used to calculate the height of the dam, using measurements from Figure 3.

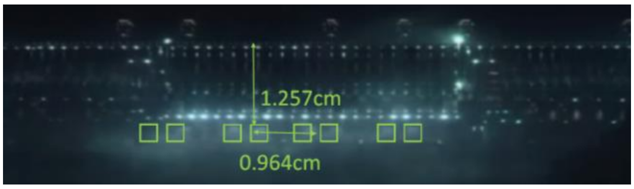

Figure 3 – The dam, with height and distance between the two water outflows. In total, there are eight outlets for the water, highlighted. Adapted from [1].

The height of the dam, and therefore, the value *H*, is

$$\frac{1.257cm}{0.964cm} \times 58.0m = 75.6m. \quad (4)$$

Flow Rate of the Dam

By assuming the water falls freely down a tube of constant diameter, the flow rate, *Q*, can be calculated by the formula [4]:

$$Q = vA. \quad (5)$$

The velocity, *v*, can be calculated by conservation of energy as the water falls:

$$mgH = \frac{1}{2}mv^2$$
$$v = \sqrt{2gH}$$
$$v = \sqrt{2 \times 9.81m/s^2 \times 75.6m}$$
$$v = 38.5ms^{-1} \quad (6)$$

The area, *A*, can be calculated assuming a rectangular pipe, and using the measurements in Figure 4.

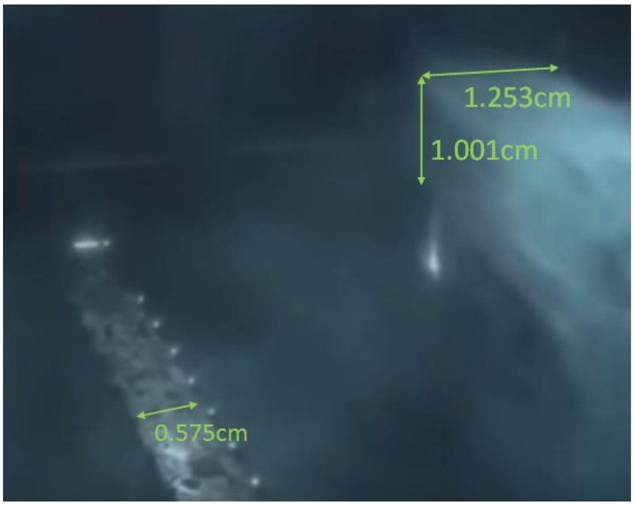

Figure 4 – Measured dimensions of the water outflow. Adapted from [1].

The area is:

$$A = \left(\frac{1.253cm}{0.575cm} \times 4.46m\right)\left(\frac{1.001cm}{0.575cm} \times 4.46m\right)$$
$$A = 75.5m^2. \quad (7)$$

Therefore, $Q = 2907m^3s^{-1}$.

Power Calculation

The value of η for the Francis turbine, the most common turbine today, is around 0.92 [5]. Thus:

$$P = \eta\rho gQH,$$
$$P = 0.92 \times 1 \times 9.81 \times 2907000 \times 75.6$$
$$P = 1.98MW. \quad (8)$$

Based on Figure 3, the dam has 8 turbines, for a total power generation of 15.84MW.

Conclusion

Based on these calculations, the entire Capitol of Panem has a power consumption of approximately 15.84MW. In comparison, the Sir Adam Beck Pump Generating Station at Niagara Falls, Ontario, Canada, produces 174MW with 6 turbines [6]. Thus, it appears that Panem's hydroelectric dam produces much less power than some modern dams. McMaster University uses 6GWh of electricity per month [7]: this is equal to a power consumption of 8.33MW, just over half of what the Capitol requires. Thus, based on the calculated power consumption of Panem's Capitol, the Capitol either has a fairly small population or uses technology that is more efficient than today's.

References

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