

A Car Engine Delivers $2.8 \times 10^4 \text{ W}$ To Its Wheels When Moving At A Constant Speed Of 11.6 m/s . What Is

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Understanding the power output of a car engine is fundamental in automotive engineering and physics. When a vehicle moves at a constant speed, the engine's work is primarily overcoming resistive forces such as air resistance, rolling resistance, and other frictional forces. In this article, we will analyze the given data: a car engine delivering 2.8×10^4 watts of power to the wheels while moving at 11.6 m/s , and explore what this information reveals about the vehicle's performance, the underlying physics principles, and how to interpret such data comprehensively.

Introduction to Power in Automotive Context

Power is a critical parameter in understanding an engine's performance. It quantifies how quickly work is done or energy is transferred over time. In the context of vehicles:

- Engine Power: The rate at which the engine produces work.
- Wheel Power: The power delivered to the wheels to propel the vehicle forward.
- Resistive Forces: Forces such as air drag and rolling resistance that the engine must overcome to maintain a constant speed.

When a car moves at a constant velocity, the engine's power output equals the power required to counteract resistive forces, leading to a steady state where the vehicle's speed remains unchanged.

Understanding the Given Data

Let's analyze the provided problem details:

- Power delivered to wheels (P): $2.8 \times 10^4 \text{ W}$ (28,000 W)
- Constant speed (v): 11.6 m/s

The key question is: What does this power represent, and what can it tell us about the resistive forces acting on the vehicle?

Calculating the Resistive Force Acting on the Vehicle

Since the vehicle maintains a constant velocity, the net acceleration is zero. According to Newton's second law, the resistive forces exactly balance the engine's driving force. The power delivered to the wheels is related to these resistive forces by the fundamental equation:

Power and Force Relationship

$$P = F_{\text{resistance}} \times v$$

Where:

- P is the power delivered to the wheels (in watts),
- $F_{\text{resistance}}$ is the total resistive force (in newtons),
- v is the velocity of the vehicle (in meters per second).

Rearranging for $F_{\text{resistance}}$:

$$F_{\text{resistance}} = \frac{P}{v}$$

Plugging in the known values:

$$F_{\text{resistance}} = \frac{28,000 \text{ W}}{11.6 \text{ m/s}} \approx 2413.79 \text{ N}$$

Interpretation:

The resistive force opposing the vehicle's motion is approximately 2414 N. This force must be countered by the engine's power to maintain constant speed.

Analyzing the Resistive Forces in Detail

Resistive forces on a vehicle moving at a steady speed mainly include:

- Air Resistance (Drag Force)
- Rolling Resistance
- Mechanical Friction

Understanding their contributions helps in vehicle design and efficiency optimization.

1. Air Resistance (Drag Force)

The drag force depends on the shape of the vehicle, the density of air, the frontal area, and the drag coefficient. It's given by:

$$F_{\text{drag}} = \frac{1}{2} \times C_d \times \rho \times A \times v^2$$

Where:

- C_d = Drag coefficient (dimensionless)
- ρ = Air density (~1.225 kg/m³ at sea level)
- A = Frontal area (m²)
- v = Speed (m/s)

Note: Exact values of C_d and A are necessary for precise calculation, but the overall force can be approximated using typical values or inferred from total resistive force.

2. Rolling Resistance

Rolling resistance is proportional to the normal force and depends on the tire-road interface:

$$F_{\text{rolling}} = C_{rr} \times N$$

Where:

- C_{rr} = Rolling resistance coefficient (~0.01-0.02 for car tires)
- N = Normal force (approximately equal to vehicle weight (mg))

For a typical car, the combined resistive forces sum up to approximately 2000-3000 N at highway speeds, consistent with our calculated value.

Implications of the Power and Force Calculations

Knowing that:

$$F_{\text{resistance}} \approx 2414 \text{ N}$$

and the vehicle travels at 11.6 m/s, the power needed to sustain this speed is:

$$P = F \times v = 2414 \, \text{N} \times 11.6 \, \text{m/s} \approx 28,000 \, \text{W}$$

which matches the given data, confirming the consistency.

This indicates the engine delivers 28 kW of power continuously at that speed, balancing resistive forces.

Understanding Power Output in Terms of Engine Efficiency

The engine's gross power output is typically higher than the power delivered to the wheels due to losses in transmission, drivetrain, and other components. The engine's brake power (actual power produced by the engine) accounts for these losses.

- Efficiency of Power Transmission: Usually ranges from 85% to 95% in modern vehicles.

Assuming an efficiency (η) of 90%, the engine's actual power output would be:

$$P_{\text{engine}} = \frac{P_{\text{wheels}}}{\eta} \approx \frac{28,000 \, \text{W}}{0.9} \approx 31,111 \, \text{W}$$

This means the engine produces approximately 31.1 kW of power, with about 3.1 kW lost in transmission.

Real-World Factors Affecting Power and Resistance

In practical scenarios, several factors influence the resistive forces and power requirements:

- Vehicle Aerodynamics: Improved design reduces (C_d) , decreasing drag force.
- Tire Quality: Low rolling resistance tires reduce (F_{rolling}) .
- Speed: Resistance increases with the square of speed due to air drag.
- Road Conditions: Rough surfaces increase rolling resistance.

Understanding these factors helps in optimizing vehicle efficiency and performance.

Conclusion and Summary

In summary:

- The engine delivers approximately 28 kW of power to maintain a constant speed of 11.6 m/s.
- The resistive force opposing the vehicle's motion is approximately 2414 N.
- The power calculation confirms the balance between engine output and resistive forces, illustrating fundamental physics principles.
- Real-world vehicle performance depends heavily on minimizing resistive forces through aerodynamic design, tire selection, and mechanical efficiency.
- Recognizing how power, force, and speed interrelate provides valuable insights into vehicle dynamics and engineering optimization.

Additional Insights and Practical Applications

Understanding these calculations helps in various domains:

- Automotive Design: Engineers can optimize vehicle shape and materials to reduce drag and rolling resistance.
- Fuel Efficiency: Less power required to overcome resistive forces means better fuel economy.
- Performance Tuning: Adjusting parameters like tire pressure or aerodynamics impacts the power needed at different speeds.
- Environmental Impact: Efficient vehicles produce fewer emissions by requiring less power for the same speed.

Final Thoughts

Interpreting the power delivered to a vehicle's wheels in relation to its speed provides a comprehensive understanding of the forces at play and the efficiency of the vehicle. The principles discussed here form the foundation for advancements in automotive engineering, leading to more efficient, powerful, and environmentally friendly vehicles.

Keywords for SEO Optimization:

Car engine power calculation, resistive forces on vehicles, vehicle aerodynamics, power and force relationship, maintaining constant speed physics, engine efficiency, automotive engineering, resistive force calculation, vehicle performance, power delivered to wheels, physics of moving vehicles

Frequently Asked Questions

What is the power output of the car engine when delivering $2.8 \times 10^4 \text{ W}$ at a speed of 11.6 m/s ?

The power output is given as $2.8 \times 10^4 \text{ W}$, which is 28,000 Watts.

How can we determine the force exerted by the engine on the wheels?

Using the relation $\text{Power} = \text{Force} \times \text{velocity}$, the force is $\text{Force} = \text{Power} / \text{velocity} = 28,000 \text{ W} / 11.6 \text{ m/s} \approx 2,413.79 \text{ N}$.

What does the power delivered to the wheels tell us about the engine's performance?

It indicates the engine's ability to do work at a rate of 28,000 Watts while maintaining the constant speed of 11.6 m/s .

If the car's speed increases, how does that affect the power delivered assuming constant force?

If force remains constant, increasing speed increases power proportionally, since $\text{Power} = \text{Force} \times \text{speed}$.

What other factors could influence the actual power required by the engine besides the wheel power output?

Factors include air resistance, rolling resistance, drivetrain losses, and aerodynamic drag.

How can this information be used to estimate fuel efficiency or engine performance?

Knowing the power output and speed helps estimate the energy consumption per unit distance, aiding in calculating fuel efficiency.

Is the power delivered to the wheels equal to the engine's power output?

Not necessarily; some power is lost due to friction and mechanical inefficiencies, so the engine's power output is typically higher than the power at the wheels.

What units are involved in expressing power and velocity in

this context?

Power is expressed in Watts (W), and velocity is in meters per second (m/s).

How does the concept of constant speed relate to the power delivered by the engine?

At constant speed, the engine delivers just enough power to overcome resistive forces; the power remains steady unless external conditions change.

Additional Resources

A Car Engine Delivers 2.8×10^4 W To Its Wheels When Moving At A Constant Speed Of 11.6 m/s. What Is

Understanding the power output of a car engine is fundamental to grasping how vehicles operate and how energy transfer occurs during motion. When we say that a car engine delivers 2.8×10^4 W to its wheels while moving at a constant speed of 11.6 m/s, we're delving into the relationship between power, force, and velocity — core concepts in physics that describe how engines convert fuel energy into motion. This article offers a comprehensive guide to interpret this scenario, explore relevant physics principles, and perform related calculations to deepen your understanding.

Introduction to Power and Mechanical Work in Vehicles

In the realm of automotive physics, power is a measure of how quickly work is being done or energy is being transferred. When an engine delivers a certain power to the wheels, it's essentially providing the force necessary to overcome resistive forces (like air resistance and rolling friction) at a given speed.

Key Concepts:

- Power (P): The rate at which work is performed or energy is transferred, measured in watts (W).
- Work (W): The product of force and displacement in the direction of the force, measured in joules (J).
- Force (F): The push or pull acting on an object, measured in newtons (N).
- Velocity (v): The speed of the object in a given direction, measured in meters per second (m/s).

Breaking Down the Scenario

The problem states:

- Power delivered to the wheels, $P = 2.8 \times 10^4$ W
- Constant speed, $v = 11.6$ m/s

From this, we are asked to determine related physical quantities, such as the force exerted by the engine, the resistive forces acting on the car, or other parameters depending on the specific question.

Step 1: Understanding Power in the Context of a Moving Car

Power at the wheels relates directly to the force the engine applies and the velocity of the vehicle:

$$P = F \times v$$

This fundamental relation states that the power is the product of the force exerted and the velocity at which that force acts.

Implication:

- If the power is known and the velocity is given, the force exerted by the engine (or the resistive force that the engine must overcome) can be calculated as:

$$F = P / v$$

Step 2: Calculating the Force at the Wheels

Using the provided data:

- Power, $P = 2.8 \times 10^4 \text{ W}$
- Velocity, $v = 11.6 \text{ m/s}$

$$\text{Force, } F = P / v = (2.8 \times 10^4 \text{ W}) / (11.6 \text{ m/s})$$

Calculating:

$$F \approx (28,000 \text{ W}) / (11.6 \text{ m/s}) \approx 2,413.79 \text{ N}$$

Result:

The engine exerts approximately 2,414 newtons of force to maintain this constant speed.

Step 3: Interpreting the Force — Overcoming Resistive Forces

Since the car is moving at a constant speed, the net force acting on it is zero, according to Newton's First Law. This implies:

- The engine's force balances the resistive forces (like air drag, rolling resistance, and mechanical losses).

Hence:

$$\text{Resistive force (drag + friction)} \approx 2,414 \text{ N}$$

This force opposes the motion, and the engine must exert an equal and opposite force to sustain constant velocity.

Step 4: Exploring Power Components and Efficiency

While the above calculations give us the force, understanding the power flow involves considering various aspects:

4.1. Power Distribution

- Input Power: Energy supplied by the engine (via fuel combustion).
- Output Power: Power delivered to wheels ($2.8 \times 10^4 \text{ W}$).
- Losses: Mechanical and thermal losses reduce the effective power reaching the wheels.

4.2. Engine Efficiency

If the power delivered to the wheels is known, and the fuel energy input is known, we can estimate efficiency:

Efficiency (η) = Power at wheels / Power input from fuel

However, since the fuel consumption or engine input power isn't provided, we focus on the power at the wheels.

Step 5: Additional Calculations and Considerations

5.1. Total Resistive Forces

Given the force exerted by the engine to sustain the speed, one can analyze how changes in speed affect the force and power:

- Doubling the speed would double the power required if the resistive force remains constant.
- Aerodynamic drag increases with the square of speed, so the resistive force often increases significantly at higher speeds.

5.2. Estimating Resistive Forces at Different Speeds

Suppose the resistive force is predominantly due to air drag, which can be approximated as:

$$F_{\text{drag}} = \frac{1}{2} \times \rho \times C_d \times A \times v^2$$

Where:

- ρ : Air density ($\sim 1.225 \text{ kg/m}^3$ at sea level)
- C_d : Drag coefficient (typical values range from 0.3 to 0.4 for passenger cars)
- A : Frontal area of the vehicle (in m^2)

Knowing $F \approx 2,414 \text{ N}$ at $v = 11.6 \text{ m/s}$, you could estimate $C_d \times A$, or vice versa, if additional data are available.

Summary of Key Findings

- The power delivered to the wheels directly relates to the force that the engine applies at a given velocity.
- Using the relation $F = P / v$, the force exerted by the engine when moving at 11.6 m/s with 2.8×10^4 W power is approximately 2,414 N.
- Since the vehicle moves at constant speed, this force balances the resistive forces, primarily air drag and rolling resistance.
- Understanding these relationships helps in designing more efficient engines and vehicles, optimizing fuel consumption, and predicting performance at different speeds.

Final Thoughts

Analyzing a car engine's power output in real-world scenarios provides insight into the complex interplay of forces and energy transfers that enable vehicles to move efficiently. The simple relation $P = F \times v$ serves as a foundational tool for understanding how force and power are related in constant-speed motion. Whether for engineers, students, or automotive enthusiasts, grasping these principles enhances comprehension of vehicle dynamics and energy efficiency.

References & Further Reading

- Fundamentals of Physics, David Halliday, Robert Resnick, Jearl Walker
- Vehicle Dynamics and Control, Rajesh Rajamani
- Automotive Engineering Principles, John Fenton
- Online resources on drag force, power calculations, and vehicle energy efficiency

This guide aims to clarify the physics behind the power delivery of a car engine at a given speed, fostering a deeper understanding of automotive mechanics and energy transfer principles.

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