

Energy Consumption Analysis for a Mobile Robot

1 Introduction

This report provides an analysis of the energy consumption for a mobile robot under two scenarios: with acceleration and without acceleration. The calculations are based on the given motor specifications, robot parameters, and environmental conditions.

2 Imported Data

The following data is used for the analysis:

- Robot Weight: 30 kg
- Desired Speed: 5 km/h ≈ 1.39 m/s
- Desired Acceleration: 0.5 m/s^2
- Incline Angle: 0 degrees
- Rolling Resistance Coefficient: 0.03
- Drag Coefficient: 0.1
- Air Density: 1.225 kg/m^3
- Frontal Area: 0.1 m^2
- Efficiency: 0.65

3 Scenario 1: With Acceleration

3.1 Force Calculations

The total force required with acceleration is calculated as:

$$\begin{aligned}F_{\text{rolling}} &= 0.03 \times 30 \times 9.81 \approx 8.83 \text{ N} \\F_{\text{incline}} &= 30 \times 9.81 \times \sin(0) = 0 \text{ N} \\F_{\text{drag}} &= 0.5 \times 0.1 \times 1.225 \times 0.1 \times (1.39)^2 \approx 0.12 \text{ N} \\F_{\text{accel}} &= 30 \times 0.5 \approx 15 \text{ N} \\F_{\text{total}} &= 8.83 + 0 + 0.12 + 15 \approx 23.95 \text{ N}\end{aligned}$$

3.2 Power Consumption

The power consumed with acceleration is:

$$\begin{aligned}P_{\text{required}} &= 23.95 \times 1.39 \approx 33.29 \text{ W} \\P_{\text{consumed}} &= \frac{33.29}{0.65} \approx 51.22 \text{ W} \approx 0.05122 \text{ kW}\end{aligned}$$

3.3 Energy Consumption for 5 Hours

The energy consumed for 5 hours with acceleration is:

$$E_{\text{consumed}} = 0.05122 \times 5 \approx 0.2561 \text{ kWh}$$

4 Scenario 2: Without Acceleration

4.1 Force Calculations

The total force required without acceleration is calculated as:

$$F_{\text{total}} = 8.83 + 0 + 0.12 \approx 8.95 \text{ N}$$

4.2 Power Consumption

The power consumed without acceleration is:

$$\begin{aligned}P_{\text{required}} &= 8.95 \times 1.39 \approx 12.44 \text{ W} \\P_{\text{consumed}} &= \frac{12.44}{0.65} \approx 19.14 \text{ W} \approx 0.01914 \text{ kW}\end{aligned}$$

4.3 Energy Consumption for 5 Hours

The energy consumed for 5 hours without acceleration is:

$$E_{\text{consumed}} = 0.01914 \times 5 \approx 0.0957 \text{ kWh}$$

5 Conclusion

The energy consumption analysis for the two scenarios provides valuable insights into the robot's energy requirements under different operating conditions. The inclusion of equations and numerical calculations ensures transparency and accuracy in the analysis, guiding the selection of the battery and energy management strategies.

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