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Investigation of Energy Efficient Power Coupling Steering System for Dual Motors Drive High Speed Tracked Vehicle

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Abstract

This paper presents an energy efficient power coupling steering system for dual motors drive high speed tracked vehicle. The system consists of a new type of center steering motor, two electromagnetic（EM） clutches, two planetary gear couplers, and two propulsion motors. The motor torque and power required by dynamic steering with different steering radiuses for dual motors drive high speed tracked vehicle were investigated. A motor-speed-based control strategy of dynamic steering is designed to achieve vehicle lateral stability enhancement. The model of the proposed control strategy in RecuDyn and Matlab/Simulink is given. The simulation results of dynamic steering with 0.5B and 2B radius show that understeer in small radius steering can be significantly improved.

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Keywords:Tracked vehicle; Dual motors drive; Dynamic steering; Power coupling; Speed control

1. Introduction

Energy saving in vehicles is becoming more important [1,2]. Electric tracked vehicle is one of the main trends of the future tracked vehicle and developed to solve problems of energy crisis and air pollution [3].

Nomenclature

2METV dual motor drive electric tracked vehicle

2MIETV dual motor independent drive electric tracked vehicle

ECDS electronic controlled differential steering

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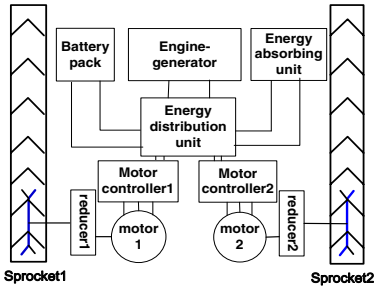
It is necessary to have higher manoeuvrability and off-road capability for high-speed tracked vehicles [4].The power of outer side motor required for the high-speed steering for 2MIETV is more than 2.5 times that of engine in internal combustion engine vehicle, which results in large size and power of motor and inverter. Especially, more power of outer side motor is required for dynamic steering. So an energy efficient power coupling steering system is proposed for the 2METV dynamic steering in the paper.

2. Mathematical Model for Dynamic Steering

The electric drive system configuration of 2MIETV is shown in Figure 1, which is widely used in the 2METV. The torque and power required by dual motors with different steering operation are calculated according to the vehicle parameters as shown in table 1. The tractive force F_1 , F_2, the output torque T_1, T_2 and the desired rotation speed n_1^* ,n_2^* can be expressed as follows:



■ Table 1. Vehicle parameters

Parameters	Value
Vehicle tread, B(m)	1.3
Wheel, 2n	10
Ground contact length, L(m)	1.7
Rolling resistance coefficient, f	0.04
Transmission efficiency, η	0.9
Drive ratio, ig	7
Mass of vehicle, m(kg)	2000
Mass gain coefficient, δ	1.5
Moment of inertia, J(kg/m2)	3000

Fig.1. Electric drive system configuration of 2MIETV

2.1.Center steering

$$T_1 = T_2 = (0.5fm\mathbf{g} + \frac{\mu m\mathbf{g}L}{4B} + \frac{J}{B}\frac{d\omega}{dt})\ r_z/i_g\eta \le F_z r_z/i_g\eta \tag{1}$$

$$n_1^* = n_2^* = \frac{1000 i_g}{120\pi r_z}\cdot 3.6\cdot\omega^*\cdot\frac{B}{2} = n_0 \tag{2}$$

2.2.Small radius steering

$$\begin{cases} T_1 = F_1 r_z / i_g\eta = [0.5fm\mathbf{g} + \frac{\mu m\mathbf{g}L}{4B} + \left(\frac{J}{B} - 0.5\delta Rm\right)\frac{d\omega}{dt}]r_z / i_g\eta \le F_z r_z / i_g\eta \\ T_2 = F_2 r_z / i_g\eta = [0.5fm\mathbf{g} + \frac{\mu m\mathbf{g}L}{4B} + \left(\frac{J}{B} + 0.5\delta Rm\right)\frac{d\omega}{dt}]r_z / i_g\eta \le F_z r_z / i_g\eta \end{cases} \tag{3}$$

$$\begin{aligned} n_1^* &= \frac{1000 i_g}{120\pi r_z} * \frac{v_{des}}{R_{des}} * \left(\frac{B}{2} - R_{des}\right) \\ n_2^* &= \frac{1000 i_g}{120\pi r_z} * \frac{v_{des}}{R_{des}} * \left(\frac{B}{2} + R_{des}\right) \end{aligned} \tag{4}$$