HANDLING OF HIGH-SPEED TRACKED VEHICLES

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Abstract. The handling behaviour of skid-steered tracked vehicles is more complex than conventional wheeled vehicles because of their non-linear characteristics. One of the traditional methods used for establishing the handling of wheeled vehicles is the constant radius test, where the variation of steer angle with lateral acceleration is investigated. There have been no comparable studies either experimentally or theoretically for a tracked vehicle for this type of test. With the introduction of a variable-steer-ratio (ratio of sprocket angular speeds) system on tracked vehicles it may be possible to perform this test experimentally. This study addresses the problem of producing a theoretical prediction for the constant-radius test for a current in-service tracked vehicle, Combat Vehicle Reconnaissance (Tracked) CVR(T) manufactured by Alvis in the UK. A model of a general skid-steer tracked vehicle is developed and validated against experimental data from a trial on CVR(T). The model is then used to predict the results for a constant radius turn for this vehicle. The results show that the CVR(T) initially understeers before going into oversteer.

NOMENCLATURE

C	Half distance between track centres
F	Force
g	Acceleration due to gravity
H	Height to centre of mass from ground
I_z	Yaw moment of inertia
L	Half length of track on ground
M	Moment
m_v	Mass of vehicle
n	Steer ratio
R_s	Sprocket radius
r	Yaw rate
u	Velocity in x direction
V	Velocity of vehicle
v	Velocity in y direction
x_i	Distance to track section i
α	Angle of sliding
β	Non-dimensional slip radius
μ	Coefficient of friction
ψ	Yaw angle between earth fixed and body centred axis systems
ω_s	Angular speed of sprocket
Superscript	
i	Section
s	Sliding
Subscript	
x, y, z	Directions
l, r	Left, right
t	Track
n	Nominal

INTRODUCTION

The vast majority of high-speed military tracked vehicles employ skid steering to change their direction. The mechanics of skid steering are complex and the resulting equations are sufficiently non-linear to prevent linearisation techniques being applied successfully. Thus the fundamental handling characteristics of tracked vehicles are significantly more difficult to establish theoretically than for wheeled vehicles [1]. The reason for this greater complexity is the sliding (skidding) interface between the track and ground, which occurs during turning. To simplify this, most of the workers in this field have assumed a hard level surface for the investigation [2].

When a skid-steer tracked vehicle is in a steady turn the outer track sprocket is rotating faster than the inner. The ratio of the outer to the inner sprocket angular speed is called the steer ratio n and is analogous to the steer angle of the front wheels of a wheeled vehicle.

The initial investigation into the steering of tracked vehicles, was by Merritt [3], involved a model of a single track, which slid over the ground, generating a longitudinal force and resisting moment but no resultant lateral force. The forces generated between the track and ground were assumed to follow the law of Coulomb friction. The analysis introduced the concept of slip radius, which is the instantaneous centre of rotation of the track sliding across the surface of the ground. The model was then extended to form a vehicle with two tracks, which was not subjected to any external forces or moments other than those generated by the tracks. This work allowed the low-speed handling behaviour of tracked vehicles to be investigated, on level ground with uniform friction.

The work by Merritt [3] was extended by Steeds [4]. Perhaps the most interesting element of the paper by Merritt is the discussion of the question posed by Steeds on the derivation of the slip radius, which resulted in an appendix being added. The work by Steeds incorporated into the track model the generation of a resultant lateral force, as a result of the centre of rotation of the sliding motion being moved forward. The vehicle model also included weight transfer, in the lateral direction, and longitudinal forces acting on it. The resulting model was unwieldy and solution was by ‘trial and error’ and the author noted the ‘tedious’ nature of the solution.

The models of Steeds and Merritt were simplified in unpublished work by Wormell [5], who used the method for teaching the subject for many years. The method used is graphical and for the case when lateral acceleration (latac) is ignored is straightforward to use. The technique suffers from

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