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Development of high-mobility tracked vehicles for over snow operations ☆

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Abstract

This paper describes a detailed investigation into the effects of some of the major design features on the mobility of tracked vehicles over snow. The investigation was carried out using the latest version of an advanced computer simulation model, known as NTVPM, developed under the auspices of Vehicle Systems Development Corporation (VSDC), Ottawa, Ontario, Canada. Results show that the road wheel system configuration, initial track tension (i.e., the tension in the track system when the vehicle is stationary on a level, hard ground) and track width have significant effects on vehicle mobility over snow. On deep snow where the vehicle belly (hull) contacts the snow surface, the location of the centre of gravity (C.G.) of the sprung weight in the longitudinal direction has a noticeable effect on vehicle mobility, as it affects the attitude of the belly and the belly–snow interaction. Based on the investigation, a conceptual high-mobility tracked vehicle for over snow operations is discussed. Results of this study will provide the vehicle designer with guiding principles for the development of high-mobility tracked vehicles. It also demonstrates that NTVPM is a useful and effective tool for design and performance evaluation of tracked vehicles from a traction perspective.

Keywords: High-mobility; Over snow operations; Tracked vehicles; Traction

1. Introduction

In many parts of the world, including Alaska of the United States and Canada, the ground is covered with snow for an extended period of time each year. Mobility over snow-covered terrain is of considerable interest to the resource industry, as well as the military. In comparison with wheeled vehicles of the same class, tracked vehicles offer better tractive performance, particularly over snow, due to their larger ground contact area and longer ground contact length [1]. Consequently, tracked vehicles are more widely used than wheeled vehicles on snow-covered terrain, particularly deep snow.

This paper focuses on an investigation into the effects of some of the major design features on the mobility of tracked vehicles on snow-covered terrain. Results of this study will provide the vehicle designer with guidance for the development of high-mobility tracked vehicles for over snow operations.

In the past, owing to a lack of understanding of terrain behaviour under vehicular load and of the mechanics of vehicle–terrain interaction, the development of off-road vehicles has been, by and large, guided by past experience and the "cut and try" methodology. This approach to off-road vehicle development has become extremely inefficient and prohibitively expensive in today's competitive global market. This has led to the recognition of the needs for the development of mathematical models to guide the development and design of off-road vehicles.

Empirical models for predicting off-road vehicle performance in a computerized format emerged in the 1970s. The approach to the development of these empirical models is

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to conduct tests of a select group of vehicles over a range of terrains of interest. Terrain behaviour is characterized by the cone index (or its derivatives). Based on the test results, the performances of the vehicles are then empirically correlated with vehicle design parameters and the cone index (or its derivatives). These empirical models may play a role in estimating the performances of off-road vehicles with design features similar to those that have been tested on similar operating environments. It is by no means certain, however, that these empirical relations can be extrapolated beyond the conditions upon which they were derived. Consequently, it is questionable that these models can play a useful role in guiding the development of new vehicles operating under different environments.

In view of the limitations of empirical models, mathematical models based on an in-depth understanding of terrain behaviour and on a detailed analysis of the mechanics of vehicle–terrain interaction emerged in 1980s. Based on these mathematical models, a series of user-friendly computer simulation models for design and performance evaluation of off-road vehicles have been developed [2–6].

2. Computer simulation model NTVPM for tracked vehicles

To provide the vehicle designer with a user-friendly, comprehensive and realistic tool for design and performance evaluation of tracked vehicles from a traction perspective, a simulation model known as NTVPM has been developed under the auspices of Vehicle Systems Development Corporation (VSDC), Ottawa, Ontario, Canada. The theoretical basis, governing equations and solution procedures are discussed in detail in references [2–4]. In this paper, applications of NTVPM to the evaluation of the effects of some of the major design parameters on the mobility of tracked vehicles over snow are presented.

NTVPM is for vehicles with either band (rubber belt) tracks or segmented metal tracks with relatively short track pitch, commonly used in the current generation of combat vehicles. The model is based on a detailed analysis of the physical nature of track–terrain interaction and on the principles of applied mechanics. It focuses on the prediction of normal and shear stress distributions on the track–terrain interface under steady-state operating conditions, from which the tractive performance of the vehicle is predicted. It can be used to evaluate the mobility of either single-unit tracked vehicles or two-unit articulated tracked vehicles [4,7]. NTVPM has been undergoing continual improvements and updates since its inception. In the latest version of the model, all major design features of the tracked vehicle have been taken into account. These include vehicle sprung weight, unsprung weight, location of the centre of gravity, number of road wheels, road wheel dimensions and spacing, track dimensions and geometry, initial track tension (i.e., the tension in the track system when the vehicle is stationary on level, hard ground), track longitudinal stiffness, locations of sprocket and idler, supporting roller arrangements, road wheel suspension characteristics, etc.

The characteristics of road wheel suspensions are fully taken into account in NTVPM. Pivot-arm suspensions, such as torsion bar suspensions and most hydropneumatic suspensions, and translational spring suspensions, with either linear or non-linear load-deflection characteristics,

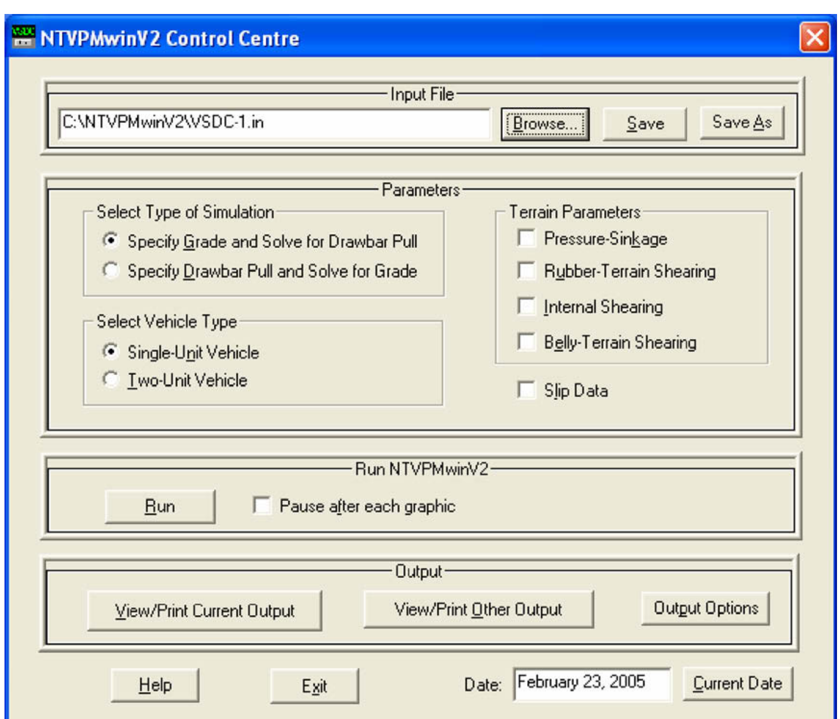

Fig. 1. Control centre for operating the simulation model NTVPM, as displayed on the computer monitor screen.