CHAPTER I

INTRODUCTION

1.1 DEVELOPMENTS IN TERRAIN-VEHICLE MECHANICS

For a long period, one of the challenges in the design of an off-road vehicle was to equip it with a traction device that can develop high traction efficiently with the minimum soil degradation. The aim of terrain-vehicle mechanics is to provide guiding principles to obtain a better understanding of the interaction of the soil-vehicle system. The studies of terrain-vehicle mechanics are generally directed toward the problems most frequently encountered in the categories of (Yong, 1984):

- excessive soil compaction induced by vehicle traffic;
- excessive wheel or track sinkage due to the imposed ground pressure and physical characteristics of both the soil and the vehicle; and
- excessive wheel or track slippage and insufficient traction caused by internal soil shear or surface friction failure.

Generally, terrain-vehicle mechanics can be divided into three highly interdependent areas as shown in Figure 1.1. Traffic ability and terrain characterization is concerned with the ability of the terrain surface to support vehicle traffic and the environmental consequences of damage to the terrain. Performance prediction and evaluation for a vehicle is the core issue when one considers the vehicle and the environment as an integral system to be optimized. The vehicle design considerations are relevant to the design parameters and specifications of the vehicle.

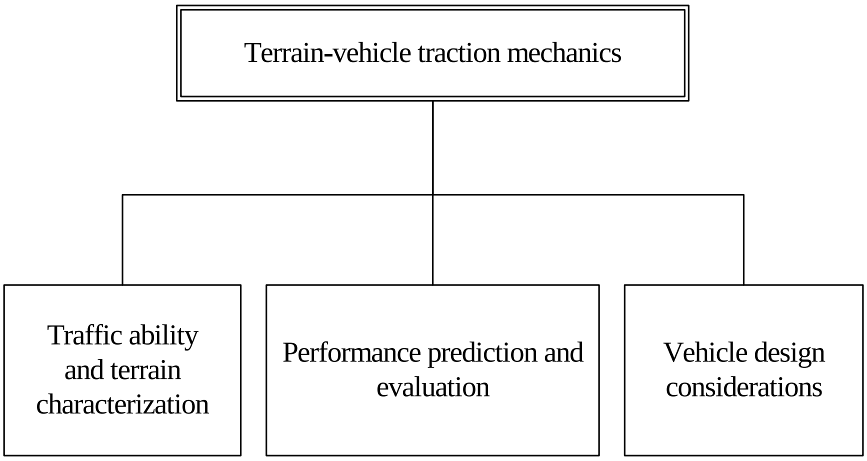

Figure 1.1. The related areas of terrain-vehicle mechanics (Yong, 1984)

1.2 OPTIMIZATION OF NEW TRACTION SYSTEMS

In the past, the choice of conventional tractive elements used for off-road vehicles to generate tractive effort was mainly restricted to either pneumatic tyres or steel tracks.

It is commonly recognized that tracked vehicles are better draught tractors because they are capable of producing high drawbar pull at a lower slip value and high tractive efficiency, even under difficult conditions such as on very soft surfaces. The large ground contact areas of the tracks result in low ground pressure and good stability on steep slopes. However, steel tracks have adverse characteristics when compared to pneumatic tyres from the point of view of steerability, manoeuvrability, noise, driver fatigue, maintenance and limited speeds. Additionally, travel on public roads is restricted in most areas due to road surface damage from penetration by the steel track grousers.

The worldwide use of steel-tracklayer tractors in the agricultural sector has declined since the introduction of large four-wheel-drive tractors. Four-wheel-drive tractors are characterized by moderate drawbar pull, high speeds, better ergonomics and good performance, increasing the productivity over steel-tracked ones. Pneumatic tyres also allow comparatively high speed traveling on public roads. With low-pressure tyres fitted onto wheeled tractors, the compaction of soil can also be reduced.

For many years there has been an interest in developing rubber tracks to be used on tractors to combine the good tractive performance and low ground pressure of the steel tracks with the non-abrasive features, higher speeds, and asphalt road-going capability of the pneumatic tyres. In recent years, the availability of rubber compounds and methods of steel reinforcement enabled manufacturers to construct rubber tracks of adequate strength and durability for use on agricultural tractors and even earth moving machines. These tracks are cost effective and lighter than the conventional steel tracks. When summarized and compared to steel tracks, rubber tracks offer additional advantages such as:

- lower noise and less hazardous vibration levels for the operator;
- relative simplicity and lighter construction;
- ability to be used on asphalt roads without damage to the road surface; and
- higher operating speeds.

The Caterpillar Challenger series of tractors represents the most successful use of rubber tracks.

Bridgestone’s positive drive rubber-covered steel tracks, driven by sprockets are also popularly used, especially for the cases of modified conventional undercarriages.

The development of alternative types of traction systems is a continuous process for many research workers, striving for better traction characteristics with less compaction or other damage to the terrain.

1.3 THE PREDICTION AND EVALUATION OF TRACTIVE PERFORMANCE

M. G. Bekker (1956, 1960, 1969) pioneered the theoretical investigation into the tractive mechanism for off-road vehicles. Although numerous attempts and considerable progress has been made in the past few decades to quantify the soil-machine interaction, understanding of this phenomenon is still far from satisfactory. Generally, models for prediction and evaluation of traction performance can be currently categorized as:

- empirical models;
- semi-empirical models; and
- analytical models.

All three methods have been used for modelling the traction of both wheeled and tracked vehicles, with various advantages and disadvantages. The details of the research undertaken by different researchers will be reviewed in Chapter 2.

1.4. THE DEVELOPMENT OF A PROTOTYPE TRACK AND THE MOTIVATION FOR THE RESEARCH

In an effort to pursue comprehensively balanced running gear for a traction vehicle to be used in agriculture, construction and military sectors in South Africa, a prototype track was developed with the feature of cable-tightened and rubber-covered steel track elements. The track is driven by smooth pneumatic tyres through rubber-rubber friction. The tractive effort of the track is also developed by soil-rubber friction and to a limited extent shear between the rubber surface of the track elements and terrain surface. Based on the walking beam concept, the track was developed to achieve a more uniformly distributed and lower vertical contact pressure, thus reducing motion resistance and soil compaction, resulting in better tractive efficiency at lower track slip values.

The aim of the design concept was to achieve greatly improved tractive performance, reduced motion resistance and soil compaction, comparable to that of a rubber crawler tracks working on soft terrain surface. This will reduce the operation cost and increase the yield of agriculture, therefore providing a significant advantage in agricultural production.

One of the important construction features for this prototype friction-based track is that it is composed out of a number of rubber covered track elements which enables low-cost replacement and maintenance when the track is partly damaged. Most of the currently in use rubber tracks are constructed as one integral single piece, i. e. a steel reinforced rubber belt, necessitating a costly replacement of the complete unit, if partly damaged.

As for other wheeled and steel-tracklayer tractors, the evaluation and performance prediction for a vehicle equipped with this prototype track is of great interest. It will assist in further validation, design modifications and optimum application of the new track system.