CHAPTER I

INTRODUCTION

The application of machines to agricultural production has been one of the outstanding developments in Indian agriculture during the last two decades. The constantly expanding population will continue to demand an ever increasing agricultural production of foods and fibres. It is recently estimated that agricultural production of 250 million tonnes will be required by the end of this century against the present production of 154 million tonnes to become self sufficient in food (Anon, 1986a). Farm mechanization, which is being increasingly recognised as one of the important inputs for achieving accelerated growth, was given a new impetus by the Government by providing incentives to the tractor and implement manufacturers and strengthening the research and development organisations. Increasing number of farmers are adopting tractors and other agricultural equipment for more profitable crop yields. It is widely accepted that the design of the implements used with the tractors greatly affects its fuel and operational efficiencies. However, it is a matter of great concern to find growing degradation in the design and quality of agricultural implements, which are known to result into avoidable excess fuel consumption of even 15 to 30 per cent. Currently the manufacture of implements is largely in the small scale sector. Due to limited access to design, manufacturing and testing technology, the quality of implements manufactured in small scale sector is not up to the standard. Although Indian standard specifications exist for implements, these are not binding on all manufacturers. Consequently, a large number of implements that are available in India are of inferior quality (Anon, 1986b). The working group constituted by the Ministry of Industry, Government of India under the chairmanship of Bains, in its recent report stressed for better research and developmental work on the design and quality of agricultural implements, in particular, tillage implements. The working group also felt that the life and efficiency of the implement will depend on the quality of the material used and accuracies achieved in the design and manufacture.

Tillage implements are subjected to dynamic loads, abrasive wear and chemical action of the external environment during their operation. The dynamic action of soil sliding over a metal surface known as abrasion, involves serious utility and cost implications in many tillage implements. The rapid wear of the tillage tools is responsible for the poor fuel efficiency of the tractors (Karatish, 1955). Further, the consequences of wear are grave in terms of both replacement cost (parts, labour and down time) and its effect on timeliness of operations. Moore (1980) reported that for some industries such as agriculture, as much as 40 per cent of the components replaced on equipment have failed by abrasive wear. The cost of parts alone due to the wear in agricultural machines is estimated as tens of millions of pounds per year (Foley et al. 1984). Therefore, increasing the service life of the machine parts has become one of the important problems of technological progress.

Wear of soil-working components is caused by the abrasive action of the soil. The interaction of soil and metal during abrasion is highly complex. But the evidence of cutting and scratching indicates that some forces are involved in the abrasion and obviously, these forces appear only when movement occurs. The dynamic properties that characterizes the forces and wear have not been identified clearly. Analytical approaches to the problem of abrasion have not been practicable in view of the complexity of the phenomena. Thus research workers have to adopt an essentially empirical approach.

Improvements in component life can be achieved by the application of knowledge on abrasive wear to the design and development of the parts and the selection of the material. But because of the complexities of the abrasive wear process, the optimum material and microstructure may vary considerably for different environments. Thus, material selection and design of the parts must be based on a full understanding of how material properties and other pertinent variables influence abrasive particle contact and material removal. The available information on the wear of metals in soil is quite meagre. There are no basic or scientific data supporting the present practice in the selection of tillage implement materials. Present practice is traditional to a degree. It is being more frequently questioned, and obviously when plough shares and cultivator shovels have to be resharpened or replaced frequently, present practice is not all that is to be desired.

Soil characteristics or conditions that affect abrasiveness include the shape and size of the soil particles, the firmness with which the soil particles are held in soil mass and the soil moisture content. The abrasive resistance of metals is influenced mainly by the composition of the material, hardness and heat treatment. In addition to these, operational parameters such as forces acting on the tool, the sliding distance and the speed are some of the factors that affect the abrasion. A knowledge of the effect of different variables on wear is essential to predict the life of soil-engaging parts of agricultural implements.

In view of the above, any practice or procedure which would prolong the life of the component would be significant contribution. To achieve this objective it is primarily imperative to develop a technique for more rapid and accurate measurement of wear. The calculation of wear rate, particularly at the design stage, plays an important role in predicting the tool life. Several investigators have studied the abrasive wear in metal against metal situations. It is a feature of most of the tests described in literature that the abrasive medium is either bonded to a backing, such as with emery cloth or pressed against the specimen by a rubber disc. It was also indicated that the wear is dependent upon conditions at hand and there is no suitable general method of studying it. Therefore, the devices for study on a laboratory scale took several forms, each assumed to approach the conditions of the application. However, there is no suitable method of predicting abrasive wear of soil-engaging components of agricultural implements.

Realizing the limitations of weather, time and soil variability involved in the field, a laboratory wear testing method simulating the field conditions as far as possible has been preferred in order to gain an understanding of the wear process, to determine the effect of different variables on abrasive wear and to select the material for specific application i.e. soil-tool interaction. The variables considered in the present study include soil type, soil moisture content, composition of the material, in particular, carbon content, heat treatment, hardness of the material, load acting on the tool and the distance travelled by the tool. Further, since the cultivator has become the most common and versatile implement with Indian farmers, the study has been confined to the cultivator shovel. In fact, the findings made on this device may partly be applicable to other tillage implements also. In order to have a clear insight into the problem of soil-tool interaction with particular emphasis on soil, tool and operational parameters which influence the abrasive wear of a cultivator shovel in different soils, the following specific objectives have been envisaged:

(i) To develop a wear testing apparatus which simulates the field conditions as nearly as possible for rapid and accurate measurement of abrasive wear of a cultivator shovel.

(ii) To study the effect of carbon content and hardness on the wear resistance of carbon steels in soil-tool interaction.

(iii) To examine the applicability of the general wear law in soil-tool interaction.

(iv) To investigate the influence of soil and operational parameters on the abrasive wear of a cultivator shovel and to develop an empirical relationship between the intensity of wear and applied conditions.

(v) To study the abrading ability of soils in terms of their mechanical composition.

A wear testing apparatus has been developed which simulates near field conditions to facilitate the measurement of abrasive wear of a cultivator shovel specimen to the best possible accuracy. Two cantilever beam type force transducers were designed and developed, one to measure the horizontal component and the other for vertical component of the resultant soil force acting on the tool specimen. Preliminary evaluation of the wear testing apparatus established a good reproducibility. The investigation of wear by one-variable-at-a-time method is relatively time consuming and expensive. Therefore, some of the experiments in the present study were conducted according to the designs developed by response surface methodology. The advantages of the response surface methodology are (i) the effect of varying all the factors simultaneously on the response characteristic can be estimated with desired accuracy and (ii) fewer experiments are only needed to get the useful and valid information without sacrificing the precision. All the coefficients and adequacy of the models were tested for their significance using response surface methodology procedure. Where response surface methodology cannot be applied, usual method of one-variable-at-a-time procedure was adopted to develop the relationships and testing for their significance. This study revealed the importance of the parameters in soil-tool interaction. Making use of the results, it is possible to estimate the maximum intensity of wear under different soil conditions. Further, knowing the maximum intensity of wear and the ultimate allowable wear, it is feasible to assess the life of the tool.