Chapter I

INTRODUCTION

1.1 General:

Mechanical drying of paddy is becoming increasingly important and popular in this country with the increase in the production of this grain. In India with the stepped up irrigation facilities and introduction of short duration high yielding varieties of paddy, it is now possible to raise more than two crops per annum. Besides, the productivity is also being increased. In this country, paddy is the most extensively grown crop. It occupies a total area of about 34 million hectares. The fact that approximately 11 per cent of the total national income is derived from paddy emphasizes further the importance of this crop.

It is known that considerable amount of paddy grains is lost during harvest and post-harvest operations. The total losses are estimated to be to the tune of 15 to 20 per cent, by weight. In addition to loss in quantity, quality deteriorates to a considerable extent due to imperfect handling of the grains.

Storage of paddy at high moisture content for even a short length of time is detrimental to its quality due to the activities of micro-organisms and mould growth. It is, on the other hand, not possible to mill the paddy into rice at high moisture content because milling losses are prohibitively high under that condition. Therefore, to keep its quality unimpaired and to bring the milling losses to a permissible limit, this important cereal needs careful processing and storage.

Paddy grain is hygroscopic. It contains moisture in liquid and vapour form inside the grain in the inter-cellular spaces and may be surrounded by a thin layer of adsorbed moisture. The freshly harvested paddy may contain moisture as high as 25 per cent on wet basis. At this moisture content the quality deterioration of the grains is very fast and hence needs quick attention to bring the moisture content to the safe level. It has been found that paddy can be safely stored for a considerable length of time without losing quality, at about 13 per cent moisture content.

Drying the paddy grains in the sun is by far the cheapest method of drying and the Indian farmers use this method extensively. But, by no means it is the best method. In the first place, under the climatic conditions of this country it is not always possible to have bright sunshine at the time of harvest when it is most required, in order to facilitate drying by direct solar heat. While the farmer waits for the sunshine the paddy grains deteriorate in quality. In the second place, large quantities of grains cannot be dried by this method due to the large amount of space and labour involved in it. In the third place, sunshine cannot dry the grains uniformly. Fast and non uniform drying results in internal cracks in the grains. This, in turn, results in milling losses. These difficulties can be minimized, if not completely eliminated, by mechanical drying.

Mechanical drying, further, has the following additional advantages:

1. The crop can be harvested earlier at a high moisture content and thereby the shattering losses of grains and lodging of the crop in the field can be avoided.

2. The grains can be dried in any season irrespective of sun or rain.

3. Since large quantities can be handled and drying can be done, 24 hours a day, the harvested paddy need not wait

for any considerable length of time before being dried.

1.2 Mechanical Drying:

In mechanical drying of paddy grains, a stream of heated air is passed around the grains which either flow, or are kept stationary in a bed or a bin.

The heated air absorbs the moisture from the grains and thus the grains get dry. The amount of moisture removed from the grains is determined by the temperature and relative humidity of the drying air. In other words, when air at a particular temperature and relative humidity is passed through a layer of grains, the moisture content of the grains changes and finally reaches its equilibrium moisture content at that temperature and relative humidity; and no further change takes place. The equilibrium moisture content - temperature - relative humidity relationship is a property of the grains. This relationship is different for different varieties of paddy.

1.3 Equilibrium Moisture Content:

A generally accepted relationship between the equilibrium moisture content, Me (per cent, dry basis), of the grains, the temperature of drying air, T (degrees K), and the relative humidity of drying air, rh (decimal), is the one proposed by Henderson (63), namely,

$$1\text{-}rh = e^{-CT(M_e)^n} \qquad 1.3.1$$

where C and n are constants which are characteristics of the grains. If a large set of drying data is available, the validity or otherwise of this relationship can be established and the values of C and n and their temperature dependance, if any, can be determined. Once this relationship is established and the values of C and n are determined, the equilibrium moisture content of the grains can be evaluated at any given temperature and relative humidity. In other words, once the values of C and n for a particular variety of paddy grains are known, it is not difficult to predict fairly accurately what would be the moisture content of that variety under the given conditions of the atmosphere surrounding the grains. Thus, it is possible to predict whether circulation of heated air through the grains is necessary to keep the moisture content at the safe level and if air circulation is necessary then at what temperature it should be circulated.

1.4 Drying Rate of Moist Paddy Grains:

The rate at which paddy grains dry in a stream of heated air depends on the moisture content of the grains at the instant under consideration, the temperature and relative humidity of the drying air and to some extent on the flow rate of the drying air. Once the drying rate constant is known, it is possible to predict the time required to dry the grains at a given moisture content to any other required moisture content under a given set of temperature, relative humidity and flow rate of the drying air.

1.5 Latent Heat of Vaporization of Moisture in Paddy Grains:

The heat required to vaporize a certain amount of water from the paddy grains is different from the heat required to vaporize the same amount of free water. Thus, it is necessary to find out the latent heat of vaporization of paddy grain moisture in order to evaluate the heat required to dry a certain amount of paddy grains at a certain moisture content to any other moisture content, and to design the heat source for this purpose. It is possible to evaluate the latent heat of grain moisture from equilibrium moisture data of the grains, by first evaluating the vapour pressure of grain moisture.

1.6 Nature of Work:

The work reported in this thesis is undertaken with the objective of evaluating the various drying characteristics of four popular varieties of paddy grains produced in this country. The work is justified by the fact that sufficient data on the different characteristics of these varieties of paddy grains, which involve in the process of drying, were not available. The importance of these data is mentioned earlier. The specific objectives of the work were as follows:

1. Evaluation of equilibrium moisture content of four common varieties of paddy grains in the temperature range of $40^{\circ}C$ to $80^{\circ}C$ for air relative humidity varying from 10 per cent to 80 per cent.

2. Plotting the desorption data and determining the validity of Henderson's equation (1.3.1) as applicable to paddy grains.

3. Evaluation of the values and temperature dependence of the coefficients C and n in equation 1.3.1.

4. Evaluation of the nature of the drying rate curves for all the four varieties of paddy grains.

5. Evaluation of the values and temperature dependence of drying rate constants.

6. Evaluation of latent heat of vaporization of grain moisture and determination of the change of the value of latent heat of vaporization of grain moisture with respect to moisture content of the grain.

The data reported in this thesis were collected on the basis of "thin layer" drying. A bed of two-grain thickness was used throughout the experiments. A laboratory experimental set up was designed and fabricated to collect the data. The details of the set up is reported in Chapter IV. Temperature, relative humidity and flow rate of air could be accurately adjusted in the set up. Continuous reading of the loss of weight of grains in the drying bed was possible with the help of the balancing unit incorporated in the experimental set up.

The results are discussed in details in Chapter V.