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DESIGN AND DEVELOPMENT OF A FRUIT SEED RECOVERY SYSTEM

by

LIAQAT MASOOD KHAN

A DISSERTATION

Presented to the Faculty of

The Graduate College in the University of Nebraska

In Partial Fulfillment of Requirements

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Major: Interdepartmental Area of Engineering

(Mechanics and Energetics)

Under the supervision of Professor Milford A. Hanna

Lincoln, Nebraska

March, 1986

TITLE

DESIGN AND DEVELOPMENT OF A FRUIT SEED RECOVERY SYSTEM

BY

LIAQAT MASOOD KHAN

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DESIGN AND DEVELOPMENT OF A

FRUIT SEED RECOVERY SYSTEM

Liaqat Masood Khan, Ph.D

University of Nebraska, 1986

Adviser: Milford A. Hanna

A system was designed, manufactured and tested to reliably recover the seeds from fruits such as plums and chokecherries. The design overcame problems inherent in earlier machines (not custom-made) , such as limited capacity, batch processing, inability to handle different sizes and shapes of fruit. However, fruit seeds are being recovered with custom-made small-scale systems. These units are generally time and labor intensive. The proposed continuous process system provides relatively large capacity with a smaller, more economical apparatus that has heretofore been available.

The system consists of (a) a feeding unit to continuously feed the fruit at a uniform rate, (b) a shearing unit to initially shear the fruit for further processing, (c) a macerating unit to further remove the pulp from the seed and to break up the skin fragments, and (d) a separating unit to achieve the targeted output "seed" by separating the seed from waste (water, pulp and skin).

Each unit was designed, manufactured and tested individually and finally arranged systematically to achieve the final fruit seed recovery system. Operational and design specifications were determined experimentally. Means to reduce adherence of fruits to machine parts during the seed recovery operation were included in the design to minimize maintenance requirements.

Preliminary investigations were conducted by constructing small scale experimental units to observe the behavior of material in the mechanical system and optimize the operational specifications. Results of the preliminary investigations were used as guidelines for the final design.

The system was extensively tested, both with native plums and chokecherries, and worked successfully. The system can handle 63 kg/h of fruit and is operated by a 3 h.p. electric motor. However, the capacity of the machine can be increased up to 250 kg/h by modifying or redesigning the final seed separating unit.

This dissertation is dedicated to my beloved parents...

Rana Dildar M. Khan and Mrs. Saddiqa Khanum.

Your kindness, interest, support, love and never ending encouragement have always been there for me to lean on throughout my educational career.

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Thanks to Mrs. Judy Nelson for her assistance in the preparation of this manuscript. Also, many thanks to friends and well wishers, who took time to make me laugh and helped me in one way or the other throughout my stay in Lincoln, Nebraska.

May God bless you all.

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INTRODUCTION

In the past few years there has been an increased interest in planting windbreaks and shelterbelts in Nebraska. Windbreaks are wind barriers generally composed of low growing shrubs and small trees in rows with relatively taller trees in the center rows. This arrangement of trees was found to be very effective in reducing wind velocity and trapping snow.

Species such as native plum, chokecherry and honeysuckle are low-growing shrubs that play an essential role in an aerodynamic windbreak. They are used in the windward and leeward rows of the windbreak and add considerably to the wildlife habitat. In addition, these plants are tolerant to many soil types and can be grown all across the state.

Due to heavy demands, the Nebraska Forest Service initiated a program to obtain quality shrub seed. The resulting seedlings are sold to interested people through the Clarke-McNary tree distribution program.

The seed cleaning equipment currently used by the Forest Service was not originally designed for this specific purpose. These equipment are either modified according to the specific needs and requirements or can handle one kind of fruit or fruits of similar kind. For example, the equipment currently used by the Nebraska Forest Service is a Dybvig seed cleaner, originally designed for depulping berry. A rotating cement mixer with attachments of soft

brush or sponge for tree seed dewinging is used at Petawana Forest Experiment Station, Chalk River, Ontario, Canada. The equipment in current use are not very efficient, are highly time and labor intensive, and are not commercially available. A shorter seed processing time is needed to reduce costs and increase efficiency.

The need for a system to handle a variety of fruits, provide clean seed efficiently and reduce the time and labor requirements were the major reasons which led Nebraska Forest Service to fund the development of a seed processing unit. The purpose of this study was to design, build, and test a system capable of handling a variety of fruits such as plums, chokecherries, honeysuckle, and prunes.

OBJECTIVES

The main objective of this research was to design a system to handle a variety of fruits such as chokecherries, plums, prunes and peaches for reliable seed recovery. More specifically, the objectives were to (a) provide a relatively large capacity with a small, relatively uncomplicated and economical system, (b) reliably remove the seed from the species such as native plums, chokecherries, etc., (c) reliably feed the product at a uniform and controlled rate, and (d) minimize maintenance by introducing means of reducing pronounced adherence of the fruit to machine parts which come in contact during the seed recovery operation.

REVIEW OF LITERATURE

To examine all of the aspects of the design of a fruit seed recovery system are beyond the scope of this review. However, an understanding of different fruit processing techniques and operation of related processing equipment is important to support the design process.

Substantial amount of savings can be achieved by eliminating the fruit storage life. This objective may be achieved by directly processing the fruit for seed recovery right after harvest. An understanding of the basic fruit pre-conditioning methods such as ripening and peeling is important for an accelerated and reliable recovery of seeds from fruits.

FRUIT RIPENING

Ripening by Addition of Heat

For centuries, people have ripened fruit by one of several methods. The Chinese, for example, ripened hard, green pears by placing them in air-tight storage chambers and burning incense in vases between bamboo racks - a semi-religious ceremony with highly practical benefits. Hills and Haywood (1911) reported that lemons have also been ripened with the fumes of incomplete combustion of

coke which contains a small proportion of the necessary gas together with many unwanted ingredients. Baile (1954) reported that, in the early years of this century, many fruit growers made a practice of ripening citrus fruit by forced "curing" in a room with a kerosene stove. The growers thought that it was the heat that turned the fruit from green to yellow, but investigations have shown that incomplete combustion products of the kerosene were responsible for the ripening.

Gouhar and Ul-Haq (1979) compared tree-ripened peaches with that of fruit picked two days before maturity and ripened at room temperature and controlled temperature (24 h at 40C and 24 h at 24C). Tabulated data showed highest scores for tree-ripened fruit. Fruit ripened at room temperature was subjected to decay and soft texture. Anderson and Magner, (1970) invented a process of degreening and ripening citrus fruit. The process involved treating stored fruit with a circulating air stream maintained at a selected fruit processing temperature. The dew point temperature of the air stream was maintained as closely as possible to the temperature of the coldest portion of the fruit until a selected dew point temperature was reached. This selected dew point temperature was maintained until the fruit was ripened. For example, if the desired processing relative humidity was 38%, at the desired processing room temperature of 22C, the dew point temperature as determined from a psychrometric chart is about 20C.

Morris et al. (1980) studied the effects of holding period and fruit ripeness on the quality of machine-harvested strawberries. Firm-fruited strawberries were mechanically harvested for processing. The fruit was separated for ripeness by sizing into three categories, and kept at 24C for 48 and 96 h or at 1.7C for 7 days followed by 48 or 96 h at 24C. Their results showed that fruit could be held at 24C for 48 h or at 1.7C for 7 days before 24C storage without excessive quality loss. High mold counts were observed after 96 h at 24C.

Cancel and Hernandez (1979) studied the effect of blanching and freezing on the texture and color of candied citron (a citrus fruit that resembles the lemon in appearance and structure). Their results showed that samples blanched in water for 0.5 min gave a candied product very similar in texture to that obtained from fresh fruit. Longer blanching times (up to 20 min) and use of $CaCl_2$ resulted in a harder texture. Candied citron prepared from unblanched frozen samples was very soft and underwent the greatest color loss.

Ripening by Ethylene

As little as one part per million of ethylene in the air will speed the onset of the climacteric rise in respiration and was eventually identified as the most effective gas (Baile, 1954). He also suggested that while ethylene affects the ripening process, it was not the main reaction.

The original discovery of the ripening properties of ethylene was made by Hibbard and Rosa (1925) by testing on tomatoes. They