# Integrated project Engineering Technology

2023-2024

# Design of an Automated Discharge & Quality-Based Buffer System for Two Fractions of Robotically Harvested Apples

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## Context and Background

### Introduction to PC Fruit [1]

- PC Fruit in Sint-Truiden drives sustainable innovation in fruit cultivation.
- It conducts applied research, demonstrations, and collaborations across industries.
- PC Fruit's facilities include laboratories, greenhouses, and orchards.

### Current apple harvesting process (PC Fruit)

- Harvesting season spans September to November.
- Apples are sorted based on quality (size, ripeness, and damage) at the facility.
- Sorting divides apples into fractions: premium for supermarkets, others for processing (e.g. products like applesauce or apple juice).

### ACRO's Project with PC Fruit

- ACRO, research consortium at KU Leuven, specializes in robotics and automation.
- ACRO collaborates with PC Fruit for an automated fruit harvesting solution.
- The project = the development of a mobile vehicle with robotic arms for automated harvesting and direct fraction-sorting (Figure 2).

Figure 2: ACRO's mobile vehicle under development (11/16/2023)

## Problem and Objectives

**ACRO's vehicle requires a compatible discharge system for buffering and discharging the apples**

**Fully automated apple buffer and discharge trailer**

- It buffers the two primary apple fractions (supermarket & processing).
- It fits within the orchard dimensions, has a trailer-like payload (Table 1).
- It buffers four paloxes, replacing them automatically (two per fraction).
- It discharges a full pallox to the ground.

### Function diagram

Figure 3 illustrates the sequential operations and processes of the machine.

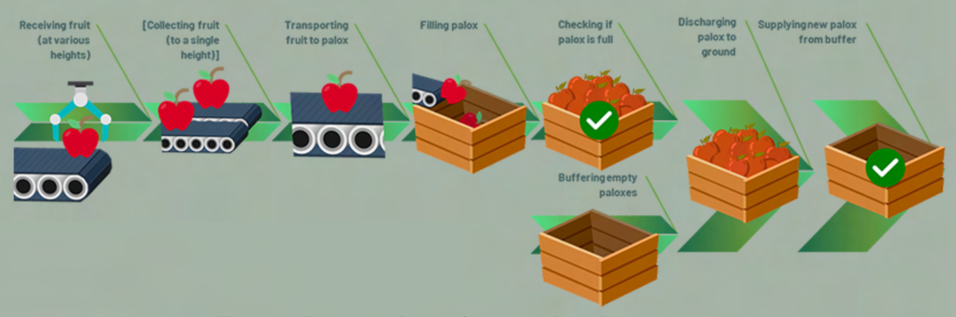


Figure 3: Function scheme of sequential machine operations

Table 1: Data from the requirements specification

| | |
|---|---|
| Payload | 2000 kg per axle |
| Length | < 4,00 m |
| Width | < 2,55 m |
| Height | < 4,00 m |

Figure 1: Discharge & Quality-Based Buffer System

## Materials and Methods

### Materials contacting the apples

The materials contacting the apples comply with the food safety standards and have FDA approval.

- Discharge pipes for fraction 2 (Figure 4): PE
- Conveyor for fraction 1 (Figure 5): polyurethane
- Filling system for fraction 1 (Figure 6): neoprene + SS



Figure 4: Discharge pipes

Figure 5: Conveyorbelt

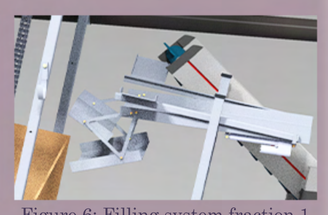

Figure 6: Filling system fraction 1

### Design approach

1.) Research was conducted on automated agricultural machinery.
2.) Function block diagram, see Figure 3 (Problems and Objectives), was made.
3.) Morphological overview was created evaluating various potential solutions for each function, selecting the optimal combination of pathways.
4.) Machine sketches were created (Figure 7), and measurements were defined.
5.) Purchasable components were selected based on the project requirements.
6.) The 3D design was created and underwent constant refinement using Creo Parametrics, an advanced Computer-Aided Design (CAD) software.

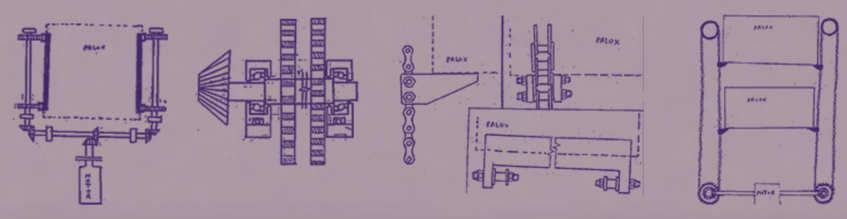

Figure 7: Sketches of the palox buffersystem mechanisms

## Results and Conclusion

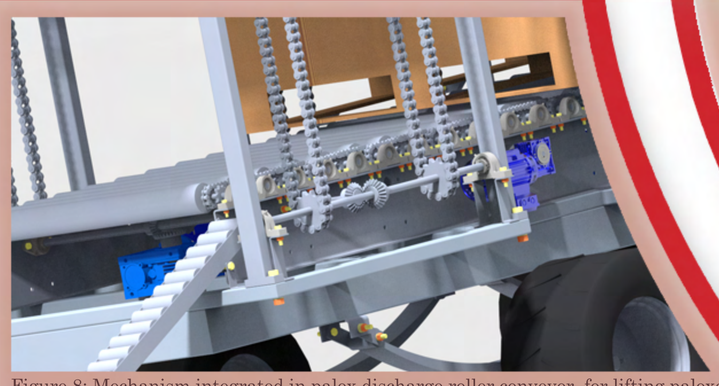

Figure 8: Mechanism integrated in palox discharge roller conveyor, for lifting paloxes

Figure 9: Inside view in palox discharge conveyor

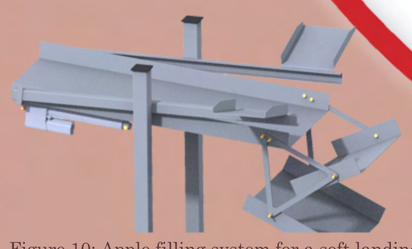

Figure 10: Apple filling system for a soft landing

### Description of the design solution

In Figure 1, the right palox tower illustrates the high-quality fraction paloxes that get filled using conveyors. Subsequently, the filling mechanism depicted in Figure 10, operated by an actuator, fills the palox after the palox is ascended to the desired height.

For fraction two, apples are conveyed via a tube into the palox, which remains in the lower position during filling.

The buffering mechanism is powered by bevel gears and electric motors on the trailer (located beneath the roller conveyor, see Figures 8, 9). It can transport the paloxes vertically. The paloxes are lifted up by custom chain links.

The palox discharge roller conveyor is entirely custom-made and integrated with the palox buffer as a single unit. It is driven by a chain transmission and powered by an electric motor on the side of the conveyor (Figure 8).

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[1] "What we do," pcfruit, https://www.pcfruit.be/en/what-we-do (accessed Nov. 16, 2023).

pcfruit PROEFCENTRUM FRUITTEELT VZW

ACRO

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