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FACULTY OF ENGINEERING TECHNOLOGY
THE DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING
EEX5362 PERFORMANCE MODELLING**

**Mini Project
Deliverable 01**

**Optimizing an Automated Egg Collection System
to Minimize Breakage and Energy Consumption**

Git: <https://github.com/ShahrulHaqPro/EEX5362-MP-322516498>

Problem Description

I'm focusing on optimizing an automated egg collection system to minimize breakage and energy consumption in a medium-large commercial egg farm. The system is an automated egg collection system with H type layer cages. The farm has 10,080 laying-hens across three cages, each with 3 tiers and 2 sides (left and right), in total the farm has 18 independent conveyor belts as 6 belt per cage to transport eggs to a collection point.

The farm owner is facing a critical operational challenge such as many eggs breaking during the egg collection especial morning collection rush, and it gets even worse during hot months (temperatures of 30-35°C and above). So, they need to use the ventilation and cooling systems more often which increases the electricity utilization more. Nowadays electricity bills are so high. And we identified as a cause that the current collection system operates with a fixed belt speed that hasn't been optimized since start.

- » Slow belt speeds cause eggs to accumulate on the belt. This leads to egg-to-egg contact, collisions, and overcrowding, and increases breakage rates.
- » Fast belts operate with low utilization because the belt is often empty, and belt motors operate at high energy costs, this wastes electricity.
- » Excessively high speeds cause eggs to shake, spin, and collide with cage or other eggs, it increases breakage.

The efficiency of this system has a direct and measurable impact on the profitability of the farm, and it lies in balancing the cost of broken eggs against the cost of energy consumption.

This is a Complex System Because:

It's a complex system because several different factors interact dynamically

1. Egg laying is not constant, it follows a temporal distribution. The rate peaks in the morning and varies throughout the day. It creates a variable and unpredictable load on the conveyor belts.
2. External temperature directly affects the hen's laying rate and the total system load, and it creates a seasonal and daily performance variation.
3. The 18 belts share the same electrical infrastructure but may have slightly different loads. So, a single solution may not work perfectly for all of them.
4. The primary objectives of reducing breakage and reducing energy consumption are requiring a balanced, optimal solution..

Dataset Description

For the model I require some data such as operational data, static and dynamic data about the farm. Some data that I collected/will collect using calculations and some using simulation as well.

Data Collection:

Data	Description
Belt count	Total number of belts
Belt length	Length of each belt
Hens per belt	Average number of hens per belt
Motor power	Power rating of each belt motor
Timestamp	Date and time of recording
Temperature	Ambient temperature
Humidity	Relative humidity
Eggs laid count	Number of eggs detected on a specific belt in a time interval
Laying rate	Estimated laying rate
Belt speed	Controlled speed of the belt
Broken eggs count	Number of broken eggs collected from a specific belt
Breakage rate	$(\text{Broken Eggs} / \text{Total Eggs Collected}) * 100$
Energy use	Energy consumed by the belt motors in a time interval

Performance Objectives

The primary goal of my model is to develop a simulation model that can identify the optimal belt speed strategy to maximize farm profitability. This will be achieved by focusing on the following measurable performance objectives:

1. Minimize Egg Breakage Rate

$$\text{Breakage Rate} = \frac{\text{Number of Broken Eggs}}{\text{Total Number of Eggs Collected}} * 100 \%$$

2. Minimize Energy Consumption per Egg

$$\text{Energy Efficiency (kWh/egg)} = \frac{\text{Total Energy Consumed by Belt Motorse}}{\text{Total Intact Eggs Collected}}$$

3. Maximize System Throughput

$$\text{Throughput (eggs/hour)} = \text{Number of damaged or spoiled eggs collected per hour.}$$

4. Identify and Quantify Bottlenecks.

$$\text{Belt Utilization} = \frac{\text{Time belt is transporting eggs}}{\text{Total operational time}} * 100 \%$$

and

$$\text{Egg Density} = \text{eggs / meter}$$