EMPIRICAL MODELING OF LINT CLEANER EFFECTS ON FIBER QUALITY

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Abstract

Lint cleaning is a necessary part of cotton ginning but produces unwanted fiber damage, mainly in terms of increasing the numbers of broken fibers and neps, both of which cause problems at the textile mill. An effort has been underway to consider the fundamental actions taking place between cotton fiber and a lint cleaning machine. The current work is aimed at modeling the effect of lint cleaning on cotton fiber based on decades of research results. A web-based simulation model has been created to provide a means to model various fiber quality outputs based on what other researchers have found over the years. Users of the model are directed to provide input regarding machine and cotton parameters and outputs desired. The model is capable of providing graphical output to assist users in discovering optimal conditions.

Introduction

Lint cleaning is performed in cotton gins to remove foreign matter, improve color and leaf grades, and prepare fibers in an open/combed state. Unfortunately, lint cleaning also (1) removes fiber, increasing the waste and reducing the bale weight, and (2) damages fibers by reducing staple length and uniformity, and particularly increasing the number of neps and amount of short fiber content. Thus there is a balance to be had among several aims: minimizing fiber damage, minimizing fiber loss, maximizing cotton price and sales value, and maximizing the profitability of ginning operations.

In research into the fundamental mechanisms of saw-type lint cleaning over the last few years, we have used two approaches.

- Physical/mathematical, in which we have asked several questions:
  - How is foreign matter particles (leaves, sticks, burs) attached to fibers?
  - How do sequential interactions between fibers and machine surfaces affect neps and short fiber content?
  - What are the important mechanical properties of cotton fibers with regards to fiber fracture?
  - Does addition of lubricant to reduce friction also reduce fiber fracture
- Empirical
  - Can we develop a computer simulation model to assist in use and design of current lint cleaners?
  - Is existing knowledge on relationships between fiber quality and lint cleaner operating parameters adequate?

The current objective of our work is to develop a web-based simulation model.

Materials and Methods

The fundamental aspects of model development have been as follows. We compiled existing data and empirical models on saw-type lint cleaners in the literature, much of which has come from USDA-ARS gin labs. A subsequent article will provide a thorough review of the literature used in developing this model. We developed computer code that requests inputs on cotton and lint cleaning parameters and presents outputs on fiber quality based on inputs. The web-based model is written in PHP and HTML languages, and Python and MATLAB graphics engines were used to present the simulation results in graphical form.

Treatment of data from lint cleaning experiments in the literature is usually presented in one of two forms: regression equations or tables. Regression equations are presented when the modeling parameters are continuous, whereas tables are presented when the modeling parameters are discrete (for example, number of lint cleaners). Since most of this literature comes from the USDA-ARS cotton ginning laboratories at Lubbock, TX, and

Stoneville, MS, the applicability and scope of our simulation model as it stands now could be considered somewhat limited to the surrounding regions. We will continue reviewing newly published experimental results and adding them into this simulation model so that the simulation model can be more geographically robust and remain current with modern technology (e.g., new varieties and harvest technologies).

Required inputs to the model are categorized into three groups. The first group is machine parameters, including number of lint cleaning stages, saw speed, and saw diameter. The second group is the operating parameters, including combing ratio, batt density, and lint moisture. The third group is the initial fiber quality parameters, including micronaire, fiber length, fiber strength, uniformity, brightness, yellowness, and nep counts. Other parameters of particular interest such as short fiber content and number of grid bars have not been included in the model yet due to a lack of relevant experimental results in the literature. The model outputs include bale weight, bale price, and HVI fiber quality characteristics after lint cleaning.

The simulation model is web-based, and a user can access the simulation model through a web browser such as Internet Explorer or Mozilla Firefox. The user can then input the needed information to set up and run the simulation model. The user is first directed to provide input information about the cotton of interest (such as geographic region, harvest method, initial fiber parameters, etc.). This information enables the program to apply the most appropriate equation or data for the user's conditions. For example, the user may wish to run a simulation for bale weight (as output) against number of lint cleaners (as input). In this case, two empirical models are available, one for picked cotton and the other for stripped cotton. The program selects the appropriate model based on the user's input regarding harvest method. Simulation results are returned to the user in the form of a point calculation or a graph based on the user's preference. Point calculations are appropriate when the user desires to know an exact result (for example, what the output fiber length would be if the combing ratio were set at 26), whereas a graph is appropriate when user input covers a range (for example, what would the range of output fiber length be if the combing ratio were to vary from 20 to 50). Results presented in graphs enable users to determine optimal ginning conditions. Currently the program can present two types of graphs: curves for continuous variables and bar graphs for discrete variables (lint cleaning stages, saw speed, and saw diameter).

The main body of the program was developed with the HTML and PHP languages. The graphing capability of the program was developed with Python's Matplotlib, an open source library to for plotting graphs. Python's Matplotlib is similar to MATLAB's plot function, so the graphing functionality is high quality, and the software enables development in a web browser quickly.

Results and Discussion

Results are presented in terms of the pages of the simulation model as the user would interact with them. On page 1 (figure 1), the user inputs basic information about the cotton of interest. That input is then used to determine what modeling equations or data the model will use.

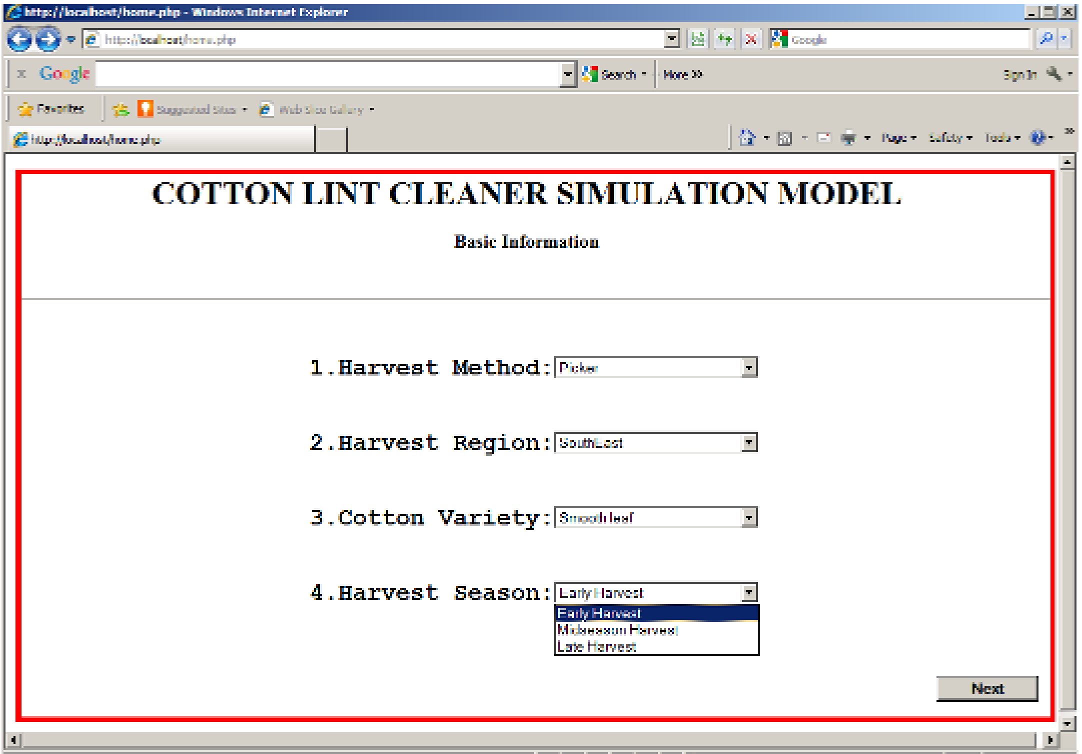

Figure 1. Page 1 of the web-based simulation model for lint cleaning.

On page 2 (figure 2), the user selects output parameters of interest. For example, the user may select fiber length to simulate effect of combing ratio on fiber length. As the model is under development, some options are currently disabled.

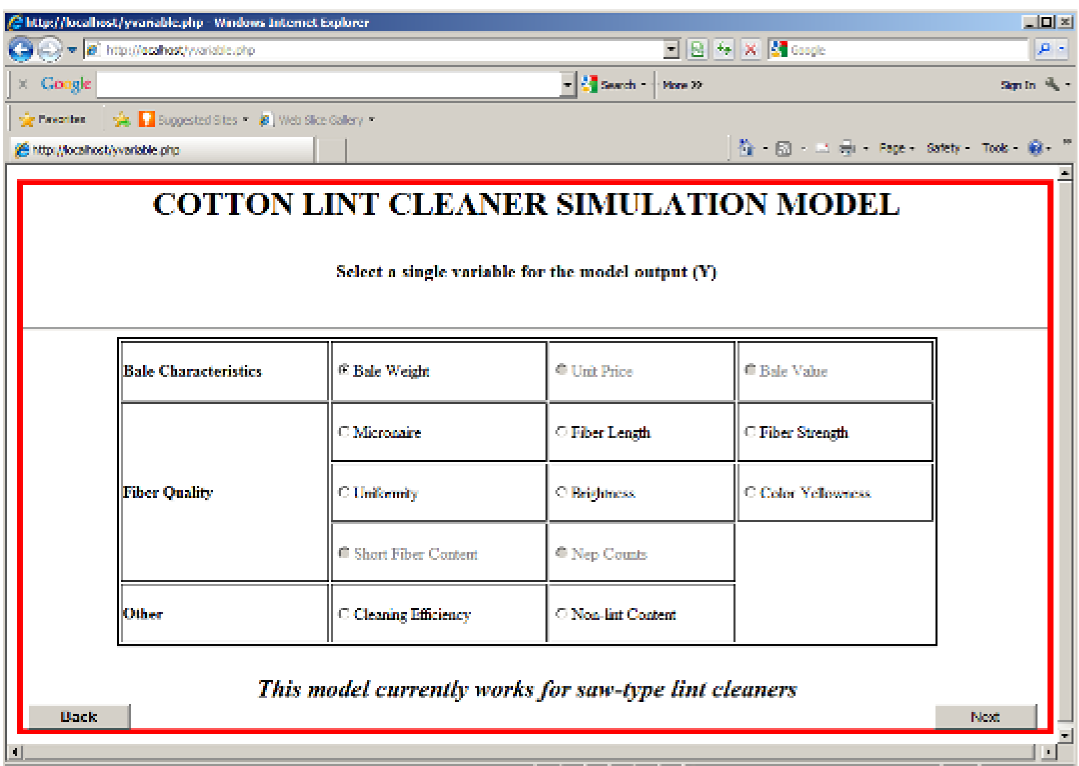

Figure 2. Page 2 of the web-based simulation model for lint cleaning.

On page 3 (figure 3), the user selects input parameters of interest. For example, the user may select a combing ratio to follow through with the aforementioned simulation.

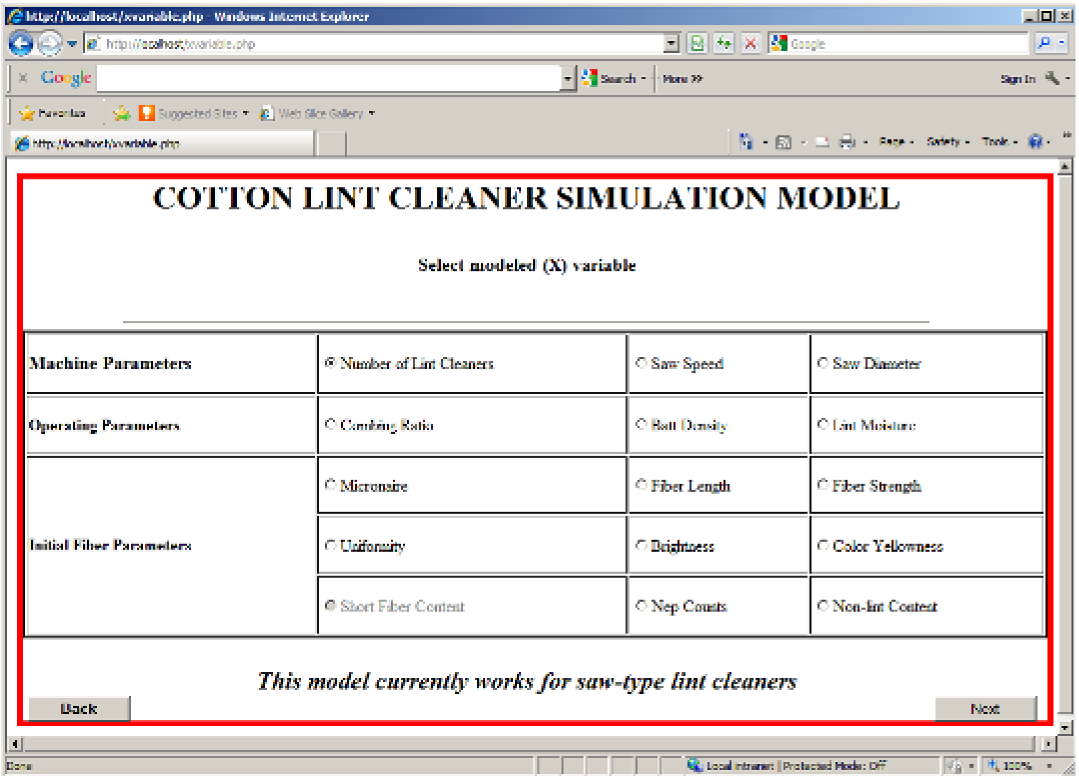

Figure 3. Page 3 of the web-based simulation model for lint cleaning.

On page 4 (figure 4), the user selects an empirical equation or dataset for modeling based on previous user inputs and available equations and data identified by the model. In the fiber length vs. combing ratio example, two equations are available. The “Graph” button allows the user to simulate a range of combing ratios and present results in graphical format. The “Point” button allows calculations at a fixed combing ratio.

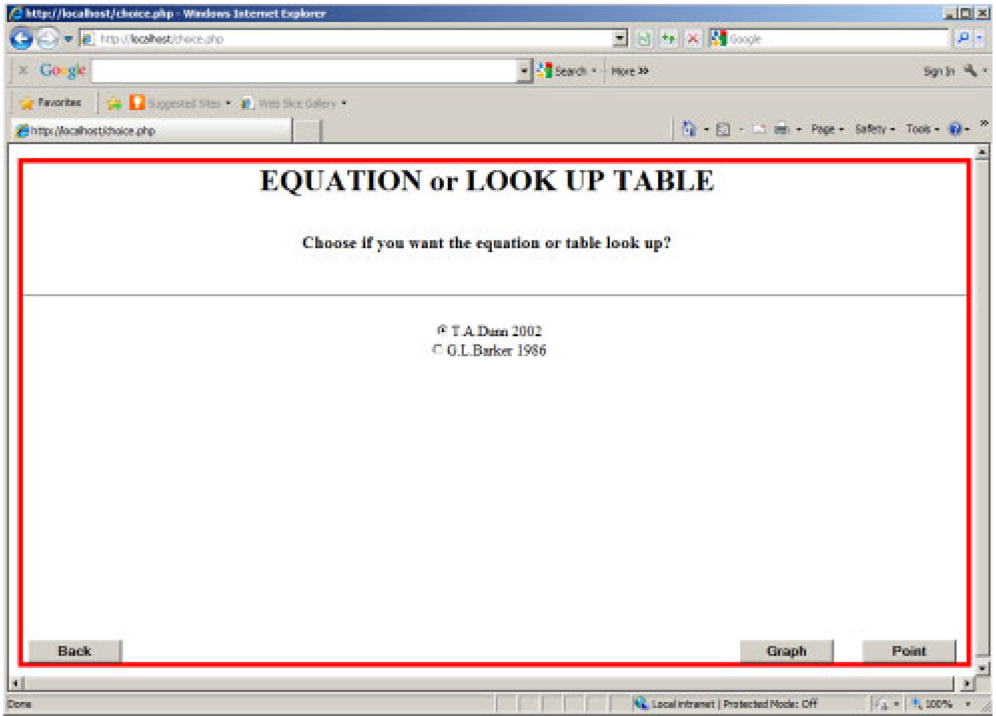

Figure 4. Page 4 of the web-based simulation model for lint cleaning.

On page 5 (figure 5), the user inputs other relevant parameters. The user can set upper and lower limits and step size to run the simulation, which have initial default values for simplicity but can be changed to match specific cotton or ginning conditions.

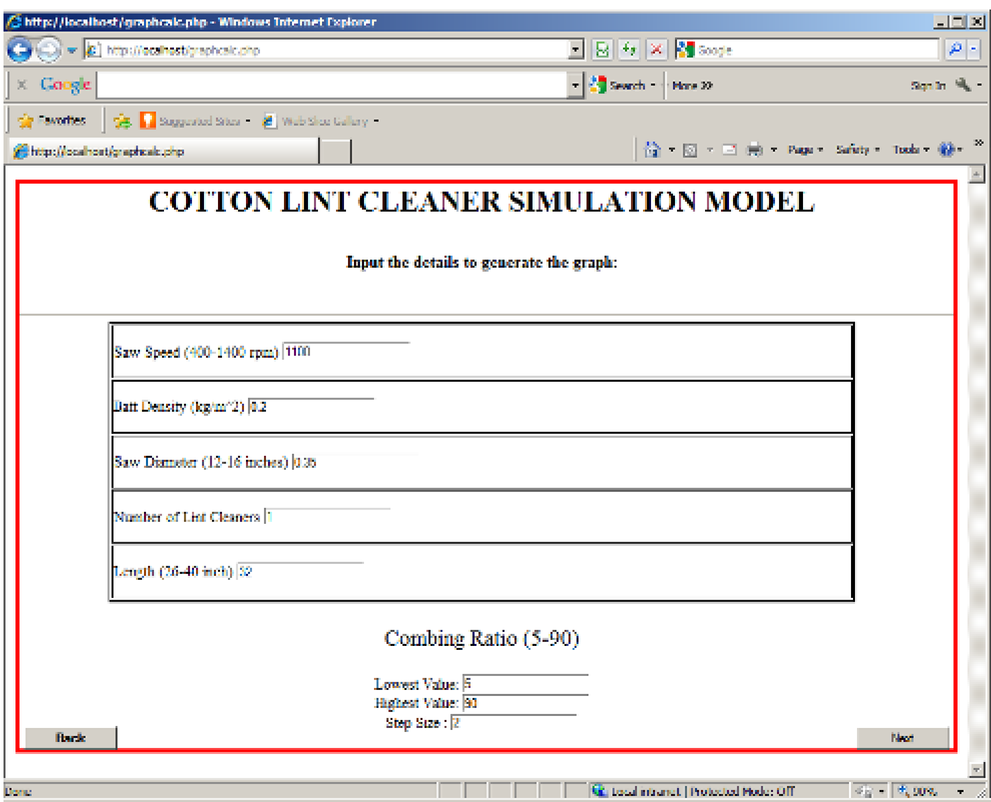

Figure 5. Page 5 of the web-based simulation model for lint cleaning.

On the results page(s) (figure 6), graphs or point calculation data are displayed. Axes can auto-scale so curve trends can be clearly seen.

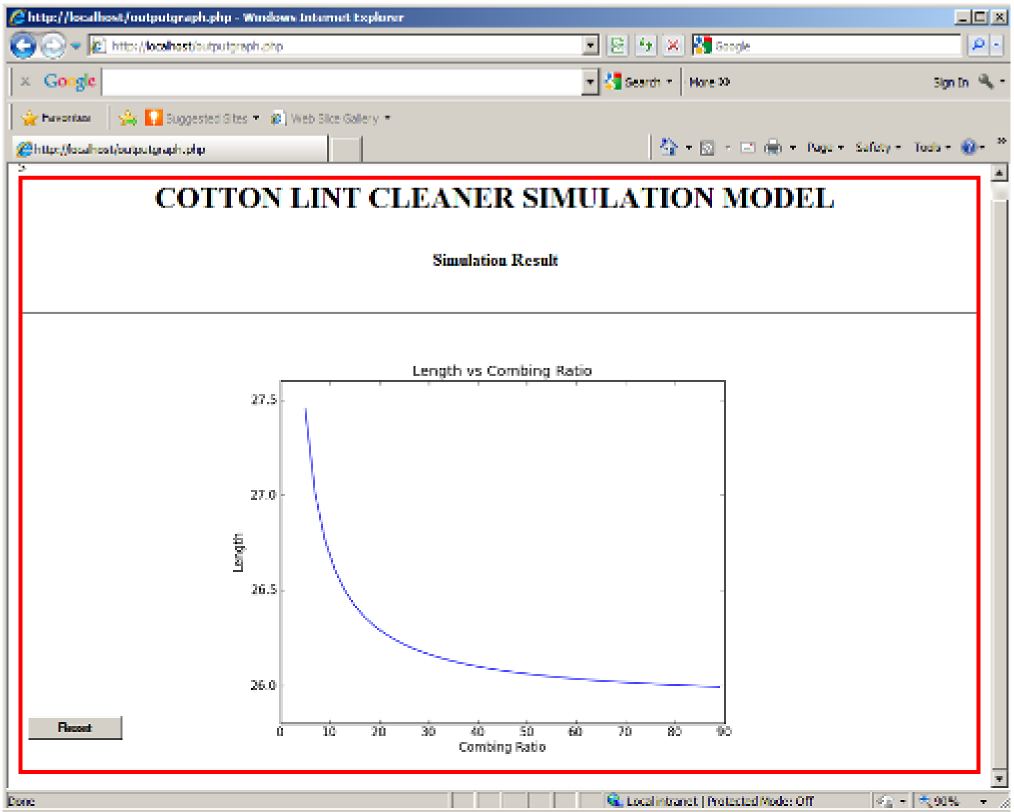

Figure 6. Results page of the web-based simulation model for lint cleaning.

Conclusions

A web-based empirical model for lint cleaner effects has been developed. The model incorporates decades of experiments and literature. The user interface allows the user to select desired inputs and outputs. The model provides numerical or graphical output. The model is usable for researchers and ginners considering various operating modes and cottons and how to optimize processing.

Future Work

We plan to continue to develop this empirical model and launch it on the internet. We will first conduct a trial run at Texas A&M University's Department of Biological & Agricultural Engineering website. Later we plan to transition it to Cotton Incorporated's website for use by the broader community. As we develop the model further, we will complete the incorporation of existing literature and use feedback to improve the user interface and model functionality.

Furthermore, we will continue the physics aspects of the modeling effort. Specifically, we will work towards developing a basic understanding of fiber breakage during lint cleaning and consider effects of lint moisture on fiber strength.

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