Feasibility of precision fruit thinning

Jim Thompson, David Slaughter, Uriel Rosa
Bio. & Ag. Engineering, One Shields Ave, UC Davis, Davis, CA 95616

This year's work covered the following objectives:

- Evaluate the capability of machine vision–based methods of counting immature fruit on a tree.
- Determine the capability of an electrically actuated shaker to remove precise numbers of green fruit.

A third objective was an unfunded project conducted with the cooperation of Sunsweet Dryers, a heat exchanger manufacture and UC Cooperative Extension:

- Estimate the gas savings from a commercially developed heat exchanger for dehydrators.

The feasibility of using machine vision technology for counting immature prunes is first dependent on the ability of a system to distinguish between the fruit and the leaves. We determined this by collecting a number of digital images of prune branches when the fruit was about 1/2" to 3/4" diameter. We also placed freshly picked fruit and leaves in a laboratory spectrophotometer to determine the spectral characteristics of the two.

In the digital images, the immature fruit were impossible to distinguish from the leaves on the basis of color. The spectrophotometric data also showed that the fruit and leaves had very similar spectral characteristics the visible spectrum, from 400 to 700 nm, figure 1. But there are differences in reflectivity in the near infrared region from 700 to 1200 nm. A special two-waveband camera, with one band in the visible and one in the near infrared, could be used to distinguish the fruit from leaves. However we observed that even if though there is a possible method of distinguishing fruit from leaves, it is not possible for an imaging method to 'see' the fruit because the leaf canopy is so well developed when the fruit need to be thinned. The leaves simply obscure the view of the fruit. We believe that it is very unlikely that a vision system could be effective in detecting and accurately counting immature fruit on a prune tree.

A second approach to the problem of improving the accuracy of mechanical fruit thinning is to measure the amount of fruit removed during the shaking procedure. This can be done by measuring the vibration characteristics of a branch before and after shaking the branch. This is like tapping a glass, then pouring out some water, and tapping it again. The amount of water removed can be estimated by comparing the tones of the glass before and after the water is removed. Experiments in the lab with immature peach fruit showed that the concept is potentially feasible, figure 2. For the individual test described in Fig. 2, it was possible to measure 600 to 1100g of fruit removed on a branch that had a total of 1400 g of fruit. More testing is needed to confirm this preliminary finding.

This approach does not determine the amount of fruit originally on the tree so it is not possible to precisely control the amount of fruit remaining on the branch. But the concept is an improvement on the existing mechanical shaking system because a measured amount of fruit is removed from each tree, rather than just shaking each tree for a constant amount of time. The system could eventually be designed so that an electromechanical shaker could be controlled to remove a measured amount of fruit from each tree. The operator could then adjust the weight removed based on the appearance of the shaken branch, rather than just adjust the shaking time as is done now.

The energy savings potential of the heat exchanger was tested in a double-track tunnel at the Sunsweet drying facility in Marysville. The air-to-air heat exchanger was manufactured by Max Good, Phoenix, AZ (602-274-8054), Figure 3. The unit fits within the dryer and is completely passive; it does not require a fan or a control system. Gas meters were installed on the tunnel with the heat exchanger and on a neighboring tunnel that was operated conventionally. Air recirculation in each tunnel was adjusted so that each operated at a wet bulb temperature of about 118°F. The humidity conditions were confirmed by the dryer operators who indicated that dried fruit from both tunnels was about the same moisture.

The drying facility had a very reduced drying season this year and the tunnels were only operated from 6PM to noon each day. Based on the energy use from August 9 to August 16 the control tunnel used 316,700 cubic feet at meter pressure. The tunnel with the heat exchanger used 262,878 cubic feet of natural gas, a 15.7% reduction in gas use compared with the control tunnel. The manufacturer does not yet have a firm price for subsequent installations but believes they can be priced for a three to four year simple payback. Due to the limited testing this season, additional tests should be conducted involving more tunnels and different tunnel designs.

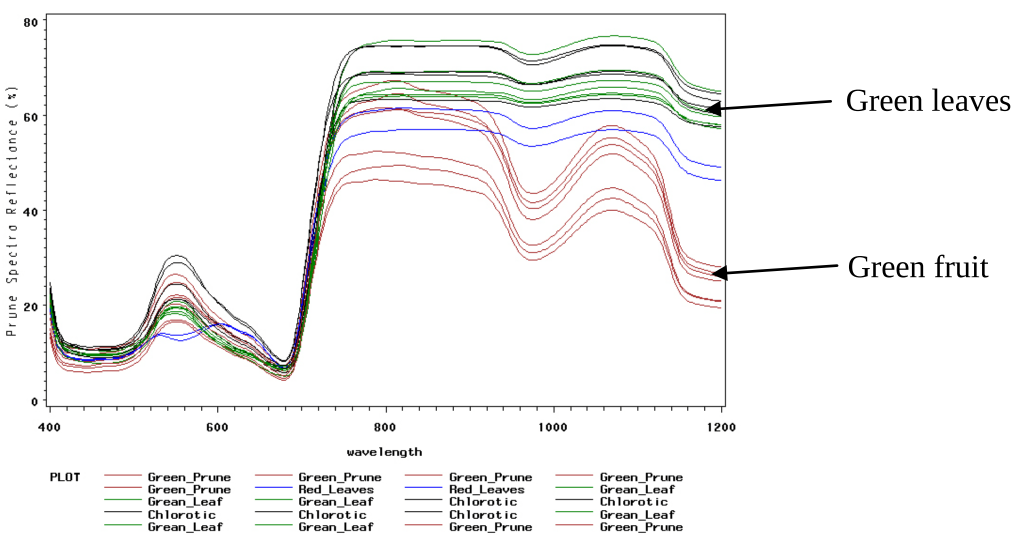

Figure 1. Prune fruit and leaf spectral reflectance in the visible and silicon region of near infrared

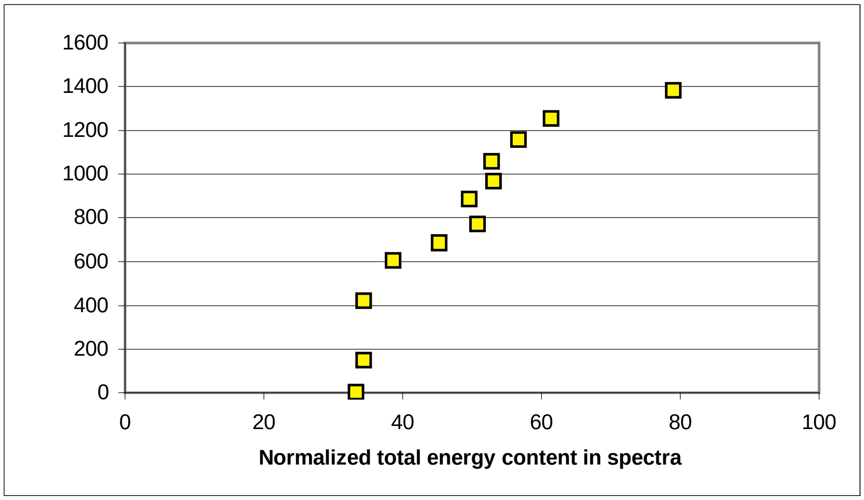

Figure 2. Example of predicting fruit removal based on vibration characteristics of a branch measured before and after shaking.

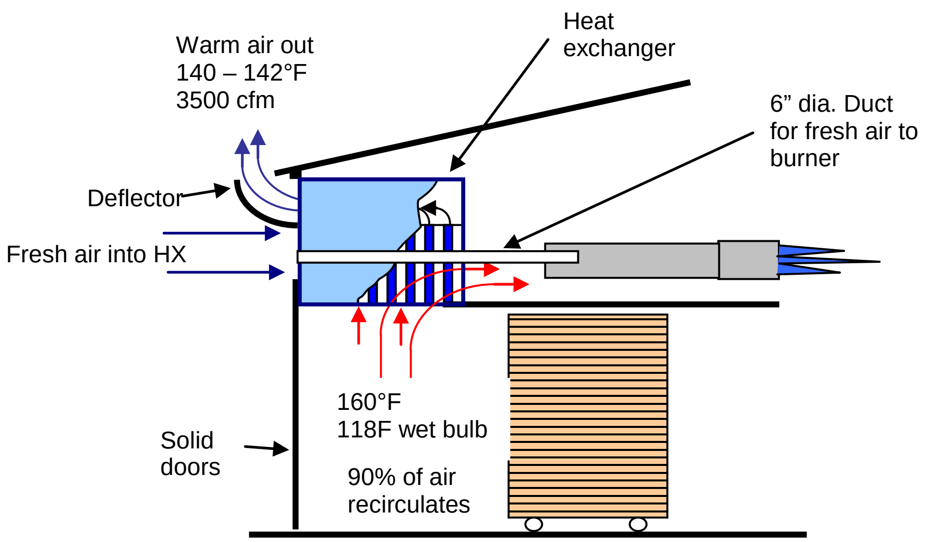

Figure 3. Schematic of passive heat exchanger installed in a transite prune dryer