Energy Efficiency Analysis of a Mechanical Shaker for Sweet Cherry Harvest

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Introduction

❖ Washington State is the main sweet cherry producing state in U.S., producing 245,000 tons in 2009.

❖ Mechanical shaker have been used to harvest various kinds of tree fruit.

❖ Sweet cherry growers are seeking for mechanical harvesting solutions for fresh-market sweet cherries.

❖ Energy consumption is also an important evaluation criteria for a mechanical shaker.

Objectives

❖ Obtain the response of the Y-trellis sweet cherry tree (Max. kinetic energy) and its distribution in the branches of the tree under the excitation of the developed shaker.

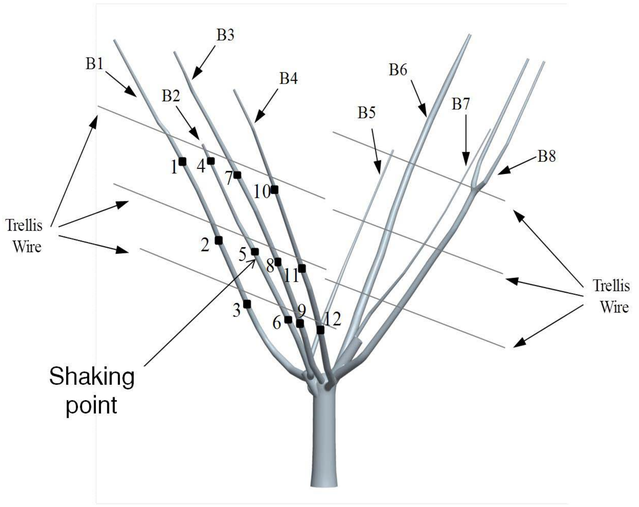
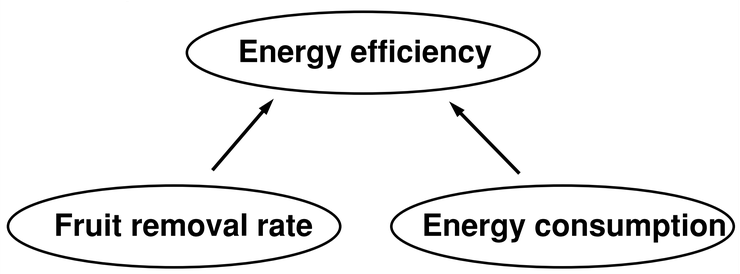


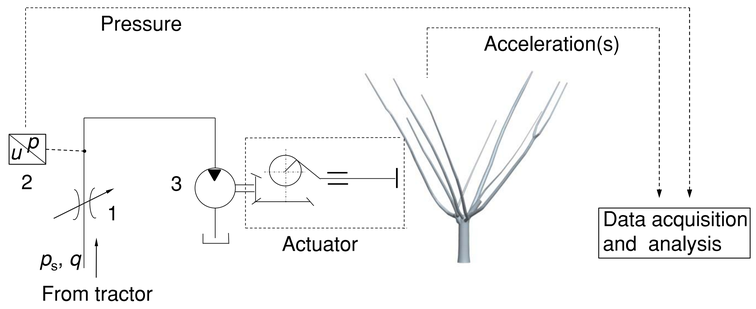
Fig. 1 Y-trellis sweet **c**herry tree and accelerometers location

❖ Obtain the energy efficiency (fruit removal rate every 1 kJ energy consumption) of the shaker to evaluate the harvest operation of the shaker by the combination of fruit removal rate and energy consumption.



Material and Method

The test system constitutes of a hydraulic circuit, an actuator, and a data acquisition and analysis system. A tractor was used to provide the power source for the hydraulic circuit. A hydraulic motor was used as the drive for the shaker, and inlet pressure was monitored via an inline pressure transducer. An adjustable flow control valve was used to adjust the inlet flow rate of the motor to get different excitation frequency.



1 flow control valve 2 hydraulic pressure transducer 3 hydraulic motor

Fig. 2 Experiment system for Y-trellis sweet cherry tree dynamic tests and harvest tests

Field Tests

Dynamic tests

A set of dynamic tests were conducted before harvest season in the excitation frequencies of 6, 10, 14 and 18 Hz using developed shaker. The accelerations and pressure were recorded.

Fig. 3 Field tests in sweet cherry orchard using developed shaker system

Harvest tests

All harvest tests were conducted in a combination of two previously identified optimal impact frequencies of 14 and 18 Hz with two intermittent impact durations of 2 and 5 s. The fruit removal rates of every harvest cycles were calculated and hydraulic pressure was recorded.

Results

Based on the data connected from dynamic tests and harvest tests, the results showed from Fig. 4 to Fig.6.

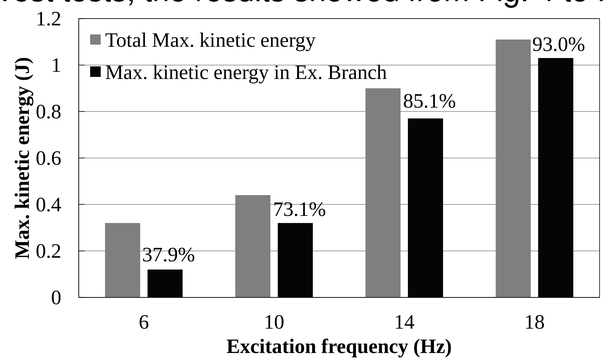


Fig. 4 The total Max. kinetic energy delivered to the excitation side, Max. kinetic energy in Ex. Branch and the percentage of that in Ex. Branch to the total in different excitation frequencies

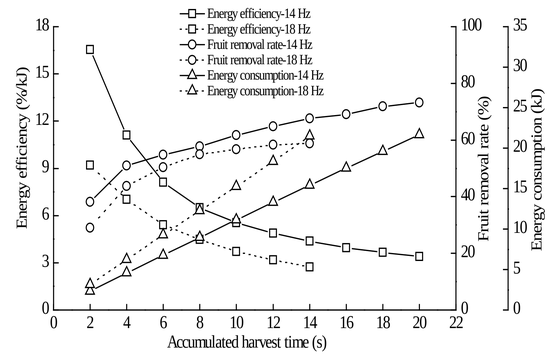


Fig. 5 Energy efficiency, fruit removal rate and energy consumption of 2 s durations harvest mode in different excitation frequencies

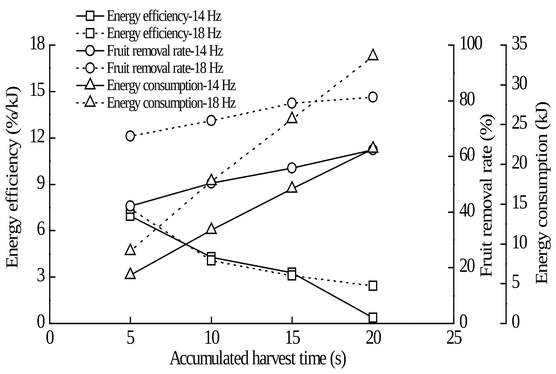


Fig. 6 Energy efficiency, fruit removal rate and energy consumption of 5 s durations harvest mode in different excitation frequencies

Conclusions

➢ The energy delivered to the tree and the percentage of that to the excitation branch increased with the increase of the excitation frequency.

➢ As the more cycles applied, the fruit removal rate increased, while the energy efficiency was rapidly getting down in all harvest operations.

➢ The combination of 5 s under 18 Hz excitation could provide the best overall harvest performance for using the developed shaker in harvesting sweet cherry on “Y” trellis.