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Final Report for Project Number 03-DD-01: Engineering an In-line Monitor for Evaluating Dust Generation from Nut Harvesting Equipment

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Abstract: Contact was made with a harvester industry representative (Flory Industries, Salida, CA) as an initial step to begin understanding dust generation and air flows associated with nut harvesters. A commercially available dust measurement sensor was identified and purchased for use in future studies associated with monitoring dust during nut harvesting activities.

Introduction

Generation of dust from almond harvesting is an increasing problem and continues to be a focus of regulatory activity. Filter deposition measurements of airborne particulate matter (PM) are time consuming and expensive; this limits the number of experiments that can be executed. Also, results tend to be averaged over long time periods. An in-line sensor could provide real-time information and allow a fast, low cost method for evaluating changes in machine design, operation or orchard cultural factors. The goal of this project was to identify and purchase a commercially available sensor that could be mounted on an almond harvester during pick-up operations, and provide real time estimates of dust generated after separation of nuts and dust by the harvester fan.

Objectives:

1. Investigate commercially-available sensors used for particulate emission measurements in other industries and determine potential for use on almond harvesters.
2. Purchase a commercial sensor for further testing; if no commercial unit appears acceptable, design a prototype unit.

Results

Initial visits to the manufacturing plant and discussions with the Research and Development Section at Flory Industries were made in May 2004. These visits provided several results: they established a relationship with industry; they provided an opportunity to learn about nut harvesting equipment; and they provided initial design discussions for future dust monitoring.

Objective 1: The hypothesis of this work was that dust load from harvester air exhaust could be measured as opacity or light extinction. These types of measurements are commonly used in industrial smoke stack emission monitoring and equipment is available commercially. This project investigated available light measurement instruments (laser or opacity instruments) for measuring ambient dust in and near the discharge of harvesting equipment. An overview of some of the instruments and discussions with instrument manufactures are presented.

Model FW300 dust concentration monitor manufactured by Sick Maihak (www.sick-maihak.de). Technical discussions with representatives were informative with respect to device operation. The instrument retains measurements within the electronics on the device and these can be downloaded to a computer. The user manual was clear and instructive. Measurement capability of the instrument was indicated as approximately 12 g/m^3. Complete instrument cost (2004 dollars) was approximately $10,000.

Model D-R 290 opacity and dust concentration monitor manufactured by Durag (www.durag.net). Technical discussions with representative were not very informative with respect to device operation. The instrument required an additional data-logger, peripheral equipment for capturing data and the user manual and operational instructions were not clear. Measurement capability was approximately 4 g/m^3 and the instrument cost was approximately $10,000 (2004 dollars), not including cost of peripheral devices. Additionally, the device had half the measurement capability (in concentration units) versus the FW300.

Model DataRAM 4, manufactured by Thermo Electron Corp. Technical discussions with the representative were informative with respect to device operation. This is a gravimetric system which required pre-filter weighing, an environmentally controlled room and micro-balance (capability of weighing to 0.1 μg). Instrument cost was approximately $10,550, not including additional peripheral devices.

Model 300L, manufactured by Teledyne Monitor Labs (www.monitorlabs.com). Discussions by email with the technical representative indicated they did not feel this device, nor any of their devices, were appropriate for our measurement application. They indicated we should talk with Sick-Maihak.

Model 4200 opacity and dust monitor, manufactured by Land Instruments International (www.landinst.com). Discussions by email with technical representatives indicated they felt we should use their device, however the upper limit on the instrument's measurement capability was 1 g/m^3, which was considered too low for our measurement needs. Additionally, the instrument cost was approximately $14,000.

Objective 2: Based on the information gathered for the different instruments used to measure dust as opacity, light measurement instruments cost approximately $15,000 each. The most likely system to work on an almond harvester was selected. The unit selected was an FW300 dust concentration monitor, manufactured by Sick-Maihak (Minneapolis, MN). Instrument specifications indicate that concentrations up to 12 g/m^3 of dust can be measured. We received the instrument in late July 2004 so initial plans to test the instrument with Arizona test dust (graded based on particle size in μm and available in different size ranges) in the laboratory were postponed. Future work will include installing the instrument onto a platform that can be used to measure dust during nut pick-up operations. Additionally, differences in machine operation will be evaluated, to the extent possible, within the time frame available of the remaining 2004 almond harvesting season.