



Company Information

Company Name	<i>Electrolux North America</i>	Date Submitted	<i>06/3/2020</i>
Project Title	<i>Design and Build of a Portable Shadowgraph System (ELEC_SHADOW)</i>	Planned Starting Semester	Fall 2021

Senior Design Project Description

Personnel

Typical teams will have 4-6 students, with engineering disciplines assigned based on the anticipated Scope of the Project.

Please provide your estimate of staffing in the below table. The Senior Design Committee will adjust as appropriate based on scope and discipline skills:

Discipline	Number	Discipline	Number
Mechanical	3	Electrical	
Computer	2	Systems	
Other ()			

Company and Project Overview:

Electrolux makes products to serve a wide variety of customers' needs in households across the world. Our products cook, clean, wash, dry using as little energy and natural resources as possible. Whether our products meet these demands needs depends strongly on our ability to predict and control the flow of heat, air, and humidity to exactly where we want it. The goal of this project is to develop a tool to help our designers visualize the flow of hot and cold fluids using the shadowgraph technique that uses changes in refraction due to temperature and density changes to create images that reveal the flow path that is invisible otherwise.

Project Requirements:

The objective of this project will be to design and build a portable test system for generating, capturing, and analyzing the shadowgraph images with a portable system that can be shared between Electrolux's test labs throughout the world. A Shadowgraph is a simpler form of a Schlieren method. See more about Shadowgraph's at this Wikipedia link:

<https://en.wikipedia.org/wiki/Shadowgraph>

There are three key performance metrics that will be critical to the project's success:

- Range of applications cases: The system should be able to capture images from flow features from several standard test cases:
 - o Natural Burner
 - Typical natural gas flame in air about 3x3cm.
 - o Exhaust Hood Plume
 - The flow of steam and hot air rising above a pot of boiling water (100 °C) into an overhead exhaust hood with surroundings at standard ambient conditions, about 200x200cm scale maximum.
 - o Oven Door
 - The flow of hot air and water vapor (up to 450 °C) out of an oven cavity when the door is opened
- Portability and Shareability: The system should be easily movable and shippable between international locations less than 10kg and can be packed inside 30x30x50cm box) and should be usable by a non-expert technician using only written instructions (User Manual).
- Open-Source: The capturing and analysis of images should not rely third party software (e.g. LabVIEW, MATLAB, DSPACE) and license agreements. The preferred solution would be python or java based.
- Controllable and Flexible: The system should be able to capture images in several different modes
 - o Single Frame with Countdown Timer
 - o Multiple Frames with Countdown Timer
 - o Single Frame with External Trigger
 - o Multiple Frames with External Trigger
- Framerate and Exposure Time: The system should not require more than 30ms exposure time for any single image and be capable of capture at least 10 still images per second when multiple frames are taken in sequence.

Expected Deliverables/Results:

- Shadowgraph System
 - o Light Source
 - o Camera
 - o Trigger
 - o Image Capture/Storage/Analysis Device(s)
 - o Software
- Documentation
 - o User Manual
 - o Source Code

Disposition of Deliverables at the End of the Project:

Hardware developed is the property of the Industry Supporter. Typically, the work product is displayed at the last Expo then immediately handed over to the supporter unless arrangements have



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been made to deliver at a future date. Please confirm your expectation in this section.

List here any specific skills, requirements, specific courses, knowledge needed or suggested (If none please state none):

- Fluid mechanics, thermodynamics, instrumentation/automation, digital signal processing