Design Project Proposal Form
University of Rochester
Department of Mechanical Engineering
ME 205: Advanced Mechanical Design

Project title:
Design of evaporative dryer nozzle for high efficiency and low wear

Engineering discipline(s):
ME, Chemistry

Required skills, materials, & equipment:
Skills:
Mechanical design, abrasive wear

Materials:
Phosphor Slurry

Equipment:
Use of spray dryer or equivalent test setup.

Background & motivation:
What is the current situation, and how would this project improve it?

Carestream makes equipment for computed radiography. Computed radiography (CR) is used to image the body for a wide range of reasons, from broken bones to looking for cancer growths in mammography. CR is also used for non-destructive testing as well as veterinary applications. With computed radiography, a phosphor plate is exposed to X-Rays that have passed through an object of interest. The phosphor stores the latent image that can then subsequently be read by raster scanning the plate with a laser of a particular wavelength and collecting the position and power of the energy released at each point.

In the phosphor plate manufacturing process, the basic material must go through an evaporative drying process. In this process a slurry of material at 20C is injected thorough an atomizer wheel nozzle into a spray dryer high air temperature and speed. As the material travels from the nozzle to the wall of the spray dryer, evaporative cooling changes the air temperature from 350C to 110C. The dried material is collected from the spray dryer and processed further to produce the phosphor screens. This evaporative cooling process is similar to that that produces powdered milk. See figure below.

Different from dairy milk, the phosphor slurry in this case contains materials that are abrasive (Al2O3 or Alumina) and corrosive (BaI2 or Barium Iodide) to traditional stainless steel. The spray dryer cannot contain ferrous material and is currently made from a Stellite alloy to attenuate these problems.

A significant problem in this process is the wear that occurs on the spinning nozzle due to the abrasive nature of the material. As the nozzle wears the efficiency of the evaporative process declines. Wear of
the nozzle is measured by examining the mass. A 2% reduction in the mass of the material will reduce the efficiency of the process by 10%. The nozzles themselves are on order of ~$2K each and frequency of replacement is an issue.

The image below shows the nozzle. The square openings are where the material exits. These become worn and misshaped over time leading to degradation in performance.

Evaporative Cooling - http://www.niro.com/niro/cmsdoc.nsf/webdoc/webb7I5I4w
CR Process - https://www.imt.liu.se/edu/courses/TBMT02/ct/m223r1.pdf
Objective:
What does the project hope to accomplish? What applicability will it have, what risk and promise does it bring, and what intellectual property will it likely generate?

The goal of the effort would be to increase the life of the nozzle substantially. This can be done through a number of different methods including material changes all or in parts as well as design changes.

Deliverables:
What specific products should the project produce, and when? What will be the criteria for success?

- Benchmarking of the current system with understanding of current costs and requirements
- Several design improvement alternatives including modeling of abrasive processes
- Decision matrix indicating most promising design alternative
- CAD of design proposal, including associated drawing package
- Prototype of design
- Ideally a working breadboard/engineering model

Recommended team size:
3-4