University of South Florida

Fresh Water Using low Grade Heat and Alternative Energy
(Formerly titled: Clean Drinking Water using Advanced Solar Energy Technologies)

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Description: This project is being pursued by means of two tasks: Task 1: Water desalination by the use of optimized thermodynamic systems; and Task 2: Design of a photocatalytic reactor for air purification.

Budget: $326,756
Universities: USF

Progress Summary

Water Desalination

Water and energy crises have forced researchers to seek alternative water and energy sources. Seawater desalination can contribute towards meeting the increasing demand for fresh water using alternative energy sources like low-grade heat. Industrial waste heat, geothermal, solar thermal, could help to ease the energy crisis. Unfortunately, the efficiency of the conventional power cycle becomes uneconomically low with low-grade heat sources, while, at the same time, seawater desalination requires more energy than a conventional water treatment process. However, heat discarded from low-grade heat power cycles could be used as part of desalination energy sources with seawater being used as coolant for the power cycles. Therefore a study of desalination using low-grade heat is of great significance.

This research has comprehensively reviewed the current literature and proposes two systems that use low-grade heat for desalination applications or even desalination/power cogeneration. The results suggest two cogeneration systems, that is, a supercritical Rankine cycle-type coupled with a reverse osmosis (RO) membrane desalination process, and a power cycle with an ejector coupled with a multi-effect distillation desalination system. The first configuration provides the advantages of making full use of heat sources and is suitable for hybrid systems. The second system has several advantages, such as handling highly concentrated brine without external electricity input as well as the potential of water/power cogeneration when it is not used to treat concentrated brine. Compared to different stand-alone power cycles, the proposed systems could use seawater as coolant to reject low-grade heat from the power cycle to reduce thermal pollution.

Photocatalytic Reactor
Description
This study focuses on the enhancement of the effectiveness of the photocatalytic process by the introduction of artificial roughness on the interior reactor surface in a photocatalytic system. Artificial roughness elements on the catalytic surface could enhance the turbulence intensity close to the catalytic surface. The enhanced turbulence intensity would translate to an increase in the mass transfer of airborne contaminants to the catalyst surface, improving the efficiency of photocatalysis. For maximum enhancement of the turbulence intensity (or mass transfer or reactor performance) in the photoreactor channel, different shapes, sizes, and arrangements of roughness elements have been numerically investigated. A model reactor was fabricated to carry out the experimental study for air purification. The experimental results compare well with simulations.

Table 1. Summary of the optimum parameters for different roughness arrangements

		Continuous rib roughness			
	Smooth	Transverse	Inclined	V shape	Mesh
Pitch ratio (p/e)	----	10	10	10	10
Relative height (e/h)	----	0.05	0.05	0.05	0.05
Flow attack angle (α)	----	----	75	75	75
Turbulence intensity	7.95%	9.78%	10.49%	10.54%	10.26%

- ❖ The order of the increased turbulence intensity in reactor channel (or the possible reactor performance) is: V shape > inclined > mesh > transverse > smooth.

Experimental study

The purpose of the experiment was to clean contaminated air in a closed chamber by a model reactor. 1ppm toluene was used as the representative air contaminant. The samples were analyzed by GC/FID.

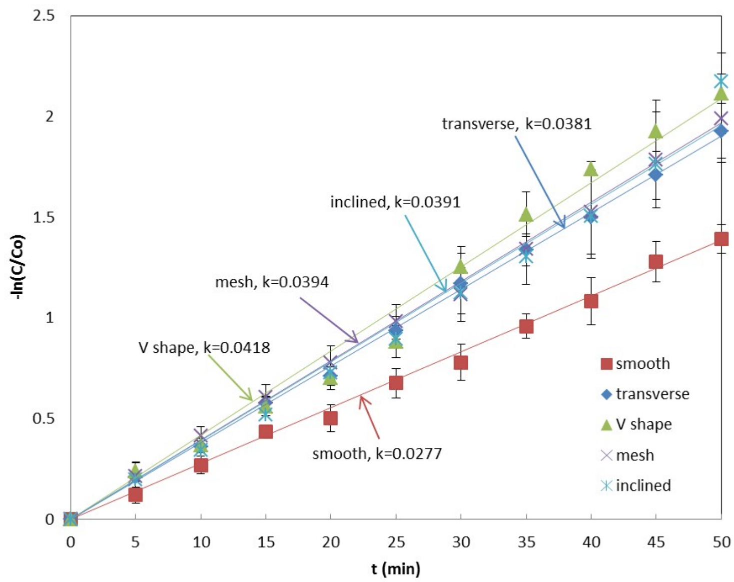

Figure 1. Comparison of toluene photocatalytic oxidation of the reactor with various rough catalyst plates in terms of $-\ln(C/C_0)$

- ❖ The order of the reactor performance with various rough catalyst surfaces could be V shape > mesh > inclined > transverse > smooth.

Conclusions

- The optimum pitch ratio (p/e) of roughness was determined equal to 10.
- The optimal flow attack angle (α) would be 75^o for inclined, V shape and mesh roughness pattern.
- The order of the reactor performance for various rough catalyst surfaces could be V shape > mesh > inclined > transverse > smooth.
- The ideal could also be used in water application.

Publications

1. Yangyang Zhang, Manoj K. Ram, Elias K. Stefanakos, and D. Yogi Goswami, Synthesis, Characterization, and Applications of ZnO nanowires. *Journal of Nanomaterials* 2012 (published)

2. Yangyang Zhang, Elias K. Stefanakos, and D. Yogi Goswami, Effect of photocatalytic surface roughness on reactors effectiveness for indoor air cleaning. *Atmospheric Environment* 2012 (Under review)

3. Yangyang Zhang, Elias K. Stefanakos, and D. Yogi Goswami, Optimum photocatalytic reactor performance with surface roughness arrangement for indoor air cleaning. *Atmospheric Environment* 2012 (finished)

4. Yangyang Zhang, Elias K. Stefanakos, and D. Yogi Goswami, Design of an efficient photocatalytic reactor with artificial surface roughness for air purification. *Atmospheric Environment* 2012 (finished)