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DESORPTION PHENOMENA IN SOLID-LIQUID SYSTEM USING SOLAR ENERGY

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Abstract

In an industry, desorption has been widely used to regenerate extraction equipment contents, absorption, water purifier, chemical reactor and contaminant reduction in environment. For the purpose of this worksheet, a desorption system is planned using solar because the solar energy is an alternative renewable source of heat over the time.

The absorption material of solar as a heat source in desorption is a particle contaminated in certain material. The liquid fluid is a contaminant solvent bonded in particle surface. The objective of this study is to determine the temperature distribution and mass transfer from a particle to the liquid solvent using solar energy.

From the model and based on the object nature and the law of solar flux, heat, mass, and profile momentum and mass and heat balance in desorption system, the equation (1), (2), and (4) are obtained, while the mass transfer constant and the time needed to perform the desorption process use equation (3) and (4).

Key Words : solar energi , desorption

Introduction

In chemical industry, the heat used is usually from reaction heat and also from steam and electrical fluid originated from soil heat, solar, river, wind, biomes, nuclear, fossil fire materials, and coal

Until recently, the most widely used heat sources are non renewable fossil fire materials and coal that has been widely used in chemical petrochemical so it will suffer a energy crisis in the future (Wahib *et al.*, 1999). Among the heat sources, the solar energy can be obtained in all area and it will never be empty all the time so it becomes a promising alternative. But, the problem around the technology provision using the solar power is how to make program so it can meet the need and has achievement in technology. For this purpose, the investigator thought about the resolution by the science of solid, liquid, and gaseous nature because things has a nature of absorption, reflection, and transmission of solar radiation (Middleman, 1997). In his paper, Thibodeaux (1978), proposed that when the electromagnetic wave of sunlight radiation that is spreading in the earth surface fall on a thing, the thing will absorb and store them in the form of heat (Thibodeaux, 1979). And then, the heat collection will move to its surrounding to increase the surrounding temperature and the temperature increasing can be used to do process.

Based on the idea above, many scientists investigate the nature of thing and the tools to change the solar power to heat based on the basic argument such as solar flux, heat, mass, and momentum. In the efforts of investigating the solar energy, Kusu (1964) investigated the characteristic of light–perforate material that was exposed by solar. The model used to analyze the distribution of its temperature is one-dimension finite difference by assuming that the solar flux is spread evenly in the medium. Witek *et al.* (1986) also analyzed it using a material that perforate the light. He analyzed the temperature distribution using two dimension model by assuming that the medium was even and the

solar flux was not evenly spread (Safdari *et al.*, 1999). This semi-light-perforate material analysis was then followed by Jayaprakash *et al.* (1999) by exposing the sunlight inside five kinds of semi-light-perforate material. To know the temperature distribution and its efficiency, they used finite difference method in hot flow. From the previous three worksheet, the temperature characteristic of the things had the similar form and although there was some differences, they resulted from assumption both in solar flux and in the medium.

In other side, beside the light-perforate material, material black is good changer from solar power to the heat because its absorption quality is so high. Therefore, Midelement *et al.* (1997) analyzed material as a water heater or heat exchanger. This investigation is then examined by Jamalias *et al.* (1999) by isolating black plate to be a solar power exchanger tools. The investigation of material and tools of solar power exchanger grow rapidly so Supranto *et al.* (1999) investigated two-passes heat exchanger using air, plate material, and holed media. In its investigation, he used air as a heat transporter from the tools, while the plate is used as solar power exchanger and then the heat is channeled to the medium. In this investigation, the characteristic and the medium efficiency used can be determined. For this worksheet, the material chosen is air, liquid and particle. The sunlight absorber materials as a heat source in the tools are particle contaminated with the material. The liquid is contaminant solvent that bonded in the particle surface. The difference of this investigation compared to previous investigation is that although this investigation explains the effect of heat to the desorption, it also explains the mass transfer from particle to the solvent using the solar power.

From the mass transfer point, the desorption system is widely used by many main tools in chemical industry, such as in chemical reaction, extraction, absorption, desorption, distillation, and water treatment. These tools often use the material contents in which its effective life usually doesn't agree with the plan so, it will cause a potential problem in the future, i.e. the losses both in the company or its surrounding. The more times it's used, the more ineffective and inefficient and if it's used all time, the company will suffer of loss. To avoid these problems, the researcher Forzatti *et al.* (1989) made a program of gaseous solid system of absorption temperature to determine the material efficiency life. In the practice, the regeneration of these tools usually used steam and hot air, while in this worksheet, the material used is liquid. The objective of the research is to obtain the contaminant desorption profile of particle contaminated in the solution using the sunlight help.

The purpose of the research from the mass transfer point of view is to obtain the method of content material regeneration used in extraction, absorption, water purifying, catalist of chemical reactor and also in decreasing of contaminant to its surrounding. Besides, this investigation can also be developed to process the chemical reaction in low temperature, the process that using microbiology in low temperature using solar power.

Objctive

The objective of this research is to study the characteristic of solid-liquid system separation using particle contaminated with the variable of contaminant contents in the solution, temperature, and desorption mass. These variables will form the characteristic of contaminant desorption from particle using solar flux.

The purpose of the research from the mass transfer point of view is to obtain the method of content material regeneration used in extraction, absorption, water purifying, catalyst of chemical reactor and also in decreasing of contaminant to its surrounding. Besides, this investigation can also be developed to process the chemical reaction in low temperature, the process that using microbiology in low temperature using sunlight power.

Discussion

In the desorption tools, the particle contaminated with the things is made in fixed bed form. The top section is covered with light-perforate material and the down section is isolated. There's a solar flux collector room that will exposed to the particle surface in the top section, while there's precipitation room in the down section.

In desorption process, the sunlight exposing the particle surface is altered to heat. The heat in particle will be a convection heat in the particle heap cavity. The heat transfer will increase the system temperature. If the temperature increase, the contaminant mass flux from a particle to the solvent will increase, otherwise if the temperature decreases, the heat in a particle will retain the system temperature for a certain time.

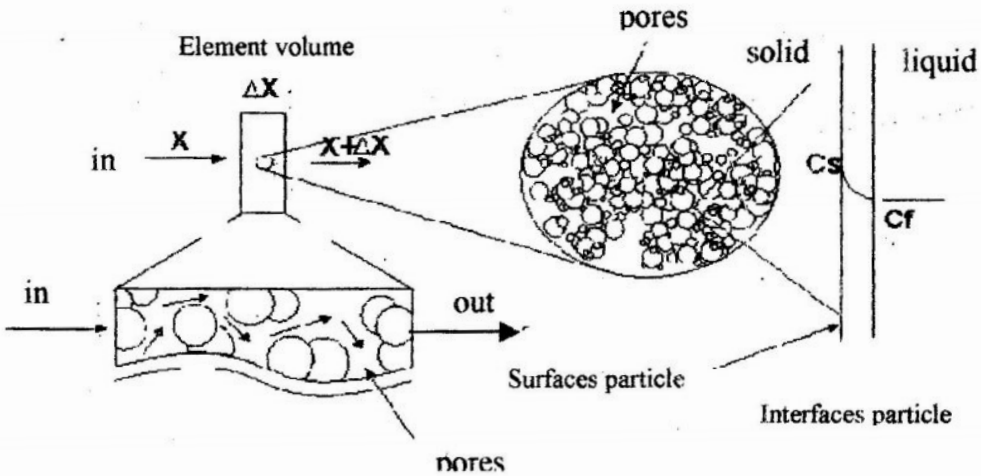

Fig.1. Desorption from particle which is porous

From the model and based on the object nature and the law of solar flux, heat, mass, and profile momentum and mass and heat balance in desorption system, the equation (1), (2), and (4) are obtained, while the mass transfer constant and the time needed to perform the desorption process use equation (3) and (4).

Temperature distribution:

$$\frac{d^2T_s}{dx^2} = \left(\frac{\sigma}{k_{peff}}\right)(T_s^4 - T_s^4) \quad \text{.....(1)0}$$

BC: $x = 0,\ T = T_{fl}$ dan $x = L\ \frac{dT_s}{dx} = 0$

or

$$\frac{d^2T_f}{dx^2} - \frac{V}{\alpha}\frac{dT_f}{dx} = \frac{S_0}{\alpha}\left(\frac{T_s - T_0}{T_f - T_0}\right) \quad \text{.....(2)}$$

BC: $x = 0,\ T = T_o$ dan $x = L,\ {dT_f}/{dx} = 0$

Difusivity actual of desorbtion contaminant:

$$\frac{D_{eff}}{K_r} = \frac{a\,T_f}{\varepsilon + (1-\varepsilon)\rho_s\ bT_f} \quad \text{.....(3)}$$

Contaminant concentration distribution:

$$\frac{D_{eff}}{K_r}\frac{\partial^2 C}{\partial x^2} + A(x)\frac{\partial C}{\partial x} + B(x)C = \frac{\partial C}{\partial t} \quad \text{.....(4)}$$

with

$$A(x) = \left(\frac{2\,\varepsilon\, D_{eff}}{T\, K_r^{\,2}}\left(\frac{dT}{dx}\right)^2 + \frac{D_{eff}}{K_r}\frac{d^2T}{dx^2} - \frac{V}{K_r}\frac{dT}{dx}\right)\Big/\frac{dT}{dx}$$

$$B(x) = \frac{\varepsilon(1-\varepsilon)\rho_s a\, b}{K_r^{\,3}}\left(\frac{dT}{dx}\right)^2 + \frac{\varepsilon a}{K_r^{\,2}}\frac{d^2T}{dx^2} + \frac{V}{K_r}\frac{dT}{dx}$$

In the analysis of equation (4) A(x) and B(x) are complex interaction coefficient of temperature changes along x to the actual diffusivity and solvent convection. If the temperature is the same and the material content in the solvent is very small, the A(x) = V/K, and B(x) = 0. It means that the contaminant concentration distribution is influenced by the solar flux, mass flux, and convection. Then, if the temperature is the same and the fluid content is equal to zero, A(x) = 0 and B(x) = 0. It means that the contaminant concentration distribution is only influence by solar flux and mass flux. In equation (4), T(x) is represented by equation (2), a and b are desorption actual diffusivity coefficient mobility to the temperature along x. Equation (4) is controlled by boundary condition of C(0,0) = 0 and C(L,0), dC/dx=0. From the equation (4), it can be determined the mass needed to desorption and the desorption process is controlled by the contaminant mass diffusion of a particle.

Conclusion

The desorption characteristic using solar energy is represented by equation (1), (2) and (4). Coefficient of mass transfer in the desorption process is controlled by equation (3), while the mass needed to desorption process uses equation (4).

To estimate this desorption system achievement, it needs to test these equations. The material used in the test is tetrachlorobenzen and water. Before the experiment is done, some part of tetrachorobenzen is made saturation in the particle. The equipment scheme used is shown in the appendix. The equation (1), (2) and (4) are done simultaneously by using numeric method. The iteration calculation give us the coefficient value k_{peff}, α, S_o, a, b and a desorption characteristic equation using sunlight power.

Notation

C	Contaminant mol per mix content, mgmol./ml C_s contaminant mol per particle mass, mgmol/g	K_p	Particle conductivity, W/m °C
		K_{peff}	Particle effective conductivity, W/m °C
		K_f	Fluid conductivity
C_f	Contaminant mol per liquid content, mgmol/ml pore fraction	K_{eff}	Fluid effective thermal conductivity
		V	Velocity, cm/hour
ρ_s	Particle density, g/ml	C_p	Particle internal heat, W.s/kg °K
K_p	Balance constant	S_e	Heat from solid to liquid, W/m^2
T_s	Particle temperature, °C	D_{eff}	Effective diffussion, cm/j
T_f	Fluid temperature, °C	K_r	Pore resistant
T_a	Air temperature, °C	K_p	Balance constant
H	Solution heat, W/j		

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