Mech 2060 Spring 2020 Quiz 3

Diffusion is the process that materials transport through atomic motion. During heat treatment, material of different atoms can be introduced to the body of another material through this process. There are two mechanism involving into diffusion, vacancy diffusion and interstitial diffusion. Diffusion can be modelled by Fick's first law (steady state diffusion) and Fick's second law(non-steady state diffusion).

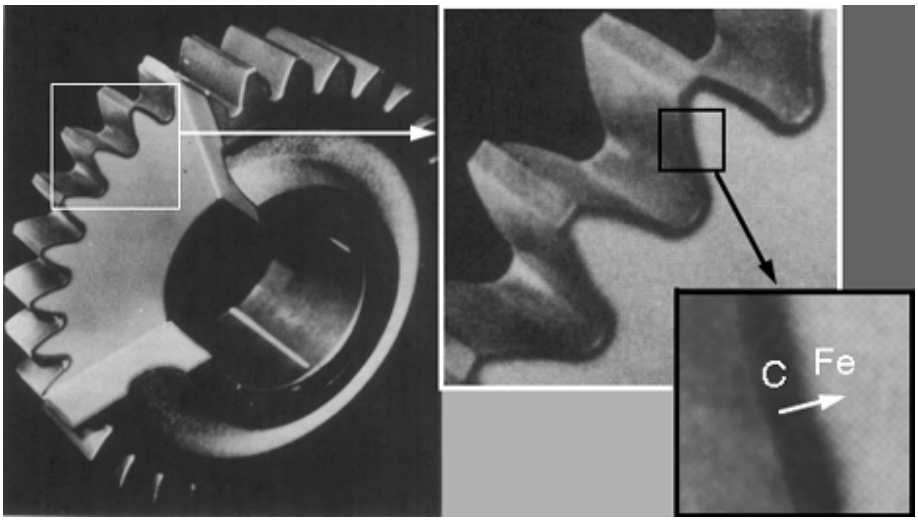

Figure 1 Case harden gear by diffusion process

When manufacturing gears with steel, it is necessary to harden the surface of a steel(iron-carbon alloy) above that of its interior, see figure 1. One way this may be accomplished is by increasing the surface concentration of carbon in a process termed carburizing. The steel piece is exposed, at an elevated temperature, to an atmosphere rich in a hydrocarbon gas, such as methane(CH_4). Consider one such alloy that initially has a uniform carbon concentration of 0.25 wt% and is to be treated at 950 °C. If the concentration of carbon at the surface is suddenly brought to and maintained at 1.20 wt%, how long will it take to achieve a carbon content of 0.80 wt% at position 0.5 mm below surface? The diffusion coefficient for carbon in iron at this temperature is 1.6×10^{-6} m^2/s; assume the steel piece is semi-finite.

Hint: Use Fick's second law.

Please provide detailed assumptions and calculation steps, possible MATLAB programs, all included at the end of this word document and submit by 11:59pm Sunday, March 1st through blackboard.

It will take 0.2536 s to achieve a carbon content of 0.80 wt% at position 0.5 mm below surface.

Code:

```
%% Quiz3 for Introduction of Mech
% Name: Horace
% Date: 25 March 2020
% Description: this script make a calculation for quiz3.
```

```
%% Code
%clear processor
clear all; clc;

%% Calculation
% Set konwn numbers
Co = 0.25; % wt% initial uniform carbon concentration.
Cs = 1.20; % wt% Concentration of carbon at the surface.
Cx = 0.80; % wt% Concentration of carbon at position 0.5 mm
below surface.
x = 5*10^(-4); % m The lenghth below below surface.
dc = 1.6*10^(-6); % m2/s The diffusion coefficient for
carbon in iron at this temperature.
% Calculate the time
erf=1-(Cx-Co)/(Cs-Co); % Calculate the erro of function.
z=(0.40-0.35)/(0.4284-0.3794)*(erf-0.3794)+0.35; %
Calculate the value of z.
t = (x/(2*dc^(1/2))/z)^2; % Calculate the time.
fprintf('It will take %0.4f s to achieve a carbon content
of 0.80 wt%% at position 0.5 mm below surface.',t);
```