

Prince of Songkla University
Faculty of Engineering

Midterm Examination: Semester 1
Date: 1st August 2004
Subject: 237 – 513 Surface Engineering

Academic Year: 2004
Time: 9.00am-12.00pm
Room: A401

- Instructions:** 1. Lecture handouts and notes are not allowed.
2. Answer all questions in the answering sheets provided.

ทฤษฎีในการสอบโทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทฤษฎีและพักการเรียน 1 ภาคการศึกษา

1. (a) Indicate two classifications of methods for the surface hardening of steel and briefly describe their general processes.

(b) Discuss two methods of each of the above classifications. (write as much as you can)
In each case,
 - (i) explain the basic principle
 - (ii) types of steels suitable
 - (iii) give some process characteristics or benefits
 - (iv) give some typical engineering applications
(c) In a carburisation process, consider a semi-infinite steel piece with an initial carbon content of 0.2wt%C which has been treated at 950°C. The carbon environment provided from a hydrocarbon gas is used to set the surface carbon content at 1.2wt%. Using the error function table (Table1), calculate how long it will take to achieve a carbon content of 0.7wt% at a position 1mm below the surface. Suggest how the case depth could be reduced.
(The diffusion coefficient for carbon in iron at 950°C is $1.6 \times 10^{-11} \text{ m}^2/\text{s}$)

TABLE1 Tabulation of error function values

Y	erf(Y)	Y	erf(Y)	Y	erf(Y)
0	0	0.55	0.5633	1.3	0.9340
0.025	0.0282	0.60	0.6039	1.4	0.9523
0.05	0.0564	0.65	0.6420	1.5	0.9661
0.10	0.1125	0.70	0.6778	1.6	0.9763
0.15	0.1680	0.75	0.7112	1.7	0.9838
0.20	0.2227	0.80	0.7421	1.8	0.9891
0.25	0.2763	0.85	0.7707	1.9	0.9928
0.30	0.3286	0.90	0.7970	2.0	0.9953
0.35	0.3794	0.95	0.8209	2.2	0.9981
0.40	0.4284	1.0	0.8427	2.4	0.9993
0.45	0.4755	1.1	0.8802	2.6	0.9998
0.50	0.5205	1.2	0.9103	2.8	0.9999

The amount of carbon diffuses at the distance below surface follows Fick's law: -

$$C - C_o = (C_1 - C_o) \left[1 - \operatorname{erf}\left(\frac{x}{2\sqrt{Dt}}\right) \right]$$

- where
- C = amount of carbon at the distance x cm. below surface
 - C_o = amount of carbon prior to carburizing
 - C₁ = amount of carbon at the surface
 - x = distance below surface (cm.)
 - D = diffusion coefficient of carbon (cm²/s)
 - t = time (s)
 - erf = error function

2. Describe the wear processes that occur in a drive gear of an automotive engine.
How would you design the material and explain which surface treatment you would choose for the following steel components (give your reason):
 - (i) automotive gears
 - (ii) die-blocks

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