CORROSION

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KEBUTUHAN PASAR KERJA

- Biaya Penanggulangan korosi negara berkembang : 1.5% dari GDP.
- Biaya Penanggulangan korosi negara berkembang: 2.5% - 3% dari GDP.
- GDP Indonesia 2004 : > 200 Miliar Dollar.
- Potensi Kerugian : > 3 Miliar Dollar

Sumber : INDOCOR,2004

PERBANDINGAN 2002

- Indonesia memiliki sekitar 100 teknisi korosi dan 24 ahli korosi (tidak semuanya bersertifikat).
- Jepang : ~ 2000 Ahli Korosi
- USA : ~ 3500 – 4000 Ahli Korosi

Sumber : INDOCOR,2004

KEBUTUHAN PASAR KERJA : 2002

- **Kebutuhan belanja logam 2002 : 96 triliun rupiah**
- **Biaya pencegahan korosi : 5%**
- **Biaya tenaga kerja dalam bidang korosi : 10% dari biaya pencegahan korosi atau ~ 500 miliar rupiah**
- **Estimasi kebutuhan tenaga kerja bidang korosi untuk INSTALASI BARU : 10,000 Orang.**
- **DENGAN MEMPERHITUNGKAN INSTALASI LAMA, jumlah kebutuhan tenaga kerja lebih besar dari 10,000.**
- **LAPANGAN KERJA BIDANG KOROSI BANYAK DIISI OLEH TENAGA AHLI DAN TEKNISI ASING.**

Sumber : INDOCOR,2004

KEBUTUHAN 2004 - -

- Jika investasi tetap sama dengan tahun 2002: 10,000 Orang (hanya untuk instalasi baru).
- Jika diasumsikan pertumbuhan dalam belanja logam naik 3% (sebanding dengan pertumbuhan ekonomi), kebutuhan tenaga kerja 2004 menjadi 10,609 (hanya untuk instalasi baru).
- Estimasi kebutuhan 2005: 10,927 (hanya untuk instalasi baru).

PELUANG BAGI PESERTA

- Industri Konstruksi
- Industri Logam
- Industri Otomotif
- Industri Elektrik
- Industri Telekomunikasi
- Industri Perhiasan
- Wirausaha/Home Industry

COST OF CORROSION

- Cost for oil and gas producers : $ 2 billion
- Cost for corrosion maintenance in chemical company : $ 400,000 per year
- Cost for painting steel to prevent rusting by a marine atmosphere : $ s million per year

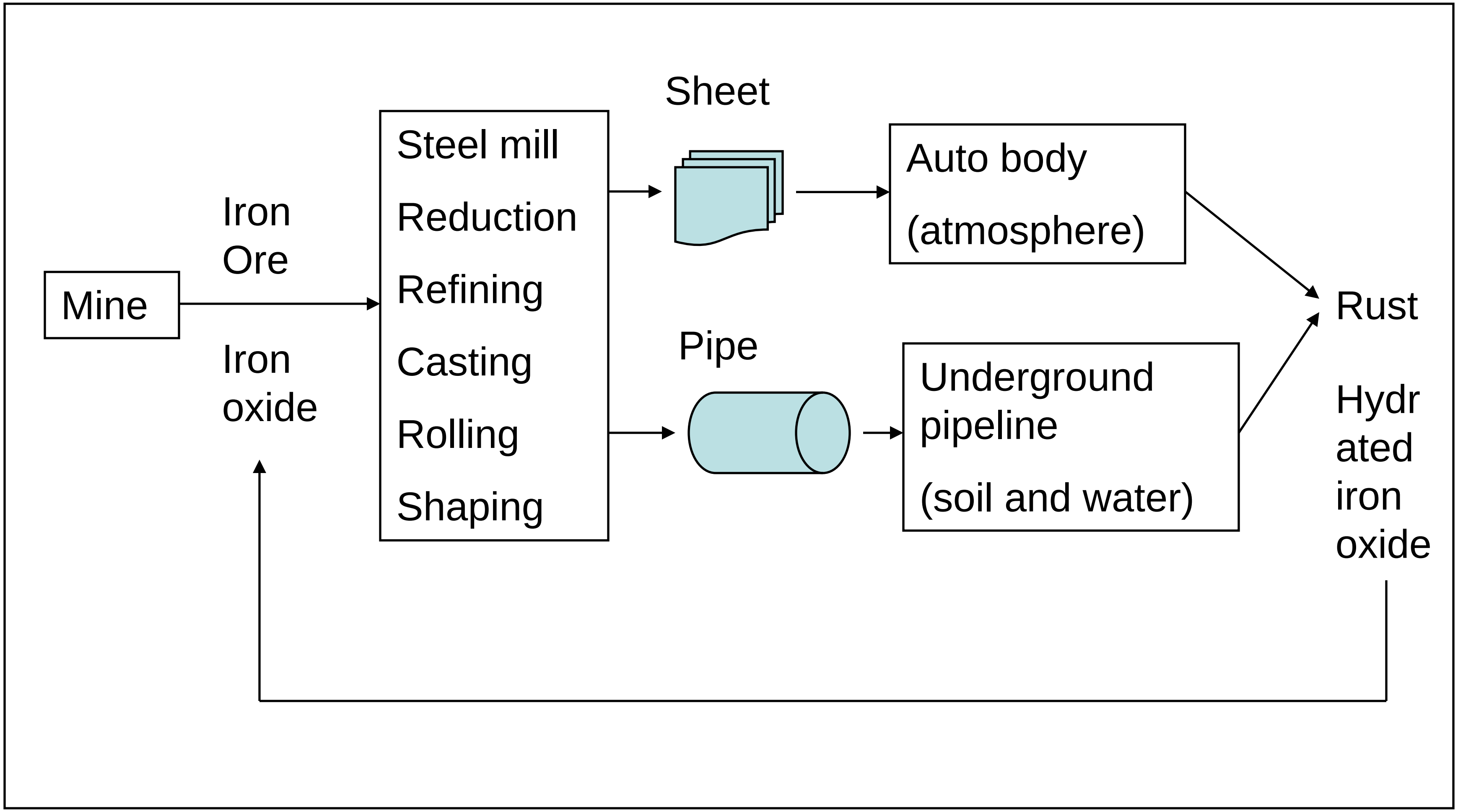
Wall Street Journal, Sept. 11, 1981

DEFINITION OF CORROSION

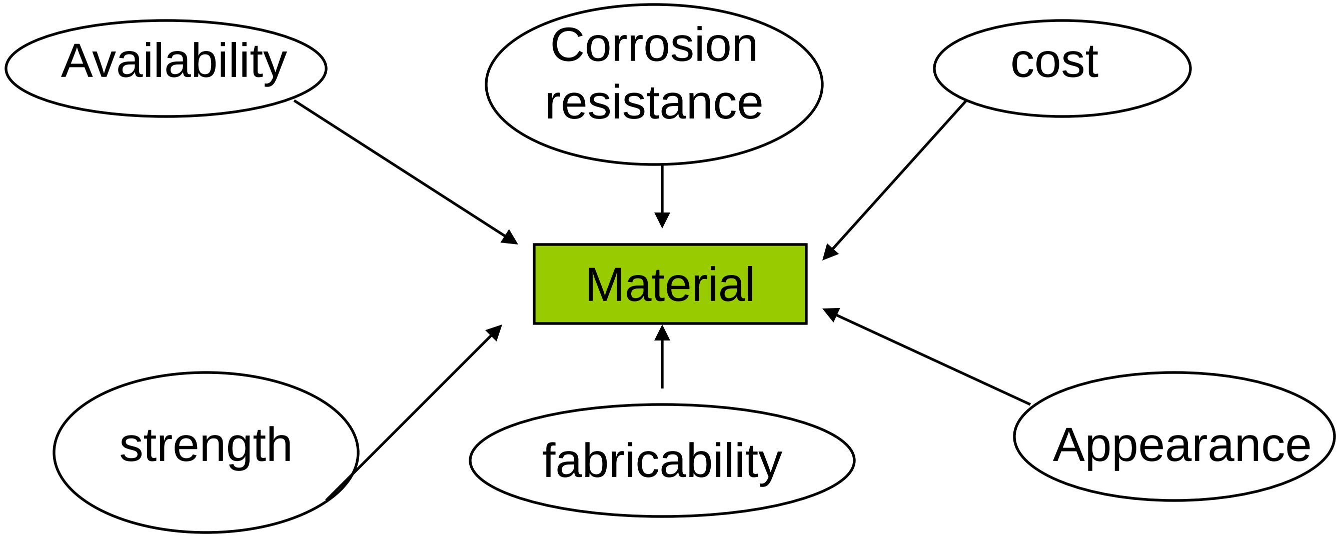
Corrosion

is defined as the destruction or deterioration of on material because of reaction with its environment

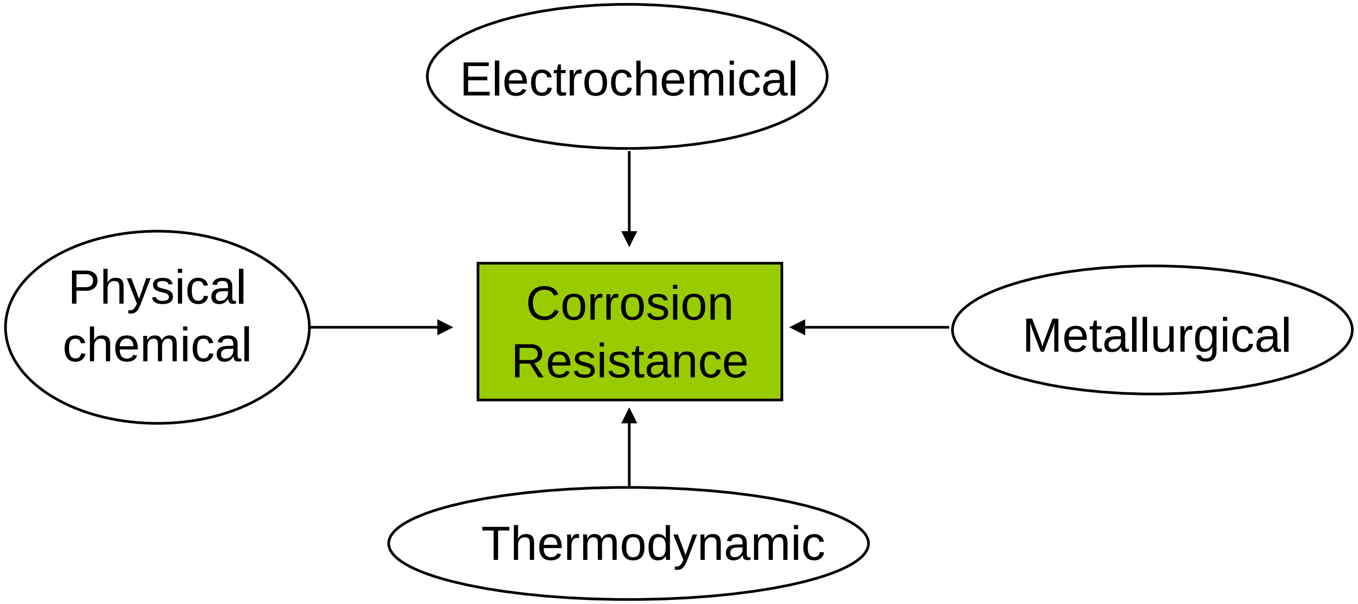
CORROSION IS METALLURGY IN REVERSE



FACTORS AFFECTING CHOICE OF AN ENGINEERING MATERIAL

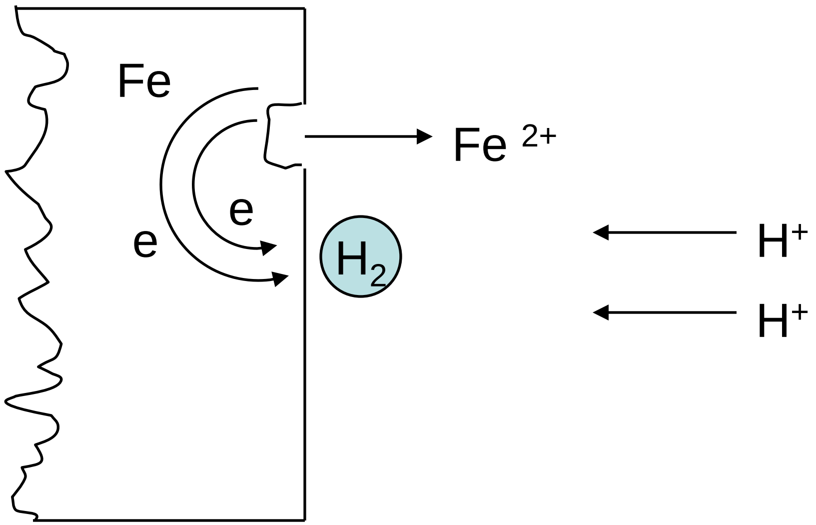


FACTORS AFFECTING CORROSION RESISTANCE OF A METAL



CORROSION PRINCIPLE

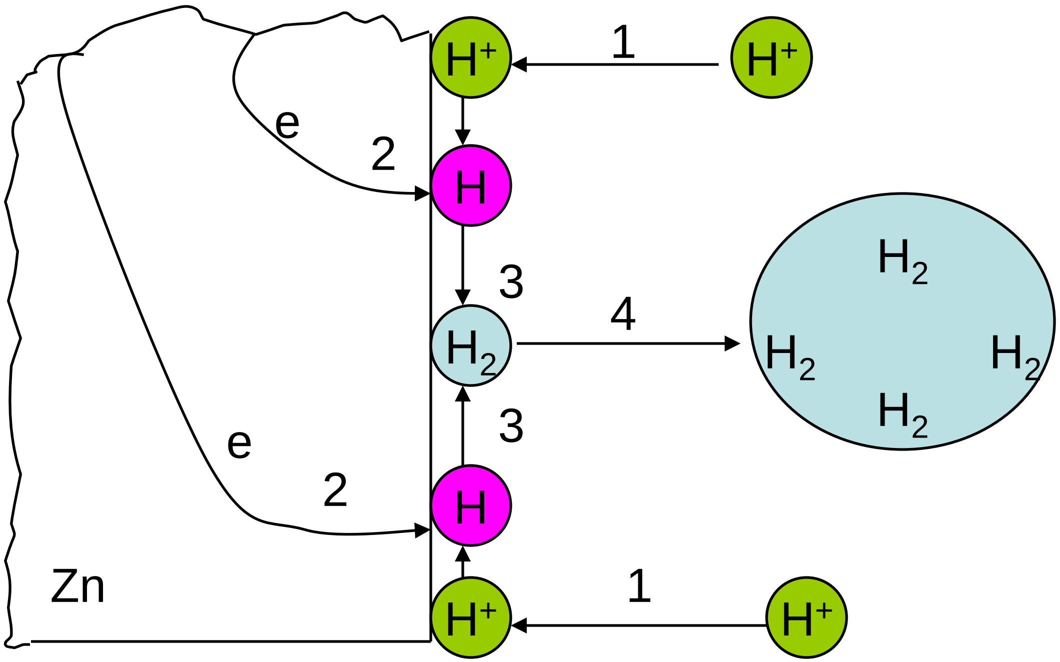
Steel in HCl Solution



HCl Solution

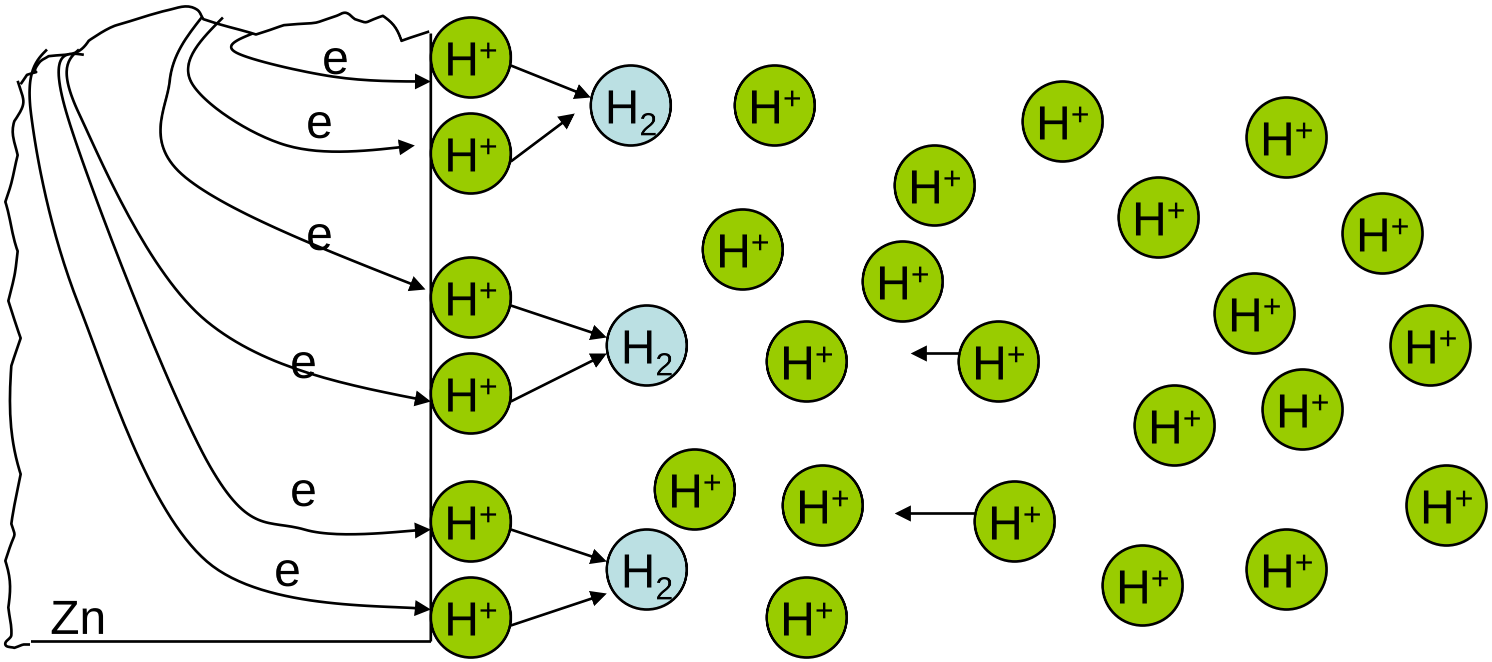
POLARIZATION

Hydrogen – reduction reaction under activation control



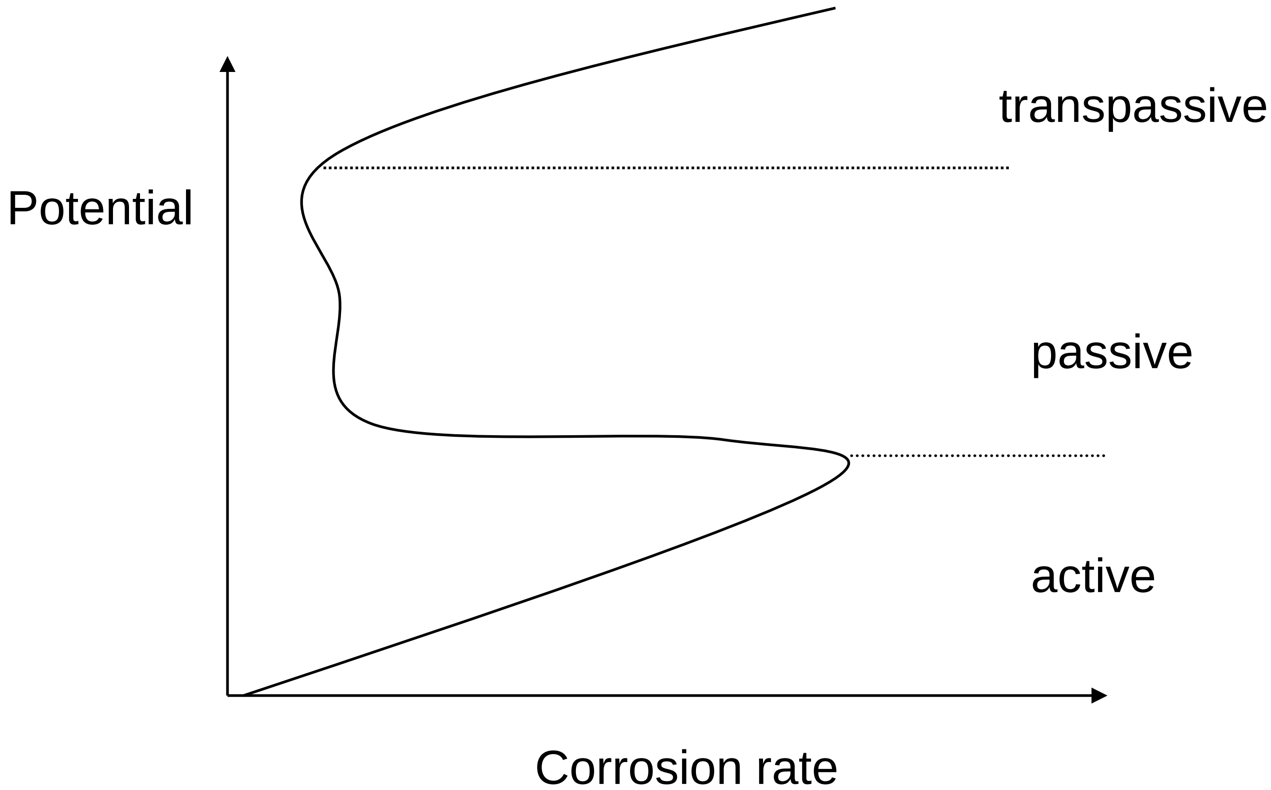
POLARIZATION

Concentration Polarization during hydrogen reduction



PASSIVITY

Corrosion characteristic of an active – passive metal

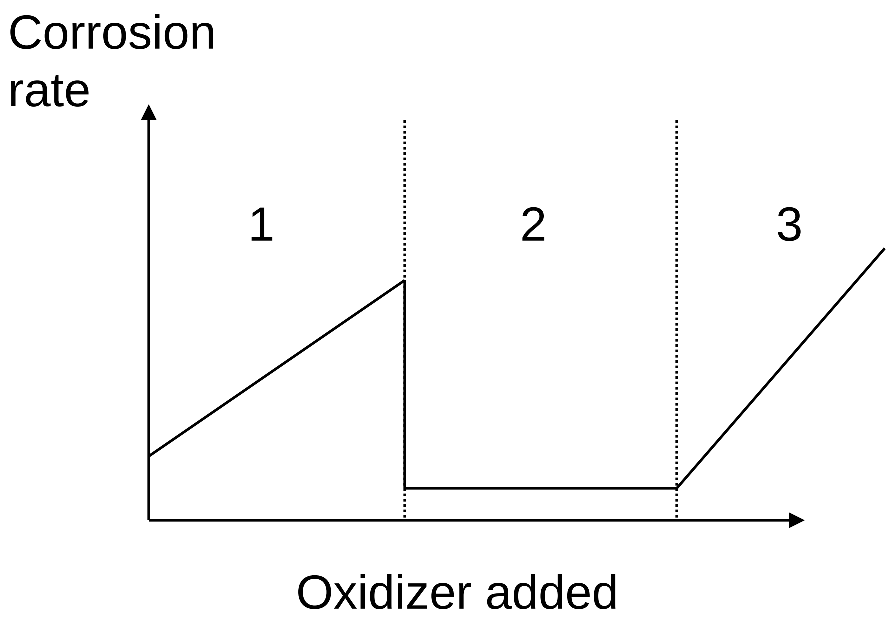


ENVIRONMENTAL EFFECT

- **EFFECT OF OXYGEN AND OXIDIZERS**
- **EFFECT OF VELOCITY**
- **EFFECT OF TEMPERATURE**
- **EFFECT OF CORROSIVE CONCENTRATION**
- **EFFECT OF GALVANIC COUPLING**

EFFECT OF OXYGEN AND OXIDIZERS

Effect of oxidizers and aeration on corrosion rate



<u>Examples</u>

1 : Monel in HCl + O_2

Cu in H_2SO_4 + O_2

Fe in H_20 + O_2

1-2 : 18 Cr–8Ni in H_2SO_4 + Fe^{+3}

2 : 18 Cr–8Ni in HNO_3

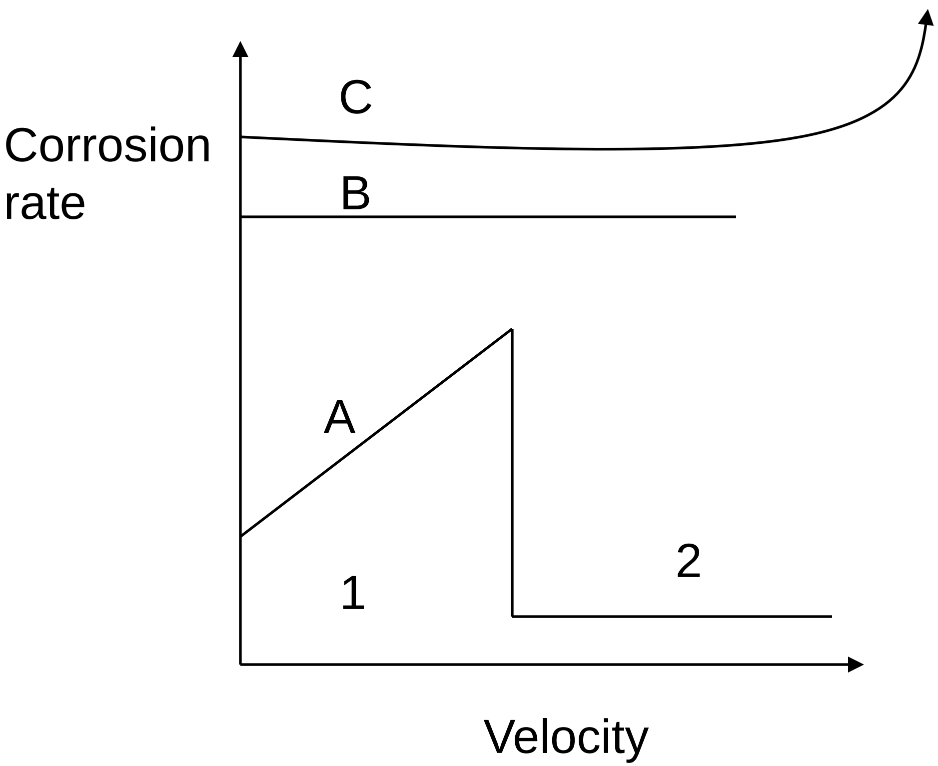
Hostelloy C in $FeCl_3$

2-3 : 18 Cr–8Ni in HNO_3 + Cr_2O_3

1-2-3 : 18 Cr–8Ni in concentrated H_2SO_4 + HNO_3 mixtures at elevated temperatures

EFFECT OF VELOCITY

Effect of velocity on corrosion rate



Examples :

Curve A :

1 : Fe in $H_2O + O_2$

Cu in $H_2O + O_2$

1-2 : 18 Cr-8Ni in $H_2SO_4 + Fe^{+3}$

Ti in HCl + Cu^{+2}

Curve B : Fe in dilute HCl

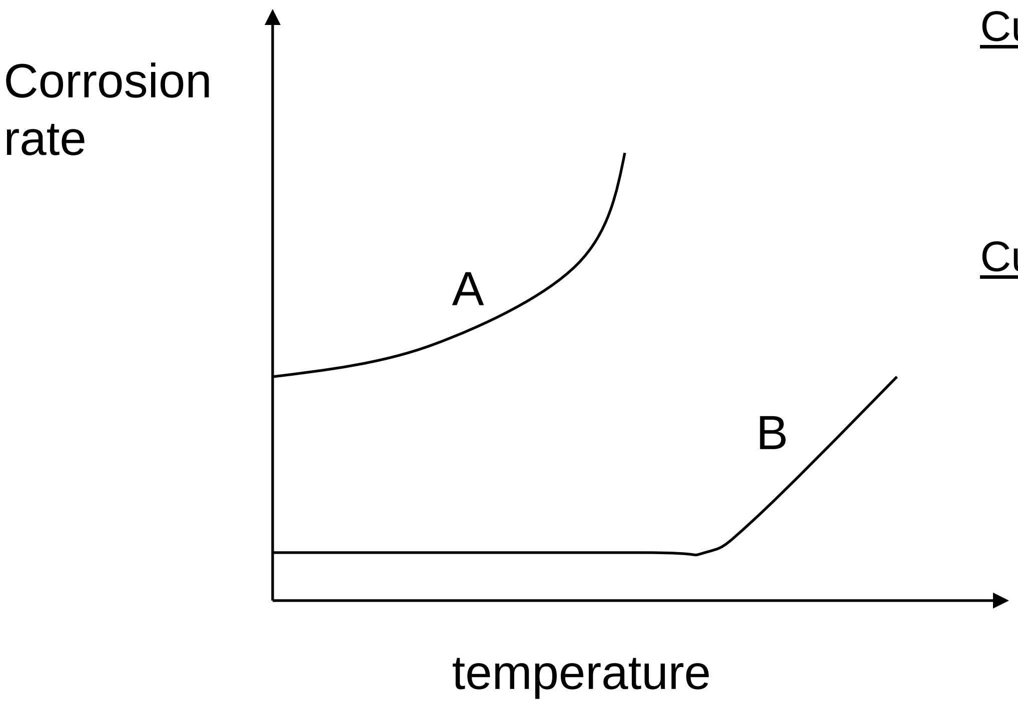
18 Cr-8Ni in H_2SO_4

Curve C : Pb in dilute H_2SO_4

Fe in concentrated H_2SO_4

EFFECT OF TEMPERATURE

Effect of temperature on corrosion rate



Examples :

Curve A : 18 Cr-8Ni in H_2SO_4

Ni in HCl

Fe in HF

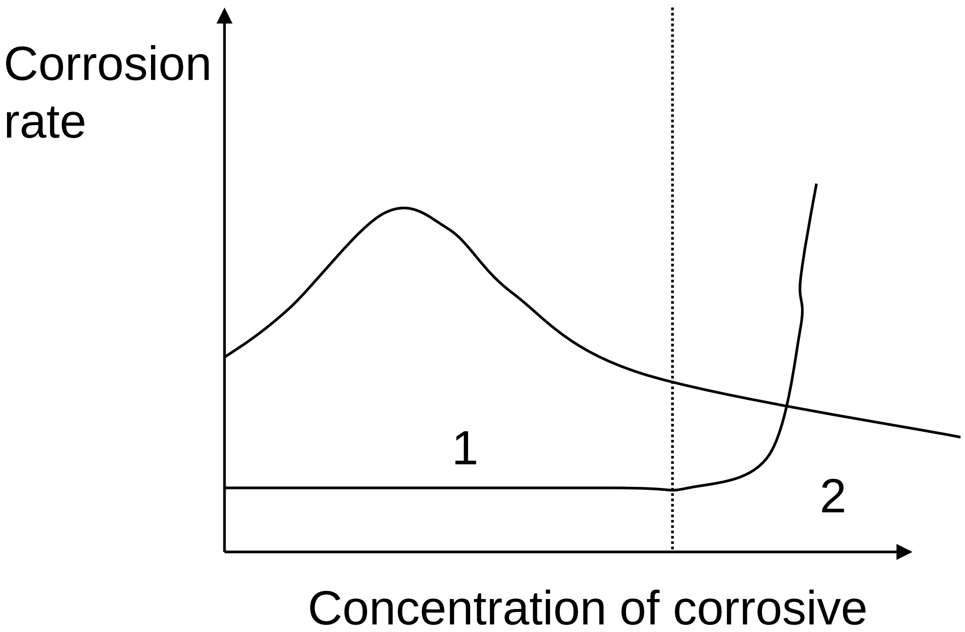
Curve B : 18 Cr-8Ni in HNO_3

Monel in HF

Ni in NaOH

EFFECT OF CORROSIVE CONCENTRATION

Effect of corrosive concentration on corrosion rate



<u>Examples :</u>

Curve A :

1 : Ni in NaOH

18 Cr-8Ni in HNO_3

Hastelloy B in HCl

Ta in HCL

1-2 : Monel in HCl

Pb in H_2SO_4

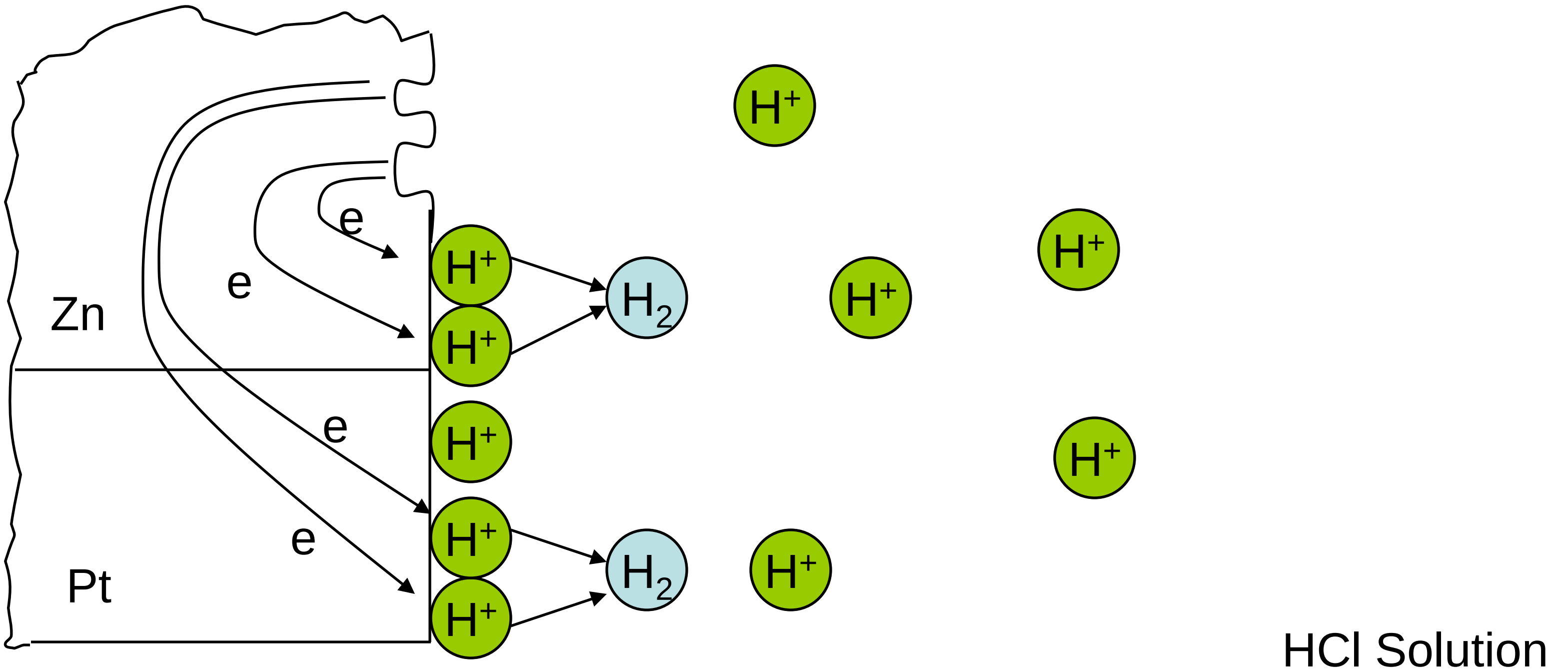
Curve B : Al in acetic acid and HNO_3

18 Cr-8Ni in H_2SO_4

Fe in H_2SO_4

EFFECT OF GALVANIC COUPLING

Electrochemical reactions occurring on galvanic couple zinc (Zn) and platinum (Pt)



CORROSION RATE

Standard Expressions for Corrosion Rate

- Mils per year **(mpy) = 534 W / DAT**

  W = weight loss, mg

  D = density of specimen, g/cm^3

  A = area of specimen, in^2

  T = exposure time, hr

- 1 mpy = 0.0254 mm/yr = 25.4 µm/yr = 2.9 nm/hr

  = 0.805 pm/sec

- Faraday's law : **corrosion penetration rate = K ai/nD**

  K = Constant, 0.129 to mpy, 3.27 to µm/yr, 0.00327 to mm/yr

  a= atomic weight of metal

  i= current density, $\mu A/cm^2$

  n= number of electron

COMPARISON OF CORROSION RATE

Relative corrosion resistance *	Approximate metric equivalent				
	mpy	mm/yr	μm/yr	nm/yr	pm/sec
Outstanding	<1	<0.02	<25	<2	<1
Excellent	1-5	0.02-0.1	25-100	2-10	1-5
Good	5-20	0.1-0.5	100-500	10-50	5-20
Fair	20-50	0.5-5	500-1000	50-150	20-50
Poor	50-200	1-5	1000-5000	150-500	50-200
Unacceptable	200+	5+	5000+	500+	200+

*based on typical ferrous and nickel based alloys

STANDAR POTENTIALS

Au^{3+} + 3e = Au	+ 1.498 V
Pt^{3+} + 3e = Pt	+ 1.200 V
Ag^{+} + e = Ag	+ 0.779 V
Hg_2^{2+} + 2e = 2Hg	+ 0.788 V
Fe^{3+} + e = Fe^{2+}t	+ 0.771 V
Cu^{2+} + 2 = Cu	+ 0.337 V
Sn^{4+} + 2e = Sn^{2+}	+ 0.150 V
$2H^{+}$ + 2e = H_2	0.000 V
Pb^{2+} + 2e = Pb	- 0.126 V
Sn^{2+} + 2e = Sn	- 0.136 V
Ni^{2+} + 2e = Ni	- 0.250 V
Co^{2+} + 2e = Co	- 0.277 V
Cd^{2+} + 2e = Cd	- 0.403 V
Fe^{2+} + 2e = Fe	- 0.440 V
Cr^{3+} + 3e = Cr	- 0.744 V
Zn^{2+} + 2e = Zn	- 0.763 V
Al^{3+} + 3e = Al	- 1.662 V
Mg^{2+} + 2e = Mg	- 2.363 V
Na^{+} + e = Na	- 2.714 V
K^{+} + e = K	- 2.925 V

EXERCISES

A Iron specimen exposed to an acid solution loses 25 milligrams during a 12 hour exposure.

a. What is the equivalent current flowing due to corrosion ?

b. If the specimen are is 200 cm^2, what is the corrosion rate in *mg per dm^2 per day* (mdd) due to this current ?

c. What is the corrosion rate in mpy ?

d. What is the corrosion rate in µm/yr ?

Ar Fe = 56 D Fe = 7,8 gr/cm3