CORROSION TYPES
CHAPTER 4
8)EROSION CORROSION

LECTURER

SAHEB M. MAHDI

8) EROSION CORROSION :

Erosion corrosion is the acceleration or increase in rate of deterioration or attack on a metal because of relative movement between a corrosive fluid and the metal surface. Generally this movement is quite rapid, and mechanical wear effects or abrasion are involved.

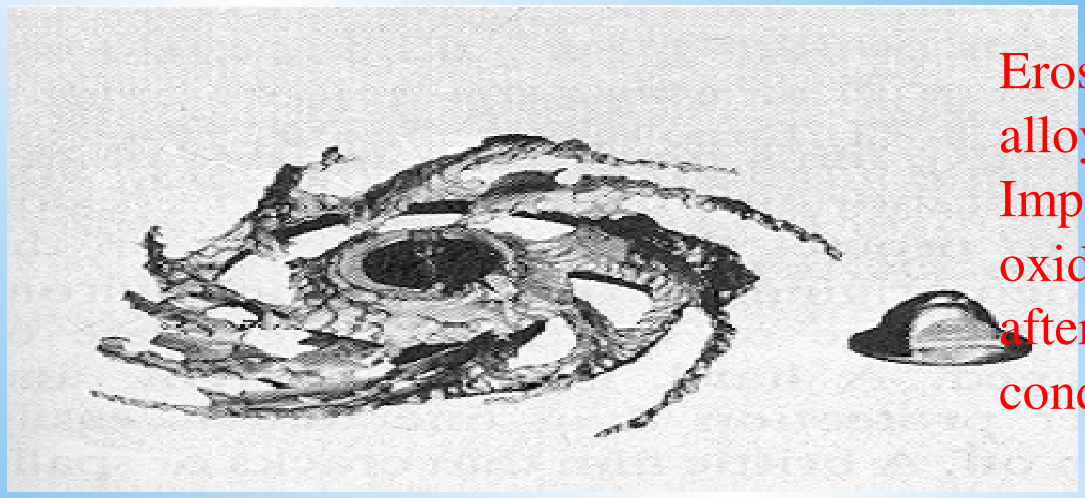
Removal of the metal may be:

- **as corrosion product which "slips off" the surface because of the high fluid shear and bares the metal beneath.**
- **as metal ions, which are swept away by the fluid flow before they can deposit as corrosion product.**

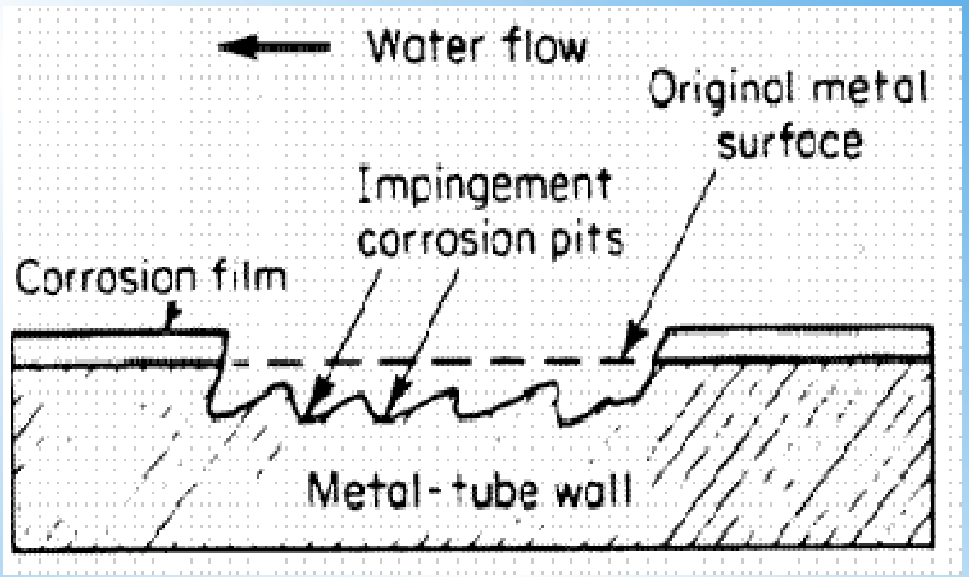
erosion is the straightforward wearing away by the mechanical abrasion caused by suspended particles. e.g., sand-blasting, erosion of turbine blades by droplets .

erosion-corrosion also involves a corrosive environment the metal undergoes a chemical reaction.

Erosion-corrosion produces a distinctive surface finish: grooves, waves, gullies, holes, etc., all oriented with respect to the fluid flow pattern . . . "scalloping"...



Erosion-corrosion of stainless alloy pump impeller.
Impeller lasted ~ 2 years in oxidizing conditions;
after switch to reducing conditions, it lasted ~ 3 weeks!



Erosion-corrosion of condenser tube wall.

Most metals/alloys are susceptible to erosion-corrosion. Metals that rely on protective surface film for corrosion protection are particularly vulnerable, e.g.: Al , Pb , SS , CS. Attack occurs when film cannot form because of erosion caused by suspended particles (for example), or when rate of film formation is less than rate of dissolution and transfer to bulk fluid.

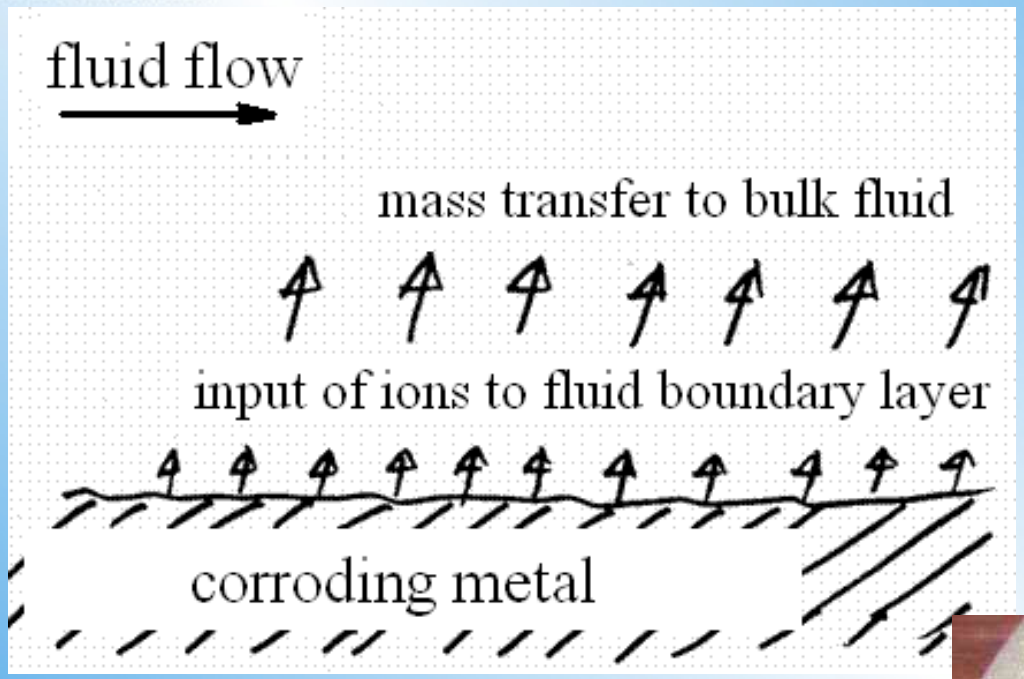
Erosion-Corrosion found in:

- **◇ aqueous solutions;**
- **◇ gases;**
- **◇ organic liquids;**
- **◇ liquid metal.**

If fluid contains suspended solids, erosion-corrosion may be aggravated.

Vulnerable equipment is that subjected to high-velocity fluid, to rapid change in direction of fluid, to excessive turbulence . . viz. equipment in which the contacting fluid has a very thin boundary layer

- **high mass transfer rates.**


fluid flow
mass transfer to bulk fluid
input of ions to fluid boundary layer
corroding metal

Vulnerable equipment includes:

- pipes (bends, elbows, tees);
- valves;
- pumps;
- blowers;
- propellers, impellers;
- stirrers;
- stirred vessels;
- HX tubing (heaters, condensers);
- flow-measuring orifices, venturies;
- turbine blades;
- nozzles;
- baffles;
- metal-working equipment (scrapers, cutters, grinders, mills);
- spray impingement components;
- etc.

Surface film effects

Protective corrosion-product films important for resistance to erosion-corrosion.

Hard, dense, adherent, continuous films give good resistance, provided that they are not brittle and easily removed under stress.

Lead sulphate film protects lead against DILUTE H_2SO_4 under stagnant conditions, but not under rapidly moving conditions.

pH affects films in erosion-corrosion of low-alloy steel. Scale generally granular Fe_3O_4 (non-protective). But at pH 6 & pH 10, scale $Fe(OH)_2/Fe(OH)_3$ . . . hinders mass transport of oxygen and ionic species.

Good resistance of Ti to erosion-corrosion in:

- **seawater**
- **Cl^- solutions;**
- **HNO_3;**
- **and many other environments.**

Resistance depends on formation and stability of TiO_2 films.

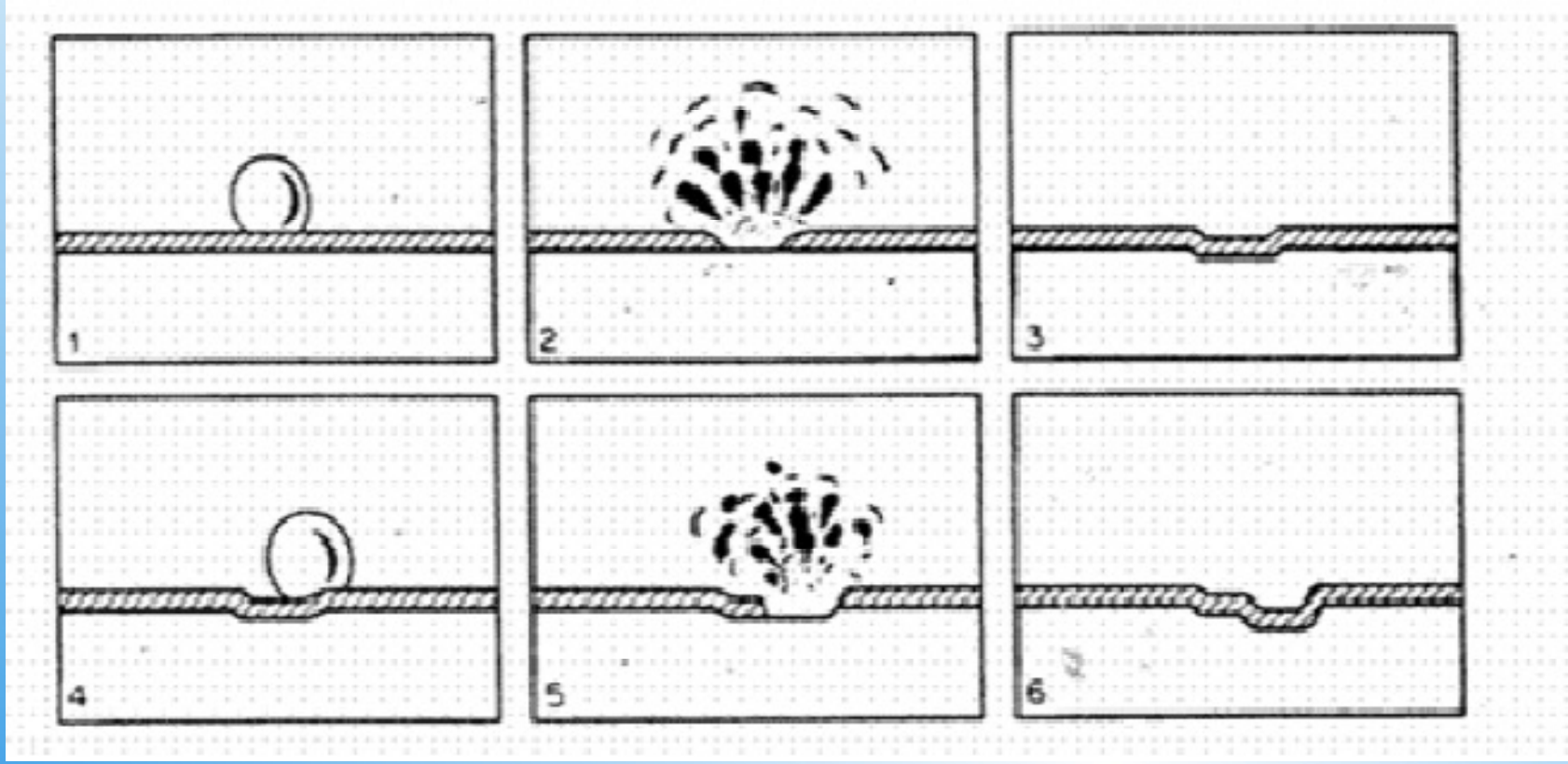
- **Cu alloys.**

Prevention of Erosion-Corrosion

- **design (avoid impingement geometries, high velocity, etc.);**
- **chemistry (e.g., in steam supply systems . . . for CS or low-alloy steel add O_2,**
- **maintain pH > 9.2, use morpholine rather than NH_3);**
- **materials (use Cr-containing steels);**
- **use hard, corrosion-resistant coatings.**

CAVITATION DAMAGE

Similar effect to E-C: mechanical removal of oxide film caused by collapsing vapor bubbles.

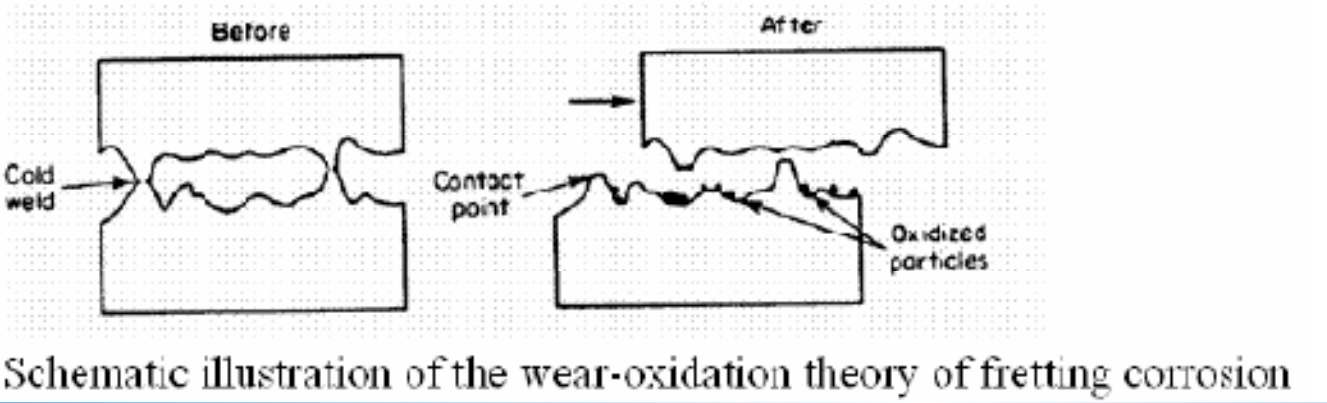


High-speed pressure oscillations (pumps, etc.) can create shock waves > 60,000 psi. Surface attack often resembles closely-spaced pitting.

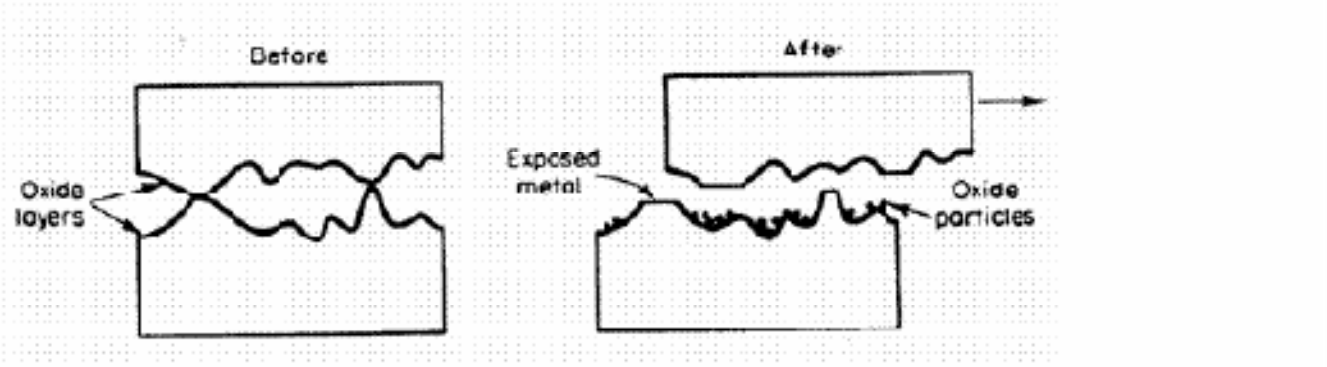
FRETTING CORROSION

Similar to E-C but surface mechanical action provided by wear of another surface generally intermittent, low-amplitude rubbing.

Two theories . . . with same overall result . . .



Schematic illustration of the wear-oxidation theory of fretting corrosion



Schematic illustration of the oxidation-wear theory of fretting corrosion

Prevention of Fretting Corrosion

- **lubricate;**
- **<u>avoid</u> relative motion (add packing, etc.);**
- **<u>increase</u> relative motion to reduce attack severity;**
- **select materials (e.g., choose harder component).**