

Some of the Basic Questions

What is wear?

What is wear type?

What is the wear mechanism?

How do we measure the wear rate?

How should we reduce the wear rate of materials?

What factors would affect the wear rate?

How can wear be prevented?

Wear

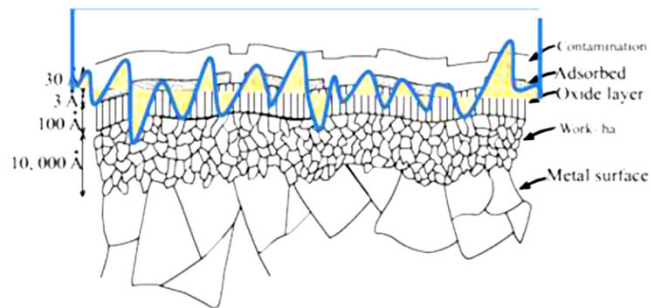
➤ Loss of material by the passage of hard particles over a surface

Wear can be defined as the **damage or removal of material** that a solid **surface** has undergone due to **sliding, rolling, and impact against another solid surface**.

Wear **contribute to friction**, because wear processes require the **application of force and consume energy**.

Wear is the damaging, gradual removal or deformation of material at solid surfaces.

Causes of wear can be mechanical (e.g., erosion) or chemical (e.g., corrosion). The study of wear and related processes is referred to as tribology.



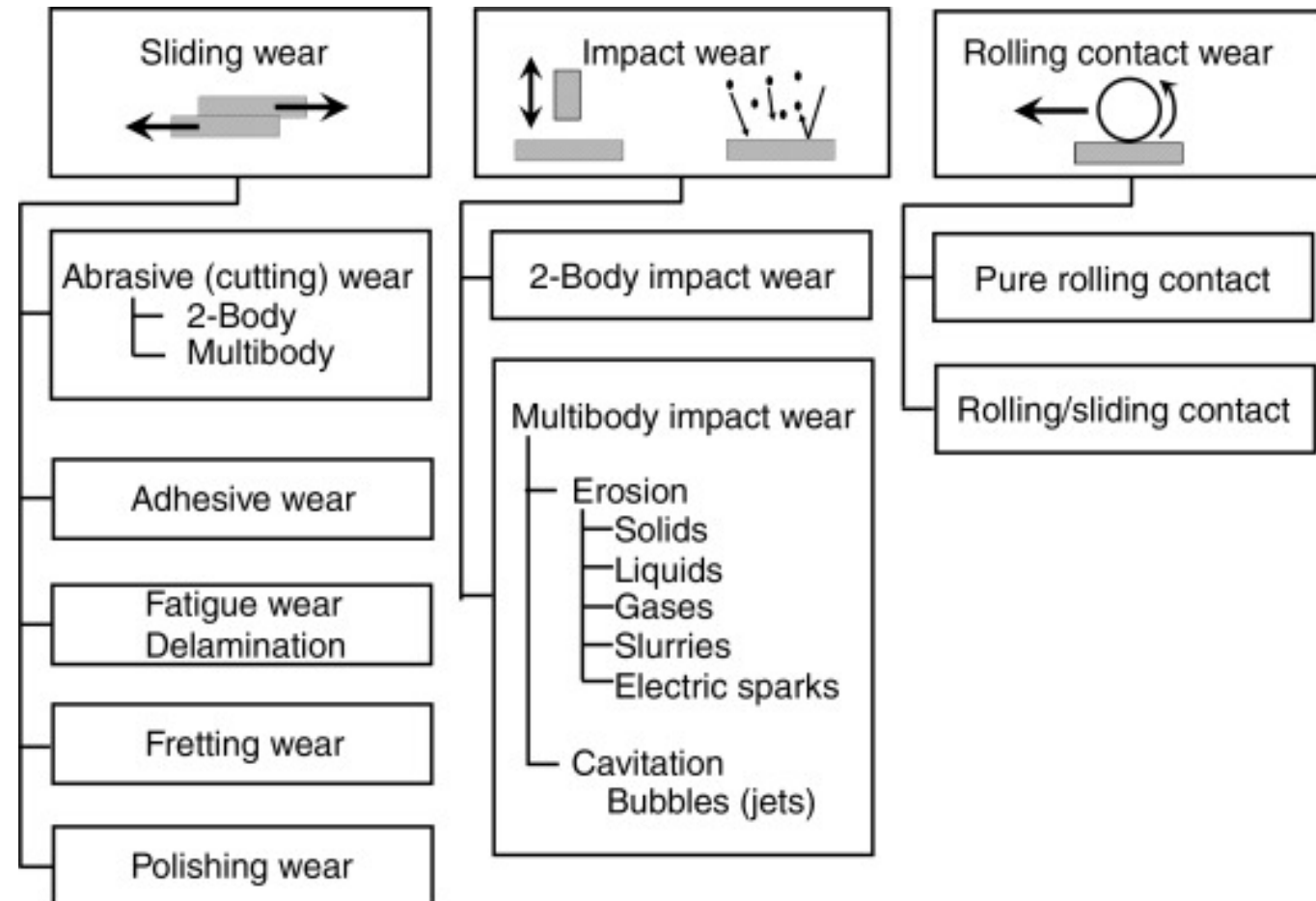
Wear

It is not a material property, **but rather a system response**.

Typically, wear is undesirable as it can lead to **increased friction**, and ultimately **to material failure or loss of functionality**.

Thus, in order to reduce wear (and consequently friction) a thin film of lubricant is inserted between the rubbing surfaces or other materials would be chosen with higher hardness.

Type of wear



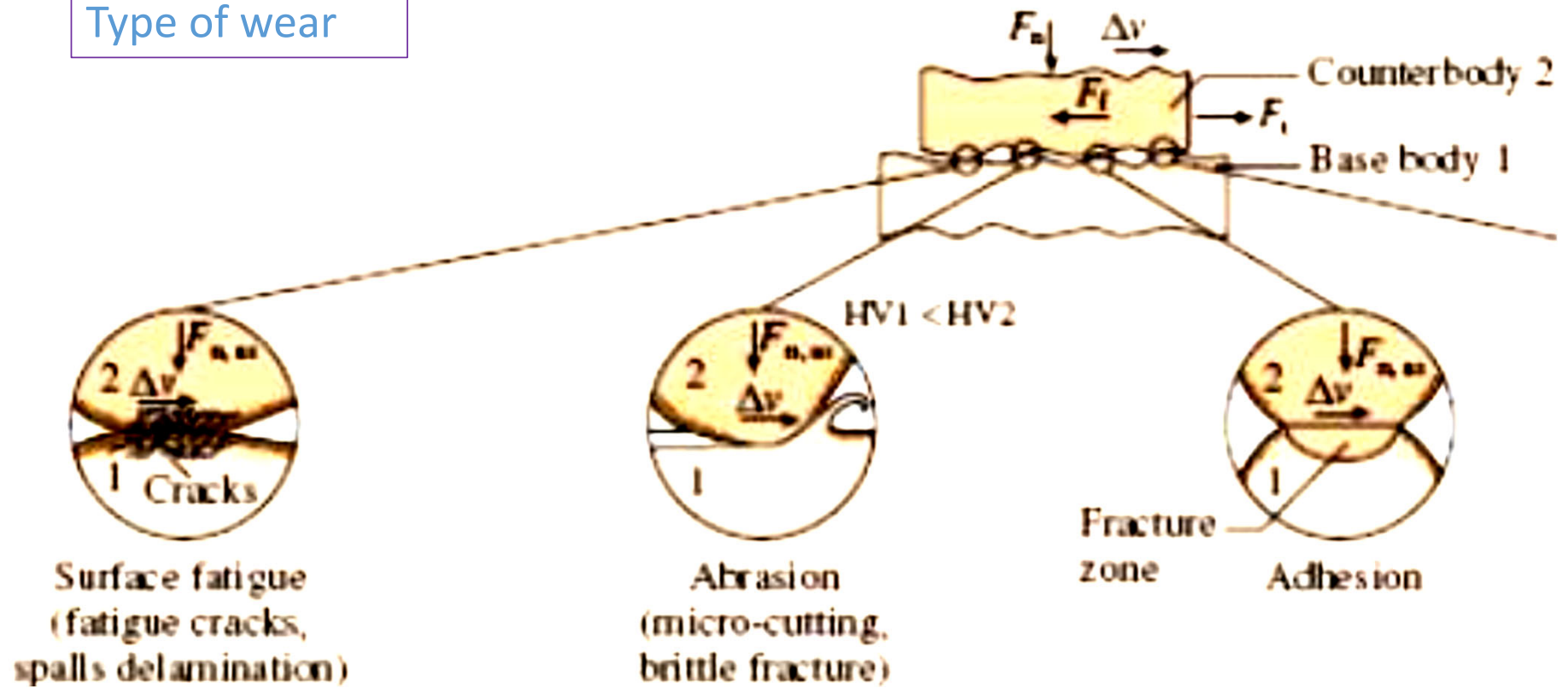
Wear Mechanisms

- Wear can be classified based on the ways that the frictional junctions are broken, that is, elastic displacement, plastic displacement, cutting, destruction of surface films and destruction of bulk material. There are many types of wear mechanisms, but we shall discuss about common wear mechanisms, which are:

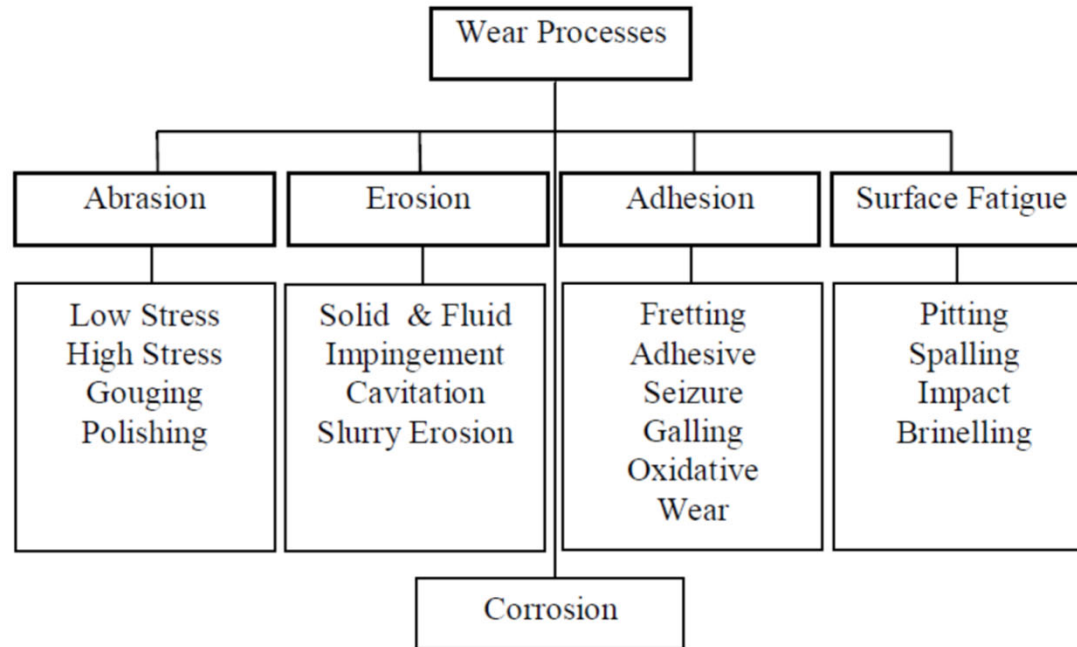
Types of wear

- Adhesive wear
 - Abrasive wear
 - Surface fatigue

Type of wear

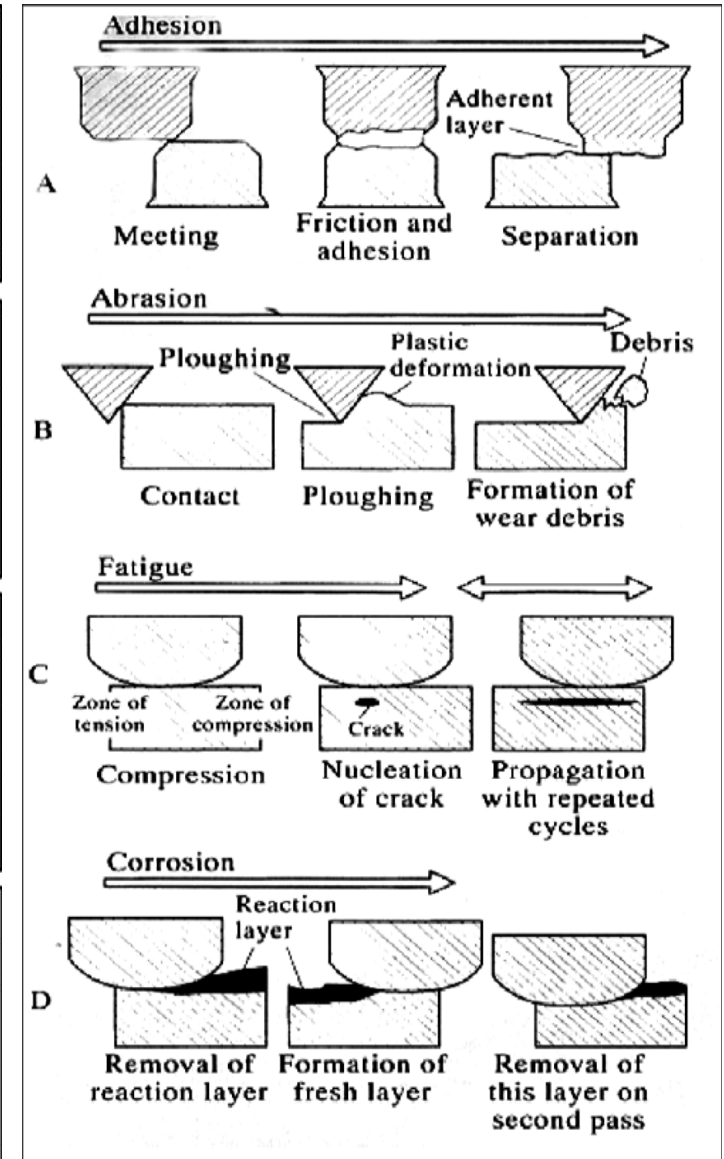
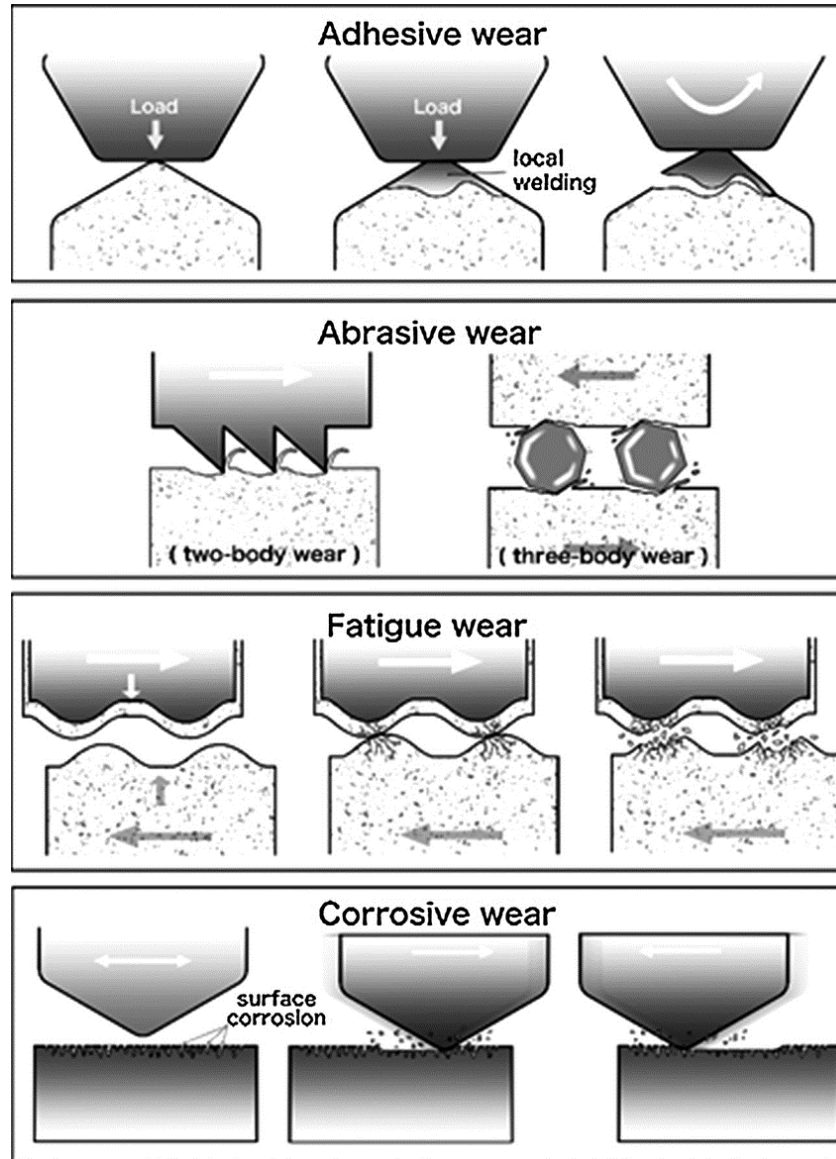


Types of wear process



- Erosive wear is caused by the impact of particles against a solid surface.
- Cavitation wear is caused by the localized impact of fluid against a surface or fast flowing fluids.

Type of wear

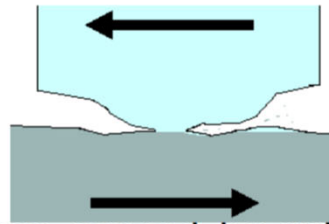


CLASSIFICATION OF WEAR

Type	Typical characteristics and definitions	observed In
Sliding wear (delamination wear)	Wear due to localized bonding between contacting solid surfaces leading to material transfer between the two surfaces or the loss from either surface. Plastic deformation, crack nucleation and propagation in the surface	Sliders, bearing, gears and camshaft.
Fretting wear	Wear arising as a result of fretting (Small amplitude oscillatory motion, usually tangential, between two solid surfaces in contact).	Press fit parts with a small relative Sliding motion
Abrasive wear	Wear due to hard particles or hard protuberances forced against and moving along a solid surface.	Sliding surfaces ,earth-removing Equipment
Erosive wear (solid particle impingement)	Wear due to mechanical interaction between that surface and a fluid, a multi component fluid, or impinging liquid or solid particles	Turbine, pipes for coal slurries and helicopter blades
Fatigue wear	Wear of a solid surface caused by fracture arising from material fatigue.	Ball bearing, roller bearing glassy solid slider
Cavitation wear	A form of erosion causing material to wear by the action of vapour bubbles in a very turbulent liquid.	Soft Bearing Surfaces



Adhesive wear



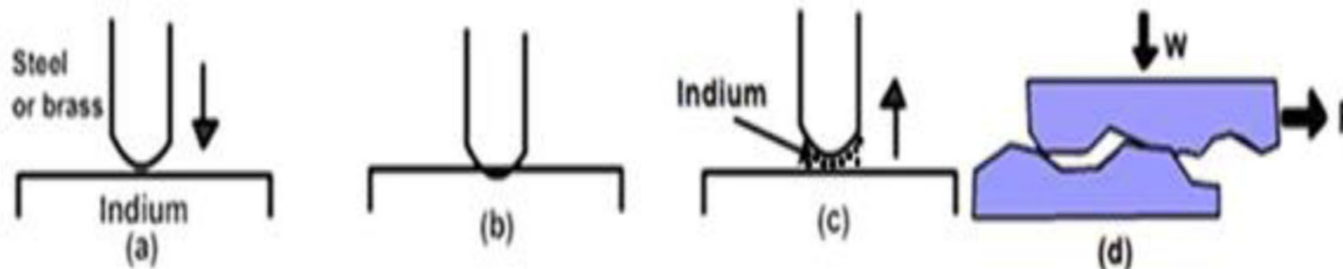
Adhesive wear are caused by relative motion, "direct contact" and plastic deformation which create wear debris and material transfer from one surface to another.

Example of Adhesive Wear:

- A Shaft rotating in a bushing
- Chalk on board-while writing

Adhesion Wear

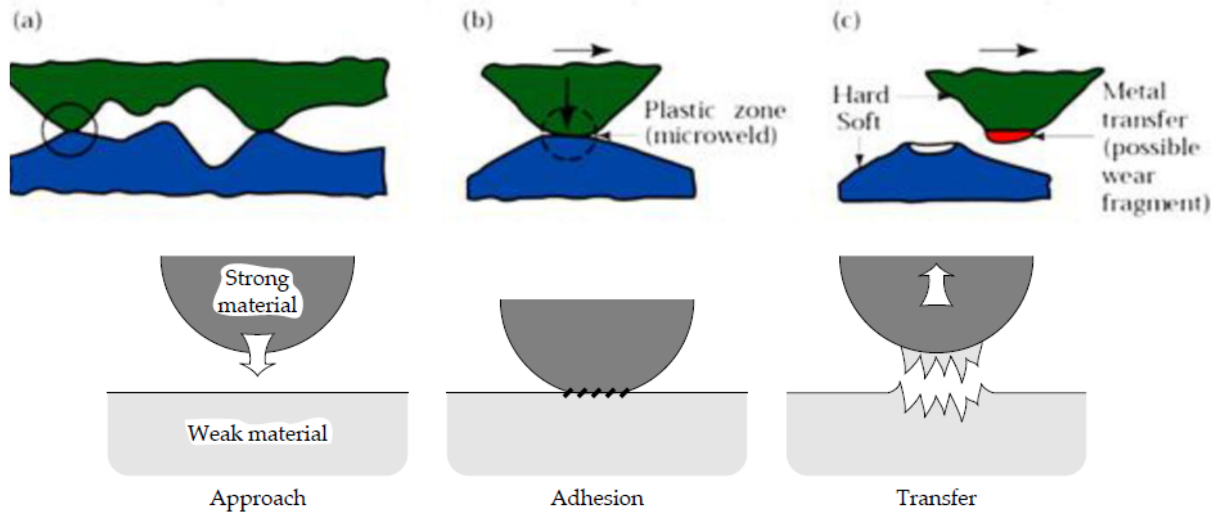
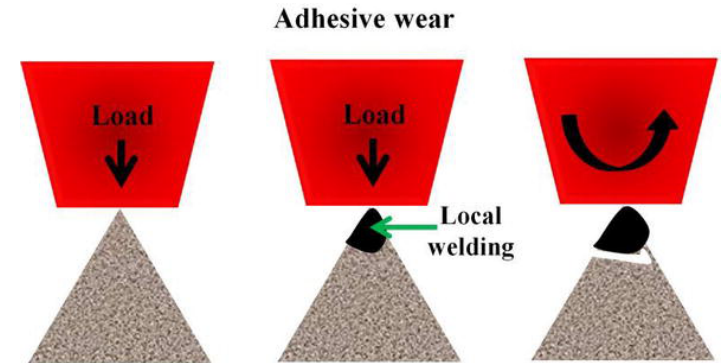
- Adhesive wear is very common in metals. It is heavily dependent on the mutual affinity between the materials. Let us take example of steel and indium.
- When steel pin under load is pushed [Fig. 3.5(b)] in indium block, and subsequently retracted, a thin layer of indium transferred on the steel pin.



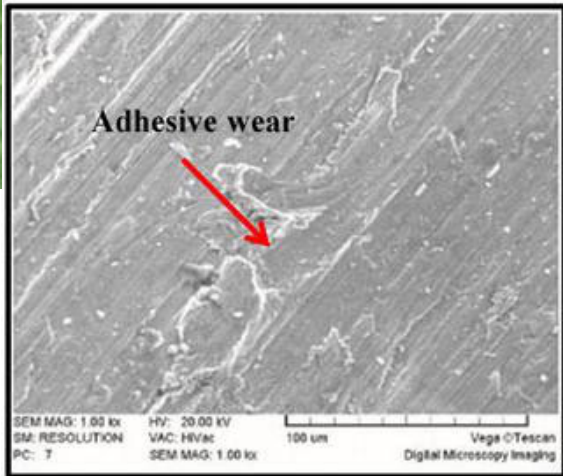
Steps in Adhesion Wear

Steps can be summarized as follows:

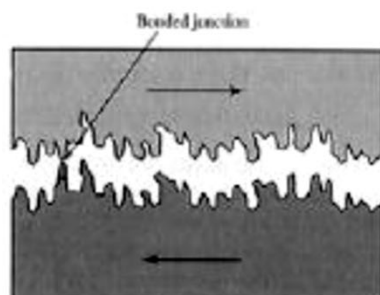
1. Deformation of contacting asperities
2. Removal (abrasion) of protective oxide surface film.
3. Formation of adhesive junctions
4. Failure of junction by pulling out large lumps and transfer of materials



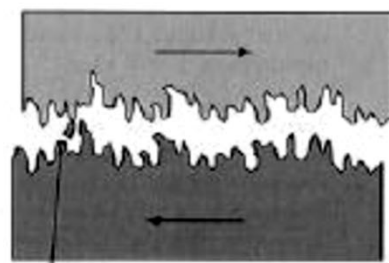
Adhesive wear



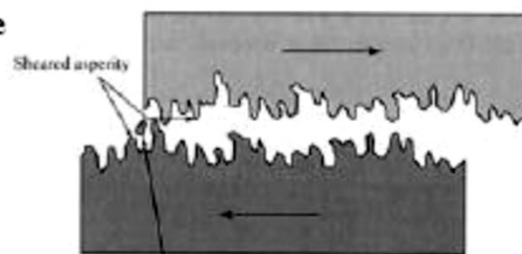
The sequence of steps occurring during adhesive wear:



(a) High local stresses **plastically deform** the material in the vicinity of the contact points, resulting in the formation of **atomic bonds** across the interface.



(b) As the force causing the relative sliding motion is increased, the **shear stress** in the joined region **increases** until it exceeds the shear strength of one of the solids.



(c) Subsequently, material is lost into the region between the two solids.

Laws of Adhesive Wear

1. Wear Volume proportional to sliding distance of travel (L)
- True for wide range of conditions
2. Wear Volume proportional to the load (W)
- Dramatic increase beyond critical load.
3. Wear volume inversely proportional to hardness(H) of softer material

Archer's Adhesion Wear Model

As per adhesion wear laws, wear volume is given by $V = K_1WL/3H$. This equation is known as **Archard's Wear Equation**.

The value of k_1 depends on;

- *elastic-plastic contacts,*
- *shearing of those contacts,*
- *effect of environment,*
- *mode of lubrication, etc.*

This expression of wear volume is a simple expression, as it does not require to estimate constant n ($A = (W/H)^n$), individual shear strength of elastic and plastic junctions, effect of lubricant thickness, roughness, etc.

Wear Measurement

➤ Archard wear Equation :

$$W \propto \frac{W}{H}$$

w = wear

w = Normal Load on contact

H = surface hardness of the wearing material

K = wear coefficient (dimensionless)

$$W = K \frac{W}{H}$$

$\frac{K}{H}$ = is called Dimensional wear constant
Unit = (volume)/(Load/meter)

Frictional wear / adhesive wear

Two **bodies sliding** over or **pressed** into each other which promote the **material transfer** from one to another.

$$\frac{V}{L} = K \frac{P}{3\sigma_y}$$

Where

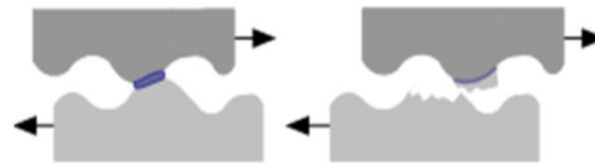
V = wear volume

L = sliding velocity

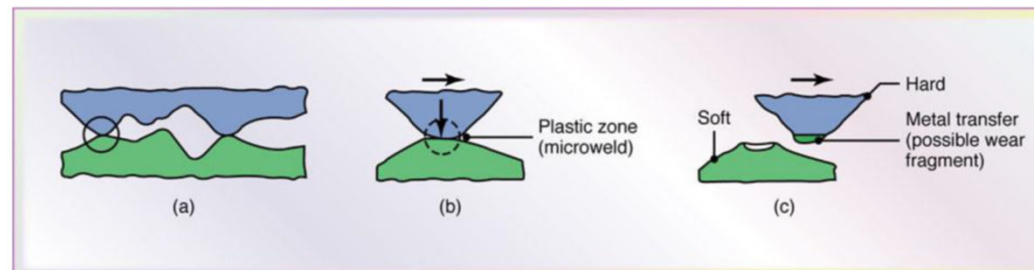
P = applied load

σ_y = yield stress of softer material

K = wear coefficient



Ref.: www.substech.com



1.1. Adhesive Wear - Prevention

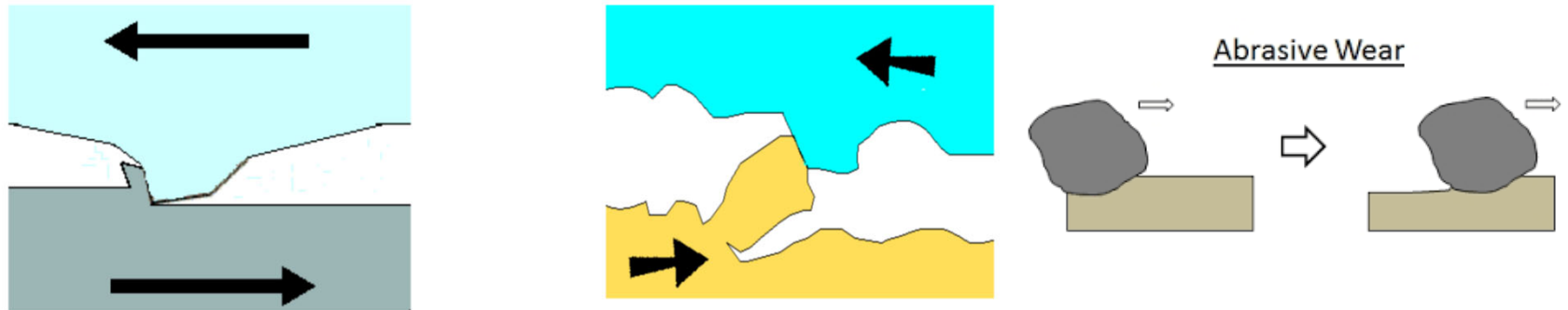
□ MECHANICAL

1. Reduce load, speed and temperature
2. Improve oil cooling
3. Use compatible metals
4. Apply surface coatings such as phosphating

LUBRICANT

1. Use more viscous oil to separate surfaces
2. Use "extreme pressure" (anti-scuff) additives such as a sulfur-phosphorous or borate compounds

Abrasive Wear



Abrasive wear occurs when a hard rough surface slides across a softer surface. ASTM International (formerly American Society for Testing and Materials) defines it as the loss of material due to hard particles or hard protuberances that are forced against and move along a solid surface.