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Flaws or imperfections may be from the original material, caused by process used, created by human error or defects during operating life or combination of some of them.

A clear understanding of material, the process and the possible interaction between them is very important to determine any discontinuity/defects.

Discontinuity: An interruption (crack, forging lap, seam, inclusion, porosity, etc.) in the normal physical structure or configuration of an article, It may or may not be a defect

Defect: a discontinuity that interferes with the usefulness of a part or exceeds acceptability limits established by applicable specifications, Not all discontinuities are defects

# Classification of Defects by Origin

Typically grouped into 3 stages:

1. Inherent

Related to the melting and original solidification of metal in the ingot

2. Processing

Formed by forming or fabrication operations (casting, rolling, forging, machining, grinding, heat treating, welding, plating)

3. Service-Induced (also call In-service)

Discontinuities caused by fatigue, corrosive environments, or overheating

















# Processing Discontinuities

- Formed by forming or fabrication operations
- Typically subdivided into:
  - primary processing discontinuities – casting, rolling, forging
  - secondary processing discontinuities – machining, grinding, heat treating, welding, plating





# Casting Discontinuities

Casting of metal involves pouring or injection of molten metal into a cavity.

## Non-metallic Inclusions:

- Is a general term applied to sand, slag, oxide etc trapped in casting.
- Most of non-metallics generally lighter than the molten metal. Are mostly found on the top of the ingot. Nevertheless, there are some which are trapped at the bottom since they did not have sufficient time to reach the surface before molten metal above solidifies.
- Usually irregular in shape.







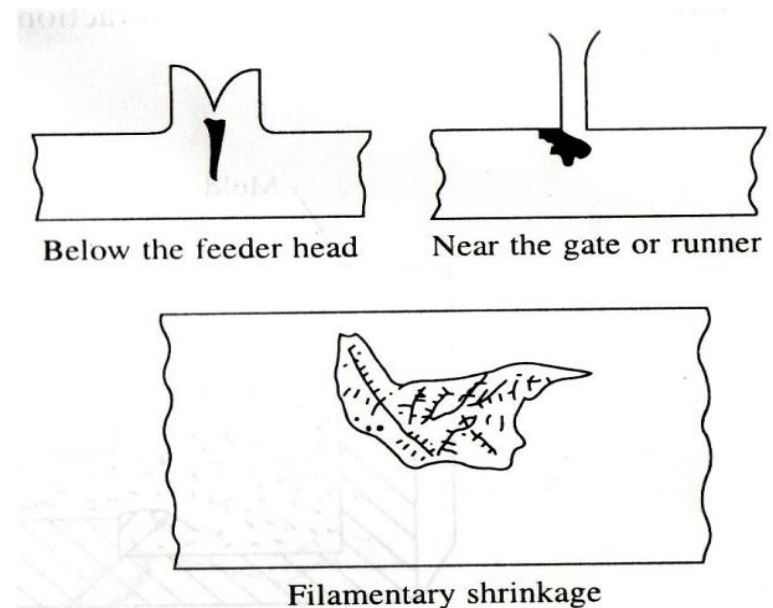




# Casting Defects

## Shrinkage flaws

- These are cavities formed during liquid to solid contraction.
- Macro-shrinkage (piping defect): Solidification of molten material starts from surface and progresses to center of ingot. Since the center of ingot is the last to cool and solidify, most of the cavity due to shrinkage forms at center.























# Forming Discontinuities

- Extrusion is a process by which a block of material is reduced in cross section by forcing it to flow through a die under high pressure. Following defects generally formed:



## Internal pipe or extrusion defect

- Trapping of oxidized outer skin of the billet into the central region of the extruded product.

## Cracks

- If the material does not flow through the die properly, 'cracks' are generated.







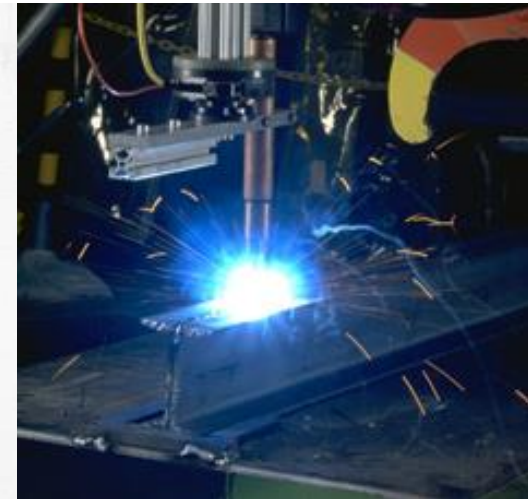
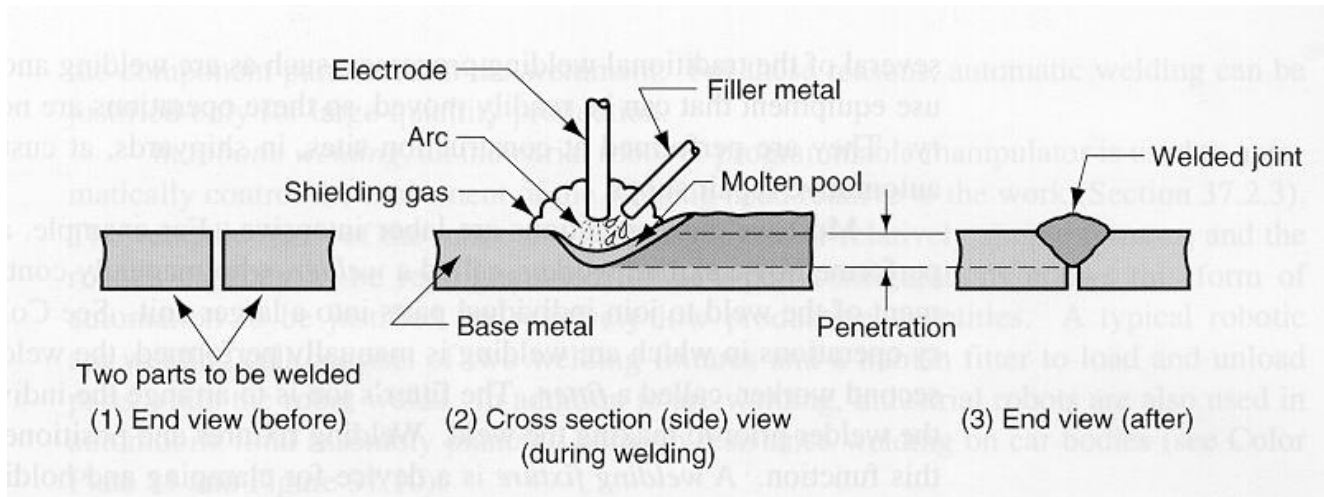




# Welding Discontinuities

A concentrated heat source melts the material in the weld area; the molten area then solidifies to join the pieces together

Sometimes a filler material is added to the molten pool to strengthen the weld

























# Service-Induced Discontinuities

## Cause of Material Failures

- Products and structures may be subjected to a number of varying service conditions. Loads may be static loads (stationary or fixed) or dynamic loads (varying).
- The environment may also contribute.
- Mechanical failure is always a result of presence of stresses above some critical value, leading to deformation or fracture.
- Such excessive stresses are set up by combination of material defect, excess load, improper load application or design error.

# Service-Induced Discontinuities

- Discontinuities caused by fatigue, corrosive environments, or overheating

# Fatigue Cracks

- Fatigue Cracks
  - Develop at areas of high stress concentrations such as holes, fillets, keyways, etc.
  - May be due to mechanical or thermal fatigue
  - Once crack initiates, it can quickly propagate resulting in failure









# Material Losses

- Service-Induced Discontinuities also due to loss of material
  - Wear
  - Erosion
  - Corrosion