WIRE DRAWING
Objectives

• This chapter provides fundamental background on processes of drawing of rods, wires and tubes.

• Mathematical approaches for the calculation of drawing load will be introduced.

• Finally drawing defects occurring during the process will be highlighted and its solutions will be included.
Introduction: wire drawing

- Wire drawing involves reducing the diameter of a rod or wire by passing through a series of drawing dies or plates.

- The subsequent drawing die must have smaller bore diameter than the previous drawing die.
Introduction

• Drawing operations involve pulling metal through a die by means of a tensile force applied to the exit side of the die.

• The plastic flow is caused by compression force, arising from the reaction of the metal with the die.

• Starting materials: hot rolled stock (ferrous) and extruded (non-ferrous).

• Material should have high ductility and good tensile strength.

• Bar, wire and tube drawing are usually carried out at room temperature, except for large deformation, which leads to considerable rise in temperature during drawing.

• The metal usually has a circular symmetry (but not always, depending on requirements).
Rod and wiredrawing

- Reducing the diameter through plastic deformation while the volume remains the same.
- Same principals for drawing bars, rods, and wire but equipment is different in sizes depending on products.

Rods relatively larger diameter products.

Wires small diameter products < 5 mm diameter.
WIRE DRAWING

Sheave and Speed Control Wheel

Draw Block

Wire Rod

Dies

Finish Draw Block
Die for Round Drawing

Terminology of a typical die used for drawing round rod or wire.

Bell (angle or radius)
Entering angle
Approach angle
Bearing surface (land)
Back relief angle

Tungsten-carbide die insert in a steel casing. Diamond dies, used in drawing thin wire, are encased in a similar manner.

Steel casing

Tungsten-carbide insert (nib)
Wire drawing die

Conical drawing die

- **Shape of the bell** causes hydrostatic pressure to increase and promotes the flow of lubricant into the die.

- **The approach angle** – where the actual reduction in diameter occurs, giving the half die angle $\alpha$

The bearing region produces a frictional drag on the wire and also remove surface damage due to die wear, without changing dimensions.

The die nib made from cemented carbide or diamond is encased for protection in a thick steel casing.

- **The back relief allows** the metal to expand slightly as the wire leaves the die and also minimizes abrasion if the drawing stops or the die is out of alignment.
Die Materials Overview

• Cemented carbides are the most widely used for drawing dies due to their superior strength, toughness, and wear resistance.

• Most drawing dies are cemented carbide or industrial diamond (for fine wires).

• Polycrystalline Diamond (PCD) used for wire drawing dies – for fine wires. Longer die life, high resistance to wear, cracking or bearing.

• Cemented carbide is composed of carbides of Ti, W, Ni, Mo, Ta,
The effect of die angle on the total energy required to cause deformation

Ideal work of plastic deformation $U_P$ independent of die angle $\alpha$.

Work to overcome friction $U_f$

Redundant work $U_r$

The summation of $U_P$, $U_f$ and $U_r$ gives the total energy $U_T$.

This has a minimum at some optimum die angle $\alpha^*$. 

The reduction and the friction
Wire drawing process

- **Hot rolled rod**

- **Pickling, descaling**
  - Remove scale - causing surface defects.

- **Lubricating**
  - Cu and Sn are used as lubricants for high strength materials. Or conversion coating such as sulphates or oxalates.

- **drawing\**
  - Oils and greases for wire drawing
  - Mulsifiable oils for wet wire drawing
  - Soap for dry drawing.
Mechanical descaling
Stepped-cone multiple-pass wiredrawing

- More economical design.
- Use a single electrical motor to drive a series of stepped cones.
- The diameter of each cone is designed to produce a peripheral speed equivalent to a certain size reduction.
Rods which can not be coiled, are produced on draw benches.

- Rod is swaged
- Insert though the die
- Clamped to the jaws of the draw head
- The draw head is moved by a hydraulic mechanism
Classification of tube drawing processes

There are three basic types of tube-drawing processes:

- Sinking
- Plug drawing
  - Fixed plug
  - Floating plug
- Mandrel drawing.

Diagram showing steps:
- Tube sinking
- Fixed plug
- Floating plug
- Moving mandrel
Sinking

- The tube, while passing through the die, shrinks in outer radius from the original radius.
- No internal tooling (internal wall is not supported), the wall then thicken slightly.
- The final thickness of the tube depends on original diameter of the tube, the die diameter and friction between tube and die.
- Lower limiting deformation.
Stationary plug

- Use conical plug to control size/shape of inside diameter.
- Use higher drawing loads than floating plug drawing.
- Greater dimensional accuracy than tube sinking.
- Increased friction from the plug limit the reduction in area (seldom > 30%).
- can draw and coil long lengths of tubing.
A tapered plug is placed inside the tube.
• As the tube is drawn the plug and the die act together to reduce both the outside/inside diameters of the tube.
• Improved reduction in area than tube sinking (~ 45%).
• Lower drawing load than fixed plug drawing.
• Long lengths of tubing is possible.
• Tool design and lubrication can be very critical.
Draw force is transmitted to the metal by the pull on the exit section and by the friction forces acting along the tube-mandrel interface.

- minimized friction.
- $V_{\text{mandrel}} = V_{\text{tube}}$
- The mandrel also imparts a smooth inside finish surface of the tube.
- mandrel removal disturbs dimensional tolerance.
Defects in rod and wiredrawing

Defects in the starting rod (seams, slivers and pipe).
Defects from the deformation process, i.e., center burst or cracking (cupping).

- This defect will occur for low die angles at low reductions.
- For a given reduction and die angle, the critical reduction to prevent fracture increases with the friction.