



From Mandrel to Form

Creating an Electroforming Process



By Berl Stein, CEF

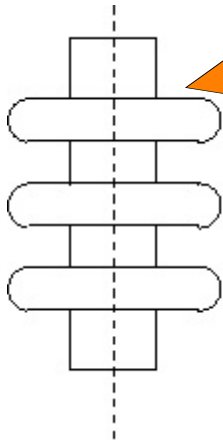
Electroforming Process Scope

- Mandrels:
 - Design&material
 - Preparation (cleaning, passivation, parting layer)
- Metal(s) and electroforming chemistry
- Deposition technique/equipment
- Electroform/mandrel separation
- Finished electroform processing:
 - Mechanical
 - (Electro)Chemical
 - Thermal

Electroforming a Dynamic Hollow Element

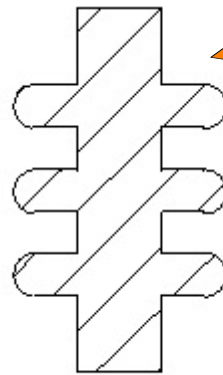
(Expansion joint or bellows)

**Mandrel is
Designed and
Machined**



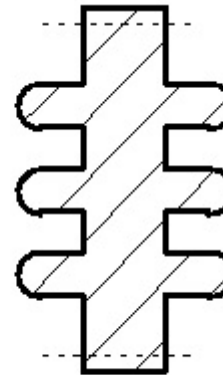
Part Drawing

**Metal layer is
formed and
prepared for
mandrel removal**

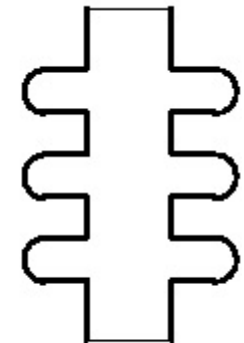


Mandrel

**Mandrel is
removed, form
is finished**



Mandrel Inside the Form



Finished Form

Why Develop a New Process?

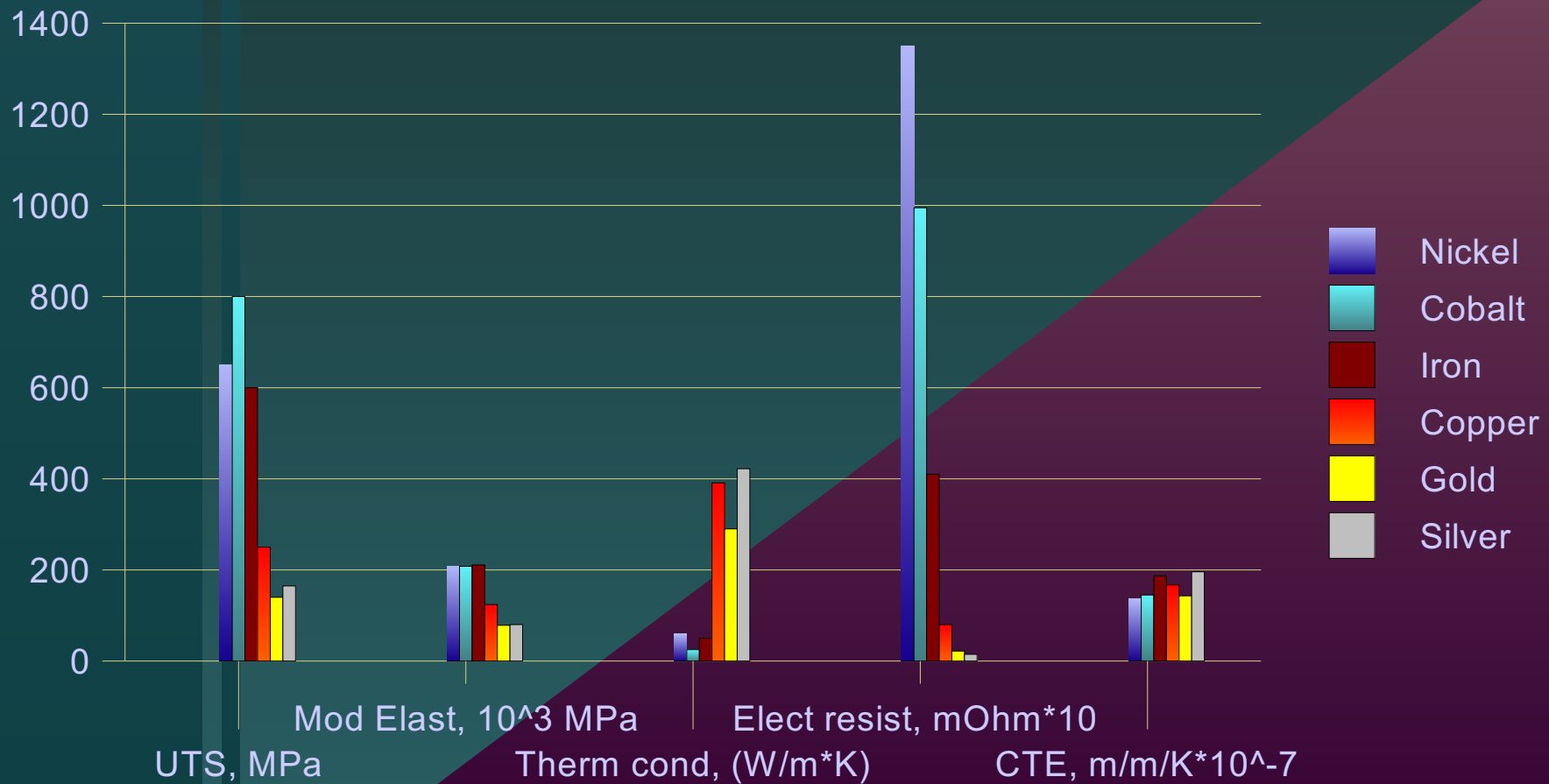
- **No process available to you meets requirements for:**
 - Mechanical properties: UTS, hardness, Young's modulus, wear resistance etc.
 - Thermal conductivity
 - Electrical properties: conductivity, contact resistance
 - Magnetic properties
 - Bio-compatibility and/or corrosion behavior
 - Plating uniformity/throwing power
 - Optical properties: reflectivity, surface finish, tarnish resistance
- **Existing process is inconsistent, difficult to control, etc.**
- **Existing process needs to be modified for a new application or product**

Start With the End in Mind:

Preparation and Literature Search

- Select an electroformable metal based on product requirements and published deposit properties
- Preselect bath chemistry alternatives based on their descriptions vs. requirements
- Put together a list of mandrel material choices
- Outline the pre- and post- electroforming steps

Some Properties of Electroformable Metals



Useful Information Resources

Where to Find It

1. Books:

- a. Safranek, W. H. *The Properties of Electrodeposited Metals and Alloys*, AESF, Orlando, FL, 1986.
- b. Dini, J.W., *Electrodeposition*, Noyes Publications, 1993
- c. Lowenthal, F. A. *Modern Electroplating*, John Wiley & Sons, Princeton, NJ, 1973

2. Online Databases:

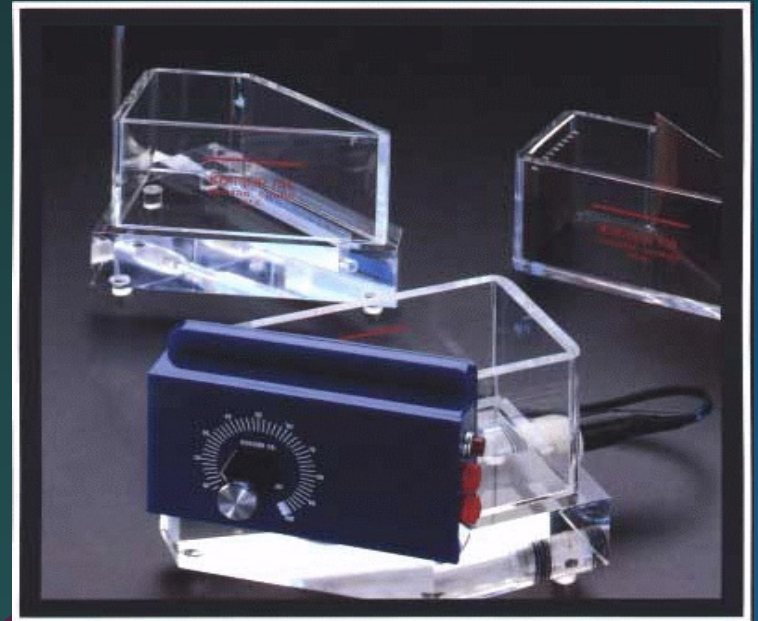
- a. US PTO online database of patents
(<http://www.uspto.gov/patft/index.html>)
- b. Compendex (COMPUTerized ENgineering InDEX) Plus
(<http://galen.library.ucsf.edu/db/compendex.html>)
- c. The Linda Hall Library (<http://www.lhl.lib.mo.us/>)

3. CD-ROM Databases

- a. MFIS (Stevenage, UK) Surface Finishing CD-ROM database

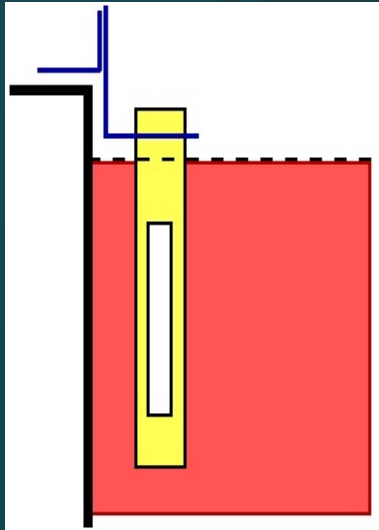
Select Plating Chemistry

- Screen preselected chemistries on paper
- Conduct beaker and Hull cell tests
- Electroform test coupons and measure deposit properties
- Finalize chemistry selection based on performed tests

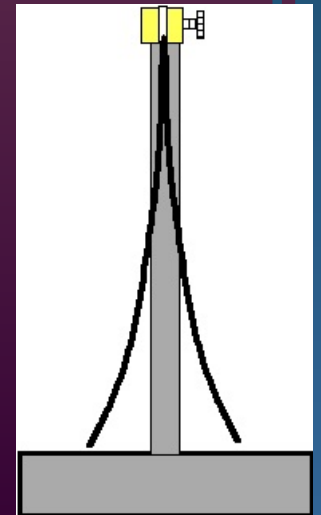


Resources you will need

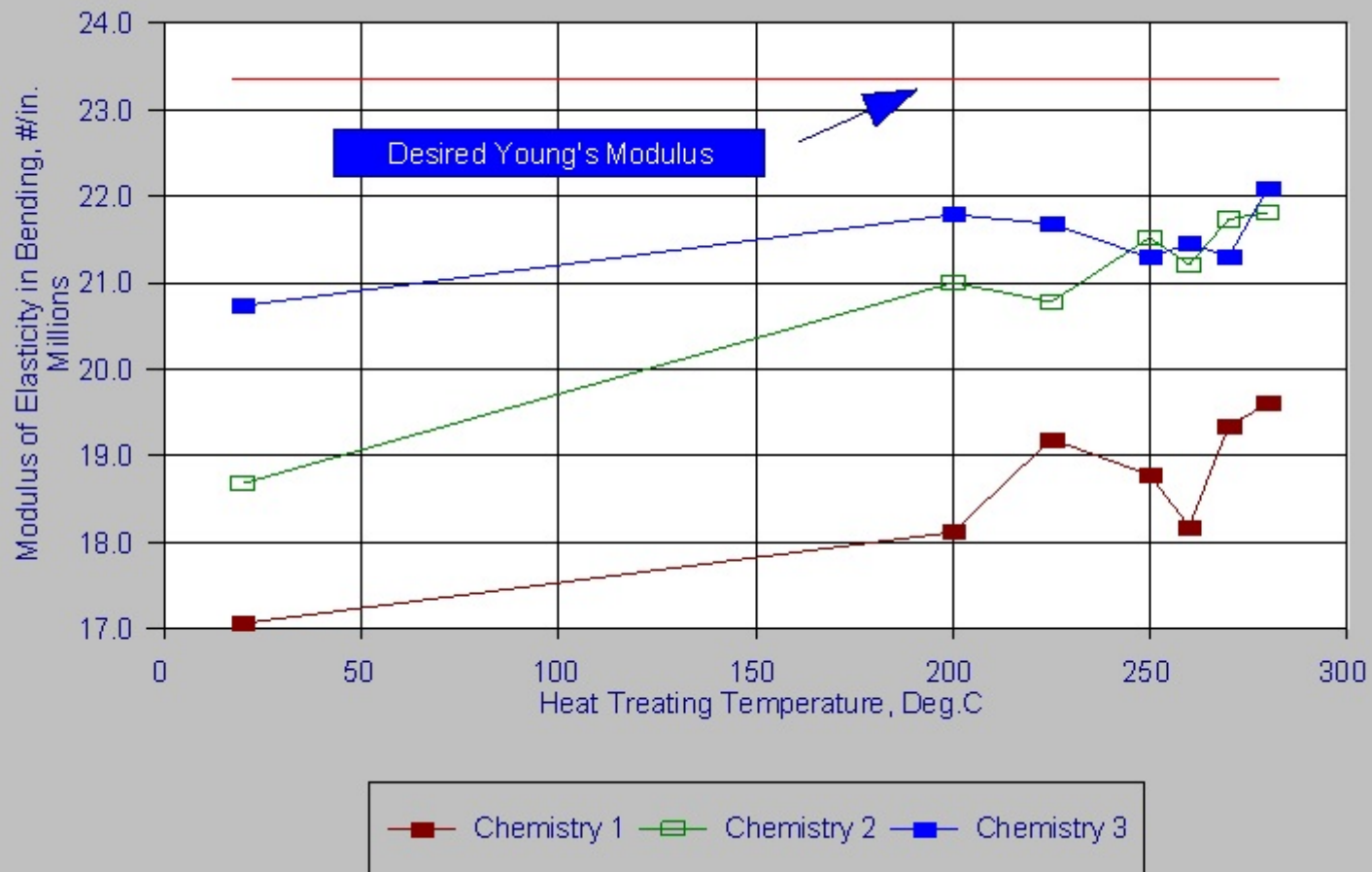
(Equipment and Instruments)



- Small electroforming tank
- Stress measurement cell & scale
- Hardness and/or tensile strength tester
- Hull cell or multi-purpose plating cell



Comparison of Ni-Co Chemistries

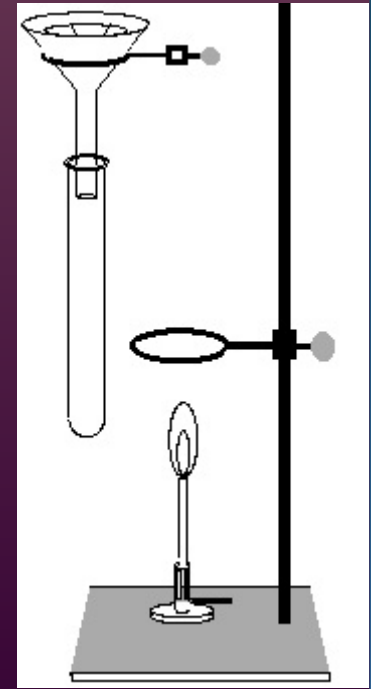


Optimize Plating Chemistry I

- Evaluate gap between requirements and known capabilities of selected chemistry
- Select the variables you are planning to utilize to close the gap:
 - existing bath variables - temperature, flow, pH, concentrations
 - additional variables - alloying metals, additives, etc.
- Design and perform a screening experiment to select the non-trivial variables

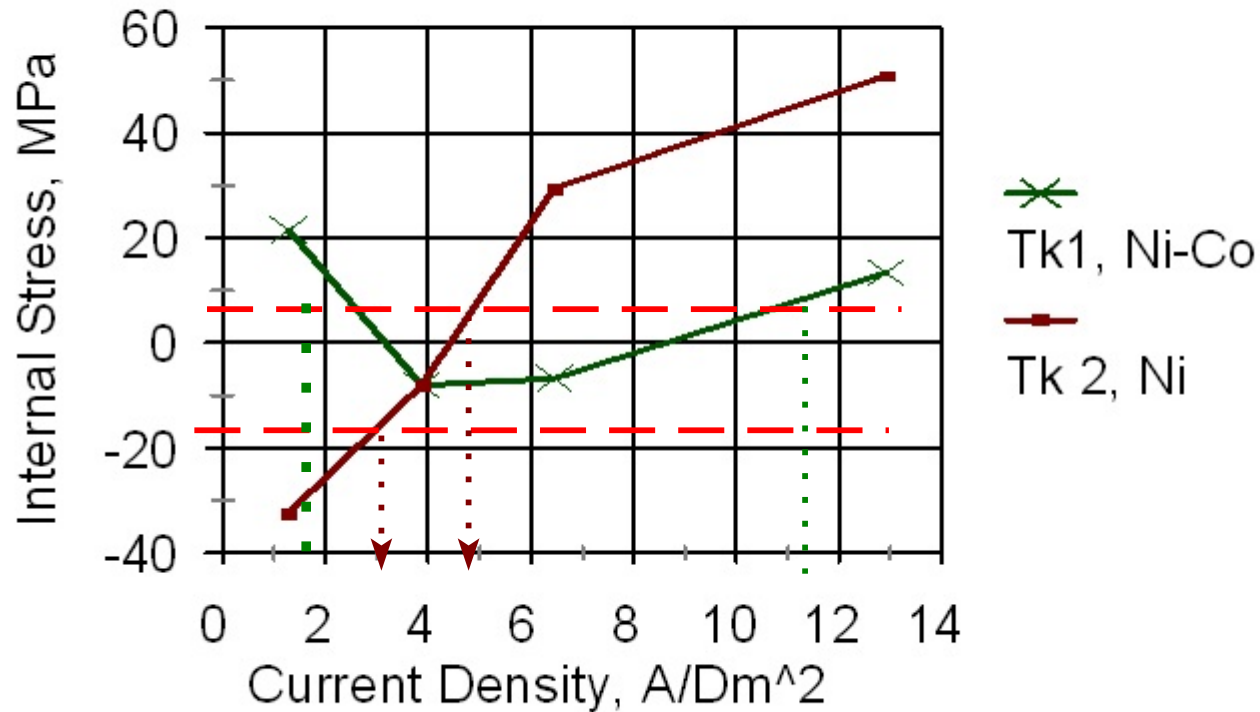
Optimize Plating Chemistry 2

- Considering only the critical variables, design an optimization experiment and carry it out to define the optimum combination of process parameters
- Document the emerging process - map its stress profile and establish the process window



Ni & Ni-Co Bath Stress Profiles and Process Windows

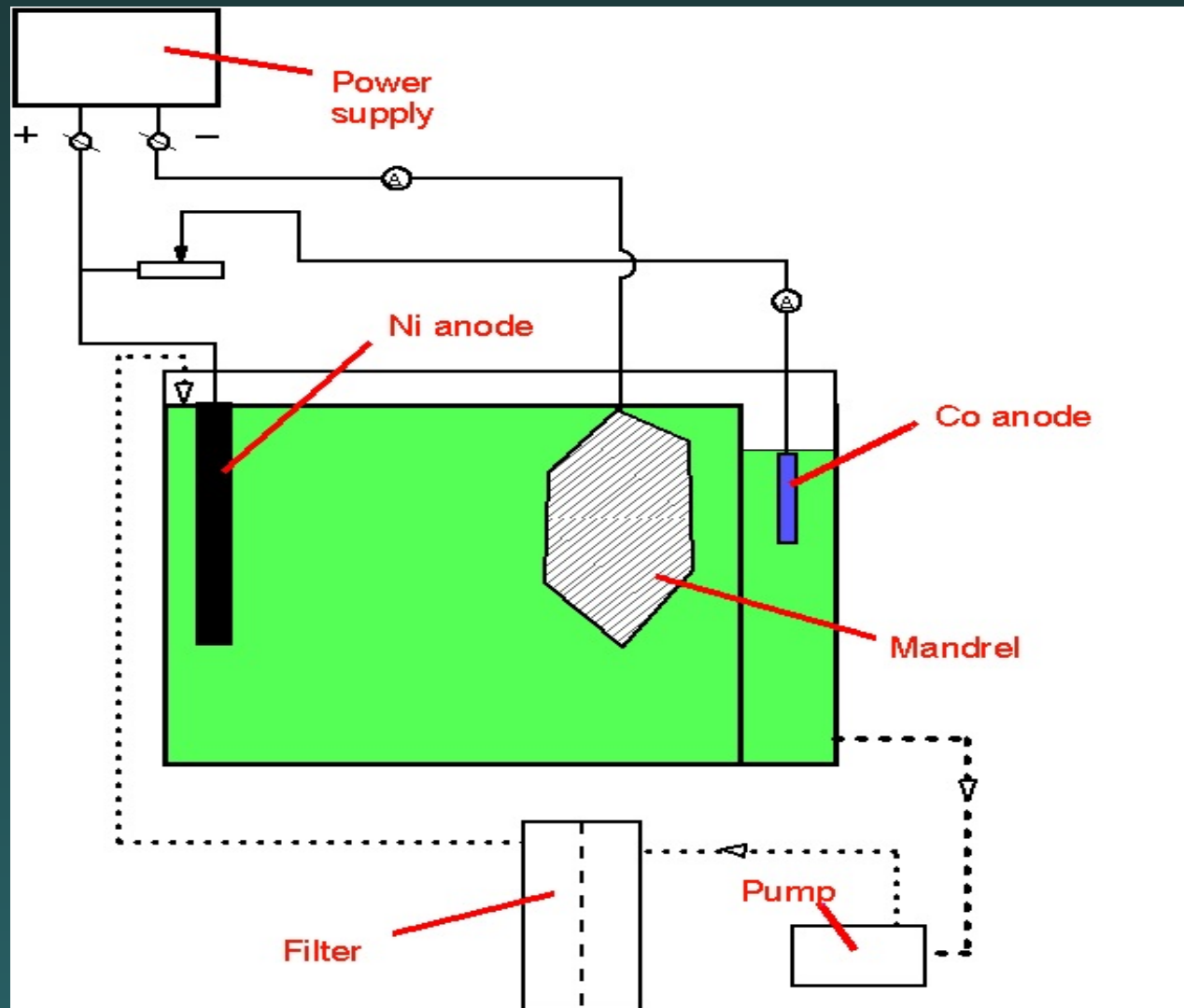
Stress Profiles
Ni & Ni-Co



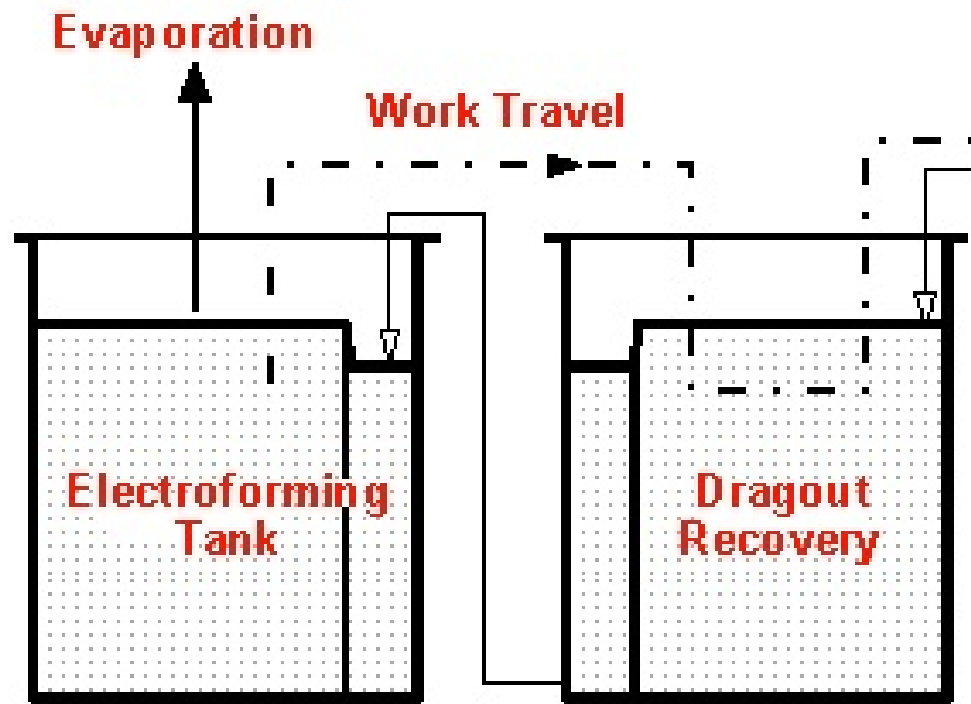
Design Electroforming Equipment

- Anode/mandrel relative size, positions, distance
- Agitation, solution flow, circulation and filtration systems
- Temperature, pH, level, additives, composition control systems
- Solution recuperation (dragout control) system

Ni-Co Electroforming Tank



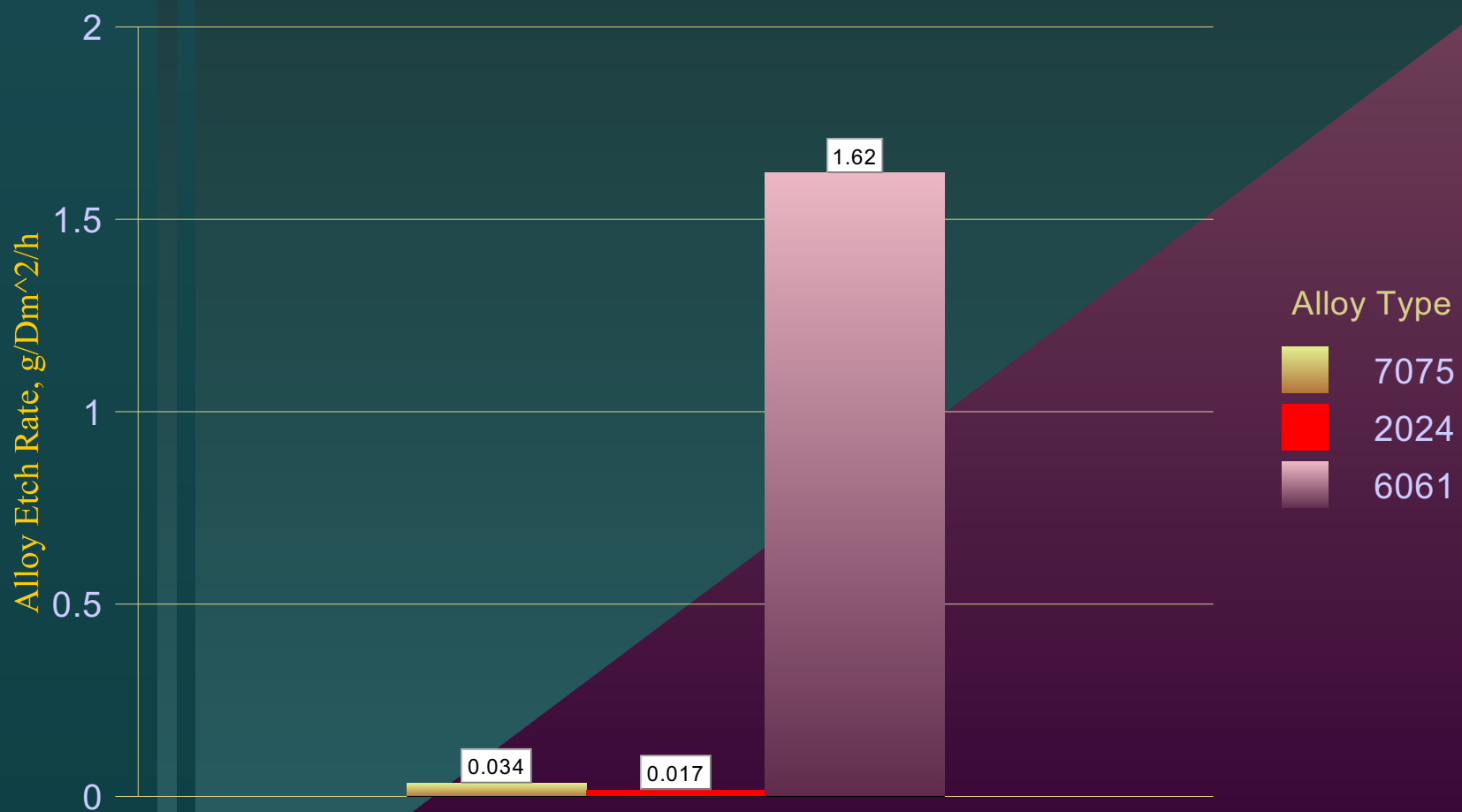
Dragout Recovery Setup



Mandrel selection and preparation

- Mandrel material selection criteria:
 - ease of machining
 - chemical stability during electroforming
 - ease of removal
- Define the pretreatment/post treatment processing steps including rinsing, drying, etc.
- Test alternative pretreatments and select the best one
- Design/specify equipment for the pre/post treatment cycles

Mandrel Material Selection for Ease of Chemical Removal

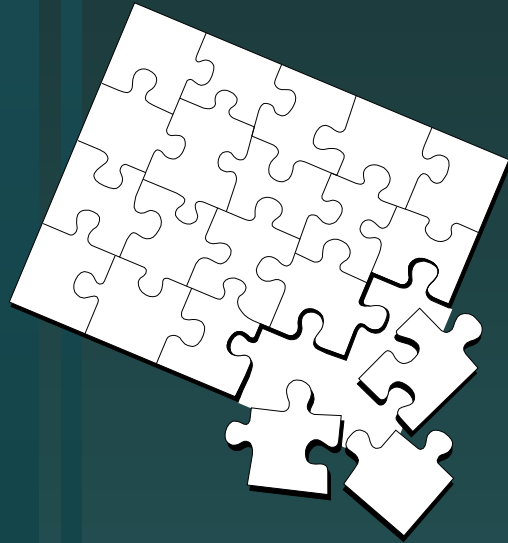


Facility-Wide Issues

- Address safety and environmental concerns:
 - Design a waste treatment system
 - Make provisions for spill containment in emergency situations
 - Design a ventilation system
- Build/purchase and install the equipment
- Start-up and trouble-shoot the process

Start Production





- Questions?
- Comments?
- Remarks?

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