Problem Statement: Silver Reduction Program - Protecting Margins through Material Optimization

Background

Danfoss manufactures sight glass components for refrigeration systems that enable moisture content identification—a critical function for system reliability and performance. Currently, the brazing process for these components uses high silver-content filler materials (15% and 55% Ag + Cu + P) in both induction and furnace brazing operations. With an annual production volume of **1 million pieces**, even marginal reductions in silver content translate to significant cost savings while maintaining product integrity.

The challenge lies in optimizing material composition and process parameters to reduce silver usage without compromising the stringent performance requirements that ensure product safety and longevity.

The Challenge

How can we systematically reduce silver content in brazing operations through simulation-driven optimization while maintaining all product performance specifications?

Your task is to develop a scalable solution that optimizes the brazing process for Danfoss sight glass components by:

- Identifying alternative filler material compositions with reduced silver content
- Validating performance through structural and thermal flow analysis
- Optimizing process parameters for both induction and furnace brazing methods
- Demonstrating cost-effectiveness and manufacturing feasibility

---

Product Requirements & Constraints

Functional Requirements:

- **Pressure Rating**: Must comply with standard 52 bar operating pressure
- **Burst Pressure**: Minimum 260 bar sustained pressure capability

- **Corrosion Resistance**: Pass 1000 hours of AASS (Acetic Acid Salt Spray) testing at 50°C
- **Brazing Quality**: Achieve 100% brazing penetration with zero porosity
- **Standards Compliance**: Meet PTV EN 14903 requirements
- **Material Integrity**: Zero color change in brass valve body and copper tube (no decolorization)

Manufacturing Constraints:

- **Base Materials**: Brass valve body and copper tube (fixed—cannot be modified)
- **Current Filler Materials**: Solder rings with 15% Ag and 55% Ag + Cu + P compositions
- **Brazing Methods**: Furnace brazing (primary) and induction brazing (select products)
- **Production Volume**: 1,000,000 pieces annually
- **Scalability**: Solution must be applicable to other product families

---

Expected Deliverables

Your solution should include:

1. Material Alloy Recommendations

- Proposed filler material compositions with reduced silver content
- Comparative analysis of mechanical and thermal properties vs. current materials
- Justification for material selection based on performance requirements

2. Simulation & Analysis Reports

- **Structural Analysis**: Demonstrate burst pressure capability and mechanical integrity
- **Thermal Flow Analysis**: Model heat distribution during brazing and validate penetration quality
- **Corrosion Resistance Prediction**: Assessment of long-term durability under AASS conditions

3. Process Parameter Optimization

- Optimized parameters for induction brazing (temperature profiles, heating rates, dwell times)
- Optimized parameters for furnace brazing (temperature cycles, atmosphere control)
- Comparison of both methods for annual volume capacity (1M pcs) and cost-efficiency

4. Cost-Benefit Analysis

- Projected cost savings from silver reduction
- Implementation costs (material procurement, process modifications)
- ROI calculation and payback period

5. Feasibility & Scalability Assessment

- Manufacturing feasibility with current equipment
- Quality control considerations
- Roadmap for scaling solution to other Danfoss product families

---

Evaluation Criteria

Solutions will be evaluated based on:

- **Silver Reduction Achieved** (% reduction in Ag content)
- **Compliance with Design Requirements** (all specifications met)
- **Cost Savings Potential** (annual savings and ROI)
- **Quality of Analysis** (rigor of simulation and validation)
- **Manufacturing Feasibility** (ease of implementation)
- **Scalability** (applicability beyond sight glass components)

Available Resources

Participants will have access to:

- Current silver content data and material specifications
- Cost data for silver and alternative materials
- Historical testing data from brazing experiments

- CAD models and technical drawings of sight glass components
- Relevant industry standards (PTV EN 14903)

Why This Matters

Silver is a precious metal with volatile pricing, directly impacting manufacturing margins. By optimizing silver usage through data-driven design and simulation, Danfoss can:

- **Protect profit margins** in a competitive market
- **Enhance sustainability** by reducing precious metal consumption
- **Maintain quality leadership** through rigorous engineering validation
- **Create scalable solutions** applicable across multiple product lines

This challenge represents a real-world engineering problem where innovation in materials science, thermal analysis, and process optimization converge to deliver measurable business impact.