COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Power Engineering

EET 305

Lecture 7

- Comparison of Conductor Materials in overhead systems II -

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Electrical Properties Comparison

Property	Copper (Cu)	Aluminium (Al)	ACSR	AAAC	AAC
Conductivity (% IACS)	100	61	~60	~52	~61
Resistivity (µΩ·cm)	1.72	2.82	3.0	3.1	2.82
Current carrying capacity	High	Moderate	High	High	Moderate
Skin effect	Low	Slightly higher	Moderate	Moderate	Moderate

🟢 **Note:** IACS = International Annealed Copper Standard

Mechanical Properties Comparison

Property	Cu	Al	ACSR	AAAC	AAC
Density (g/cm^3)	8.9	2.7	2.7–3.5	2.7	2.7
Tensile Strength (MPa)	200–250	100–150	350–500	230–300	150
Weight (relative)	1.00	0.30	0.33	0.32	0.30
Sag (for same span)	Low	High	Moderate	Low	High

Thermal Characteristics

Property	Cu	Al	ACSR	AAAC
Melting Point (°C)	1083	660	660	650
Coefficient of Expansion ($\times 10^{-6}$/°C)	16.6	23	19–21	22
Temperature Rise for Same Current	Low	Higher	Moderate	Moderate

Economic Considerations

Factor	Copper	Aluminium	ACSR
Material Cost	Very High	Low	Moderate
Installation Cost	High	Low	Low
Maintenance	Low	Moderate	Moderate
Life Expectancy	Long	Long	Long

🟢 **Conclusion:**

For modern transmission lines, **ACSR** and **AAAC** are preferred due to their **balance of strength, conductivity, and cost efficiency.**

Applications Summary

Application	Recommended Conductor
Short span, urban	AAC or Cu
Long span, rural	ACSR
Coastal region	AAAC
Extra high voltage (EHV)	ACSR or ACAR
Light-weight lines	Aluminium

Summary Table

Material	Conductivity	Strength	Weight	Cost	Corrosion Resistance	Typical Use
Copper	Excellent	High	Heavy	Expensive	Excellent	Short spans
Aluminium	Good	Moderate	Light	Cheap	Good	Distribution
ACSR	Good	Excellent	Light	Moderate	Fair	Long spans
AAAC	Fair	High	Light	Moderate	Excellent	Coastal lines

Environmental Effects

- Thermal Expansion: All materials expand and contract differently with temperature variations, affecting power line sag and tension.
- Weather Resistance: Aluminum and ACSR perform well in various adverse weather conditions, while copper can degrade in acidic environments.
- Environmental Impact: Lifecycle assessment of materials increasingly considers manufacturing impacts, recyclability, and energy efficiency.

Environmental Impact & Recycling

Aluminum & copper are highly recyclable

Recycling reduces energy consumption:

- ➢ Aluminum: ~85% savings.
- ➢ Copper: ~60% savings.
- ➢ Reduces landfill and environmental degradation.

Design Considerations

Factors affecting conductor selection:

- Maximum sag & tension.
- Temperature rise & ampacity.
- Mechanical loads (wind, ice).
- Environmental conditions.
- Cost and availability.

Ampacity & Current Rating

Depends on:

- Conductor cross-section.
- Ambient temperature & wind speed.
- Material resistivity.
- Use formulas to prevent overheating.

Lifecycle Cost Analysis

Includes: initial cost, installation, maintenance, energy losses.

- Copper: High initial, low losses.
- Aluminum: Lower cost, moderate losses.
- ACSR: Balanced.
- Optimization is critical for utility economics.

Technological Advancements

- Smart Conductor Technology: Development of conductors with built-in sensors to monitor temperature, tension, and electrical loads in real-time.
- Nanotechnology: Emerging materials and methods to enhance conductivity and strength while reducing weight.
- Sustainable Practices: Increasing use of recycled materials in conductor production to minimize environmental footprints.

Conclusion

- The **selection of conductor material** in overhead systems depends on a trade-off between **electrical performance**, **mechanical strength**, **weight**, and **cost**.
- Modern systems typically favor **ACSR** and **AAAC**, balancing efficiency and economy for reliable long-distance power transmission.