BY INVITATION

Enhanced mechanical properties with copper alloys

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High conductivity copper (HCC) is the first choice for the manufacture of bulk conductors such as cables, busbars, transformer windings and motor stators and rotors. However, for other electrical applications, such as connector parts, commutators and catenary wires, mechanical properties of HCC need to be enhanced by the addition of appropriate alloying elements. The ease with which copper can form alloys with other elements results in the availability of a very wide range of materials suitable for all electrical applications.

The tensile strength, proof stress and hardness of wrought HCC increase proportionately with the degree of cold working. If a stronger grade of HCC is required then it is alloyed with small amounts of silver. The addition of 0.03 per cent of silver makes it suitable for the production of transformer and other winding strips with controlled proof stress. For applications requiring good softening resistance during hard soldering, such as commutators, and where conductors are required to operate at higher than normal temperatures without loss of strength, such as large alternators and motors, 0.06-0.08 per cent silver is required. The softening temperature is raised by approximately 100K. Adding 0.08-0.12 per cent silver gives very good resistance to creep and is suitable for use in highly stressed rotor winding strips. Other applications are overhead collector wires for the catenary systems of railways and tramways. The conductivity of these alloys is 100 per cent International Annealed Copper Standard (IACS).

Tin, zinc, aluminium, manganese, nickel, and silicon can also be added to strengthen copper.

Alloying with beryllium creates the hardest and strongest copper alloy with mechanical properties similar to high strength steels but non-magnetic and with better corrosion resistance and higher electrical conductivity (16-65 per cent IACS). It has excellent fatigue resistance. Copper beryllium is used for connectors, contacts and relays, all of which are subject to cyclical loading. It can be replaced by copper-nickel-tin in many applications.

Copper's ability to form a wide variety of alloys with other elements for enhanced mechanical properties with limited loss of conductivity, makes it ideal for electrical applications.

Where a large amount of repetitive machining at high rates is required such as for screws, fasteners, contacts, connectors, clamps and bolts, the addition of approximately 0.5 per cent tellurium or sulphur raises the machinability rating from 20 per cent to 90 per cent, based on a scale where free-machining brass is rated at 100 per cent. The electrical conductivity remains largely unaffected at 93 per cent IACS.

Copper-chromium alloys are commonly used as bars for high strength conductors. As castings (with up to 90 per cent IACS) they find application as electrode holders in resistance welding, and electrical termination equipment where the shape required is more complex than can be machined economically.

REFERENCES

High Conductivity Copper for Electrical Engineering, ECI Publication No. Cu0232, February 2016.

Conductivity app **[http://www.conductivity-app.org/]**

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For applications requiring good softening resistance during hard soldering, such as commutators, high-conductivity copper (HCC) alloyed with 0.06-0.08 per cent silver is recommended.