Homework 4

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Copper tubing is a necessary component in a refrigerator assembly. Copper first starts with a copper ingot. The specific type of copper is cathode copper, whose name is derived from the exact way the copper is purified in electrolytic cells [1]. These cathode copper ingots can have purities close 100% [2].

The copper is then melted at a temperature between 2300-2400°F [1]. One thing to note is that copper’s melting temperature is 1970-1980°F [2]. At this point, there would be too much oxygen content, therefore some phosphorus is added. This particular formulation is C12200.

Copper is then cast into large round billets using a process called continuous casting. In this process, the molten copper is poured into a water-cooled graphite mold that turns the copper into a solid quickly. As the copper turns into a solid, grips constantly pull the newly formed cylinder out of the mold. Then, this is cut into billets and are ready for further manufacturing [1].

The billet is then heated up to 1535°F, which is a temperature where copper is pliable. A device with a pointed rod, called a piercing mandrel, pierces the billet lengthwise [1]. Now, the billet is heated to hot-working temperature so that the extrusion process can start. The heated billet is put into an extrusion press, where a hydraulically driven ram forces the billet through a die [1]. The resulting tube is relatively large in diameter and must be reduced further to be used in a refrigerator.

To reduce the diameter, a process called drawing must be used. This involved pulling the copper tube through two things: a tapered plug mandrel and a diameter reducing die. The purpose of the plug mandrel is to control the inner diameter while the tube is drawn through the die. This is done incrementally and iteratively until the desired inner and outer diameter is reached. Doing this also has the benefit of work hardening the copper, which makes the new tube stiff [1].

Unfortunately, these copper tubes for refrigerators are usually soft and bendy. To reach this state, we must anneal the copper to undo some of the work-hardening that was done through drawing. The copper is heated to 1300°F in a furnace to achieve this soft state [1]. The tube is now ready to put in a refrigerator.

Any joining or machining steps are not needed. The tube is simply plugged into the water supply and then plugged into the refrigerator using a quick connect fitting.

**References**

[1] K. J. Kundig, “How Do They Do That? Making Copper Plumbing Tube,” Sep-1998. [Online]. Available: <https://www.copper.org/publications/newsletters/innovations/1998/09/howdo_tube.html>. [Accessed: 28-May-2020].

[2] *Granta Design.* Granta EduPack, 2020.